



**PUBLIC REQUEST TO ADDRESS
THE BOARD OF SUPERVISORS
COUNTY OF LOS ANGELES, CALIFORNIA**

MEMBERS OF THE BOARD

HILDA L. SOLIS
HOLLY J. MITCHELL
LINDSEY P. HORVATH
JANICE HAHN
KATHRYN BARGER

Correspondence Received

Agenda #	Relate To	Position	Name	Comments	Attachment
80.		Favor	Michelle Frias		
		Oppose	Adi Shakti	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
			Aelita Gefter	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
			Agmet Zappa		No
			Alice Lee	<p>Fiber should be prioritized, per NTIA. This is a once in a lifetime opportunity as these federal dollars will not be available in the future. The Board should take advantage of these funds to provide futureproof, superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes at least ten times more power: researchgate.net/publication/224240247_Energy_Consumption_in_Wired_and_Wireless_Access_Networks compared to wired technologies and significantly increases our carbon footprint</p>	No
			Alison Denning	<p>Dear Supervisors, Please vote NO on item # 80 changes to titles 16 and 22. My name is Alison Denning I write you today on behalf of myself and the many members of our community who are worried about a 5G transmitter showing up outside our childrens bedroom window without the typical notice which gives us a chance to be heard on the matter. I live in Mt Baldy, and part of the year in Pomona which is in LA County. I am hyper electromagnetically sensitive having been injured by radiation 12 years ago. With the exception of the brief travel between the two homes I am unable to participate in any public activity. The prospect of the proliferation of</p>	No



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small cells will render it too unsafe for me to leave Mt Baldy at all. Recently, the FCC lost a lawsuit on EMFs (electromagnetic fields as emitted from cell towers/small cells) and health effects, as they had ignored the science and took industry advice only on the safety standards or guidelines. The suit proved there is no safe level of wireless radiation exposure for children or the environment, including plants, animals, birds, tress and insects. Adults too, but plaintiffs were temporarily prohibited from including them in their win, but may be able to soon sue the FCC as the industry/government collusion and corruption in creating the standards unravels. However, lawsuits against carriers, installers, manufacturers and municipalities for health effects to our children from wireless radiation exposure are going to now be very easily won due to this recent win against the FCC/industry. But lawsuits are expensive, lengthy, and an undesirable way to shape or create legislation. and absolutely NO ONE wants their child to get cancer that could have been prevented with responsible legislating. The proposed changes to Titles 16 and 22 of the Los Angeles County Code are inhumane, could be a death sentence to some of us currently living with illness and to our children and surely will make previously healthy people, electrosensitive, or worse and give people cancer. If any of you or a loved one currently suffers from loss of energy, headaches, kidney, liver, digestive, lymph gland, heart, blood problems, cancer or any other serious or not so serious health problem but are not sure why, you may have to look no further than to your friendly neighborhood cell tower, WIFI, smart meter, cordless phone or cell phone for your answers. 5G however, will exacerbate nearly all health problems we currently are experiencing and would be illegal were it not for the lies the wireless industry and FCC continue to fabricate on this issue. We should all be able to have a say in where a cell tower or "small cell" is placed. And BTW, small cell = big radiation, it is much higher in frequency, power density and could have very different pulse modulations than 4G which is bad enough. The changes to titles 16 and 22 would eliminate our right to be informed, let alone be able to block one of these deadly transmitters prior to installation, even if it was to go up right outside our childrens bedroom windows.

I repeat, as the FCC lawsuit proved, there is NO SAFE LEVEL OF WIRELESS RADIATION FOR CHILDREN. This finding could in fact make the county liable when our children get sick from their up close and personal exposure to one of these uninvited transmitters to be placed outside of our homes without informed consent, should the suggested changes to rules 16 and 22 be implemented and lawsuits are brought. We must hold off on rolling out the red carpet for 5G transmitters appearing overnight right outside childrens bedrooms until the FCC has stepped up to the plate, reviewed the current science on this issue and re- written the safety guidelines to incorporate it, as per court order. Here is a link to the lawsuit the FCC just lost on this matter, which includes the complaint, 11,000 pages of evidence or adverse effects on health, 4 amicus briefs and the final ruling... thepeoplesinitiative.org/lawsuits/fcc-lawsuit-2020-rf-standards/ Here is also a link to a CBS news report of multiple children getting cancer from a cell tower placed on their school property, according to the parents interviewed.



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	<p>cbsnews.com/news/cell-tower-shut-down-some-california-parents-link-to-several-cases-of-childhood-cancer/ Now that we have the 2021 ruling from the FCC lawsuit, it is entirely possible that LA County could be liable for millions, if not hundreds of millions of dollars in lawsuits should the proposed changes to titles 16 and 22 be enacted and our children become sick. It is in the best interest of the county and us citizens for you to vote NO on the proposed changes, at least until such time as the FCC has ruled on this matter. There are alternatives to 5G high speed internet, video calls, etc., that do not involve cancer and other serious illnesses and that is through hard wired, fiber optic communications. In fact there is also federal money available for this safe alternative. Fiber optics delivers fast, high quality, high speed internet and voice calls with no health problems. The federal funds available for fiber optics do not require the wireless industrys requested changes to titles 16 and 22. Please vote for fast internet for all, fairness and equality, health and safety for our children and vote NO on the proposed changes to titles 16 and 22 but say YES to federal funding for fiber optics! Thank you and sincerely, Alison Denning</p>	
Aliye Aydin	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Amelia Barton	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home, my office, nor my son's home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p> <p>I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p>	No



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	<p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>In the last 15 years there have been 4 major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods; placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A. County contain nothing about fires.</p> <p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (un-backed-up) small cell antennas are required for 911 calls is false.</p> <p>The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint.</p>	
Amy Huntington	I can confirm based on direct experience that radio waves affect health, after having a home evaluation and reducing the amount I am exposed to daily. It was remarkable how much better I felt within 24 hours. And, upon learning about the alternative of fiber optics, I can't see why this must go forward. Please say no. I would be grateful.	No
Amy Okohira	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Amy Swearingen	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.	No



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	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Amy Tam	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p> <p>The electric magnetic field (EMF) emission from these cell towers are dangerous to the health of living things and impact the eco system. Therefore, I strongly oppose of installing them.</p>	No
Anait Martirosyan		No
Andrea Sea Namaste	(see attachments)	Yes
Angela Chretin	<p>I urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that was submitted by Fiber First L.A. In my opinion, the radiation emitted from cell towers is not safe for humans or the environment — therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. We need to be protected from wildfires. In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires and they cannot be fought until the grid has been cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of fire. The proposed revisions allow cell towers to be too close to homes, schools and daycare centers. I urge you to stick to the facts. In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that are already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. Invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes at least ten times more power compared to wired technologies and significantly increases our carbon footprint.</p>	No



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	Thank you for considering my input.	
Angela sherick-Bright	I appreciate the many times in the last several months in which my supervisor's staff and through them my supervisor has listened to my expressions of concern. It is my hope that some of the modifications to the Ordinance as now proposed result from discussions like that with myself and many other concerned LA county residents. Nonetheless, I must object to the currently pending language as providing insufficient protection of the public welfare and the financial welfare of Los Angeles County.	No
Anjuli Richeson	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p> <p>I have three small children and this is a very important issue for me. Please vote No.</p>	No
Anne Holmes	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Anne Marie Reggie	<p>Vote NO: I urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that was submitted by Fiber First L.A.</p> <p>Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment — therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires and they cannot be fought until the grid has been cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of fire. The proposed revisions allow cell towers to be</p>	No



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		<p>too close to homes, schools and daycare centers.</p> <p>Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that are already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.</p> <p>Fiber First: Invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes at least ten times more power compared to wired technologies and significantly increases our carbon footprint.</p> <p>*I REQUEST MY COMMENTS AND CONCERNS BE ADMITTED TO THE PUBLIC RECORD.*</p>	
	Another Worldview Is Possible	<p>WE the People - oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>NOBODY wants a cell tower installed right outside their home - without any prior notice, opportunity for a public hearing or to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, WE also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p> <p>WE urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that LIE is being perpetrated by the telecoms and echoed by our own corrupted Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest.</p> <p>Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>In the last 15 years there have been 4 major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods; placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A. County contain nothing about fires.</p>	No



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	<p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (un-backed-up) small cell antennas are required for 911 calls is false.</p> <p>The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint.</p>	
Anthea Koutroulis	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Antoinette Samardzic	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Anton Pacino		No
Anush Martirosyan	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Aria Morgan	<p>oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>I urge the Board of Supervisors to adopt the proposed redline changes to</p>	No



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		<p>Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>In the last 15 years there have been 4 major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods; placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A. County contain nothing about fires.</p> <p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (unbacked-up) small cell antennas are required for 911 calls is false.</p> <p>The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint.</p>	
	Armaiti May	Please adopt the redline that was submitted by Fiber First LA. Fiber optics are safer, more reliable, faster, more ecofriendly, less prone to fires and in the long run less expensive than wireless infrastructure. Los Angeles county residents should have the right to have a say in whether they are exposed to the harmful microwave frequency emitted by these proposed towers.	No
	Ashley K McCauley	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the</p>	No



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	categorical CEQA exemption as it relates to Titles 16 and 22.	
Atif sui juris	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>No man or woman wants a cell tower installed right outside their home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>This is grossly illegal, unlawful, totally lacks Due Process and is therefore also Unconstitutional and racist - as our minority families and friends in the county will be most affected by this.</p> <p>Due to the lack of safety requirements, I also demand a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p> <p>I am one of many nationals in the county under Section 101(a)(21) of the INA and we are therefore able to sue any member of the Board PERSONALLY for bodily harm and damages should these amendments be passed.</p>	No
Audrey Manzano	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Baldomero Capiz	<p>Me OPONGO a las enmiendas propuestas por el Condado de Los Angeles a las Partes 16 y 22 del Código del Condado de Los Angeles. ¡Por favor vote NO!</p> <p>Enmiendas a los Títulos 16 y 22 del Código del Condado de LA" en Dic. 6th B.O.S. meeting. Ejemplo de comentario: "NO quiero una torre de celular afuera de mi casa, en mi calle, o en mi comunidad NO notificación, NO disposiciones de seguridad/ incendio, NO supervisión, NO oportunidad de apelación y NO revisión ambiental crítica. Le insto a que incorpore los cambios modulados propuestos de los títulos 16 y 22 presentados por Fiber First LA con comentarios de la comunidad</p>	Yes
Barbara Horn	<p>I oppose L.A. County's proposed amendments to Titles 16 and 22 of the L.A. County Code. Please vote NO! I do not want a cell tower right outside my home, or in any residential area, without prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard</p>	No



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	to critical environmental protections that keep us all safe. We are suffering from drought conditions and the installation of towers that are known to cause fires that require precious water to extinguish just does not make any sense. In addition, the short supply of water affects the production of electricity. These towers use a great deal of electricity. This also does not make sense. As citizens we are asked to conserve water and also electricity. I comply with both of these requests. I object to the installation of these towers not only for the reasons given above, but also because they will consume large amounts of precious resources that already in short supply. Please vote NO on agenda item #80. Thank you.	
Barry Wehrli	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Bayonne White	<p>CAUSE NO HARM</p> <p>Undue influence from telecoms</p> <p>Support private property rights</p> <p>Inform public what consequences these changes may have.Allow more time.</p>	Yes
Beate Nilsen	<p>AT&T was manning the phone lines for public comment for the hearing on 5G in LA County last month, deciding who would and who would not be able to speak, and they lied to the board when they said "there are no more callers left in the queue." Re. We won a 2020 RF Standards lawsuit against the FCC which proved there are no safety standards of wireless radiation i.e. no safe exposure levels for children, birds, animals, insects, plants, trees. The court said the FCC was sloppy in their collusion with industry when designating the safety standards and, because of this "oversight," they have now been ordered by the court to incorporate real and current science.</p> <p>We can still have high speed internet and bridge any "digital divides" by utilizing the federal funding available to LA County for hard wired fiber optics which are totally safe! I drove 2ce through Malibu Cyn today and saw loop upon loop of excess Fiberoptic cable up on the lines, just waiting to fly out in a hardwired connection to people's homes. This is possible, to vote to have safer, faster, more reliable, wired ~ NOT wireless ~ LA County homes.</p>	No
Bella Avetisian	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the</p>	No



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	categorical CEQA exemption as it relates to Titles 16 and 22.	
Ben Angelo	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>Earlier this year a Verizon 5g tower was installed on my block 250 feet from my home and less than 20 feet from my neighbor. I did not consent to this and there is reason to be very concerned about the radiation effects on my family, especially my 1 year old son.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Beverly Dangelo		No
Beverly Raimondo	The science is clear! Stop dangerous high radiation Cell towers, fiber is safe and the answer.	Yes
Bibi Caspari	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I have EHS, Electromagnetic Hypersensitivity which in the state of California is legally considered a disability. I don't want powerful wireless antennas outside my home, constantly emitting radiation. Wireless technology is not safe for us or our natural world, as shown in hundreds of peer reviewed studies. And there is an alternative: fiber optics.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p>	No
BLESSINS WINN	I insist the Board of Supervisor's stick to the facts. The Board of Supervisors are being misled to believe this infrastructure is necessary for 911 calls. But, in an emergency, like loss of power due to earthquakes or other emergencies, 911 calls would depend solely upon the macro towers that are already backed up per the California Public Utilities Commission (CPUC) Order. cpuc.ca.gov/industries-and-topics/internet-and-phone/service-quality-and-etc/communications-network-resiliency . The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments to Title 16 & 22.	No
Blues Saraceno		No
Bonnie Camo	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.	No



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	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Brenda Ping	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Brenda Trujillo	<p>VOTE NO ON TITLE 16&22!! Poor Communities, have been victims of environmental racism for decades, being environmentally impacted by many contaminants. Our soil is contaminated by lead and arsenic from EXIDE (battery recycling center). Our air is polluted by the smog of heavy traffic from six major freeways that surround us. We have been victimized and lack basic human rights, clean air, water and soil!! Now they want to stripped us of our rights to be active participants in the decision making of having wireless antennas in front of our homes, our children's daycare and school!! When will our elected officials will hear our voices, thousands have reached out and ask to stop and think!! don't move so fast. Don't use our poor communities as an excused to enriched YOUR POCKETS!!!! YOU ARE NOT FOOLING US BY SAYING THAT WITH THIS ORDINANCE YOU'LL CLOSE THE DIGITAL DIVIDE!!!</p> <p>These ordinances will not close the "Digital Divide." We have an abundance of cell service in our neighborhood and yet many cannot afford safe, inexpensive and reliable internet access. A viable solution to closing the "digital divide" is fiber optics. This proposed wireless build-out is depriving low income and minority communities of an immediately viable, safe, fast, cyber-secure, energy efficient alternative. According to a research from the USC study, "Who gets access to Fast Broadband? Evidence from Los Angeles County," by Dr. Hernan Galperin, "The findings indicate that competition and fiber-based services are less likely in low-income areas and communities of color, with the most severe deficits observed in census block groups that combine poverty and a large percentage of people of color."</p>	Yes
BRENDA L BARNETSON	<p>When two 5G towers were installed within a mile of my house, I developed severe insomnia. I work in my natural health practice with many people suffering ill effects of 5G, WIFI and other EMFs and radiation! The idea that</p>	No



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	you would allow these devices to be installed at or near our homes is completely insane and should be illegal. Please do NOT allow this!	
Brian Karvelas	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Brian Planas	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>Installing EMF emitting cell towers right outside of homes is a form of criminal trespass to those residing in the homes, especially without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>This technology needs to be redesigned. It is overwhelmingly shown by thousands of studies to be harmful, and the knowledge of its harm is being actively suppressed by the industry, just like what happened with cigarettes for so many years.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	Yes
Bridget McCook	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Cami Lewton	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p>	No



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	Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	
Camila Vogel	We need to have a say in where cell towers are placed.	No
Campbell R Wallace	prioritize the health and safety of residents and the environment and to vote NO on Dec. 6!	No
Candy Rinard	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Carol Miller	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p> <p>I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>In the last 15 years there have been 4 major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods; placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A.</p>	No



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	<p>County contain nothing about fires.</p> <p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (un-backed-up) small cell antennas are required for 911 calls is false.</p> <p>The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint.</p>	
Carolyn Daniels	<p>oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Carolyn Negrin	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Catherine Lovella	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>Cell tower installations need to require prior notice, public hearing and opportunity to appeal, fire and safety provisions, and abide by the critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Catherine McClenahan	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No



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Catherine J Dodd RN PhD	LA County sets the pace for the US, please live up to your environmental values and do NOT eliminate CEQA protections.	No
Cathey Painter	Are you kidding me! No way. I do NOT want a 5 G cell tower on my property or anywhere near it!!!	No
Cecilia Case	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	No
Celestina Sachs	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22. Thank you for your time.	No
Celine Garcia	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	No
Ceylon Zappa		No
Chantal Myers		No
Charlene Hopey	Due to the lack of safety requirements, I want a reversal of the categorical exemption to CEQA as it relates to Titles 16 and 22. I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep	No



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	<p>us all safe. Due to the lack of safety requirements, I want a reversal of the categorical exemption of CEQA.</p> <p>I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>In the last 15 years there have been 4 major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods; placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A. County contain nothing about fires.</p> <p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (un-backed-up) small cell antennas are required for 911 calls is false. The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint. Please do not risk FIRE with this ordinance. Thank you.</p>	
Chase Simmons		No
Cheryl Mathews	<p>I oppose the proposed changes to Titles 16 and 22 of the L.A. County Code. Please vote NO and adopt the redline for Titles 16 and 22 that were submitted by Fiber First L.A. Invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in residential neighborhoods. Wireless technology utilizes ten times more power compared to wired technologies and significantly increases our carbon footprint.</p>	No



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	<p>Prioritize the health and safety of residents and the protection of the environment. Please vote NO.</p>	
Cheryl van der Zaag	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>*Here are additional / optional comments that can be inserted in the email or portal if you choose:</p> <p>I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>In the last 15 years there have been 4 major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods; placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A. County contain nothing about fires.</p> <p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (un-backed-up) small cell antennas are required for 911 calls is false.</p> <p>The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint.</p>	No



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Chris Mody	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Christina Rizzoni	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Christina Whittle	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Cindy Koch	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
connie Acosta		No
Connie Ambrosia-Wann	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p>	No



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	Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	
Craig Adams		No
Cynthia Clark	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Daciana Iancu	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Daren Black	<p>Cell towers should never be allowed within 100 yards of any house, apartment or other dwelling or office.</p> <p>Reverse CEQA exemption.</p> <p>Take CEQA exemption out of titles 16 and 22.</p>	No
Dave Goodspeed	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. I asked that you please vote NO on this amendment.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No



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	<p>I'm appalled that this is even being considered. Please vote NO.</p> <p>Best, Dave</p>	
David Donner	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
David Martirosyan		No
Dawn R DelMonte	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Deborah Baird	<p>Do not deregulate cell companies. You are an essential gateway for citizen safety, correct infrastructure, and maintaining the community. Businesses do not put these things first and giving up that control is an absolute mistake. They have tried many cities and will keep trying to have more control. Stand up and show your citizens you have their back by not giving cell companies freedom to install the cheapest equipment where ever they want and however they want.</p>	No
Denise Lenardson	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p>	No



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	<p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Desiree Brendel	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p> <p>I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>In the last 15 years there have been 4 major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods; placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A. County contain nothing about fires.</p> <p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (un-backed-up) small cell antennas are required for 911 calls is false.</p> <p>The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint.</p>	No
Dhun May	<p>Let's take advantage of the federal program that has \$42 billion for closing the</p>	No



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	<p>digital divide which will give preference to projects that use fiber optics. Please note that wired technology is more reliable, faster, less hackable, much more energy efficient, needs much less maintenance, is much better for the health of people and the environment AND is much cheaper in the long run.</p> <p>Also, please note that scientific studies document that continuous exposure to RF or EMF radiation increases terpene in conifers and terpene is highly flammable. And telecom equipment itself has caused electrical fires which became major wildfires.</p> <p>It should also be noted that telecom customers have ALREADY been charged special fees in their bills that were purported for the express purpose of funding more WIRED internet connections in the future.</p> <p>Thousands of peer reviewed studies show that microwave radiation promotes cancer, DNA damage and learning deficits. Also, some scientists have indicated that wireless devices may be much more harmful to children than adults because children's skulls are thinner.</p> <p>Some scientists have indicated that the 60 giga hertz 5G frequency makes it difficult to utilize oxygen. The simultaneous occurrence (at the end of 2019 in Wuhan, China) of a big 5G rollout and the Corona virus outbreak suggests the possibility that the 5G rollout intensified illness. An analogous occurrence over 100 years ago was the simultaneous occurrence of the Spanish Flu and a big electromagnetic rollout (that facilitated common access to electricity)--suggesting that exposure or adjusting to new electromagnetic frequencies may have a negative impact on human health.</p>	
Diana Little	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Diana Parmeter	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the</p>	No



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	categorical CEQA exemption as it relates to Titles 16 and 22.	
Diane C Williamson	Anza has access to fiber optic provided by Anza Electrical Cooperative Inc. So I know how much safer buried fiber optic lines are than cell phone towers. Buried lines don't blow down and they don't start fires. Also, they work better and don't make sensitive people sick.	No
Dionne Husted	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Diva Zappa		No
Donna Umali	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Cell towers seem very safe and the amount of collateral damage it could cause is very hard to detect and perceive with our regular senses. Right now, with the advent of stronger and stronger signals, we are pushing the boundaries of what is "safe" to humans and the environment without proper awareness, and it's being pushed on the general public without notification and proper disclosures. I would not buy a property without being properly disclosed. I don't think it would be fair for people to suddenly find out that they've been exposed to something harmful that could have been prevented or at least given the facts.</p> <p>Electricity and electronic frequencies play a much bigger part and influence our bodies more than we realize. We run on electric currents. Our bodies are affected by different energies and influences. We need to understand more. To blindly install these towers without more understanding is foolhardy and hard to reverse in the future.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Douglas Ludwig	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the	No



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	<p>L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Dweezil Zappa		No
Dweezil Zappa		No
Earis Corman	<p>I live in La Mirada and have Lyme disease. I had 6 nosebleeds during the first 24 hours after 3 smart meters were installed outside my condo bedroom. The condo association doesn't care a hoot (using nice words) about our health. A friend figured it out and installed shielding material to deflect the signals. I had to spend hundreds of dollars getting a professional evaluation and hundreds more for additional remediation. My upstairs neighbor now has such strong WiFi that I had to buy special EXPENSIVE paint for my ceilings to block it. Finding a painter has been extra hard because of the COVID mess. We Lyme educated know all this wireless makes our misery even worse. We don't need more sources of wireless signals.</p> <p>VOTE NO on these amendments to Titles 16 & 22 of LA County Code.</p>	No
Edith M Yhuel	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
edward mackeen	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO on Item 80. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, & without rigorous electrical, structural, fire and building engineering requirements up front. These amendments take away our due process rights.</p> <p>Because of the lack of environmental review & safety requirements, I also want a reversal of the categorical exemption to CEQA as it relates to Titles 16 and 22. I urge you to vote NO on item 80.</p>	No
Elias Rodriguez	<p>VOTE NO EN TITULO 16 & 22. ESTOY PREOCUPADO, A USTEDES NO LES IMPORTANT NUESTRA SEGURIDAD, DE NINGUN TIPO, NI DE SALUD, NI NUESTRA INFORMACION DE DATOS QUE VA HA SER</p>	No



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	<p>COLECTADA, NI EL HECHO DE QUE ESTAS TORRES CAUSAN INCENDIOS ELECTRICOS!!!! SI LES IMPORTARA, USTEDES LEERIAN EL REDLINE DE FIBER FIRST LA!! TODAVIA HAY TIEMPO...VOTEN NOOOOO!!!</p> <p>VOTE NO IN TITLE 16 & 22. I am worried, you do not care about our safety, of any kind, health, nor our data information that will be collected, nor the fact that these towers cause electrical fires!!! IF YOU'D CARE, YOU'D READ THE FIBER FIRST REDLINE!! THERE'S STILL TIME... VOTE NO!!!</p>	
Elizabeth Barris	<p>Dear Supervisors,</p> <p>Please OPPOSE item # 80, the amendments to titles 16 and 22 which would allow for 5G transmitters to go up unannounced right in front of peoples homes with nothing they can do about it. Below are a few links...the \$30,000,000 NTP study showed "clear evidence of carcinogenic effects from wireless radiation"</p> <p>niehs.nih.gov/news/newsroom/releases/2018/november1/index.cfm, a link to our WINNING lawsuit against the FCC proving there is no safe level of wireless radiation for children and the environment (animals, birds, bees, plants, etc.)</p> <p>thepeoplesinitiative.org/lawsuits/fcc-lawsuit-2020-rf-standards/</p> <p>CBS news covered the cancer cluster at a school in Ripon, CA where 4 students and 2 or 3 teachers all got cancer after a tower went in, in close proximity to the school cbsnews.com/news/cell-tower-shut-down-some-california-parents-link-to-several-cases-of-childhood-cancer/ and here is a link to how 5G will connect to the nano tech that is in the vaccines, per DoD patents...</p> <p>rumble.com/v1q1tmw-live-karen-kingston-people-now-connected-to-the-demonic-realm-through-covid.html</p> <p>Please VOTE NO on #80, amendments to titles 16 and 22 and say YES to federal funding for fiber optics!</p> <p>PS, I will not be calling in as AT&T mans the phone lines and never called on me after waiting 5 and a half hours last time before announcing "there was no one left in the queue!" The fox is guarding the hen house on this issue with regards to the phone lines and public comment.</p> <p>Thank you and sincerely,</p> <p>Liz Barris Director The Peoples Initiative Foundation,</p>	No
Elizabeth Gschwind	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside of homes without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No



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	I realize that I do not live in LA County, but reject this on behalf of LA residents who are my friends and family. Thank you.	
Elizabeth D Armstrong		No
Elle Fiero	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. These towers are NOT SAFE! They also offer no proven benefit to the individual, or our society. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	No
Ellen Marks	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. Prior notice, public hearing and the opportunity to appeal is critical. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22. As Director of the California Brain Tumor Association I have witnessed the health and safety issues associated with cell tower emissions all too often. I know you cannot deny based on health but you certainly can and should be open to be educated on the independent science. Thank you.	No
Emma F Sharp	"I request my written comments be part of the public record for Amendments to Titles 16 & 22 of LA County Code at the Dec. 6th B.O.S. meeting. I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe."	No
eric yi	Please halt the installation of any new cell/5G towers in Los Angeles County until a system of approval by citizens has been developed and implemented. I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	No
Erik Brauer		No



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Erinn Valencich	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Esther Kang	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Francine Lofrano	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Francisco Gutierrez	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Freida Dubin	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep</p>	No



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	<p>us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Garril G Page	<p>I urge adoption of Fiber First L.A. redlining for Titles 16 and 22 as essential to protection of constitutional rights of CA residents as well as protection of public health and safety. Failure to guarantee protection from threats disenfranchising homeowners and disabling the basic activities of life for those sensitive to wireless radiation is an abdication of Supervisors' oath. Cell towers do not belong in close proximity to homes, hospitals, schools or other vulnerable populations. CPUC regulations ensure macro towers allow 911 function; proliferation of small cells is unwonted. Federal dollars are more more wisely spent on reliable, faster fiber optic broadband than on lesser-performing wireless broadband. Please, vote NO on CEQA exemption & changes to Titles 16 and 22. Thank you.</p>	No
Gary Akopyan	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Gary Simmons		No
Gary Simmons		No
Gene Wagenbreth	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p>	No



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George Martinez	<p>Ignoring Science for Profit- This is another EXIDE on the works and you can stop it NOW!!</p> <p>Only people living under a rock are unaware of the media assault of 5G technology. The marketing muscle behind this next phase of wireless communication is like nothing ever seen before. It makes you wonder – why are they putting so much money into this breathless race to get 5G into our lives?</p> <p>Well, wait a minute. Wasn't there a study by the National Institutes of Health (NIH) that proved that exposure to wireless radiation causes cancer? In fact, didn't an expert review panel, called in to evaluate the results of the study, report that not only did the exposure cause cancer, but that it also caused damage to DNA and the heart?</p> <p>Actually, there was such a study, and that's exactly what the scientists found. So why aren't we taking some precautions? Why aren't we developing phones that are safer to use? Why are we exposing kids in school to near-constant radiation from wireless networks? Any why are we racing to put radiation-emitting small cell antennas on every block in every wealthy neighborhood in California, close to homes and apartments where people live?</p> <p>Maybe the "race" to 5G is not really a race with other countries, but a race against science and public awareness. Maybe it's a race to generate profits for investors before the public finally understands that exposure to wireless radiation is not relatively harmless, as the industry has claimed for 40 years, but is in fact, a serious public health issue.</p> <p>The Federal Communications Commission's human exposure guidelines are based on science from the 1980s, and the FCC hasn't updated those guidelines in almost 25 years. When the NIH study came out, the FCC (whose five commissioners either come from the wireless industry or expect a lucrative consulting contract with the industry when they leave) calmly announced in coordination with the FDA that the findings didn't apply to humans.</p> <p>Are you kidding? That was the expressed purpose of the study – the most expensive, most exhaustive, most carefully controlled and monitored study ever conducted on the subject. A study originally supported by the industry... until the preliminary results came out in 2016. Since then it's been full-speed-ahead, not on research to find less harmful solutions, but to build a billion-dollar marketing campaign and salvage the investment they've made in their wireless network. Meanwhile, like the tobacco industry before them, they've been doing everything possible to bury the news about the study and pretend nothing is wrong.</p>	No
George Montes	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the	No



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	<p>L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Geraldine F May	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Glen Kohler	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Glenn B Frieder		No
Grasshopper Kaplan	<p>Cut this shit out.</p> <p>End the scamdemic Harmacide.</p> <p>Hacksxxxine Biowarfare must end now, dammit</p>	No
Gregory Akopyan	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Gretchen Weinzimer		No
Hannah Costa	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p>	No



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Hannah Haehn	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Harmony Blossom		No
Heidi OBrien	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Henry Wadsworth	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Hillary Smith		No
Honey Zappa		No
Hortensia A Tamayo	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p>	No



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	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p> <p>Please do nit vote for this.</p> <p>I am totally against any amendments. The existing laws protect us an allow for more studies. There are so Amy items against what we the constituents actually want. Please be a voice for those who have no access to any of this and vote No.</p>	
irvin harrington	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Isela Ruiz	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Izabela Frank	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Jack Neff	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p>	Yes



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	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Jacki Reichenbach	<p>1-Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>2-Protect Us From Telecom Wildfires. In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires and they cannot be fought until the grid has been cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of fire. The proposed revisions allow cell towers to be too close to homes, schools and daycare centers.</p> <p>3-In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that are already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments</p> <p>4-Invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes at least ten times more power compared to wired technologies and significantly increases our carbon footprint.</p>	No
Jackie Lynds		No
Jackie M Pointer	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Jacquelyn Kendall-Singh	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p>	No



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	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Jacquelyn Robbins	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Jaeffrey ARTZ	<p>5G radio hurts sensitive people, and may even harm cellular respiration in normal, insensitive people. The short wavelength corresponds to molecular chains absorbed through the cellular membrane. Besides, 5G is dominated by the Communist Party of China, and is a potential National Security threat. Even Elon Musk counts on it to increase his wealth and control of phone calls and other social media via through his global satellite system.</p>	No
Jaime Scher		No
James Kang	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
JAMIE BER	<p>Please vote in favor of your constituents and their well being and property rights - not cell phone companies profits.</p>	No
Jane Benjamin	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p>	No



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	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Jane McAllister	<p>No CEQA and no review = bad idea. While costs of County employee review of these projects would be absorbed by the developer, one "mistake" with no review will lead to far more tremendous costs shouldered solely by the County - which really means us taxpayers. Thus despite the seeming time and cost savings to the developers, and supposedly the County building departments, this revision leaves the public unprotected. I cannot understand how the County Supervisors would come to believe that this, or any significant development affecting public and private property rights, should be allowed to be performed WITHOUT any actual "supervision" by qualified authorities.</p>	No
Jane Warner	<p>Across the planet, there are varying levels of community concern about electromagnetic wave lengths, cell tower installations, etc. Some communities have chosen to freeze approval indefinitely for 5G installations. There is simply not enough known about health risks. In October, I shared a link to an appeal by scientist David Carpenter to the school board of Portland Oregon, requesting that Wi-Fi equipment be removed from schools and instead wired connections be installed. I've attached a pdf of that report. Dr. Carpenter attached approximately 400 scientific studies supporting this recommendation. I am also attaching here the report by the International Commission on the Biological Effects of Electromagnetic Fields, alerting to the dangers of Wi-Fi and electromagnetic fields. It's a long report, but their findings include the following:</p> <ul style="list-style-type: none"> • The limits set for radiofrequency radiation established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Federal Communications Commission (FCC) are based upon invalid assumptions and outdated science; they are not protective of human health. • That there be an independent assessment of the dangers of radio frequency radiation based on scientific evidence from peer-reviewed studies conducted over the past 25 years. They are seeking health standards for workers and the public. • That the public be informed of the health risks of EMF and encouraged to do everything they can to minimize exposures, especially for children, pregnant women and people who are hypersensitive. • That there be an immediate moratorium on further rollout of 5G wireless technology until safety is actually demonstrated. <p>Individuals have widely differing responses to electromagnetic fields. For some it can bring about powerful acute health effects, for others a general malaise. It is quite true that the majority of people do not experience acute effects, however, as the studies I have provided show, they may experience</p>	No



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	significant adverse health effects over time.	
Janet Zoya		No
Janet K Zoya	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Jason LaBerge	<p>There has not been sufficient study of the impacts of 5G radiation on human and animal populations and should not be allowed in residential areas</p>	No
Jazmin Garcia	<p>I request my written comments be part of the public record for Amendments to Titles 16 & 22 of LA County Code at the Dec. 6th B.O.S. meeting.</p> <p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p>	No
Jeff Stein		No
Jen Hen	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Jen Wong	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No



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Jennifer Goodnow	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Jennifer Powell	<p>I OPPOSE L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do NOT want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Jerry Kaplin	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Jessica Holloway	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Jill McManus	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p>	No



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	Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	
Jillian Hollingshead	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Jillian Stone	Protect Us from Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires, and they cannot be fought until the grid has been cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of fire. The proposed revisions allow cell towers to be too close to homes, schools and daycare centers.	No
Jillian Stone	Fiber should be prioritized, per NTIA. This is a once in a lifetime opportunity as these federal dollars will not be available in the future. The Board should take advantage of these funds to provide futureproof, superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes at least ten times more power: researchgate.net/publication/224240247_Energy_Consumption_in_Wired_and_Wireless_Access_Networks compared to wired technologies and significantly increases our carbon footprint	Yes
Jim Hearn	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No



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Jim P Blickenstaff	See Below :	No
Joanie D Murphy	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
JoAnna Elliott	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22. Please support WIRED communications and utilities delivered via UNDERGROUND wires.</p>	No
Jodi Nelson	<p>Dear Board of Supervisors:</p> <p>I'm urging the L.A. Board of Supervisors to vote NO on Title 16 & 22 or at minimum delay the vote so that the newly elected Board member, Lindsay Horvath, can become apprised of the issues surrounding Title 16 & 22.</p> <p>I also strongly urge the Board of Supervisors to engage with Fiber First L.A. Attorneys to obtain an objective understanding of the legal requirements the Board must consider. These legal obligations are outlined in the redline ordinance submitted by Fiber First L.A for Titles 16 and 22. Currently the ordinance (Title 16 & 22), as written, does not uphold specific legal & procedural requirements, especially those that pertain to CEQA.</p> <p>As well the ordinance as written:</p> <p>DOES NOT - Safeguard Due Process Rights</p> <p>The radiation emitted from cell towers is not safe for humans or the environment — therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>DOES NOT - Protect Us From Telecom Induced Wildfires</p> <p>In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires and they cannot be fought until the grid has been cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of fire. The proposed revisions allow cell towers to be too close to homes, schools and daycare centers.</p>	Yes



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DOES NOT - Consider Important Facts About Safety

The Board of Supervisors are being misled to believe this infrastructure is necessary for 911 calls. This is NOT true. In an emergency, like during an earthquake with loss of power, 911 calls would depend solely upon the macro towers that are already backed up per the California Public Utilities Commission (CPUC) Order. Claims that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments to Title 16 & 22.

DOES NOT – Solve the Digital Divide

Fiber should be prioritized, per NTIA. This is a once in a lifetime opportunity as these federal dollars to upgrade to fiber will not be available in the future and will extend the digital divide into the next decade. The Board should take advantage of these funds to provide futureproof, superior fiber optic broadband connections to the home rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods.

DOES NOT Consider Energy Consumption or Carbon Footprint

Wireless technology utilizes at least ten times more power compared to wired technologies and significantly increases our carbon footprint. Therefore, we should try to mitigate the use of these technologies and use them only when fiber to the home (FTTH) can't be accomplished.

DOES NOT Fully Consider or Understand FCC Orders and Law

The Board is being misled into believing that the ordinance as written is necessary in order to stay within the FCC wireless rules and laws. FCC rules and federal laws do not supersede other laws. The FCC, Congress and the courts all agree that local control is necessary. Congress explicitly preserved to local governments the general authority to regulate the placement, construction, and modification of wireless facilities within their jurisdiction, subject to five (5) finite constraints as outlined by 47 U.S.C.A. §332 (C)(7) subparagraph (B) entitled "Limitations." These smart planning provisions were designed to enable wireless carriers the ability to (a) saturate the local jurisdiction with personal wireless coverage (not for gaming and streaming but for the ability to make a phone call also known as significant gap in coverage), (b) minimizing the number of wireless facilities necessary to provide such coverage and (c) minimize, the greatest extent possible, adverse impacts upon residential developments, individual homes, and communities in general.

Instead, the L.A. Board of Supervisors are throwing away all local control and handing over their powers to "Big Telecom," thereby buying into and propping up telecom's disinformation machine! Giving Big Telecom carte blanche, and betting on a temporary broadband band-aid to triage the digital divide will only extend it into the next decade. You have one chance to get this right and end the digital divide once and for all by using the powers given to you by our federal government and prioritizing fiber to the home (FTTH)! There is no



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	<p>meaningful justification for not doing this. Local governments, like the LA Board of Supervisors, are the only protection from Big Telecom for unserved, underserved and vulnerable populations. You are the line that is supposed to be protecting your constituents. Doing the right thing might be hard, but in the long run, it serves those you purport to want to protect. The unserved and underserved of L.A. County. Regards, Jodi Nelson Director of Californians for Safe Technology</p>	
Joe Faris	<p>"I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22." (If necessary, leave a message with the above statement and include your name.)</p> <p>If you prefer, Email: Please copy and paste the following two paragraphs into an email to your Supervisor. Feel free to also include your personal comments and/or add any of the additional comments below.*</p> <p>"I request my written comments be part of the public record for Amendments to Titles 16 & 22 of LA County Code at the Dec. 6th B.O.S. meeting.</p> <p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22."</p>	No
John Levine	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
john a nau	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior</p>	No



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	<p>notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Jonas Goodman	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>In the last 15 years there have been 4 major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods; placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A. County contain nothing about fires.</p> <p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (unbacked-up) small cell antennas are required for 911 calls is false.</p> <p>The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint.</p>	No
Julia Black		No
Julie Levine		Yes



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Julie Stander	Please install fiber optics in my Julian (San Diego County) neighborhood which is faster and healthier for humans and wildlife.	No
Julien Zacher	No towers	No
Justin Miller	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
kalli Holmes Sorensen	<p>I oppose the proposed changes to Titles 16 and 22 of the L.A. County Code. Please vote NO on Dec. 6 and adopt the redline for Titles 16 and 22 that was submitted by Fiber First L.A.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety scrutiny before the towers are built or without regard to critical environmental protections that keep us all safe. I demand the following protections are implemented in regard to the installation of wireless communications infrastructure.</p>	No
Kara Nau	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Karen Carlton	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No



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Karena Luna	<p>I Oppose LA Countys proposed amendments to Titles 16 & 22 of the LA County Code, please vote NO! I do not want a cell tower installed outside or NEAR my home without any prior notice, public hearing or opportunity to appeal. There is no regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to titles 16 & 22.</p> <p>There are just so many issues with these changes that it does not make sense to move forward with it! Thank you for your consideration.</p>	No
Kari Bowles		No
Karin Johnston	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Karine Akopyan	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Kasia Leavitt	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22</p>	No
Katherine M Waller	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior</p>	No



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	<p>notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Kathleen Boggs	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Kathleen Egbert	<p>I work in LA County and live in Anaheim. I must ALWAYS wear EXPENSIVE radio frequency protective clothing when I go outside my home. The roads are hell from all the wireless, and there are few places to work where one is not exposed to massive wireless from smart phones, smart meters and WiFi. A person on the EMF study group I listen to said passing these amendments to Titles 16 & 22 of LA County Code will disqualify LA County from receiving any of the recently allocated Federal funds earmarked for fiber optic broadband. Fiber optic is faster, more secure, and much safer health wise. When some of these wireless antennas start fires, cities, counties and California must pay to fight them. Ruined property increases insurance rates, decreases the tax base and people are killed, traumatized and displaced. Those of us with good understanding of the detrimental health aspects of wireless that Big Telecom has been actively suppressing for @ 30 years all oppose wireless installations. I know many people sickened from this ever increasing wireless. Some are homeless and jobless because of it. Some have the funds to protect themselves from the worst of it and many do not. The east half of my home in Anaheim is fried whenever the 5G antenna across the street is activated; the one in my back yard fortunately points away from my house. I have spent thousands of dollars shielding the interior from the ever present 4G antennas that form the backbone of the 5G rollout. During COVID, a new 4G antenna (they are ON ALL the TIME) was installed a couple hundred yards from my house. At least I am not required to have a smart meter, but had to have my gas shut off to avoid a smart gas meter. So now I heat water in an electric coffee pot to pour over my body to bathe, and use cold water for all else. Fortunately my wired internet/VOIP phone can be connected to fiber optic.</p> <p>Please, PLEASE. VOTE NO on these amendments to Titles 16 & 22 of LA County Code.</p>	No



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Kathleen Gildred	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p>	No
Kathleen Rosenblatt	<p>Fiber optics are more efficient, not harmful, and less expensive than 5G/ These amendments do not protect us from telecom induced wildfires. In the last 15 years there have been 4 major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods; placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A. County contain nothing about fires.</p> <p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cells are required for 911 calls is false. Small cells do NOT carry our 911 calls.</p>	No
Kathleen Sundmark	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Kathryn L Hettich	<p>I oppose L.A. County's proposed amendments to to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p> <p>I live in Redding, CA, but as a CA resident, I do not want L.A. to set a precedent in the matter of erecting cell towers without residents' approval and without informing the public of potential health risks. Thank you.</p>	No
Kathy Knight	<p>I oppose LA County's proposed amendments to TITLES 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No



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	<p>I urge the Board of Supervisors to adopt the redline changes to Title 16 and 22 that were submitted by Fiber First LA and to prioritize future -proof fiber to the home for everyone in Los Angeles County.</p> <p>It is not true that the FCC requires these amendments to be made to our existing LA County Code. The radiation emitted from cell towers is not safe for humans or our natural world, therefore the placement of these antennas is a matter of urgent public interest.</p>	
Kathy T hill	<p>NO! I OPPOSE proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Kay Love	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Kelly Tourgeman	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Kelly Vodnoy	<p>NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Kenneth HABOUSH	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p>	No



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	<p>Please respect your constituents and to not allow our neighborhoods to become "microwave ovens". Yes the power intensity of 5G antennas are not as high as an oven, HOWEVER low intensity NON_IONIZING electromagnetic radiation has the ability to change cell membrane permeability and cause an inflammatory response capable of damage DNA. Do not let telecom profits overshadow a healthy environment free of Cancer and Chronic disease. Alternatively, in residential and high population areas, running fiber optic cable to end users versus microwave antennas, will provide even faster internet service, and although more costly up front, will save both the city and communication companies costs in litigation and removal and replacement costs when the public at large becomes aware of this threat to their health and life.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p> <p>Thank you.</p>	
Kerstin I Knuepfer	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p> <p>I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>In the last 15 years there have been 4 major Southern California wildfires</p>	No



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	<p>initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods; placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A. County contain nothing about fires.</p> <p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (un-backed-up) small cell antennas are required for 911 calls is false.</p> <p>The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint.</p>	
Kim Turner	The radiation emitted from cell towers is not safe for humans or the environment — therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.	No
Krishnan Unnikrishnan	<p>I oppose the proposed changes to Titles 16 and 22 of the L.A. County Code. Please vote NO on Dec. 6 and adopt the redline for Titles 16 and 22 that was submitted by Fiber First L.A.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety scrutiny before the towers are built or without regard to critical environmental protections that keep us all safe. I demand the following protections are implemented in regard to the installation of wireless communications infrastructure:</p> <p>?? Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment — therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>?? Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires and they cannot be fought until the grid has been cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of fire. The proposed revisions allow cell towers to be too close to homes, schools and daycare centers.</p>	No



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	<p>?? Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that are already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.</p> <p>?? Fiber First: Invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes at least ten times more power compared to wired technologies and significantly increases our carbon footprint.</p> <p>Prioritize the health and safety of residents and the protection of the environment. Please vote NO.</p>	
Krista Harris	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
kristin nugent	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Lala Zikakis	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Larry Nelson	<p>I urge the Board of Supervisors to vote NO on the ordinance as written. I urge the Board of Supervisors to adopt the redline copy of Title 16 & 22 submitted by Fiber First L.A.</p>	No



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larry ortega		Yes
Laura Slaven	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>In the last 15 years there have been 4 major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods; placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A. County contain nothing about fires.</p> <p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (un-backed-up) small cell antennas are required for 911 calls is false.</p> <p>The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint.</p>	No
Laura Tomasiello	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep</p>	No



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	us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	
Lauren Knudsen		No
Lily Colovic	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	No
Lina Karpman	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22. Potential Health Risks: <ul style="list-style-type: none">• Different Cancers• Reproductive Problems; Infertility• Suppressed Immune System Function• Neurological Problems• Headaches/Migraines• Effects on Eyes, Heart, Lungs, Head – Essentially your entire body is affected• Single & Double DNA Strand Breaks• Oxidative Damage• Stress of Proteins• Disruption to Brain for Glucose Metabolism• Reduces Melatonin in the Brain• Brain Barrier Permeability (Could result in brain bleeds; Stroke)• Cell Metabolism Disruption Our Environment In Crisis: <ul style="list-style-type: none">• Affected Cell Growth Rates• Makes Things Bacteria Resistant• Plant Health Decline• Effects on Atmospheric• Depletion of Fossil Fuels• Ozone Layer Effects	No



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	• Disruption of Ecosystem	
Linda Gerlach	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. PLEASE vote NO!</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Lindsay Elliott	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Lisa Hannifin	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Lisa Hochman	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Lisa Kassner	<p>I live in L.A. County. I am opposed to these items because it's not right for 5G and cell towers to be installed in my neighborhood, even in front of my home, without my being able to object to it. These towers put out radiation. 5G</p>	No



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	frequency has the same impact on the body as Covid. Electromagnetic frequencies decrease our immune system. In this fraught time in particular, YOU HAVE AN OBLIGATION TO PROTECT PUBLIC HEALTH. VOTE NO ON THE CHANGES TO TITLE 16 AND TITLE 22 of L.A. Co. Code.	
Lisa Larson	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Lisa C Smith	<p>We oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>We do not want cell towers installed right outside of people's homes without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep people safe.</p> <p>Due to the lack of safety requirements, we also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Livinio Stuyck Sanchez	I WILL NOT allow a cell tower being installed in my property.	No
Lizbeth Hernandez	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Lois F Wagner		No
Lonnie Gordon	<p>Honorable Supervisors,</p> <p>You need to hear the truth about Titles 16 and 22, not just lobbying from telecom and staff, before you vote on Tuesday.</p> <p>You, our Supervisors have been misled! The FCC does not require that environmental review be waived; in fact they still expect the cities to regulate safety as they normally would. They have imposed the shot clock and that means that some additional people, perhaps outside consultants, should be added to staff. They need what Malibu has and that is a very thorough</p>	No



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application checklist upfront. Immediately the application is reviewed when it comes in and if it is missing anything from the safety checklist (electrical and structural safety) the county or their consultant representative writes to the carrier and stops the shot clock. It's that simple. It's also essential.

LA County has had multiple fires but two of the biggest ones in the last 15 years were Malibu Canyon Fire and the \$6 billion Woolsey Fire. Both were started by telecommunications equipment. That's why we passed the strict ordinance that we did in Malibu. We don't see any of those safety precautions here in LA County. In fact, LA County staff has already had the supervisors vote to exempt CEQA! This is wrong.

We have a red lined version of Titles 16 & 22 from the very same attorney who helped Malibu, Scott McCollough, who went through your proposal line by line. He inserted safety language that is essential. This was sent to every Supervisor and Planning staff, but we have not been contacted once. Planning has refused to see Scott McCollough and Julian Gresser, two of the top attorneys in this specialty in the country. Staff says we are a "special interest group." Yes – we care for the environment and we care for the residents. If we are a special interest, what is telecom?...\$\$\$

CEQA is our state environmental law and there is supposed to be environmental review when there is a fundamental change and that's what the cell towers are. They come with their fire risks, fossil fuel consumption, and RF hazards. Even the FCC says the RF should be measured yet the Planning Department has waived all environmental considerations under the false (inaccurate) representation that RF cannot be discussed when it comes to the placement of cell tower. RF cannot be the reason for denial of towers but it can be discussed. You need to hear both sides of the story. The fire risks of the cell towers MUST be dealt with before LA County has more catastrophic fires like Woolsey. You have allowed huge installations on Kanan Dume which is supposed to be a scenic highway, and it is one of our only escape routes out of Malibu

Between the two fires, here are the carriers, and one utility with their own telecommunications company that were involved: AT&T, Verizon, Sprint (now T-Mobile) SCE (their own telecommunications back haul line).

ALL OF THESE PARTIES were accused by the CPUC of impeding fire investigations both in Malibu Canyon Fire and Woolsey. And were going to trust them come into LA County and make sure all of the electrical, structural, fire & building safety codes are followed? That is what the Planning Department is telling the Supervisors they must do and that is false information.

We need a NO vote on item 80, Tuesday, on Titles 16 and 22. The supervisors need to hear from attorneys McCollough and Gresser before they make a decision that will affect all of Los Angeles County. Please allow your newest Supervisor, Lindsey Horvath and the rest of the Board, a chance to learn about this issue before a vote is taken. This is vitally important! Please



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	<p>feel free to contact me so I can connect you with our attorneys who will give you the real facts.</p> <p>Sincerely,</p> <p>Ms. Lonnie Gordon Executive Director MalibuForSafeTech.org malibuforsafetech.org H: 310 457-2725 C: 310 804-7102</p> <p>--</p> <p>"The world is not dangerous because of those who do harm, but because of those who look at it without doing anything". Albert Einstein</p>	
Lori Field	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Lorna Paisley	This is another way people are injured for the benefit of corporations	No
Louis Cangemi		No
Luana Navarro	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Madeline Harris		No
Madeline McFadden	Citizens need a say before a cell tower goes in net to their property! Please provide the studies that show this technology is even safe! You cannot grant telecom giants a pass to do what they please without 1. Showing without a doubt there are no harmful effects from these towers. 2. Give residents the opportunity to object to a mechanism like this going in adjacent to their property.	No
Mahatma Kane-Jeeves	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.	No



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I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.

Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.

I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.

It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?

The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.

In the last 15 years there have been 4 major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods; placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A. County contain nothing about fires.

In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (unbacked-up) small cell antennas are required for 911 calls is false.

The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather



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	than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint.	
manu hipkins	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Mara c luthy	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Marco LaGrande	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Maren Dellin		No
Margot P Ehret	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep</p>	No



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	us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	
Maria Ioanna	I request my written comments be part of the public record for Amendments to Titles 16 & 22 of LA County Code at the Dec. 6th B.O.S. meeting. I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe."	No
Maria R Kydonieus	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	No
Marie Hunter	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	No
Marin Lutz	As a molecular biologist and geneticist that has worked in academic research at UCLA, published peer reviewed papers and was a founding member of AGRE (The Autism Genetic Resource Exchange), I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I have worked alongside scientists and researchers to address neurodevelopmental disorders and the data is clear - there is a statistical correlation to children with neurodevelopmental disorders (now 1 in 5	Yes



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	<p>children) and exposure to electrical, magnetic and RF radiation.</p> <p>You have the ability right now to stop this. The decisions made in Los Angeles County affects other major cities in Ca. Where Ca goes related to these decisions so goes the rest of the nation. This vote is significant.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Marina Benvenga	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>Our health, meaning human health comes first.</p> <p>The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint.</p>	No
Mark Bonnlander	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Mark Busch	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the</p>	No



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	<p>L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Mark Graham	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>As you may know overexposure to legal and FCC approved amounts of non-ionizing radiation can injure a person, causing lasting damage to the central nervous system. A person so injured then feels non-ionizing radiation as headaches and suffers insomnia, tinnitus, fatigue, etc. It can really ruin your life.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these? For example the City of Elk Grove adopted an ordinance containing the "front yard rule" for cell antennas, based on aesthetics. It prohibits placement of cell antennas immediately adjacent to or immediately across the street from the front yard of a residential dwelling. (EGMC 23.94.050 A.6.b., Ord. 19-2019)</p> <p>I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p>	No
Mark OBrien	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Mark Towns	Please. No thank you.	No
Marla Mckemy		No



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Martine English	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Mary Collins	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Mary Martinez	<p>No experimental technology should ever be installed without proper consent of the governed, by our electors and their subservient contractors. No proper studies have been published to the residents about the safety and practical use of commonly known "5G towers". I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO for all our sakes as humans, men and women, and for the future of our sons and daughters.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Mary Zakrasek	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p>	No



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Mary Anne Payne	I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	No
Mary Beth Brangan		Yes
Mary R Guillermin	I request my written comments be part of the public record for Amendments to Titles 16 & 22 of LA County Code at the Dec. 6th B.O.S. meeting. I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe." I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County. It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these? The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint. Mary Guillermin (Mrs) Topanga	No
Maryon Kinsella		No
Maurine Worthington		No
Megan Zappa		No
Megan Zappa		No
Melanie Fisher	I do not want cell towers near my home. Must receive notification and opportunity to oppose such things. Please vote no. Thank you!	No



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Melinda Miller	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22</p>	No
Melissa Smith	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p> <p>Evidence that radiofrequency radiation from cell towers is dangerous:</p> <p>1) Dr. Anthony B. Miller (longtime advisor to the World Health Organization (WHO), and Senior Epidemiologist for the International Agency for Research on Cancer (IARC)) gave 8 policy recommendations in 2019 related to the protection of the public from RF exposure, including "limiting RFR exposure in children under 16 years of age." Risks to Health and Well-Being From Radio-Frequency Radiation Emitted by Cell Phones and Other Wireless Devices. Miller A et al. Aug 13, 2019. frontiersin.org/articles/10.3389/fpubh.2019.00223/full</p> <p>2) 4) The California Department of Public Health in 2017 stated, "RF [radiofrequency] energy can reach a larger area of a child's brain than an adult's brain. A child's brain and body grow and develop through the teen years. During this time, the body may be more easily affected by RF energy and the effect may be more harmful and longer lasting."</p> <p>3) Miscarriage rates triple for women with top radiation exposures. Reuters. reuters.com/article/us-health-mobilephone-miscarriage/miscarriage-rates-triple-for-women-with-top-radiation-exposures-idUSKBN1EE2AU</p> <p>4) The American Academy of Pediatrics (AAP) has advised the US</p>	No



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	<p>government since 2013 to reassess regulations regarding human exposure to wireless radiation, especially for children and pregnant women, and "[adopt] standards that are protective of children and reflect current use patterns." AAP Letter to FCC regarding Reevaluation of Radiofrequency Electromagnetic Fields and Safety Standards 2013.</p> <p>5) Numerous peer-reviewed studies have demonstrated other biological harm from wireless radiation exposure including damage to mitochondrial DNA, heart palpitations, reproduction issues, sleep problems, depression, headaches, ear ringing and more.</p> <p>6) In the August 13, 2021 ruling against the FCC, the DC Court of Appeals held that the FCC failed to respond to "record evidence that exposure to RF [radiofrequency] radiation at levels below the Commission's current limits may cause negative health effects unrelated to cancer." United States Court of Appeals for the District of Columbia. cadc.uscourts.gov/internet/opinions.nsf/FB976465BF00F8BD85258730004EFD77/%24file/20-1025-1910111.pdf</p>	
Mia Marsicano		No
Mia Marsicano		No
Michael Brin	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Michal Lynch	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Miles Hack	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior</p>	No



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	notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	
Mitchell Tsai		Yes
Mitchell M Tsai	A revised copy of comment letter to correct clerical error.	Yes
mojgan sarshar		No
Monique Ussini	Please vote NO Due to lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	No
Moon Zappa		No
nancy HARRINGTON	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	No
Nancy Motherway	Vote NO on Dec. 6 to the Proposed Changes to Titles 16 and 22 I oppose the proposed changes to Titles 16 and 22 of the L.A. County Code. Please vote NO on Dec. 6 and adopt the redline for Titles 16 and 22 that was submitted by Fiber First L.A. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety scrutiny before the towers are built or without regard to critical environmental protections that keep us all safe.	No
Nancy G Boyer	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety	No



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	<p>provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Naomi Mattana	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.	No
Natalie Tavares	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Neil A Nesti	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Nelson Stoll	The medical dangers of this in close proximity for extended periods is shown to be unsafe based on a number of studies. Please oppose until the issues are better understood and shown to the public for vote.	No
Nichola Alva	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22."</p>	No
Nicole Angelo	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>Earlier this year a Verizon 5g tower was installed on my block 250 feet from my home and less than 20 feet from my neighbor. I did not consent to this and there is reason to be very concerned about the radiation effects on my family, especially my 1 year old son.</p>	No



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	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p> <p>I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>In the last 15 years there have been 4 major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods; placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A. County contain nothing about fires.</p> <p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (un-backed-up) small cell antennas are required for 911 calls is false.</p> <p>The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint.</p>	
Nicole BetanCourt	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety</p>	No



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	<p>provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Nicole Gage	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Odette J Wilkens	<p>I urge the Board of Supervisors to vote NO on the ordinance as written. I urge the Board of Supervisors to adopt the redline copy of Title 16 & 22 submitted by Fiber First L.A. fiberfirstla.org/documents</p> <p>· Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment — therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (CEQA) is unjustified.</p> <p>· Protect Us from Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires, and they cannot be fought until the grid has been cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of fire. The proposed revisions allow cell towers to be too close to homes, schools and daycare centers.</p> <p>· I insist the Board of Supervisor's stick to the facts. The Board of Supervisors are being misled to believe this infrastructure is necessary for 911 calls. But, in an emergency, like loss of power due to earthquakes or other emergencies, 911 calls would depend solely upon the macro towers that are already backed up per the California Public Utilities Commission (CPUC) Order. cpuc.ca.gov/industries-and-topics/internet-and-phone/service-quality-and-etc/communications-network-resiliency. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments to Title 16 & 22.</p>	No



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KATHRYN BARGER

Correspondence Received

	<p>Fiber should be prioritized, per NTIA. This is a once in a lifetime opportunity as these federal dollars will not be available in the future. The Board should take advantage of these funds to provide futureproof, superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes at least ten times more power: researchgate.net/publication/224240247_Energy_Consumption_in_Wired_and_Wireless_Access_Networks compared to wired technologies and significantly increases our carbon footprint</p>	
Olga Hernandez	I oppose having a cell tower by my home or any homes and schools	No
Ophira Levant	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Pamela Klein		No
Patricia Moore	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Patrick Mckemy	<p>publiccomment.bos.lacounty.gov/</p> <p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p>	No



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	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Patty Mendoza	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Paula Gomez	<p>I do not want a cell tower installed right outside my home without protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Peter Garcia	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Qian Xu	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Rafi Mitilian		No



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Raluca Ploog	Please vote NO, and adopt the redline for Titles 16 and 22 that was submitted by Fiber First LA. I do not want a cell tower installed right outside my home w/o any prior notice, public hearing or opportunity to appeal. Thank you.	No
Randi E Johnson	There are too many unresolved health issues around these 5G towers. The County could be liable for all manner of lawsuits in the future if these towers are allowed to be placed willy-nilly around the county.	No
Rebecca Doll	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	No
Reiko Gregory	The radiation emitted from cell towers is not safe for humans or the environment — therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.	No
Richard Chan	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.	No
Richard Tamm	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside anyone's home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22. There are many people who are sensitive to 5G EMF. Some get terribly ill from it. It could force people to move, just for their health, and could greatly reduce a person's home value for resale. This is playing Russian roulette with people's physical and economic health.	No
Robert Aguilera	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety	No



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	provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	
Robert Campos	There is ample evidence that exposure to radiation from cell phone towers can be detrimental to human health. I have enclosed just a few items from scientists who have carefully studied this issue.	Yes
Robert Gaylord	(See attached PDF)	Yes
Robert Rhoden	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Robert Warner	<p>Dear Supervisors,</p> <p>HERE IS THE FUNDAMENTAL PROBLEM AS I SEE IT. HISTORY REVEALS HUMANS TO BE FANTASTICALLY CREATIVE AND CAPABLE, BUT OFTEN EXPEDIENT, EVEN CARELESS. "GET IT DONE NOW, ASK QUESTIONS LATER" IS A COMMON OPERATING BASIS. I'll provide a few examples below.</p> <p>In seeking to understand a topic it is sometimes helpful to make comparisons to something which is more familiar. EMF radiation, as a global phenomenon, is a very recent concern. It was only 30 years ago that reduced cell phone size enormously increased the popularity of cell phone usage. Complete internet service on the mobile web has only been available for a little over 20 years – mere seconds when it comes to biological research.</p> <p>But the phenomenon is not without precedent. A similar situation existed in the mid-20th century with regard to skyrocketing chemical use in agriculture and industry. The general population was being exposed to thousands of toxic chemicals and there were no studies which had examined the effects of prolonged exposure to such chemicals over a lifetime, and, through placental blood transfer and other factors, over many generations. The renowned environmental scientist and pathologist, Dr. Rene Dubos of the Harvard Medical School, sounded the alarm in 1968 in the journal Environmental Scientist, writing, "THE GREATEST DANGER OF POLLUTION MAY WELL BE THAT WE SHALL TOLERATE LEVELS OF IT SO LOW AS TO HAVE NO ACUTE NUISANCE VALUE, BUT SUFFICIENTLY HIGH, NEVERTHELESS, TO CAUSE DELAYED DISEASE AND SPOIL THE QUALITY OF LIFE.</p>	No



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Dubos is credited with popularizing the environmental maxim, "Think globally, act locally".

Dubos words were prophetic. The US Environmental Protection Agency's National Human Adipose Tissue Survey (NHATS) has found dozens of carcinogenic chemicals (herbicides, pesticides, industrial chemicals such as PCBs) at low levels in virtually every human ever tested. According to a report in the journal, Environment International, these chemicals "concentrate in fatty tissues and bioaccumulate as they move up the food chain; travel long distances in global air and water currents; and have been linked with serious health effects in humans, even at low exposures" (Environment International, Vol. 39, Issue 1, Feb., 2012).

We are now in the middle of a decades-long human experiment with low-level chemical exposure on a global scale, the effects of which we simply have not been able to fully study. There are so many substances which were tested and "proven" safe at given levels by top scientists decades ago. Now we know more. If you will allow me to give just one example. This year the EPA reported that PFAS (per- and poly-fluoroalkyl substances), carcinogenic chemicals in use since the 1940s for nonstick cookware, fabrics and flame-retardant equipment, are far more dangerous than previously known. THE EPA HAS NOW SET NEW LEVELS WHICH ARE 3,000 TO 17,000 TIMES LOWER THAN PREVIOUS "SAFE" STANDARDS. [washingtonpost.com/climate-environment/2022/06/15/epa-pfas-forever-chemicals/](https://www.washingtonpost.com/climate-environment/2022/06/15/epa-pfas-forever-chemicals/). PFAS are in the drinking water of a majority of Americans and in the blood of almost everyone. It's worth pausing to consider this: the adverse effects of a chemical in use for 80 years are only now being understood. (Teflon pans – never caused me any problems, right?)

IT IS MY OPINION THAT A VERY SIMILAR GLOBAL EXPERIMENT IS NOW OCCURRING WITH ELECTROMAGNETIC FREQUENCY RADIATION (EMF). I imagine dozens of studies showing the adverse effects of EMF will be brought to your attention. I will mention only one: Oncology Letters, in 2020 (Oncology Letters, 2020 October; 20(4): 15), entitled, "Health risks from radiofrequency radiation, including 5G, should be assessed by experts with no conflicts of interest". The researchers wrote:

"The fifth generation, 5G, of radio frequency radiation is about to be implemented globally without investigating the risks to human health and the environment. This has created debate among concerned individuals in numerous countries. In an appeal to the European Union (EU) in September 2017, currently endorsed by >390 scientists and medical doctors, the moratorium on 5G deployment was requested until proper scientific evaluation of potential negative consequences has been conducted. This request has not been acknowledged by the EU. The evaluation of RF radiation health risks from 5G technology is ignored in a report by a government expert group in Switzerland and a recent publication from The International Commission on Non-ionizing Radiation Protection. Conflicts of interest and ties to the industry seem to have contributed to the biased



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reports. The lack of proper unbiased risk evaluation of the 5G technology places populations at risk. Furthermore, there seems to be a cartel of individuals monopolizing evaluation committees, thus reinforcing the no risk paradigm. We believe that this activity should qualify as scientific misconduct.”

WITH REGARD TO THIS LAST REPORT, I WOULD PARTICULARLY LIKE TO DRAW YOUR ATTENTION TO TWO IMPORTANT PEER-REVIEWED STUDIES. In 2016, 40% of scientists surveyed by the journal, Nature (1500 scientists) believed that fraud was always or often a factor in research. This is the scientific community commenting on itself. An astonishing 70% cited the bias of “selective reporting”, the suppression of undesirable facts and findings (Nature, Vol. 533, pages 452–454, 2016). John Ioannidis, M.D., of the Stanford University School of Medicine reached a similar conclusion. Ioannidis is an internationally recognized expert in the study of scientific research. In 2005 he published a paper entitled, “Why most published research findings are false” (PLoS Med. 2005 Aug;2(8):e124. doi:10.1371/journal.pmed.0020124). Ioannidis reported:

“The greater the financial and other interests and prejudices in a scientific field, the less likely the research findings are to be true. Conflicts of interest are very common in biomedical research, and typically they are inadequately and sparsely reported.”

The question for Los Angeles is whether or not it will, by default, side with industry and continue the EMF experiment, or whether it will act now to reduce our exposure to EMF. Will there be, to quote Dubos, very little in the way of “acute nuisance value” but eventual “delayed disease”? If you research this field you will likely encounter those who will tell you that there are no studies which have proven long-term adverse health effects on large groups exposed to EMF. Of course, they are absolutely right! But those who wish to act responsibly must then ask themselves the other question: While most people do not experience, or do not notice, any acute effects, are there any studies which prove that there are NO long-term adverse health effects from prolonged exposure to EMF radiation? Who has the burden to answer that question? Industry, yes; medicine, yes. But you and I as well.

LOOK AT OUR OCEANS AND RIVERS, OUR AIR, OUR SOIL, OUR FOOD SUPPLY. IT'S HARD TO ARGUE THE CHARGE THAT HUMANS ARE AN EXPEDIENT SPECIES: PUSH AHEAD NOW, “GET IT DONE” – ASK QUESTIONS LATER. ARE WE MAKING THE SAME MISTAKE WITH EMF?

Sincerely,
Robert Warner

Robina Suwol

oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.

No



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	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22. Thank you for your consideration.</p>	
Rollo Zappa		No
Rosadel McClure	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
rosanna libertucci	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Roy Komoto	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Vote NO!</p> <p>I don't want, and won't accept, a cell tower installed right outside my home with NO prior notice, public hearing or opportunity to appeal, with NO fire or safety provisions, and with NO regard to critical environmental protections. I also want and expect you to reverse the categorical CEQA exemption as it relates to Titles 16 and 22. This exemption was issued WITHOUT critical safety requirements.</p>	No
Roya Almotahari	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the</p>	No



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	categorical CEQA exemption as it relates to Titles 16 and 22.	
Ruben Tadeo	POR FAVOR/ VOTEN NO EN TITULO 16 Y 22. NO LO ADOPTEN, NOS VA HA LASTIMAR A NOSOTROS, LOS QUE VIVIMOS EN ESTE CONDADO!! USTEDES ESTAN ACTUANDO EGOISTAMENTE!! VOTEN NO!!!MANDELO DE REGRESO A PLANEACION PLEASE. VOTE NO ON TITTLE 16 & 22!!! DO NOT ADOPT, YOU WILL HURST US, THOSE WHO LIVE IN THE COUNTY!! YOU ARE ACTING SELFISHLY!! VOTE NO!!! SEND IT BACK TO PLANNING!!	No
Samantha Hinton	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	No
Sandra Hibarger	Do people not have common sense anymore to advocate such toxic and cancer causing atrocities in you neighborhood? Towers such as these "Will guarantee cancer" I previously worked at the USC Cancer Center and saw the ramifications of what this can do to people. Do you want this for yourself or your own families? Please forget about monetary pay backs. Trust me it is not worth your health!	No
SANDRA MARQUEZ	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22. IM	No
Sarah H Aminoff	Safe Tech International opposes the amendments to Title 16 and 22. We oppose the amendments to Title 16 and 22. Please vote NO. We urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that was	Yes



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submitted by Fiber First LA. They will provide you with the best legal footing on which to evaluate the placement of wireless infrastructure now and in the future.

Please safeguard due process rights. The radiation emitted from cell towers is not safe for humans or the environment — therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. The Sierra Club's letter to Sacramento, states, "that for more than 50 years, the California Environmental Quality Act (CEQA) has been one of the most important disclosure laws in the state..." "the CEQA process is critical for communities to have a meaningful voice in local planning decisions to protect the environmental health of their neighborhoods."
sierraclub.org/california/letter-sacramento-let-s-talk-about-ceqa

In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires and they cannot be fought until the grid has been cut, which can take up to 60 minutes. Amidst Santa Ana conditions, telecommunications fires become catastrophic. The Malibu Canyon Fire in 2007 and Woolsey Fire in 2018 were telecom initiated. The 2020 Silverado Fire in Irvine forced the evacuation of over 130,000 people started when a T-Mobile lashing wire dropped. Cell tower placement close to homes or schools may not allow enough time for escape in the event of fire. The proposed revisions allow cell towers to be too close to homes, schools and daycare centers.

In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that are already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.

Please take advantage of federal dollars to provide superior fiber optic broadband connections (fiber to and through the premises) rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. The 4G/5G network uses up to 10 times more power than wired technologies and significantly increases our carbon footprint. Fiber optics is the only REAL way to end the digital divide. Not only is it faster, more secure and easier to upgrade, but it is safer in our fire-prone state, does not rely on the proliferation of Wireless Transmitters via poles, large exposed transformers, and RFR, and it's more reliable with multiple users!

A postponement and a reevaluation of Titles 16 and 22 would be prudent in light of the extraordinarily serious environmental concerns we have raised. In conclusion, please oppose the current changes to Titles 16 and 22.

Thank you for your valuable time.
Sarah Aminoff, Kate Kheel and the Team at Safe Tech International



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Shana Zappa		No
SHANNON Horton	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety scrutiny before the towers are built or without regard to critical environmental protections that keep us all safe. I demand the following protections are implemented in regard to the installation of wireless communications infrastructure:</p> <p>?? Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment — therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>?? Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires and they cannot be fought until the grid has been cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of fire. The proposed revisions allow cell towers to be too close to homes, schools and daycare centers.</p> <p>?? Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that are already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.</p> <p>?? Fiber First: Invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes at least ten times more power compared to wired technologies and significantly increases our carbon footprint.</p> <p>Prioritize the health and safety of residents and the protection of the environment. Please vote NO.</p>	No
Shant Akopyan	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the</p>	No



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	categorical CEQA exemption as it relates to Titles 16 and 22.	
sharon sumich	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
sharon I ledbetter	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Shaun Ryan	<p>There needs to be due process involving the communities with complete transparency and awareness for the residents as to any wireless technology being used. Especially with the unforeseen and thoroughly untested safety and hazardous aspects of this newer technology.</p> <p>Thank you for your consideration.</p>	No
Shauna Torok Reppe	<p>I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>In the last 15 years there have been 4 major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods;</p>	No



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KATHRYN BARGER

Correspondence Received

	<p>placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A. County contain nothing about fires.</p> <p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (un-backed-up) small cell antennas are required for 911 calls is false.</p> <p>The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint.</p>	
Shelley J Cerny	<p>This is a horrible idea. I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Shelly Fong	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p>	No



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	Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	
Simona Escobar	<p>I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p> <p>It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>In the last 15 years there have been 4 major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. With California's unique and rapidly changing climate, any revision to our Code must include strict safety standards to protect our homes and neighborhoods; placement too close to homes or schools may not allow enough time to escape in the event of fire. The proposed revisions/amendments by L.A. County contain nothing about fires.</p> <p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (un-backed-up) small cell antennas are required for 911 calls is false.</p> <p>The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy, and significantly increases our carbon footprint.</p>	No



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	<p>Thank you for taking action!</p> <p>We MUST stop this NOW!</p>	
Skye Byrne	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Stacy Sebasty	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
stephanie hauptli	I strongly don't agree with this! Stop	No
Steve D Dietrich	<p>Regarding L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code, I'm in opposition to these amendments. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p> <p>In addition I urge the Board of Supervisors to adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A. and to prioritize future-proof fiber to the home for everyone in Los Angeles County.</p> <p>With regards to the FCC requiring these amendments to be made to our existing L.A. County Code, this is not true; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these?</p> <p>It is well documented that radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input</p>	No



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	<p>and ignoring environmental laws (including CEQA) is unjustified.</p> <p>In case of emergency, if there is a loss of electricity, 911 calls will depend solely upon the macro towers already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new (un-backed-up) small cell antennas are required for 911 calls is false.</p> <p>The Supervisors should be investing resources and taking advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes ten times as much energy.</p>	
Steven Gregory	<p>The radiation emitted from cell towers is not safe for humans or the environment — the placement of antennas is a matter of public health and urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.</p> <p>Despite posing a significant fire threat, and perpetually exposing us, our children and the environment to toxic levels of RF radiation, wireless facilities will be installed without any prior notice, public hearing or opportunity to appeal — without fire or safety scrutiny before the towers are built and without regard to critical environmental protections.</p>	No
SURAJ MODY	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Susan Foster		Yes
Susan Purkhiser	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Susan Slutzky	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p>	No



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	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
susan wiles		No
Susie Cheek	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Suzanne Bertsch	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Suzanne Zoller	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Tami Reece	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p>	No



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	<p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Tara Brancato	<p>My son has autism and is badly affected by 5G. I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Tara B Shakeshaft	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Terry Marquez	<p>I urge the Board of Supervisors to vote NO on the ordinance as written, and I urge the Board of Supervisors to adopt the redline copy of Title 16 & 22 submitted by Fiber First L.A.</p>	Yes
Thomas Nordegg		No
Tim McArdle	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Todd Whiting	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the</p>	No



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	<p>L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	
Tracee N Miller	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Traci Rubner	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Tracy Cuneo	<p>Please vote NO on LA county's proposed amendments to Title 16 and Title 22.</p> <p>Due to lack no safety or fire provisions in the amendment and being unable to appeal the decision to place towers in any location, I oppose the amendments.</p> <p>Also, reverse the CEQA exemption related to Titles 16 and 22.</p> <p>Thank you.</p>	No
Tracy A Off	<p>Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment — therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Fiber First: Invest in resources and take advantage of federal dollars to provide superior</p>	No



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	fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes at least ten times more power compared to wired technologies and significantly increases our carbon footprint.	
Travis Warner	<p>Across the planet, there are varying levels of community concern about electromagnetic wave lengths, cell tower installations, etc. Some communities have chosen to freeze approval indefinitely for 5G installations. There is simply not enough known about health risks. In October, I shared a link to an appeal by scientist David Carpenter to the school board of Portland Oregon, requesting that Wi-Fi equipment be removed from schools and instead wired connections be installed. I've attached a pdf of that report. Dr. Carpenter attached approximately 400 scientific studies supporting this recommendation. I am also attaching here the report by the International Commission on the Biological Effects of Electromagnetic Fields, alerting to the dangers of Wi-Fi and electromagnetic fields. It's a long report, but their findings include the following:</p> <ul style="list-style-type: none">• The limits set for radiofrequency radiation established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Federal Communications Commission (FCC) are based upon invalid assumptions and outdated science; they are not protective of human health.• That there be an independent assessment of the dangers of radio frequency radiation based on scientific evidence from peer-reviewed studies conducted over the past 25 years. They are seeking health standards for workers and the public.• That the public be informed of the health risks of EMF and encouraged to do everything they can to minimize exposures, especially for children, pregnant women and people who are hypersensitive.• That there be an immediate moratorium on further rollout of 5G wireless technology until safety is actually demonstrated. <p>Individuals have widely differing responses to electromagnetic fields. For some it can bring about powerful acute health effects, for others a general malaise. It is quite true that the majority of people do not experience acute effects, however, as the studies I have provided show, they may experience significant adverse health effects over time.</p>	Yes
Tsakhkanush Hakopyan	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p>	No



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	Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	
Tyler Sussman	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	Yes
Urszula Beaudoin	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Veronica Moreno	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Vicki and Eric Goldbach	STRONGLY ASK YOU TO vote NO on the proposed changes to Titles 16 and 22 of the L.A. County Code. to protect all of us and our health from close proximity cell towers in our neighborhoods!	No
Vicki and eric Goldbach	<p>WE STRONGLY oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p>	No



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	Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	
	ERIC AND VICKI GOLDBACH LA county residents for 62 years	
Victoria Colligan	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Victoria D Sievers	We urge the Board of Supervisors to vote NO on the ordinance as written. Please adopt the redline copy of Title 16 & 22 submitted by Fiber First L.A. fiberfirstla.org/documents	No
Viet Nguyen	Frequencies in the RF range have had negative impacts on the health of individuals who live within a close proximity of RF emitters and transmitters.	No
Virginia Ruiz	<p>I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.</p> <p>I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.</p> <p>Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.</p>	No
Vivian M Escalante	<p>Why Fiber:</p> <ul style="list-style-type: none"> • Fiber is faster: Fiber is easily capable of speeds of 100Gbps, with that fast of a connection, everyone can send emails faster, send files faster, download large attachments and upload information quickly. That saves time and money, and fiber internet is faster and more reliable than the 5G network. • Fiber is scalable: Flexible bandwidth options ensure quality performance, and whatever is required, internet service delivered over a fiber network can be easily adjusted to accommodate growth needs without additional hardware. • Fiber is more secure and more available: A fiber line is dedicated, which means the service is much more secure, with less opportunity for interference • Fiber is cost-effective: 	Yes
Wendra Reese	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.	No

				I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	
			Wendy Caminiti	I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe. Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.	No
			William H Plummer	Older WIFI systems use the same radiation frequencies as our microwave ovens. The safety standards are based solely upon heating of human bodies, not on short term results like dead bugs and small animals near the cell-towers, nor on long term results like cancers and heart arrhythmias. Please vote "No."	No
			yelena sonkin	I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.	No
			Yoko Zappa		No
			Zola Zappa		No
		Item Total	366		
Grand Total			366		

From: [Maya Solis](#)
To: [ExecutiveOffice](#)
Subject: 5g towers
Date: Thursday, December 1, 2022 6:10:08 PM

CAUTION: External Email. Proceed Responsibly.

I request my written comments be part of the public record for Amendments to Titles 16 & 22 of LA County Code at the Dec. 6th B.O.S. meeting.

I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO. I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe."

At this time the public is looking to their city counsel to actually do their job and protect their community. Please don't be just another sell out like everybody in Government. We have to be able to trust someone with the current state of affairs being so in your face corrupt. How do you want to been seen in history? Someone who stands with the people or a narsassistic leach? People have had enough of all the corporate overreach and collusion with the government. Can you at least vote the correct way and protect what little we have left?

Maya Solis

Not Playing, just saying

From: [K.T](#)
To: [ExecutiveOffice](#)
Cc: 5gfreecalifornia@gmail.com
Subject: proposed amendments to TITLES 16 and 22 of the L.A. County Code
Date: Thursday, December 1, 2022 7:12:31 PM

CAUTION: External Email. Proceed Responsibly.

Dear Board of Supervisors, Executive office,

I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. I am a tourist of Los Angeles and resident of Santa Barbara. You have the power to prevent irresponsible and unnecessary installment of 4G/5G infrastructure by having the correct guidelines within your county code. Please vote NO.

Katie Mickey
Vice President of Safe Technology of Santa Barbara County
Director of the Santa Barbara Body Therapy Institute

From: [vdzaag](#)
To: [ExecutiveOffice](#)
Subject: (No Subject)
Date: Thursday, December 1, 2022 9:04:34 PM

CAUTION: External Email. Proceed Responsibly.

"I request my written comments be part of the public record for Amendments to Titles 16 & 22 of LA County Code at the Dec. 6th B.O.S. meeting.

I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.

I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe."

Sent using [Zoho Mail](#)

From: [Jason Stolarczyk](#)
To: [PublicComments](#); [Barger, Kathryn](#); [Supervisor Janice Hahn \(Fourth District\)](#); [Sheila; hollymitchell@bos.lacounty.gov](#); [First District](#)
Subject: Opposed to SR Cell Tower
Date: Tuesday, November 29, 2022 10:27:33 PM

CAUTION: External Email. Proceed Responsibly.

Hi -

I'm joining a growing list of area homeowners+voters, in addition to the NewHall School District, realtors and Regional Planning Commissioner Mike Hastings, in opposing the SR Cell Tower.

It's well known the tower has no measurable value to the surrounding community, nor to its primary objective of providing cell access to the most needed area. Specifically:

- > It will reduce property values by 10% or more (according to at least 10 different realtors who work in our community).
- > It will expose SRE school children (my daughter is one of them), park goers and neighbors to radiation.
- > It will be highly visible throughout much of the community, ruining views.
- > It will **NOT** provide cell service to those in the northwest of the community, the area with the worst coverage.

Based solely on the points above, a decision to move forward on this kind of project would show gross negligence in protecting people and property. In addition, a vote to continue this plan clearly shows political favor to AT&T, who is not getting compensated to uphold our community's health.

From this voter's perspective, as well as the majority of my community, the SR Cell Tower plan satisfies short-term thinking, without accounting for long-term ramifications. And history never treats that kind of approach kindly.

Jason Stolarczyk
Stevenson Ranch HomeOwner

From: [Akshay Sharma](#)
To: [PublicComments](#); [Barger, Kathryn](#); [Supervisor Janice Hahn \(Fourth District\)](#); [Sheila; hollymitchell@bos.lacounty.gov](#); [First District](#)
Subject: Fw: AT&T 75-95 Foot Cell Tower
Date: Tuesday, November 29, 2022 2:14:39 PM

CAUTION: External Email. Proceed Responsibly.

We are opposing the tower. The unsightly tower will:

- Reduce property values by 10% or more (according to 10 different realtors who work in our community)
- Expose SRE school children, park goers, and neighbors to radiation
- Be highly visible throughout much of the community, ruining views
- Only serve AT&T customers
- **NOT** provide cell service to those in the northwest of the community, the area with the worst coverage

The proposed tower belongs in an industrial park, not our beautiful residential community. But, it is the cheapest solution for AT&T. Alternatives in the form of microsites and smaller towers away from homes and school children should be explored.

The Project No. PRJ2021-000295 and hearing date 12/20/22 in your email.

For more information, please visit the following website: StopTheSRTower.com

From: [Bill Hornstein](#)
To: [PublicComments](#); [Barger, Kathryn](#); [Supervisor Janice Hahn \(Fourth District\)](#); [Sheila; hollymitchell@bos.lacounty.gov](#); [English, Stephanie](#); [Vartanian, Natalie](#); [First District stopthesrtower@gmail.com](#)
Cc:
Subject: Project No. PRJ2021-000295
Date: Tuesday, November 29, 2022 7:58:31 AM

CAUTION: External Email. Proceed Responsibly.

Hello. My name is Bill Hornstein and my family has lived in Stevenson Ranch since 1999 and we are opposed to the AT&T cell tower in our community.

A gigantic and unsightly tower of this magnitude will not only be an eyesore throughout most of our beautiful neighborhood but, according to local realtors, decrease our property values.

Since this tower would be self serving for only AT&T does this open the door for Verizon, T-Mobile, Mint Mobile and any other new carrier to build their own towers in other parts of the community?

Also, reports indicate that it won't even service customers in the northwest of the community, an area that already is reported to have the worst coverage.

The solutions are simple:

1. Residents with poor cell service should ask their carrier for a wifi network extender. I have had one for years and my cell phone works great.
2. Instal microsites or smaller towers away from schools and homes instead of this single massive tower which is the cheapest solution possible for AT&T.

AT&T customers pay a lot of money each month and they should be expected to find a better solution than an ugly 10 story cell tower buzzing and crackling over our homes and school children.

I am asking that the Los Angeles Board of Supervisors vote no to Project No. PRJ2021-000295 at the December 20, 2022 hearing.

Thank you.

Bill Hornstein

From: [Kelly Wasserman](#)
To: [PublicComments](#); [Barger, Kathryn](#); [Supervisor Janice Hahn \(Fourth District\)](#); [Sheila](#); [hollymitchell@bos.lacounty.gov](#); [First District](#)
Cc: [pawlawscv@gmail.com](#)
Subject: SUPPORT for the AT&T 75-95 Foot Cell Tower
Date: Tuesday, November 29, 2022 7:32:02 AM

CAUTION: External Email. Proceed Responsibly.

RE: Project No. PRJ2021-000295

We are in SUPPORT of the cell tower. We've lived in Stevenson Ranch for 24 years. The cell service is terrible here. We are in complete support for a cell tower to be installed.

Below is an email string stating who to contact. I am using this to voice our support of the cell tower,

Thank you,

Kelly & Philip Wasserman
26128 Carroll Lane
Stevenson Ranch, CA 91381
Cell: 661-510-5952
Land: 661-254-0128

From: Ti H <stopthesrtower@gmail.com>
Sent: Monday, November 28, 2022 9:26 PM
To: undisclosed-recipients:
Subject: AT&T 75-95 Foot Cell Tower

Dear Neighbors,

Before you voice your opinion on the SR Cell Tower, make sure you get all the information. Currently, the hearing is set for December 20, 2022. However, AT&T failed to make the required notifications, so this date may change. The Board of Supervisors will hear AT&T's request to install a **75 to 95-foot tower (approximately 10 stories) in the center of our community, by homes, and the elementary school.** Please join your neighbors, the Newhall School District, realtors, and Regional Planning Commissioner Mike Hastings in opposing the tower. The unsightly tower will:

- Reduce property values by 10% or more (according to 10 different realtors who work in our community)
- Expose SRE school children, park goers, and neighbors to radiation
- Be highly visible throughout much of the community, ruining views
- Only serve AT&T customers
- **NOT** provide cell service to those in the northwest of the community, the area with the worst coverage

The proposed tower belongs in an industrial park, not our beautiful residential community. But, it is the cheapest solution for AT&T. Alternatives in the form of microsites and smaller towers away from homes and school children should be explored.

ACT NOW: AT&T is extremely powerful and the only chance to stop the tower is to tell the Board of Supervisors we don't want it! Please email the Board of Supervisors and tell them how you feel: publiccomments@bos.lacounty.gov, kathryn@bos.lacounty.gov, fourthdistrict@bos.lacounty.gov, sheila@bos.lacounty.gov, hollymitchell@bos.lacounty.gov, and firstdistrict@bos.lacounty.gov.

Make sure to note the Project No. PRJ2021-000295 and hearing date 12/20/22 in your email.

For more information, please visit the following website: StopTheSRTower.com

December 4, 2022

Dear Los Angeles Board of Supervisors,

Our organization, Safe Tech International has been following the developments in Los Angeles County and your proposed changes to the county code with respect to the siting of telecommunications facilities (Titles 16 and 22). We believe the actions you take on Tuesday, December 6th will impact not only Los Angeles County, but other counties throughout California. Several of our members are residents of California. That is why we are writing to you today.

Please vote No. We urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that was submitted by Fiber First LA. They will provide you with the best legal footing on which to evaluate the placement of wireless infrastructure now and in the future.

Please safeguard due process rights. The radiation emitted from cell towers is not safe for humans or the environment — therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. The Sierra Club's letter to Sacramento, states, "that for more than 50 years, the California Environmental Quality Act (CEQA) has been one of the most important disclosure laws in the state..." "the CEQA process is critical for communities to have a meaningful voice in local planning decisions to protect the environmental health of their neighborhoods." <https://www.sierraclub.org/california/letter-sacramento-let-s-talk-about-ceqa>

In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires and they cannot be fought until the grid has been cut, which can take up to 60 minutes. Amidst Santa Ana conditions, telecommunications fires become catastrophic. The Malibu Canyon Fire in 2007 and Woolsey Fire in 2018 were telecom initiated. The 2020 Silverado Fire in Irvine forced the evacuation of over 130,000 people started when a T-Mobile lashing wire dropped. Cell tower placement close to homes or schools may not allow enough time for escape in the event of fire. The proposed revisions allow cell towers to be too close to homes, schools and daycare centers.

In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that are already backed up [per the California Public Utilities Commission \(CPUC\) Order](#). The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.

Please take advantage of federal dollars to provide superior fiber optic broadband connections (fiber to and through the premises) rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. The 4G/5G network uses up to 10 times more power than

wired technologies and significantly increases our carbon footprint. Fiberoptics is the only REAL way to end the digital divide. Not only is it faster, more secure and easier to upgrade, but it is safer in our fire-prone state, does not rely on the proliferation of Wireless Transmitters via poles, large exposed transformers, and RFR, and it's more reliable with multiple users!

A postponement and a reevaluation of Titles 16 and 22 would be prudent in light of the extraordinarily serious environmental concerns we have raised. In conclusion, please oppose the current changes to Titles 16 and 22.

Thank you for your valuable time.

Sarah Aminoff, Kate Kheel and the Team at Safe Tech International

December 4, 2022

Dear Los Angeles Board of Supervisors,

Our organization, Ecological Options Network, has been following the developments in Los Angeles County and your proposed changes to the county code with respect to the siting of telecommunications facilities (Titles 16 and 22). We believe the actions you take on Tuesday, December 6th will impact not only Los Angeles County, but other counties throughout California.

Please vote No. We urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that was submitted by Fiber First LA. They will provide you with the best legal footing on which to evaluate the placement of wireless infrastructure now and in the future.

Please safeguard due process rights. The radiation emitted from cell towers is not safe for humans or the environment — therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. The Sierra Club's letter to Sacramento, states, "that for more than 50 years, the California Environmental Quality Act (CEQA) has been one of the most important disclosure laws in the state..." "the CEQA process is critical for communities to have a meaningful voice in local planning decisions to protect the environmental health of their neighborhoods." <https://www.sierraclub.org/california/letter-sacramento-let-s-talk-about-ceqa>

In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires and they cannot be fought until the grid has been cut, which can take up to 60 minutes. Amidst Santa Ana conditions, telecommunications fires become catastrophic. The Malibu Canyon Fire in 2007 and Woolsey Fire in 2018 were telecom initiated. The 2020 Silverado Fire in Irvine forced the evacuation of over 130,000 people started when a T-Mobile lashing wire dropped. Cell tower placement close to homes or schools may not allow enough time for escape in the event of fire. The proposed revisions allow cell towers to be too close to homes, schools and daycare centers.

In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that are already backed up [per the California Public Utilities Commission \(CPUC\) Order](#). The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. Please take advantage of federal dollars to provide superior fiber optic broadband connections (fiber to and through the premises) rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. The 4G/5G network uses up to 10 times more power than wired technologies and significantly increases our carbon footprint. Fiber optics is the only REAL way to end the digital divide. Not only is it faster, more secure and easier to

upgrade, but it is safer in our fire-prone state, does not rely on the proliferation of Wireless Transmitters via poles, large exposed transformers, and RFR, and it's more reliable with multiple users!

A postponement and a reevaluation of Titles 16 and 22 would be prudent in light of the extraordinarily serious environmental concerns we have raised. In conclusion, please oppose the current changes to Titles 16 and 22.

Thank you for seriously considering opposing this,
Mary Beth Brangan

Moskowitz: Cellphone radiation is harmful, but few want to believe it

By **Anne Brice**, Berkeley News | JULY 1, 2021

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The vast majority of American adults — 97% — own a cellphone of some kind, according to the [Pew Research Center](#). (Photo by [Susanne Nilsson](#) via [Flickr](#)).

For more than a decade, **[Joel Moskowitz](#)**, a researcher in the School of Public Health at UC Berkeley and director of Berkeley's Center for Family and Community Health, has been on a quest to prove that radiation from cellphones is unsafe. But, he said, most people don't want to hear it.

"People are addicted to their smartphones," said Moskowitz. "We use them for everything now, and, in many ways, we need them to function in our daily lives. I think the idea that they're potentially harming our health is too much for some people."

Since cellphones first came onto the market in 1983, they have gone from clunky devices with bad reception to today's sleek, multifunction smartphones. And although **cellphones are now used by nearly all American adults**, considerable research suggests that long-term use poses health risks from the radiation they emit, said Moskowitz.



Joel Moskowitz is a researcher in the School of Public Health and director of the Center for Family and Community Health at UC Berkeley. (School of Public Health photo)

“Cellphones, cell towers and other wireless devices are regulated by most governments,” said Moskowitz. “Our government, however, stopped funding research on the health effects of radiofrequency radiation in the 1990s.”

*Since then, he said, research has shown significant adverse biologic and health effects — including brain cancer — associated with the use of cellphones and other wireless devices. And now, he said, with the fifth generation of cellular technology, known as **5G, there is an even bigger reason for concern.***

Berkeley News spoke with Moskowitz about the health risks of cellphone radiation, why the topic is so controversial and what we can expect with the rollout of 5G.

Berkeley News: I think we should address upfront is how controversial this research is. Some scientists have said that these findings are without basis and that there isn’t enough evidence that cellphone radiation is harmful to our health. How do you respond to that?

Joel Moskowitz: Well, first of all, few scientists in this country can speak knowledgeably about the health effects of wireless technology. So, I’m not surprised that people are skeptical, but that doesn’t mean the findings aren’t valid.

A big reason there isn’t more research about the health risks of radiofrequency radiation exposure is because the U.S. government stopped funding this research in the 1990s, with the exception of a **\$30 million rodent study** published in 2018 by the National Institute of Environmental Health Sciences’ National Toxicology Program, which found “clear evidence” of carcinogenicity from cellphone radiation.

In 1996, the Federal Communications Commission, or FCC, adopted exposure guidelines that limited the intensity of exposure to radiofrequency radiation. These guidelines were designed to prevent significant heating of tissue from short-term exposure to radiofrequency radiation, not to protect

us from the effects of long-term exposure to low levels of modulated, or pulsed, radiofrequency radiation, which is produced by cellphones, cordless phones and other wireless devices, including Wi-Fi. Yet, **the preponderance of research published since 1990** finds adverse biologic and health effects from long-term exposure to radiofrequency radiation, including DNA damage.

More than 250 scientists, who have published over **2,000 papers and letters** in professional journals on the biologic and health effects of non-ionizing electromagnetic fields produced by wireless devices, including cellphones, have signed the **International EMF Scientist Appeal**, which calls for health warnings and stronger exposure limits. So, there are many scientists who agree that this radiation is harmful to our health.

I first heard you speak about the health risks of cellphone radiation at Berkeley in 2019, but you've been doing this research since 2009. What led you to pursue this research?

I got into this field by accident, actually. During the past 40 years, the bulk of my research has been focused on tobacco-related disease prevention. I first became interested in cellphone radiation in 2008, when Dr. Seung-Kwon Myung, a physician scientist with the National Cancer Center of South Korea, came to spend a year at the Center for Family and Community Health. He was involved in our smoking cessation projects, and we worked with him and his colleagues on two reviews of the literature, one of which addressed the tumor risk from cellphone use.

At that time, I was skeptical that cellphone radiation could be harmful. However, since I was dubious that cellphone radiation could cause cancer, I immersed myself in the literature regarding the biological effects of low-intensity microwave radiation, emitted by cellphones and other wireless devices.

After reading many animal toxicology studies that found that this radiation could increase oxidative stress — free radicals, stress proteins and DNA damage — I became increasingly convinced that what we were observing in our review of human studies was indeed a real risk.

While Myung and his colleagues were visiting the Center for Family and Community Health, you reviewed case-control studies examining the association between mobile phone use

and tumor risk. What did you find?

Our **2009 review**, published in the *Journal of Clinical Oncology*, found that heavy cellphone use was associated with increased brain cancer incidence, especially in studies that used higher quality methods and studies that had no telecommunications industry funding.

Last year, **we updated our review**, published in the *International Journal of Environmental Research and Public Health*, based on a meta-analysis of 46 case-control studies — twice as many studies as we used for our 2009 review — and obtained similar findings. Our main takeaway from the current review is that approximately 1,000 hours of lifetime cellphone use, or about 17 minutes per day over a 10-year period, is associated with a statistically significant 60% increase in brain cancer.

Why did the government stop funding this kind of research?

The telecommunications industry has almost complete control of the FCC, according to **Captured Agency**, a monograph written by journalist Norm Alster during his 2014-15 fellowship at Harvard University's Center for Ethics. There's a revolving door between the membership of the FCC and high-level people within the telecom industry that's been going on for a couple of decades now.

The industry spends about \$100 million a year lobbying Congress. The **CTIA**, which is the major telecom lobbying group, spends \$12.5 million per year on 70 lobbyists. According to one of their spokespersons, **lobbyists meet roughly 500 times a year with the FCC** to lobby on various issues. The industry as a whole spends \$132 million a year on lobbying and provides \$18 million in political contributions to members of Congress and others at the federal level.

The telecom industry's influence over the FCC, as you describe, reminds me of the tobacco industry and the advertising power it had in downplaying the risks of smoking cigarettes.

Yes, there are strong parallels between what the telecom industry has done and what the tobacco industry has done, in terms of marketing and controlling messaging to the public. In the 1940s, tobacco companies hired doctors and dentists to endorse their products to reduce public health

concerns about smoking risks. The CTIA currently uses a nuclear physicist from academia to assure policymakers that microwave radiation is safe. The telecom industry not only uses the tobacco industry playbook, it is more economically and politically powerful than Big Tobacco ever was. This year, the telecom industry will spend over \$18 billion advertising cellular technology worldwide.

You mentioned that cellphones and other wireless devices use modulated, or pulsed, radiofrequency radiation. Can you explain how cellphones and other wireless devices work, and how the radiation they emit is different from radiation from other household appliances, like a microwave?

Basically, when you make a call, you've got a radio and a transmitter. It transmits a signal to the nearest cell tower. Each cell tower has a geographic cell, so to speak, in which it can communicate with cellphones within that geographic region or cell.

Then, that cell tower communicates with a switching station, which then searches for whom you're trying to call, and it connects through a copper cable or fiber optics or, in many cases, a wireless connection through microwave radiation with the wireless access point. Then, that access point either communicates directly through copper wires through a landline or, if you're calling another cellphone, it will send a signal to a cell tower within the cell of the receiver and so forth.

The difference is the kind of microwave radiation each device emits. With regard to cellphones and Wi-Fi and Bluetooth, there is an information-gathering component. The waves are modulated and pulsed in a very different manner than your microwave oven.

What, specifically, are some of the health effects associated with long-term exposure to low-level modulated radiofrequency radiation emitted from wireless devices?

Many biologists and electromagnetic field scientists believe the modulation of wireless devices makes the energy more biologically active, which interferes with our cellular mechanisms, opening up calcium channels, for example, and allowing calcium to flow into the cell and into the

mitochondria within the cell, interfering with our natural cellular processes and leading to the creation of stress proteins and free radicals and, possibly, DNA damage. And, in other cases, it may lead to cell death.

In 2001, based upon the biologic and human epidemiologic research, low-frequency fields were classified as “possibly carcinogenic” by the International Agency for Research on Cancer (IARC) of the World Health Organization. In 2011, the IARC classified radiofrequency radiation as “possibly carcinogenic to humans,” based upon studies of cellphone radiation and brain tumor risk in humans. Currently, we have considerably more evidence that would warrant a stronger classification.

Most recently, on March 1, 2021, **a report was released by the former director of the National Center for Environmental Health at the Centers for Disease Control and Prevention**, which concluded that there is a “high probability” that radiofrequency radiation emitted by cellphones causes gliomas and acoustic neuromas, two types of brain tumors.

Let’s talk about the fifth generation of cellphone technology, known as 5G, which is already available in limited areas across the U.S. What does this mean for cellphone users and what changes will come with it?

For the first time, in addition to microwaves, this technology will employ millimeter waves, which are much higher frequency than the microwaves used by 3G and 4G. Millimeter waves can’t travel very far, and they’re blocked by fog or rain, trees and building materials, so the industry estimates that it’ll need 800,000 new cell antenna sites.

Each of these sites may have cell antennas from various cellphone providers, and each of these antennas may have microarrays consisting of dozens or even perhaps hundreds of little antennas. In the next few years in the U.S., we will see deployed roughly 2.5 times more antenna sites than in current use unless wireless safety advocates and their representatives in Congress or the judicial system put a halt to this.

How are millimeter waves different from microwaves, in terms of how they affect our bodies and the environment?

Millimeter wave radiation is largely absorbed in the skin, the sweat glands, the peripheral nerves, the eyes and the testes, based upon the **body of research that's been done on millimeter waves**. In addition, this radiation may cause hypersensitivity and biochemical alterations in the immune and circulatory systems — the heart, the liver, kidneys and brain.

Millimeter waves can also harm insects and promote the growth of drug-resistant pathogens, so it's likely to have some widespread environmental effects for the microenvironments around these cell antenna sites.

What are some simple things that each of us can do to reduce the risk of harm from radiation from cellphones and other wireless devices?

First, minimize your use of cellphones or cordless phones — use a landline whenever possible. If you do use a cellphone, turn off the Wi-Fi and Bluetooth if you're not using them. However, when near a Wi-Fi router, you would be better off using your cellphone on Wi-Fi and turning off the cellular because this will likely result in less radiation exposure than using the cellular network.

Second, distance is your friend. Keeping your cellphone 10 inches away from your body, as compared to one-tenth of an inch, results in a 10,000-fold reduction in exposure. So, keep your phone away from your head and body. Store your phone in a purse or backpack. If you have to put it in your pocket, put it on airplane mode. Text, use wired headphones or speakerphone for calls. Don't sleep with it next to your head — turn it off or put it in another room.

Third, use your phone only when the signal is strong. Cellphones are programmed to increase radiation when the signal is poor, that is when one or two bars are displayed on your phone. For example, don't use your phone in an elevator or in a car, as metal structures interfere with the signal.


Also, I encourage people to learn more about the 150-plus local groups affiliated with **Americans for Responsible Technology**, which are working to educate policymakers, urging them to adopt cell tower regulations and exposure limits that fully protect us and the environment from the harm caused by wireless radiation.

For safety tips on how to reduce exposure to wireless radiation from the California Department of Public Health and other organizations, Moskowitz recommends readers visit his website, **[saferemr.com](#)**, **[Physicians for Safe Technology](#)** and the **[Environmental Health Trust](#)**.

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**To: His Excellency Antonio Guterres, Secretary-General of the United Nations;
Honorable Dr. Tedros Adhanom Ghebreyesus, Director-General of the World Health Organization;
Honorable Inger Andersen, Executive Director of the U.N. Environment Programme;
U.N. Member Nations**

International Appeal: Scientists call for Protection from Non-ionizing Electromagnetic Field Exposureⁱ

We are scientists engaged in the study of biological and health effects of non-ionizing electromagnetic fields (EMF). Based upon peer-reviewed, published research, we have serious concerns regarding the ubiquitous and increasing exposure to EMF generated by electric and wireless devices. These include—but are not limited to—radiofrequency radiation (RFR) emitting devices, such as cellular and cordless phones and their base stations, Wi-Fi, broadcast antennas, smart meters, and baby monitors as well as electric devices and infra-structures used in the delivery of electricity that generate extremely-low frequency electromagnetic field (ELF EMF).

Scientific basis for our common concerns

Numerous recent scientific publications have shown that EMF affects living organisms at levels well below most international and national guidelines. Effects include increased cancer risk, cellular stress, increase in harmful free radicals, genetic damages, structural and functional changes of the reproductive system, learning and memory deficits, neurological disorders, and negative impacts on general well-being in humans. Damage goes well beyond the human race, as there is growing evidence of harmful effects to both plant and animal life.

These findings justify our appeal to the United Nations (UN) and, all member States in the world, to encourage the World Health Organization (WHO) to exert strong leadership in fostering the development of more protective EMF guidelines, encouraging precautionary measures, and educating the public about health risks, particularly risk to children and fetal development. By not taking action, the WHO is failing to fulfill its role as the preeminent international public health agency.

Inadequate non-ionizing EMF international guidelines

The various agencies setting safety standards have failed to impose sufficient guidelines to protect the general public, particularly children who are more vulnerable to the effects of EMF. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) established in 1998 the “Guidelines For Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz)”¹. These guidelines are accepted by the WHO and numerous countries around the world. The WHO is calling for all nations to adopt the ICNIRP guidelines to encourage international harmonization of standards. In 2009, the ICNIRP released a statement saying that it was reaffirming its 1998 guidelines, as in their opinion, the scientific literature published since that time “has provided no evidence of any adverse effects below the basic restrictions and does not necessitate an immediate revision of its guidance on limiting exposure to high frequency electromagnetic fields”². ICNIRP continues to the present day to make these assertions, in spite of growing scientific evidence to the contrary. It is our opinion that, because the ICNIRP guidelines do not cover long-term exposure and low-intensity effects, they are insufficient to protect public health.

The WHO adopted the International Agency for Research on Cancer (IARC) classification of extremely low frequency magnetic fields (ELF MF) in 2002³ and radiofrequency radiation (RFR) in 2011⁴. This classification states that EMF is a *possible human carcinogen (Group 2B)*. Despite both IARC findings, the WHO continues to maintain that there is insufficient evidence to justify lowering these quantitative exposure limits.

Since there is controversy about a rationale for setting standards to avoid adverse health effects, we recommend that the United Nations Environmental Programme (UNEP) convene and fund an independent multidisciplinary committee to explore the pros and cons of alternatives to current practices that could substantially lower human exposures to RF and ELF fields. The deliberations of this group should be conducted in a transparent and impartial way. Although it is essential that industry be involved and cooperate in this process, industry should not be allowed to bias its processes or conclusions. This group should provide their analysis to the UN and the WHO to guide precautionary action.

Collectively we also request that:

1. children and pregnant women be protected;
2. guidelines and regulatory standards be strengthened;
3. manufacturers be encouraged to develop safer technology;
4. utilities responsible for the generation, transmission, distribution, and monitoring of electricity maintain adequate power quality and ensure proper electrical wiring to minimize harmful ground current;

¹ <http://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf>

² <http://www.icnirp.org/cms/upload/publications/ICNIRPStatementEMF.pdf>

³ <https://monographs.iarc.fr/wp-content/uploads/2018/06/mono80.pdf>

⁴ <https://monographs.iarc.fr/wp-content/uploads/2018/06/mono102.pdf>

5. the public be fully informed about the potential health risks from electromagnetic energy and taught harm reduction strategies;
6. medical professionals be educated about the biological effects of electromagnetic energy and be provided training on treatment of patients with electromagnetic sensitivity;
7. governments fund training and research on electromagnetic fields and health that is independent of industry and mandate industry cooperation with researchers;
8. media disclose experts' financial relationships with industry when citing their opinions regarding health and safety aspects of EMF-emitting technologies; and
9. white-zones (radiation-free areas) be established.

Initial release date: May 11, 2015

Date of this version: November 29, 2020

Inquiries, including those from qualified scientists who request that their name be added to the Appeal, may be made by contacting Elizabeth Kelley, M.A., Director, EMFscientist.org, at info@EMFscientist.org.

Note: the signatories to this appeal have signed as individuals, giving their professional affiliations, but this does not necessarily mean that this represents the views of their employers or the professional organizations they are affiliated with.

Signatories

Armenia

Prof. Sinerik Ayrapetyan, Ph.D., UNESCO Chair - Life Sciences International Postgraduate Educational Center, Armenia

Australia

Dr. Priyanka Bandara, Ph.D., Independent Environmental Health Educator/Researcher, Advisor, Environmental Health Trust; Doctors for Safer Schools, Australia

Dr. Peter French BSc, MSc, MBA, PhD, FRSM, Conjoint Senior Lecturer, University of New South Wales, Australia

Dr. Bruce Hocking, MD, MBBS, FAFOEM (RACP), FRACGP, FARPS, specialist in occupational medicine; Victoria, Australia

Dr. Gautam (Vini) Khurana, Ph.D., F.R.A.C.S., Director, C.N.S. Neurosurgery, Australia

Dr. Don Maisch, Ph.D., Australia

Dr. Mary Redmayne, Ph.D., Department of Epidemiology & Preventive Medicine, Monash University, Australia

Dr. Charles Teo, BM, BS, MBBS, Member of the Order of Australia, Director, Centre for Minimally Invasive Neurosurgery at Prince of Wales Hospital, NSW, Australia

Austria

Dr. Michael Kundi, MD, University of Vienna, Austria

Prof. Pierre Madl, EE MSc & PhD, Paris Lodron University of Salzburg (PLUS), Radiological Measurement Laboratory Salzburg (RMLS), Edge Institute (AT), Austria

Dr. Gerd Oberfeld, MD, Public Health Department, Salzburg Government, Austria

Dr. Bernhard Pollner, MD, Pollner Research, Austria

Prof. Dr. Hugo W. Rüdiger, MD, Austria

Bahrain

Dr. Amer Kamal, MD, Physiology Department, College of Medicine, Arabian Gulf University, Bahrain

Belgium

Prof. Marie-Claire Cammaerts, Ph.D., Free University of Brussels, Faculty of Science, Brussels, Belgium

Joris Everaert, M.Sc., Biologist, Species Diversity team, Research Institute for Nature and Forest, Belgium

Dr. Andre Vander Vorst, PhD, professor emeritus, University Louvain-la-Neuve, Belgium

Brazil

Vânia Araújo Condessa, MSc., Electrical Engineer, Belo Horizonte, Brazil

Prof. Dr. João Eduardo de Araujo, MD, University of Sao Paulo, Brazil

Dr. Francisco de Assis Ferreira Tejo, D. Sc., Universidade Federal de Campina Grande, Campina Grande, State of Paraíba, Brazil
Prof. Alvaro deSalles, Ph.D., Federal University of Rio Grande Del Sol, Brazil
Prof. Adilza Dode, Ph.D., MSc. Engineering Sciences, Minas Methodist University, Brazil
Dr. Daiana Condessa Dode, MD, Federal University of Medicine, Brazil
Michael Condessa Dode, Systems Analyst, MRE Engenharia Ltda, Belo Horizonte, Brazil
Prof. Orlando Furtado Vieira Filho, PhD, Cellular & Molecular Biology, Federal University of Rio Grande do Sul, Brazil

Canada

Dr. Magda Havas, Ph.D., Environmental and Resource Studies, Centre for Health Studies, Trent University, Canada
Dr. Paul Héroux, Ph.D., Director, Occupational Health Program, McGill University; InvitroPlus Labs, Royal Victoria Hospital McGill University, Canada
Dr. Tom Hutchinson, Ph.D., Professor Emeritus, Environmental and Resource Studies, Trent University, Canada
Prof. Ying Li, Ph.D., InVitroPlus Labs, Dept. of Surgery, Royal Victoria Hospital, McGill University, Canada
James McKay M.Sc., Ecologist, City of London; Planning Services, Environmental and Parks Planning, London, Canada
Prof. Anthony B. Miller, MD, FRCP, University of Toronto, Canada
Prof. Klaus-Peter Ossenkopp, Ph.D., Department of Psychology (Neuroscience), University of Western Ontario, Canada
Dr. Malcolm Paterson, PhD. Molecular Oncologist (ret.), British Columbia, Canada
Prof. Michael A. Persinger, Ph.D., Behavioural Neuroscience and Biomolecular Sciences, Laurentian University, Canada
Dr. Margaret Sears MEng, PhD, Ottawa Hospital Research Institute, Prevent Cancer Now, Ottawa, ON, Canada
Sheena Symington, B.Sc., M.A., Director, Electrosensitive Society, Peterborough, Canada

China

Prof. Huai Chiang, Bioelectromagnetics Key Laboratory, Zhejiang University School of Medicine, China
Prof. Yuqing Duan, Ph.D., Food & Bioengineering, Jiangsu University, China
Dr. Kaijun Liu, Ph.D., Third Military Medical University, Chongqing, China
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Vale Crocetta, Ph.D. Candidate, Biomolecular and Pharmaceutical Sciences, "G. d'Annunzio" University of Chieti, Italy

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New Zealand

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Prof. Olatunde Michael Oni, Ph.D, Radiation & Health Physics, Ladoke Akintola University of Technology, Ogbomoso, Nigeria

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Poland

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Portugal

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Michelle Casciani, MA, Environmental Science, President/Chief Executive Officer, Salvator Mundi International Hospital, Rome, Italy
Enrico Corsetti, Engineer, Research Director, Salvator Mundi International Hospital, Rome, Italy
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Xin Li, PhD candidate MSc, Department of Mechanical Engineering, Stevens Institute of Technology, New Jersey, USA
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Rodolfo Touzet, PhD, Senior regulator on Radiological Safety, Comisión Nacional de Energía Atómica, Buenos Aires, Argentina
Sumeth Vongpanitlerd, Ph.D., retired Electrical Engineer, Thailand Development Research Institute, Bangkok, Thailand

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Review Article

Health Implications of Electromagnetic Fields, Mechanisms of Action, and Research Needs

Sarika Singh and Neeru Kapoor

Occupational Health Division, Defence Institute of Physiology & Allied Sciences, DRDO, Lucknow Road, Timarpur, Delhi 110054, India

Correspondence should be addressed to Neeru Kapoor; neerukapoor0260@yahoo.com

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Electromagnetic fields (EMF) have been implicated to influence a range of bodily functions. Given their ubiquitous nature, widespread applications, and capability to produce deleterious effects, conclusive investigations of the health risks are critical. Accordingly, this paper has been constructed to weigh the bioeffects, possible biointeraction mechanisms, and research areas in bioelectromagnetics seeking immediate attention. The several gaps in the existing knowledge do not permit one to reach a concrete conclusion but possibility for harmful effects cannot be underestimated in absence of consistent findings and causal mechanisms. Several studies with appropriate methodologies reflect the capacity of electromagnetic radiations to cause adverse health effects and there are several credible mechanisms that can account for the observed effects. Hence, need of the hour is to activate comprehensive well-coordinated blind scientific investigations, overcoming all limitations and demerits of previous investigations especially replication studies to concretize the earlier findings. Furthermore, appropriate exposure assessment is crucial for identification of dose-response relation if any, and the elucidation of biological interaction mechanism. For the time being, the public should follow the precautionary principle and limit their exposure as much as possible.

1. Introduction

The terrestrial electromagnetic environment has been and is being rapidly altered by humans as a result of technological advancements. This was well recognised very early in the seventies by Dr. Robert O. Becker (twice nominated for Nobel Prize) who said “I have no doubt in my mind that, at the present time, the greatest polluting element in the earth’s environment is the proliferation of electromagnetic fields (EMFs).” On one hand, these electromagnetic waves (EMW) provide immeasurable benefits; on the other hand, they may also create potential hazards through uncontrolled and excessive radiation emissions. There are various types of electromagnetic radiations (EMRs) and depending upon their frequency and wavelength they are categorized into different types. Broadly the EMFs are categorized into two groups, namely, extremely low frequency (ELF) EMF (>3 Hz–3 kHz) and radiofrequency radiation (RFR) EMF (3 kHz–300 GHz). Scientific investigations concerning the interaction of EMF with living systems, especially its health effects,

are increasing in number. There are arguments for both positive [1–3] and negative bioeffects [4–8]. However, the lack of sufficient knowledge on biological effects of the vast majority of frequencies even below the safety limit leads to several apprehensions [9–11]. The discussion is still ongoing especially regarding the contentious nonthermal effects. It is considered that the energy absorbed calculated in terms of specific absorption rate (SAR) [12] is too low to produce biological effects [13]. At the same time, several studies have demonstrated the influence of EMF by energies that are much lower than those capable of producing temperature changes in living tissues [10, 14]. The cell physiology either in vitro [14] or in vivo [15] can be affected by these temperature-insensitive reactions. Whether this could result in pathological alterations in higher life forms is a matter of debate [16]. Despite the documentation of temperature-insensitive biological effects, they have not been considered in the existing EMF safety standard; rather it is principally based on heating effect of EMF [17]. The current SAR values

TABLE 1: Showing the SAR values for general public and occupational groups laid by ICNIRP [18], International Commission on Nonionising Radiation Protection; SAR stands for specific absorption rate expressed in Watts per kilogram (W/kg).

Frequency range	General public			Occupational exposure		
	Whole body SAR	Localized SAR-head and trunk	Localized SAR-limbs	Whole body SAR	Localized SAR-head and trunk	Localized SAR-limbs
100 KHz–10 MHz	0.08	2	4	0.4	10	20
10 MHz–10 GHz	0.08	2	4	0.4	10	20

for general and occupational groups are presented in Table 1. As a result, current recommendations are established on the lowest exposure known to induce acute observable effects due to heating [7].

In the past, when much of the attention was centered on certain EMW called ionizing radiation, the others called nonionizing radiation (NIR) were generally assumed to be harmless. However, after World War II, this assumption has been reconsidered. The overwhelming scientific investigations concerning health effects of NIR have highlighted their potential to affect the well-being of biological organism. Several researchers have raised questions regarding adequacy of current safety limits [17] and asserted for their revival so that the new biologically based exposure limits will be capable of eliminating the possibility of bioeffects [19].

Some of the documented bioeffects include changes in melatonin levels [20–25], induction of heat shock protein (hsp) [26], effects on spatial memory [27, 28], alteration of intracellular calcium concentration [29], changes in blood-brain-barrier permeability (BBB) [30], enzyme activity [31], genotoxicity [32, 33], nonspecific disabilities, and subjective symptoms [34–37] to name a few. Also, radiation exposure from mobile phones (MPs) has been linked with tinnitus, brain tumours, and acoustic neuroma [38–41]. Additionally, studies at cellular/molecular level are important in illuminating the actual primary injury produced by EMFs [17, 27].

The field of bioelectromagnetics is surrounded with controversies because some studies are contradictory [11, 42] and not always corroborated by independent researchers [35]. The lack of any accepted causal mechanism further adds to the controversy. As a result, important details are simply not comprehended and generate confusion in the general public. As uses expand, the new situations are likely to further increase the environmental EMF levels. To cope with these situations and to promote life of biological organisms more comfortably and efficiently achieving a scientific understanding of the biointeractions of these fields and evaluation of health risks is highly desirable. This paper, therefore, has been constructed to weigh carefully the bioeffects, biointeraction mechanisms and lacunae in EMF research areas seeking immediate attention so that the public is not excessively exposed nor the technological advancements suffer a setback by unjust fears that may or may not exist. In this review, we shall restrict our discussion to the health relevant effects of ELF-EMF and RFR-EMF.

ELF and RFR-EMF related studies were identified by peer-reviewed literature and data searched in electronic database (PubMed) using a number of key words and their

combinations (electromagnetic field, health effects, electric, magnetic, reproductive outcome, and biointeraction mechanisms as examples) in order to find English-language reports related to electromagnetic field health effects and their probable modes of action. A number of papers were retrieved by hand searching several journals and few were obtained through direct correspondence with the authors. Unlike other review papers, no strict inclusion criteria were set. However, a rational explanation of the experimental design, use of control/sham population, exposure conditions, blinding of the research, statistical assessment of the data, and role of artifacts could be reached for most, but not all investigations.

2. Health Effects of Electromagnetic Fields

2.1. Electromagnetic Hypersensitivity (EHS). EHS is a recent phenomenon of occurrence of subjective signs and symptoms in some sensitive individuals with EMF experience from varied electronic sources. Despite lower levels of exposures, symptoms of ill health have been observed among the subjects [34]. According to WHO [43], about 1–3% of the world's population are affected by this EHS syndrome. The exposure to EMFs especially at lower levels and for long duration was originally reported among the East European radar workers and linked with a number of subjective and objective (skin and mucosa-related) symptoms. Sufferers often label EHS as loner's disease because of the consequent social isolation [9]. Epidemiological investigations have been conducted on people complaining about unpleasant symptoms (Table 2). Complainants have related their symptoms most frequently to exposure to MP base stations (74%) followed by MPs (36%), cordless phones (29%), and power lines (27%) [36]. Objective skin symptoms of EHS have been related to increase in mast cell counts and their degranulation, thereby causing the release of inflammatory substances such as histamine responsible for allergic hypersensitivity, sensation of itch and pain, edema, local erythema, and many kinds of dermatoses [19]. With reference to effects of ELF-EMF, Barsam et al. [44] studied the effect of occupational exposure on sleep quality in high voltage substation workers. In their case-control study, they found poor sleep quality among 90.5% of cases and 85.3% of controls. Despite, the increased prevalence of poor sleep quality in exposed group, no statistically significant difference was reached. Similar occupational studies conducted in substation units of a petroleum complex also revealed higher percentage of poor sleep quality in addition to poor health condition in

TABLE 2: Subjective signs and symptoms of electromagnetic hypersensitivity (EHS) [34, 36].

(1) Sleep disorders	(2) Headaches	(3) Palpitations	(4) Hot flushes
(5) Sweating	(6) Tinnitus	(7) Fatigue	(8) Dizziness
(9) Concentration difficulties	(10) Limb pain	(11) Heart disease	(12) Nervousness
(13) Arthropathy	(14) Skin rash	(15) Oculopathy	(16) Depression
(17) Back pain	(18) Tremor	(19) Nausea	(20) Loss of energy
(21) Circulatory disturbance	(22) Loss of appetite	(23) Breathing difficulties	

exposed population when compared to control population [45]. However, the researchers in this group also could not reach any statistically significant correlation between the ELF-EMF exposure level and poor quality of sleep and health status. Another case-control study undertaken on the occupational group of electric utility workers highlighted the increased rate of suicide attempts in exposed group as compared to controls [46]. The authors also suggested that the occurrence of depression in the exposed workers might be the plausible reason. A study by Beale et al. [47] demonstrated the occurrence of psychological symptoms like suicide, depression, and unmanageable emotional condition amongst the residents exposed to chronic 50 Hz MF exposure as a result of their residence in the vicinity of high-voltage substations and power transmission lines. Case studies and anecdotal reports in this regard indicate that people's health problems like diabetes, multiple sclerosis, asthma, and so forth could have some association with biologically active dirty electricity which has been found to improve when levels are reduced [48]. Dirty electricity present in the surroundings has been shown to affect the well-being of teachers and pupils. Use of filters ameliorated the effects, thereby protecting sensitive individuals [49].

As regards RFR-EMF, Navarro et al. [37] carried out a health survey in the vicinity of a cellular phone base station, working in DCS-1800 MHz frequency range with exposition time greater than 6 hours/day, 7 days/week, in 95% of the subjects. Exposure assessment was done by measuring microwave power densities at residence of respondents. Statistical analysis revealed a significant correlation between the declared severity of symptoms and measured power density. The study also showed an increase in the declared severity in groups with higher exposures. Comparable studies have also been performed reporting significant relation of some symptoms to the measured exposures [34]. Epidemiological studies suggest that frequency and severity of symptoms tend to increase with duration of exposure and are reversible if exposure is discontinued temporarily or permanently with symptomatic and general supportive treatment and also severity weakens for those residing far away from exposure source. For instance, in one of the health surveys among self-declared EHS individuals, 90% of subjects reported occurrence of health symptoms when present in the exposure area and disappearance of the same after leaving the exposure area [36]. Studies have also highlighted the significant link between longer duration of daily MP use and health effects [31, 50, 51]. The MP use by children in this regard can be

deleterious as their nervous system is under development and greater amount of energy is absorbed because of their thinner skull bones as compared to adults; additionally longer exposure duration increases their vulnerability to a greater extent [52]. However, to date, quality double-blind studies have not shown any correlation between subjective health complaints and RF exposure [43]. At the same time, epidemiological studies of EMF well-being are difficult to conduct because of imprecision in exposure assessment [53–56] and lack of objectivity in measuring health effects or complaints [35]. In addition, the symptoms are nonspecific and subjective, based on self-reporting, and hence difficult to prove clinically in absence of clear diagnostic criteria for the condition [57]. The subjective complaints of well-being also vary from individual to individual and are a function of several variables like age, sex, social status, anxiety, current health status and accompanying disease, and personality traits [35] as well as the fear generated due to awareness of adverse effects from EMF exposures [34]. Psychological stress may be one of the consequences of EHS in patients and incomplete understanding of pathophysiology of these complex symptoms in absence of any single biomarker so far recognized unique to EHS makes the diagnosis and medical treatment a complicate endeavour [9, 35]. It has also been suggested that subjective symptoms could be the consequence of already prevailing psychiatric condition or stress response resulting from EMF health concerns instead of the exposure itself [43]. In today's modern world, when we cannot part away from electronic gadgets, the EMF experiences are real and practically unavoidable, resulting in disturbances, which could be devastating for a few afflicted individuals. In dearth of any visible causal mechanism and pathophysiological biomarker, its etiology is quite incomprehensible. The pain of EHS patients aggravates further, when the majority of population do not experience any symptom with EMF exposures. The increasing number of reports on EHS however warns us to take this research promptly and locate the biomarkers that could give some clue in ameliorating the problems of such individuals. More investigations are hence needed to completely delineate the pathophysiology of EHS along with the generation of clear diagnostic criteria to identify the problem and develop strategies to limit the suffering of afflicted individuals. Besides, investigations dissecting the relation between EHS manifestation in elderly, children, and diseased persons (like neurodegenerative diseases, mentally and genetically unstable conditions) with EMF experiences are crucial. The lacunae in human studies, with regard to

exposure assessment, inclusion of suitable controls, and data collection, and so forth, need to be eliminated to reach fruitful insights. For the time being, individuals with EHS need to be supported by the family, society, and the government to lead a normal and respectable life.

2.2. Cytotoxic and Genotoxic Effects. DNA alteration is considered to instigate carcinogenesis [8, 58] and change in DNA or micronuclei (MN) generation is an accepted indication for genotoxicity [59]. Different cell types and organisms have been reported to react differently to differing exposure characteristics [26, 32, 60]. Concerning this, Ivancsits and coworkers [61] have identified three responders (fibroblast and melanocytes from human, granulosa cells from rat) and three nonresponder cell types (lymphocytes, monocytes, and skeletal muscle cells from human) when exposed to intermittent ELF-EMF using alkaline and neutral comet assays. Delimaris et al. [62] examined the effect of pulsed 50 Hz EF on human lymphocytes and showed significant DNA damage in exposed group in comparison to controls. However, Scarfi et al. [58] could not detect any statistically significant genotoxic difference in human fibroblasts exposed to intermittent 50 Hz EMFs. A number of studies have demonstrated the potential of ELF-EMF to cause DNA damage [33, 63–66].

As regards RFR-EMF, d'Ambrosio and coworkers [67] have documented significant micronuclei occurrence with phase modulated RFR as against no effect by continuous wave (CW). Phillips et al. [68] observed reduced and increased SSB, at least in some experiments at low and high SARs, respectively, with RF-EMF exposures as opposed to sham controls. Increased DNA damage was reported in human lens epithelial cells exposed to 1.8 GHz at 3 W/kg [69]. Similar findings were reached by Sun et al. [70] on the same cell types after two-hour exposure to 1.8 GHz at SARs of 3 and 4 W/kg. DNA damage at 4 W/kg was found to be irreversible. Studies on marine radar operators also registered significant increase in MN frequency and comet parameters of % of DNA in tail and tail moment after EMF exposures [1]. A detailed summary of various studies have been tabulated (Table 3). The occurrence of aneuploidy is well acknowledged to enhance the risk of tumour. In this context, linear and SAR dependent aneuploidy rise for chromosome 17 detected by fluorescence in situ hybridization post RFR exposure further substantiates their carcinogenic potential [67]. Significant DNA damage occurred after EMF exposure [71], which decreased with free radical scavenger treatment suggesting free radical involvement in inducing damage [3, 33]. Ferreira et al. [72] found a significant increase in erythrocyte MN frequency in newborn pups from irradiated pregnant rats suggesting the genotoxic potential of EMF exposure. Some investigations have shown the genotoxic potential of EMFs only when coupled with some mutagen or carcinogenic or physical agents indicating their synergistic effect [13, 64]. Cell-culture studies by Luukkonen and coworkers [73] conducted on human SH-SY5Y neuroblastoma cells to study the combined effect of CW-RF (872 MHz) and global system for mobile communication (GSM) with menadione suggested that 872 MHz CW-RF radiations at 5 W/kg might enhance chemically induced reactive oxygen species (ROS)

production and thus cause secondary DNA damage. At the same time, enhancement of chemically induced DNA damage observed in this study was associated only with the CW-RF; no effects were seen with GSM signal. Amid these positive effects, Lagroye and coworkers [8] did not find any alkali-labile DNA damage, DNA-DNA cross-links, and DNA-protein cross-links in mouse fibroblast cells exposed to continuous 2450 MHz at 1.9 W/kg for two hours implying their inability to produce genotoxic effects directly by damaging the DNA. Proteomic study on endothelial cell-lines showed the manifestation and phosphorylation of various, chiefly unidentified proteins with RF-EMF exposure [14]. Amid these proteins is Hsp 27, a biomarker for cellular stress. Variation in the expression of cellular stress marker Hsp 90 postirradiation suggests the complex cell defense mechanism and cell response to EMF [26]. EMF interaction with biological system is a very complex process and is a function of several biological, physical, and environmental factors. The exquisite sensitivity of biological systems to EMF experiences leads to intriguing results and regardless of scientific evidences accumulated so far, it is difficult to conclude about EMF toxic effects as the contradictory findings tangle the results confounding the true findings. The differences in experimental protocols in terms of frequency applied, modulation, intensity, investigated endpoints, cell type used, sample size, and so forth have also added to the controversy [5, 10, 60]. Evaluation of present data also becomes difficult due to relatively small number of replication studies because of want for funding. However, possibility of genetic hazard cannot be eliminated in view of conflicting scientific outcomes and lack of accepted causal mechanisms, as the confusion has been generated by some commercial groups in their own interest. Therefore, the need of the hour is to critically analyse the differences and similarities in study variables with greater emphasis with regard to biological systems used, exposure characteristics, study protocol used, findings, data interpretation, and conclusions drawn along with recognising the source of funding, rather than giving weight to the number of studies either observing or not observing an effect. Addition of statistically sound scientific investigations dissecting EMF biointeraction with respect to field direction, orientation, polarization, duration and time of exposure, and so forth needs to be elucidated to gain fruitful insights into cellular behaviours and their responses. However, this province seems of least interest in bioelectromagnetics research. Further investigations investigating the link between EMF exposures and the blue print, that is, the DNA of children, aged, and sick (neurodegenerative, genetic, or mental disease), are needed and will further substantiate the earlier findings. Given the inconspicuous nature of EMF health effects, even slight deviations in experimental protocols can head towards intriguing outcomes. Therefore, sound experimental designs with appropriate methodologies are critical in order to reach firm grounds. In light of the researches done so far, we conclude that the bulk of literature on EMF and cytogenetic endpoints reflect both positive as well as negative effects. Hence, for now, precautions should be taken to limit the exposures as much as possible.

2.3. EMF and Cancer. Epidemiological investigations have focused attention towards association between ELF-EMF exposures and incidence of tumours [6, 40, 41, 77]. Investigations concerning military personnel also indicate the development of tumours [17]. Amongst all cancer endpoints weighed in epidemiological investigations, childhood leukemia in connection to postnatal exposure exceeding $0.4 \mu\text{T}$ gets the maximum support for an association [54]. Recently, a formal assessment for suggestion of carcinogenesis from exposure to static and ELF fields by the International Agency for Research on Cancer [78] concluded that ELF-MFs are possibly carcinogenic to humans and grouped them in 2B category.

With regard to RFR-EMF, Hardell et al. [38] in their study suggested that occurrence of vestibular schwannoma has increased in the decades after introduction of cell phones in Sweden, the country with the highest use of mobile technology [17]. Hardell et al. [38] conducted a cross-sectional study in order to find the association between cell phone usage and vestibular schwannoma. Self-administered questionnaire was used for exposure and symptom assessment. Cases were identified from the Swedish cancer registries with age, sex, and geographical area matched control. Histopathological and anatomical tumour localization was done by CT and MRI scans. The authors reported risks for vestibular schwannoma among cell phone users. Significant rise in risk was reached for analogue phone users. Elevated risks were also calculated for cordless and digital phones but these results could not reach statistical significance. The researchers also reported cases of unilateral tinnitus in some persons using cell phone on ipsilateral side; however, a causal relation could not be established on the basis of case report. With regard to association between vestibular schwannoma and cordless and cellular phones, another interesting finding was observed. The highest rising incidence was obtained for men and the age group of 50–59 years. MP use has also been associated with ipsilateral cerebral brain tumours [77, 79], astrocytoma and acoustic neuroma [40, 41], and contralateral temporal tumours [79]. Muscat et al. [79] evaluated the risk of brain tumour in relation to handheld cellular phone use. They included the malignant brain tumour patients as cases (469) and hospital patients as controls (422) after matching for gender, age, race, hospital, and month of admission. Structured interview was employed to gain information related to MP use. The mean duration of MP usage for cases and controls was found to be 2.8 years and 2.7 years, respectively. Out of the 41 measurable tumours, 26 appeared on the ipsilateral side while 15 appeared on the contralateral side. The authors did not find any association between short-term handheld cellular phone use and cerebral brain tumour risk. Another study by the same group [80] based on hospital derived acoustic neuroma patients as cases (90) and patients with nonmalignant diseases as controls (86) reported an average cell phone use of 4.1 and 2.2 years, respectively. Odds ratio was found to increase from 0.5 for 1–2 years cell phone use to 1.7 for 3–6 years group; however, the relative risk did not differ significantly with regard to the frequency, duration, and lifetime hours of use. The study by Muscat group was surrounded with limitations like lack of data on long-term

users especially with regard to under-estimation of risks for slow growing tumours. Hepworth et al. [81] found no association between increased glioma risk and MP use along with absence of any relation with time since first use, years of use, total hours of use, or number of phone calls. The positive association observed between glioma risk and ipsilateral MP use in conjunction with the negative association as regards contralateral MP use was attributed to recall bias as the glioma patients tend to overreport the use on the same side of the tumour while under mentioning the same on the opposed side. This large case-control study was carried out with cases identified from hospital records and cancer registries whereas controls were selected randomly from the general practitioner's list after matching and personal contact. The details regarding the tumour site and laterality and tumour grade were judged from the pathology reports and scans. Computer assisted personal interviews were used to extract the details pertaining to MP use, number of calls made and received, start and stop year, side of use, model and make of MP used, network operator, use of handsfree, usage in rural/urban area, and so forth. On the basis of two case-control studies on brain tumours with regard to MP and cordless phone use, the Hardell group found an elevated risk for ipsilateral exposure with >10 years latency period and subjects started using MP and cordless phone below 20 years of age as regards both astrocytoma and acoustic neuroma [41]. Questionnaire method was employed to evaluate the exposures and cases were identified from the cancer registries. The tumour was assessed with regard to the anatomical region in the brain and was associated with the head side used during phone calls with ipsilateral use defined as greater than 50% and contralateral as less than 50% of the calling time. A review was undertaken with an aim to assess the brain tumour risk in relation to long-term use of mobile phones greater than 10 years and ipsilateral exposure [40]. The reviewers based their findings on the basis of 18 studies (2 cohort and 16 case-control) and found an increased risk for acoustic neuroma and glioma. In addition, the chance of tumour was found to be the highest for ipsilateral exposure in all the studies as reflected by the increased odds ratio. Another review by Levis et al. [82] concluded that the risk for head tumours doubles with long-term MP use. They also observed that methodological flaws with regard to nonblinding of experiments produce negative results and underestimate the risk for tumour development, whereas those studies, which are free from errors, biases, and financial interests, therefore, employing blind protocols, yield positive results indicating a cause-effect link between long-term use of MPs and statistically significant rise in head tumour risk. With increasing number of dynamic MP users worldwide, scientists consider this as the “largest biophysical human experimentation” ever conducted in the past history [17]. An interesting finding was reached in which incidence of brain tumour was found to be higher in populations of cell phone users in rural areas as compared to urban [39]. Also, average exposures have been observed to be slightly higher in rural areas compared to urban areas from MP base stations [34]. In this regard, the connection between exposures and geographic area, ethnicity, nutritional status,

TABLE 3: Studies on the cytotoxic and genotoxic effects of electromagnetic fields.

EMF characteristics	Study group	Method	Study outcome	Reference
7 mT 50 Hz MF for 3 h, ferrous chloride (FeCl_2 , 10 $\mu\text{g/mL}$), melatonin (0.5 or 1.0 mM)	Rat peripheral blood lymphocytes	Alkaline comet assay	Significant DNA damage only after simultaneous exposure to FeCl_2 and MF, melatonin ameliorates the effect.	[64]
1.748 GHz, either CW or phase only modulated wave GMSK* for 15 min. Maximum SAR = 5 W/kg	Human peripheral blood lymphocytes cultures	Cytokinesis block MN Assay and proliferation index	Statistically significant rise in MN frequency following exposure to phase modulated wave.	[67]
60 Hz MF at 0.01 mT for 24 h and 48 h	Male Sprague Dawley rats	Microgel electrophoresis assay	Significantly increased single and double DNA strand breaks, prolonged 48-hour exposure resulted in a larger increase.	[33]
847.74 MHz CDMA [†] , 835.62 MHz FDMA [‡] , 813.56 MHz iDEN [§] 836.55 TDMA [§] , 24 h	Molt-4 T lymphoblastoid cells	Single cell gel electrophoresis and annexin V affinity assay	No DNA damage or apoptosis at any frequency, modulation or exposure time.	[7]
MW frequency ranging from 800 to 2000 MHz.	MP users and age, sex matched controls	Comet assay & MN assay	Significantly elevated comet tail lengths and MN frequency in MP users	[74]
980, 950 MHz, 200 KHz modulation, 5 w and 500 ppm toluene applied for two weeks.	Male bulb/c mice	MN assay on lymphocytes	MW radiation in combination with toluene produced significant cytogenetic effects but not alone	[13]
UHF -EMF (600 mWpeak; 834 MHz; 26.8–40 V/m; vertical polarization) Irradiation from 5.30 pm to 2.00 am for 8.30 h/day, since day of sperm detection until offspring birth.	Adult pregnant Wistar rats only for irradiation and their offspring for study	MN assay, activity of antioxidant enzymes, quantified total sulfhydryl content, protein carbonyl, thiobarbituric acid reactive species, and total nonenzymatic antioxidant defense	Significant rise in MN frequency, no difference in oxidative stress parameters in offspring blood and liver	[72]
RF-EMF, SAR = 1.3 W/kg	Small area of fore arm's skin in 10 female volunteers	Collection of punch biopsies from exposed and nonexposed areas of skin. Protein extraction by 2-DE and protein expression changes analyzed using PDQuest software.	Radiation exposures from MPs have also been suggested to affect protein expression in human skin samples	[75]
MP radiation	85 MP users and 24 nonusers	MN assay on buccal mucosa epithelial cells	Significant rise in MN frequency and positive correlation with duration of use	[76]
915 MHz, 1 h/day for 2 weeks at 2.4 W/m ² , whole body average SAR-0.6 W/kg	Wistar rats	Detection of DNA alteration in peripheral leukocytes by standard and Fpg [#] modified comet assay	Oxidative stress could be the likely cause of increased DNA damage in exposed group	[71]
2.45 GHz, 2 h/day for 35 days to 0.34 mW/cm ² power density, whole body SAR = 0.11 W/Kg.	Male wistar rats, control and exposed group	Double strand DNA damage by microgel electrophoresis, antioxidant enzymes, and histone kinase estimation in brain cells	Significant elevation in comet head, tail length, and tail movement, decrease in GPx ¹ , SOD ² , and histone kinase, and increase in catalase	[31]

TABLE 3: Continued.

EMF characteristics	Study group	Method	Study outcome	Reference
Pulsed MW from 3 GHz, 5.5 GHz and 9.4 GHz Marine RADAR	Marine RADAR operators	Comet assay, MN assay, GSH ³ , and MDA ⁴ estimation	Significant changes found in comet and MN assay parameters indicating cytogenetic disruptions with dropped GSH levels and increased MDA levels in exposed groups	[1]

*GMSK: Gaussian minimum shift keying, [†]CDMA: code division multiple access, [‡]FDMA: frequency division multiple access, [§]IDEN: integrated digital enhanced network, [§]TDMA: time division multiple access, ^{||}UHF: ultrahigh frequency, [#]Fpg: formamidopyrimidine DNA-glycosylase, ¹GPx: glutathione peroxidase, ²SOD: superoxide dismutase, ³GSH: glutathione, and ⁴MDA: malondialdehyde.

economic status, and so forth may provide some remarkable insights and further enhance our understanding. However, association between brain cancer incidence and MP use remains unclear due to inconsistent findings. Short-term and long-term cellular telephone use also did not reflect any connection with cancer risk [6]. As far as cancer risk in animals is concerned, lymphoma risk was found to be significantly higher in experimental groups of mice exposed to pulsed RFR 900 MHz coming from cellular phone than in controls [83].

Study by Cho and Chung [59] suggested the role of low density ELF-EMF as an enhancer in initiation process of Benzopyrene rather than as an initiator of mutagenic effects in human lymphocytes. Most reviews, however, do not support EMF exposures to be carcinogenic. Lack of supportive animal data for carcinogenic potential of EMF also makes the understanding of epidemiological outcomes a difficult enterprise along with faults in human experiments especially with respect to exposure assessment. Majority of the reviews have indicated lack of evidence for cancer initiation by magnetic field (MF) alone; however, accumulating evidence suggests that they could act as cocarcinogens if given in combination with known genotoxic or nongenotoxic carcinogens showing their synergistic effect. Additionally, the DNA damaging potential of EMFs by free radical generation and also by increasing their lifespan coupled with alterations in DNA repair mechanisms is of concern. However, considering the information in hand on carcinogenesis, cocarcinogenesis with tangling results in the absence of established mechanisms, strict limitations to exposures are suggested till the time any firm conclusion is reached.

2.4. Effects on Endocrine System. Among the several hormones secreted by the body, melatonin gained the focus of most of the EMF investigations. Melatonin, essentially a tryptophan derivative produced chiefly from the pineal gland has been documented to be affected by EMF in animals [25, 84, 85] as well as in humans [21, 22, 24]. In addition, the enzyme machinery involved in melatonin biosynthesis has also been reported to be affected by EMF action [86, 87]. Recently, Bellieni et al. [88] investigated the effect of ELF-EMFs from incubators on melatonin production in newborns who had been kept in the incubators for at least 48 hours.

In their study, they found a transitory rise in melatonin secretion almost immediately after the babies were taken out from the incubators, highlighting the EMF potential to influence newborn melatonin production. Significant melatonin depression was registered in an occupational cluster of electronic equipment repairers exposed to ELF-EMFs due to their work in comparison to controls [89]. Epidemiological studies performed on Swiss railway workers exposed to 16.7 Hz MFs exhibited statistically significant reductions in mean evening 6-OHMS (6-hydroxymelatonin sulphate) concentrations after first and fifth days of exposure [24]. The result of yet another occupational study conducted among male electric utility workers exposed to 60 Hz yielded a decrease in postwork shift 6-OHMS/creatinine excretion with temporally stable MF exposures [21]. However, the reduction was found on second and third days of exposure whereas no change was observed on the very first day as opposed to that by Pfluger and Minder [24] indicating the role of exposure duration and that exposure effect may be delayed by several days. Anyway, the experiment of Wood et al. [22] suggested that exposure of humans to 50 Hz circularly polarized 20 μ T MF result in a delay in the onset of rise of plasma melatonin concentrations. As regards animal studies, Kumlin et al. [20] found an interesting augmenting effect on the circadian rhythm of melatonin synthesis in female mice strain (CD₂F₁) exposed to 50 Hz MF having no or very low natural melatonin rhythm in contrast to previous researches using rodents showing chiefly diminishing effects. The findings do not corroborate the registered melatonin diminution in MF-exposed animals but do imply MF effects on pineal gland. Another experiment showed striking reduction in night-time melatonin concentrations as a result of exposure to rapid on/off mode MFs during the day for several days [25]. The authors pointed that rapidly changing exposure conditions create difficulties in acclimatization as opposed to stable exposure characteristics. The inadequacy in exposure characterization and the conduct of investigation at different times, for different exposure durations and at different locations, render the comparison among studies complicated [87]. Melatonin is highly accepted for its antioxidant and tumour inhibiting properties; hence, if oxidative stress (OS) is accompanied by suppression of melatonin levels, it may produce deleterious effects [87]. Given the importance of melatonin for organisms, further

studies with better EMF characterization and standardization are crucial. Hormone serotonin, a tryptophan derivative produced chiefly from the pineal gland, has also been documented to be affected by EMF [85, 90]. However, there are very few studies investigating serotonin and EMF connection. Serum cortisol and ACTH concentrations were found to rise significantly in male guinea pigs exposed to 50 Hz EMF reflecting the capacity to cause stress regardless of being a low frequency [91]. Noticeable depression in melatonin and corticosterone levels were reached in a study investigating the effect of continuous EMF emission from video display units in exposed embryos and young chickens [92]. In addition, significant rise in fetal loss was also registered indicating the adverse effects of these EMF emissions. Occupational studies focused on the effect of EMFs released from magnetostrictive cavitrons used by dentists showed serum cortisol diminution [93]. In the midst of all these studies reporting either an increase or decrease in cortisol concentration, another group of researchers reported no significant change [94] reflecting the inconsistency in this field. With regard to adrenaline and noradrenaline level, significant suppression was registered in electric utility workers exposed occupationally to 50/60 Hz EMFs [95].

As regards RFR, 900 MHz with 217 Hz pulse frequency from digital wireless communication was reported to have no significant effect on salivary melatonin in healthy male students [96]. Cortisol which is a steroid hormone and one of the key stress biomarkers released from adrenal glands has been shown to be affected by RFR-EMF experience [96–99]. It is assumed that RFR-EMF may act as a stressor evident from the increased cortisol concentration documented in previous investigations with animals [100, 101] and humans [102–104]. However, the reports of cortisol increase are contradicted by the results of cortisol diminution [97, 98] and investigations reflecting no effect on adrenal cortisol secretion [96, 105] highlighting the disagreement in this field of investigation. Given the relevance of cortisol, any imbalance can lead to health impairments in due course [103]. More studies therefore in this connection are required to assess the course of action of the biological system in response to EMF stress. ACTH levels were reported to decrease [98] as well as not being affected [97] by RFR exposure. Significantly, higher levels of the stress biomarkers adrenaline and noradrenaline have been reported in physiotherapists [103]. Buchner and Eger [106] also assessed the catecholamines in subjects exposed to cell phone base station. They examined the acute as well as chronic effects of EMF exposure and found a significant increase in adrenaline and noradrenaline levels after EMF exposure, following a drop, but the normal levels were not restored even at the end of the study (about one and a half year). They also observed significant diminution in dopamine levels. Given the role of these catecholamines in controlling B.P., heart rate (HR), and other biological functions, the shift from baseline values due to stress has immense significance for health and well-being and, hence, their continual alteration may prove harmful in due course. Decreases in testosterone concentration with EMF exposure have been stated by some research groups [98, 105, 107] with no effect as well in some reports [97]. FSH levels have also

been found to reduce with EMF exposure at MP frequency [105]. So far as, effect on female reproductive hormones is concerned, there is limited number of studies. The few investigations on RFR from MPs and base stations have shown to mutate prolactin but not progesterone levels indicating the consequent effects on menstruation and pregnancy [98]. Significant rise in serum progesterone concentration has also been reported in pregnant rats after microwave exposure [108]. In addition, parallel studies investigating prolactin levels have documented normal levels even after exposure to radio-cellular phones [97, 109]. As far as thyroid hormones are concerned, decrease in T3 [98, 100] and T4 [98, 110] and increase in T4 [100] in parallel to no effect or retention of normal T3 levels [110] have all been documented with EMF contact. These findings when taken together reflect the variation in EMF research and puzzle the understanding about EMF biointeraction and therefore urge for more studies. In light of the above evidences, it seems that EMF acts as a stressor and has the potential to affect the various endocrine secretions posing a significant health threat.

2.5. Effects on Cardiovascular System. An experiment on human head exposure to 37 Hz EMF at a flux density of $80 \mu\text{T}$ suggested that EMF could alter nociception and may be associated with cardiovascular abnormalities [111]. Håkansson et al. [112] indicated a low level rise in AMI risk in the highest exposure group and observed by means of the synergy index of 2.7 in monozygotic twins that the genetically predisposed subjects have an increased EMF influence for AMI, possibly induced by reduced heart rate variability (HRV). A cohort study on electric utility workers pointed towards an association between occupational 50 Hz ELF-EMF exposure and arrhythmia related heart disorders [113]. On the contrary, a cohort study of railway workers exposed to 16.7 Hz intermittent MF indicated no association with fatality from arrhythmia related heart diseases or acute myocardial infarction (AMI) [4]. Because of the electric character, the circulatory and the nervous system particularly the autonomic nervous system is vulnerable to EMF effects [114]. More explicit damage of neurovegetative regulation, especially a decreased parasympathetic function, may result with high-intensity EMFs leading to cardiovascular malfunctioning [115]. ELF-EMFs have been also implicated to affect the HRV in newborns [116] and interfere with electronic medical equipment like implanted pace makers, but only when kept close to chest [117]. The detailed summary of various investigations concerning cardiovascular system effects have been listed (Table 4). Ali et al. [118] has attributed the alterations in rat heart functions as a result of decreased RBC membrane elasticity, permeability, and changes in molecular structure of haemoglobin exposed to 50 Hz, 0.2 mT MFs. Yet another study on rats linked the observed histopathological alterations like unclear cytoplasm, polymorphic nucleus, disrupted fibrous tissue, necrosis, and bleeding in heart epithelial tissue with 50 Hz EMF exposure [119].

As regards RFR-EMF, Bortkiewicz et al. [115] found more impairment in 24-hour and resting ECG in AM (amplitude modulation) broadcast station workers when compared to radio-link station workers who are supposed to have less

TABLE 4: Studies concerning the effects of electromagnetic fields on the cardiovascular system.

EMF characteristic	Study group	Method	Study outcome	Reference
Medium frequency EMF	MF broadcast and radio link station workers	General medical examination, cardiological, and family history survey, 24-hr ECG [*] , LVP [†] , HRV, and ABP [‡] measurement	EMF exposure is linked to abnormalities in the neurovegetative regulation of cardiac function	[120]
EMF exposure from MP			Interference with medical equipment like implanted pacemakers	[117]
MF exposure	Electric utility workers	Cohort study Cause of death from death certificates	Association between elevated MF exposure in electric utility jobs and mortality from arrhythmia related causes	[113]
50 Hz, 0.2 mT MF for 15 and 30 days	Male albino rats	ECG, osmotic fragility, shape of RBCs [§] , membrane and Hb [§] structure tests, dielectric relaxation of Hb molecules measured	Alterations in ECG, RBCs membrane elasticity and permeability and changes in molecular structure of Hb.	[118]
BC 6–25 MHz and TV stations: 66–900 MHz	BC, TV, and radio relay station operators	Arterial pressure, lipid profile, BMI, waist/hip ratio, smoking habits, and family history for cardiovascular disease	RF EMR exposure contributed to a higher risk of becoming hypertensive and dyslipidemic	[121]
Intermittent 16.7 Hz MF, 7.5 hrs/day and 240 working days/year was assumed	Railway workers	Cohort study Cause of death from death certificates, average ELF-MF exposure determined by measurements and modelling	No association between long-term exposure to MF and death from arrhythmia related heart diseases or AMI	[4]
EMF from incubators	Newborn babies	15-minute HRV measurement in supine position at least 1 hour after feeding	Alterations in HRV	[116]

^{*} ECG: electrocardiography, [†] LVP: late ventricular potential, [‡] ABP: ambulatory blood pressure, [§] Hb: hemoglobin, [§] RBC: red blood cell, and ^{||} BC: broadcast.

exposure. A significantly higher frequency of irregularity identified as conduction, rhythm, or repolarization disturbances in resting and 24-hour ECG (electrocardiography) was noticed among subjects exposed to medium frequency when compared to control [120]. Stress is considered to increase B.P. (blood pressure) and exposure to EMFs has been implicated to cause stress [103, 111]. Vangelova and colleagues [121] found significantly higher systolic and diastolic B.P., total cholesterol, and low-density lipoprotein cholesterol levels in radio operators exposed to RFR and confirmed stronger association between RFR-EMF exposure and the likelihood of becoming hypertensive and dyslipidemic. The researchers, however, noted that the results could be influenced by the extended shifts and monotonous work as well. The study also revealed that majority of the hypertensives who were under medication reached their normal B.P. only when stayed away from the station. Earlier findings have also reported increased hypertension with RFR exposures [115]. Significantly higher levels of stress biomarkers like adrenaline, noradrenaline, and cortisol have been documented in medical staffs with RFR-EMF exposures, which could also influence B.P., heart

rate (HR), and so forth, [103]. Recent findings have highlighted the possibility of small short-term and medium-term effects on HR and cerebral blood flow to intermittent universal mobile telecommunication system (UMTS) exposures [122]. Andrzejak and coworkers [123] reported an increased parasympathetic tone and decreased sympathetic tone during MP use measured by HRV analysis and indicated the potential of MPs in affecting the autonomic balance in healthy individuals. However, the confounding effect of talking during measurement of the parameters cannot be neglected. Similar results of sympathetic domination and parasympathetic suppression were reached by Kodavanji et al. [124] pointing towards the link between long-term MP use and adverse effects on HRV, thereby affecting the autonomic balance in healthy individuals. However, since the study was undertaken on a small population without randomization, the results need further confirmation. To add, a recent investigation with the intent to find the effect of RFR-EMF from MP on the electrocardiographic parameters in ischemic heart disease patients taking into account the gender aspect reached some interesting results. They observed prolongation

of QT interval in male subjects with or without ischemic heart disease in addition to interference with voltage property of ECG records in myocardial ischemia patients excluding the female counterparts from these effects [125]. In the midst of studies reporting positive findings, parallel studies reporting absence of effects [126–128] create confusion and hampers our understanding. Further long-term studies with better exposure characterization and health assessment are essential to depict the true picture in light of the prevailing controversy with the employment of the latest techniques. In this connection, EMF effect on newborns and patients with electronic implants or on life supporting systems needs immediate attention.

2.6. Effects on Nervous System. The inability of neuronal cells to divide and repair once damaged makes the organism susceptible to develop several neurodegenerative diseases. The occurrence of Parkinson's disease, and so forth, has been linked to cumulative DNA damage in brain tissues [60]. The increased prevalence of Alzheimer's disease reported among workers of textile factories exposed to ELF-MFs [129] could be one such instance. Ahlbom and coworkers [54] in their review also indicated towards a possible relation between amyotrophic lateral sclerosis (ALS) and occupational ELF-EMF exposure. However, effect of confounders cannot be ruled out. Cognitive performances like attention, perception, and memory have been reported to diminish instantly by 50 Hz, 1 mT ELF-EMF exposure in human subjects [130]. In concert, authors have found significant alterations in learning and information acquisition in passive avoidance learning task in both male and female mice exposed to 8 mT, 50 Hz ELF-EMF [131]. Authors have also found association between occupational ELF-EMF exposures and problems like dementia and depression [132, 133]. Results from animal studies in mice have also established the induction of depression at ELF-EMF exposures due to increased nitric oxide levels in cortex, hippocampus, and hypothalamus [134]. Studies have indicated that short-term ELF-EMF exposure may cause small alterations in neurotransmitter metabolism and in circulating amino acids [90] as well as influencing monoamine metabolism when exposure is in the same direction as the mouse position [42]. In connection, Rajeswari et al. [135] highlighted the importance of orientation of the field exposure with respect to the subject in human experiments. They found the subjects to be restless and aggressive when exposed to pulsations in north orientation, and cholinesterase levels in serum were significantly increased. In east, west, and south orientations, the subjects appeared to be calm and serum cholinesterase levels were normal, which suggested the increase of cholinesterase due to MF stress. Prato and colleagues [136] have reported significant inhibitory effects of a variety of ELF-MFs on endogenous opioid and exogenous opiate induced analgesia in snail *Cepacea*. Zecca et al. [137] found that higher field strength exposure may raise norepinephrine levels in pineal gland of rats accompanied with key changes in brain involving opioid system in frontal cortex, parietal cortex, and hippocampus. Pertaining to this, the documented calcium ion efflux from brain tissue at RFR exposure can be an important neurochemical effect as

their significance in routine nervous system operation is well known, for example, neurotransmitter release for cellular interaction [138].

With reference to RFR-EMF, authors have reported that RFR-EMFs interact with cognitive functions like shortening of reaction times, particularly during tasks that require attention or manipulation of information in the working memory [27, 143]. In yet another study, shorter latency in passive avoidance task was registered in MP RF-EMF exposed rats reflecting significant impairments in memory retention and retrieval [144]. The authors suggested that the RFR-EMF exposure induced damage might lead to alterations in neuronal functioning of both hippocampus and amygdala resulting in changed behaviour during task performance. A cross-sectional study meant to detect neurobehavioural deficits among residents living close to base stations found the prevalence of neuropsychiatric complaints such as memory changes, headache, sleep disturbance, depressive symptoms, dizziness, and tremors to be significantly higher among exposed inhabitants than controls [145]. The study outcomes were based on a questionnaire survey, clinical examination, neurobehavioural test battery (NBTB), and environmental measures with age, sex, education level, smoking habit, occupation, and MP use matching. The NBTB indicated that the exposed inhabitants exhibited a significantly lower performance than controls in one of the tests of attention and short-term auditory memory. The inhabitants opposite the station showed a major reduction in performance in problem-solving test than those under the station. However, in the tests of visuomotor speed and one test of attention the exposed individuals performed significantly well as compared to controls. A cross-sectional community based study conducted among hand-held cellular telephone users in Singapore found headache to be the most prevalent central nervous system symptom as compared to nonusers and the prevalence increased significantly with increased duration of usage per day [146]. The findings were further substantiated by reduced prevalence by more than 20% among those who used handsfree equipment as opposed to those who never used them. The reduced exposure as a result of using handsfree equipment could be possible because the antenna is kept farther away from the head. Studies have proved the sensitivity of brain cells towards RFR-EMF exposures [139, 140]. Significant increases in brain glucose metabolism in regions closest to MP antenna have been observed with acute exposures [147]. GSM-MP radiations have been demonstrated to induce seizures in rats made seizure prone by subconvulsive picrotoxin doses and to alter the cerebral activity reflected by significantly higher c-Fos levels in some brain regions, which raises question for persons with epileptic disorders [15]. MP-EMFs have been suggested to affect the normal neurophysiology through alterations in cortical excitability as a result of demodulation or direct interference with membrane ionic changes, which results in depolarisation and excitation of nerve cells [53]. However, no histopathological changes have been observed with long-term MP exposures [148]. Increased BBB permeability has also been documented not only immediately but also after seven days of exposure to MPs [30]. So far, the

TABLE 5: Studies concerning the health effects of electromagnetic fields on the nervous system.

EMF characteristics	Study group	Method	Study outcome	Reference
1 mT 50 Hz EMF plus 45 dB SPL (expand) noise for 1 hr duration	66 subjects	Double-blind study	Decreased cognitive performance in attention, perception, and memory	[130]
Four different groups with different durations, days, orientation, and levels of EMF exposure (60 Hz, 1, 3.3, 10 Gauss)	Male C57BL mice	Concentrations of DOPAC [*] , HVA [†] , and 5-HIAA [‡] in brain tissue were determined with HPLC-ECD	Monoamine levels are affected only by EMF when the exposure is in the same direction as the mouse position.	[42]
700 MHz continuous RF-EMF, 25.2–71.0 V/m, 5–15 min	Slices of rat hippocampus	Evoked field potential	Increases in the level of neuronal excitability	[139]
900 MHz CW MP emissions	15 subjects, two sessions for 45 min	Recording of motor evoked potential using paired-pulse paradigm, tympanic temperature	Influence on motor cortex excitability	[140]
ELF-MFs	Mice Balb/c	Y-maze	Impairment in spatial recognition memory depending on field strength and length of exposure	[141]
GSM 900 MHz from MP, 2 h/days for 4 days at SAR = 0.41 to 0.98 W/kg	16-week-old female rat	Morris water maze	Reduced ability to consolidate and retrieve the learned spatial information	[27]
900 MHz EMF (1 h/day for 28 days) SAR-0.016 whole body and 2 W/kg (locally in the head)	Sham exposed group, 16 rats, and four exposure groups, each with eight rats	Number of pyramidal cells in CA [‡] region in hippocampus following postnatal exposure, histopathological evaluations on sections of CA region	Significant reduction in pyramidal cell number in the CA of the EMF group	[142]
GSM 915 MHz for 2 h in TEM [§] cells at SARs of 0, 0.12, 1.2, 12 and 120 mW/kg	Forty-eight inbred male and female Fischer 344 rats	Histopathological assessment of albumin extravasation over the BBB, neuronal albumin uptake, and neuronal damage	Interruption of BBB permeability as evidenced by enhanced albumin extravasation in exposed rats after seven-day recovery period	[30]

^{*}DOPAC: dihydroxyphenylacetic acid, [†]HVA: homovanillic acid, [‡]5-HIAA: 5-hydroxyindoleacetic acid, [§]CA: cornu ammonis, and [§]TEM: transverse electromagnetic cell.

most reliable findings have been reached regarding the brain electrical activity [10]. Impairment in spatial learning and memory functions has been demonstrated in animal studies [27, 143]. Details of investigations with exposure characteristics have been tabulated (Table 5). Lai et al. [28] pointed towards 2450 MHz MW induced short-term memory deficits in rats by the stimulation of endogenous opioids in brain resulting in depressed cholinergic activity responsible for memory functions. The results of Xu et al. [149] pointed towards the connection between extended low intensity GSM 1800 MHz (2.4 W/kg) exposure and synaptic activity evident by decreased excitatory synaptic activity and excitatory synapse number in cultured rat hippocampal neurons. A study investigated the effect of GSM modulated 900 MHz RF-EMF at 1 W/kg on neuron development in two different cell systems by the assessment of morphological parameters and mRNA expression for β -thymosin and stress-related proteins [150]. The authors found a diminution in neurite generation from the soma without any effect on branching and neurite

length in both the cellular systems, which was also found to be associated with β -thymosin mRNA overexpression. Yuasa et al. [151] conducted an investigation in order to study the acute effects of pulsed high frequency MP-EMF emissions used for 30 min on somatosensory evoked potentials (SEPs) in healthy individuals. They demonstrated negative effects on SEPs as well as their recovery function indicating the absence of immediate effects on the sensory cortex. EMRs from MP base stations may expose residents to risk of developing neuropsychiatric difficulties and alterations in performance of neurobehavioural functions either by inhibition or facilitation [145]. The comparative analysis of studies relating cognitive and nervous system performance with EMF experience gets complicated due to different assessment tools employed and exposure situations and despite the bulk of scientific evidence, the results turn into conflicting and unconvincing outcomes. At present, the precise mechanism of EMF ill effects on neurons lacks sound understanding; however, some investigations have indicated the role of lipid

peroxidation and free radical generation [2, 152]. To add, the nervous system is chiefly helpless to ROS insults because of its high metabolic rate, inadequate oxidant protection, and reduced cellular turnover [152].

2.7. Effects on Reproductive Functions. Rising male infertility cases in recent times have led to scientific investigations, which indicate the involvement of EMRs as one of the possible environmental factors [153]. Understanding of EMF effect on reproductive functioning is also clouded by contradictory findings [154] despite several decades of research. MPs rather than being a status symbol nowadays have become a part and parcel of everyone's life since the past decade and a half [155]. As it is often carried in pockets in very close proximity to body and the reproductive system, effect of the same on male infertility is an important issue, which seeks immediate attention. Various studies have been undertaken to investigate the potential of ELF field characteristics in inducing damage to the reproductive system [156–160]. In this regard, intermittent 50 Hz low frequency horizontal EF exposure has been reported to cause significant histopathological alterations like focal tubular atrophy, necrosis, and seminiferous epithelial erosion in rat testis [156]. The serum testosterone levels, however, did not differ significantly between exposed and control groups. Toxic effects of 60 Hz, 1 mT ELF-EMF were also reported in male rat offspring exposed from gestation day 13 to postnatal day 21 [159]. The study found a reduction in the count, diameter, area, and volume of seminiferous tubules and height of seminiferous epithelium along with leydig cell count indicative of the harmful effects on testis development. On the contrary, 60 Hz, 500 μ T exposure for 21 hours/day from gestation day 6 to postnatal day 21 in pregnant rats did not elicit any significant difference between the exposed and the controls with regard to spermatogenesis and fertility in male offspring [160]. With reference to investigations in mice, 60 Hz EMF was found to raise significantly the germ cell death and defects in seminiferous tubules without any effect on the body or testes weights. At the same time, the same frequency of EMF at 0.5 mT was shown to induce DNA breakage though cell survival was not significantly impaired [157]. Another study at 60 Hz, 14 μ T, and 200 μ T reported the induction of apoptosis in mice testicular germ cells [158].

As regards RF-EMF exposure, animal studies undertaken so far document higher levels of sperm head abnormalities, positively correlated to RF-EMF exposures suggesting a dose-response effect [165]. Aitken et al. [166] reported alterations in genome of epididymal spermatozoa in mice exposed to 900 MHz RF-EMW, 12 h/day for 7 days. Parallel studies in rats have documented lower spermatocyte counts along with leydig cell hyperplasia and elevated testosterone levels at 2.45 GHz frequency [154]. Significant decline in protein kinase C and total sperm count together with increased apoptosis was reported in male rats exposed to RF-EMF (2 hours/days, 35 days, 0.9 W/kg) from MPs [167]. The investigators indicated the possible role of ROS behind these findings. Previous study on rats found major impairments in OS equilibrium in reproductive tissues along with modified semen parameters reflecting the fundamental connection between

RF-EMR exposures and mutations in semen quality [168]. In contradiction, no difference in testicular function was found at GSM-RF exposure from cellular phone in rats [169]. An in vitro study assessing the effect of 900 MHz MP radiation at a SAR of 2.0 W/kg on human sperm's fertilizing potential found no harmful effects on acrosome reaction [170]. However, the researchers did reach significant findings with regard to sperm morphometry and a measurable decline in sperm binding to hemizona was found thus indicating a significant effect of RF-EMF on male fertilizing potential. Interesting findings were reached in a study evaluating the effects of RFR released from GSM multiband MP (900/1900 MHz at a SAR of 1.4 W/kg) in *Drosophila melanogaster* exposed during the 10-day developmental period from egg laying through pupation [171]. The authors reported elevation in offspring count, stress protein hsp70 concentration, and binding activity of serum response element (SRE) in conjunction with phosphorylation of nuclear transcription factor, ELK-1 indicative of cellular stress, which could further lead to critical alterations in the organism. Observational studies conducted in connection to RFR-EMF exposure reported diminution in semen quality by reduced sperm count, motility, viability, and normal morphology which were also found to be a function of duration of MP use [163]. Wdowiak et al. [172] also demonstrated an increase in the proportion of sperm cells with abnormal morphology and a decrease in the proportion of rapid progressive sperms with the frequency of exposure from GSM-MPs. Davoudi et al. [161] also reported a decrease in rapid progressive motile sperm due to GSM-MPs. The details of investigations have been summarised in Table 6. Extended MP uses have been reported to elicit harmful effects on sperm motility in previous researches as well [162, 173]. Studies show a possible relationship between occupational exposure to radiofrequency equipment including radar and reduced fertility and sperm quality [164, 174]. Epidemiological investigations have indicated a link between male infertility and MP use, but the mechanism of action is unclear. The role of hyperthermia in causing infertility is apparent but the nonthermal effects are debatable [154]. However, it has been speculated that the effect could be specific to EMR effect, a thermal effect, or due to the combination of both [168]. So far, motility or sperm movement is the only factor observed to be affected significantly [155]. Reproductive functions like meiosis, fertilization, and so forth are particularly vulnerable to toxic insults [154]. De Iuliis et al. [153] have highlighted the occurrence of ROS and DNA fragmentation after RF-EMR exposure putting a question mark on the safety of MP use especially in the context of fertility and children's health. Until now, the malfunctioning porous cell membrane and disrupted calcium homeostasis along with OS can be accounted for the damaging effects on testicular cells [12]. Conclusive outcomes have not yet been reached despite extensive researches. So far, long-term studies concerning EMF effects on male reproductive functions are lacking to substantiate the findings and give any clue regarding the biointeraction mechanisms. As far as effect on female reproductive system is concerned, there is limited number of studies. RFR from MPs and base stations have been shown to mutate prolactin but not progesterone levels indicating

TABLE 6: Studies concerning the health effects of electromagnetic fields on the reproductive system.

EMF characteristics	Study group	Method	Study outcome	Reference
GSM-MP, 6 h/day for 5 days	MP users	Semen analysis	Decrease in rapid progressive motility of sperm	[161]
MP	MP users	Semen analysis	Duration of use and transmission time correlated positively and negatively with proportion of slow progressive and rapid progressive motile sperm, respectively.	[162]
MP	MP users with suitable controls	Sperm parameters like volume, liquefaction time, pH, viscosity, sperm count, motility, viability, and morphology	Statistically significant decrease in semen quality which was also a function of duration of MP use.	[163]
MP, 1 h	Human semen samples	Semen analysis	Significant decline in semen mobility, viability and ROS-TAC* score, rise in ROS level.	[164]
1.8 GHz RF EMR, SAR (0.4 W/kg to 27.5 W/kg)	Purified human spermatozoa	Vitality, motility, sperm density, DHE [†] assay, MSR [‡] assay, 8-OH-dG [§] , TUNEL assay, and flow cytometry	Significant decrease in motility and vitality and increase in ROS, 8-OH-dG and DNA fragmentation with increasing SAR.	[153]
RF radiations from GSM base station, 6-month exposure	Male mice, <i>Mus musculus</i>	Sperm head abnormality assay	High level of sperm head injury in exposed mice which correlated positively with radiation levels	[165]

* TAC: total antioxidant count, [†] DHE: dihydroethidium, [‡] MSR: MitoSOX Red, and [§] 8-OH-dG: 8-hydroxy-2'-deoxyguanosine.

the consequent effects on menstruation and pregnancy [98]. Miscarriage risks have been shown to be higher in pregnant physiotherapists due to their occupation [175]. Han et al. [176] found significant rise in risk of embryo growth cessation in the first pregnancy trimester of pregnant women especially with the medical history of embryo growth termination with regard to increased exposures from television and MPs. Animal investigations also support the toxic effects of RFR. In this connection, Gul et al. [177] registered a fall in follicles count in rat ovaries submitted to intrauterine RF exposures whereas Xu et al. [178] demonstrated toxic alterations in the reproductive organs. Further studies in females are wanted with special relevance for pregnant women, who are also carrying the future generation. Children form yet another group of prime importance since their reproductive systems are immature and exposures are prolonged; hence, they can be the worst sufferers.

2.8. Auditory and Ocular Effects. A recent study [179] concluded that higher ELF-EMF exposure at 50 Hz, 10.182 kV/m coupled to 4.45 pT MF may give rise to adverse auditory effects especially to the organ of Corti and outer hair cells as a result of decreased distortion product auto acoustic emission amplitudes in higher frequency region localized in basal turn of cochlea in rabbits which have also resemblance with human's frequency spectra. As regards RFR-EMF, MP use has been associated with tinnitus and acoustic neuroma [38, 41]. Ear is the first biological structure to be hit by

EMFs from MP. In addition, relatively greater vulnerability of cochlear outer hair cells to injuries from a diversity of exogenous and endogenous agents makes the system a victim of radiation emissions [179, 180]. These days, about 50% of world's population possesses a MP [30] and even greater than that are experiencing EMF emissions through "passive mobile phoning" [181]. Hearing problems reported in few observational studies [50] have also been investigated to occur in animals [179] with parallel contradictions [180, 182]. Studies with ten minutes acute MP radiation exposures have resulted in no immediate effect on hearing threshold level of pure tone audiometry, transient evoked otoacoustic emissions [183], auditory brain stem response [184], and any depreciation in hearing in young human volunteers. However, regular long-term MP use has been linked to increased relative risk of acoustic schwannoma [39]. Despite the interests in EMF effects due to MP, there is lack of solid evidence regarding the ill effects on auditory system and, hence, we are far from any conclusion and not able to develop safe and sound communication devices necessary for safeguarding one of the senses [11].

Heat-related skin injury and lens defects reported in eyes of man are the only undisputed harmful effects of MW exposure [56]. Carpenter [185] in late seventies reported that microwaves have the capability to induce cataracts and affect the eyes by reducing the ascorbic acid content of the lens coupled with the inhibition of DNA synthesis and mitosis in lens epithelium thereby slowing down the recovery

process. In addition, the lens becomes more vulnerable to EMF threats because of decreased water content and absence of vasculature [12, 56, 186]. Spector [187] suggested the role of OS in cataract development due to extensive oxidation of lens protein and lipid at older age. Nevertheless, the database is yet deficient to decide regarding ocular defects including cataracts in human subjects exposed for extended durations.

2.9. Effects on Sleep Parameters. Sleep insufficiency was observed to be more common in the occupational group of electronic equipment repairers exposed to ELF-EMF though not statistically significant when compared to controls [89]. Earlier studies have also documented diminished sleep and sleep efficiency with 60 Hz MF experience [188]. So far, studies evaluating sleep quality in the context of ELF-EMF exposure in humans have not reached any statistical significance [44, 45, 89].

In connection to RFR-EMF, Abelin et al. [189] reported the prevalence of difficulties of falling asleep and, in particular, maintaining sleep, which increased with increasing RF-EMF exposure in the vicinity of short-wave broadcast transmitter. In addition, sleep quality was found to improve after interruption of the exposure. A similar study found an association of EMF exposure with sleep quality and melatonin excretion but only in poor sleepers suggesting the sensitivity of a group of people [190]. The authors highlighted that the absence of blinding in their investigation could lead to such results. Another study by Wiholm et al. [191] indicated the negative influence on sleep component during laboratory exposure to 884 MHz wireless signals. Besides, volunteers with no self-reported symptoms related to MP use appear to have more headaches during actual RF exposure as compared to sham exposure. Several studies evaluating RF exposure effects on sleep parameters and sleep EEG are surrounded with contradictory outcomes owing to methodological limitations like small sample sizes and lack of replications of the previous findings. According to a clinical review [192], sleep disturbances do not seem to be a predominant complaint under exposure to high frequency EMF and with the present level of knowledge no final conclusion can be drawn concerning any potential health hazard. Hutter et al. [34] also reported no significant effect on sleep quality and pointed that it could be dominated by the fear of negative health effects of EMF radiations as well as age. Sleep is an important component of the biological species to overcome the daily wear and tear. Studies relating EMF exposures to sleep do suggest some biological effects; however, these do not provide evidence for any adverse health consequences. Further research with well-designed protocols is required with lessons from past experiments so that valuable information is updated in bioelectromagnetics field.

3. Mechanisms of Action

3.1. Thermal and Nonthermal Interactions. Due to lack of sufficient energy required to break the molecular bonds in cells by EMFs, the elicited effects are assumed to be indirect and secondary to other induced biochemical modifications [60,

76]. Ruediger [32] suggested the indirect role of microthermal processes, OS and altered DNA repair mechanisms behind the observed effects. However, studies have also pointed towards the involvement of resonance-like sensing mechanisms working only at specific combinations of frequency and amplitude suggestive of a direct EMF effect [136]. It is proposed that low frequency time varying electric fields (EFs) interact with the body by the induction of electric currents, formation of electric dipoles, and reorientation of existing dipoles whereas interaction of time-varying MFs leads to induced EFs and circulating electric currents. Higher current densities and EFs have been shown to be induced when the direction of external EF is parallel to the longer vertical axis of body (from head to feet) and the MFs are from front to back, respectively, due to better coupling with human body compared to other configurations [193]. Additionally, EMF effects are dependent on a number of physical (frequency, modulation, polarization, wave characteristics, near or far field configuration, duration and orientation of EF and MF exposure, dielectric properties, conductivity and water content of tissues, and environmental factors like humidity, temperature, etc.) and biological variables (species, shape and size of the body, weight, geometry of the body, and nutritional and health status).

The possible effect of EMF irradiation is either thermal or nonthermal depending on frequency and strength. The elicited effects are assumed to be noticeable when not shrouded by thermal noise also termed as Brownian motion which is a virtue of all objects/materials above absolute zero temperature. The thermal effects are induced as a consequence of heat gained by water contained in body tissues. Hence, body tissues or organs like lens of eye and testes with less vasculature or deficient in water content are the most vulnerable to even small rise in temperature. Usually, body parts with the smallest cross-section like hand, feet, fingers, and toes gain the maximum values of current densities and EFs [193].

3.2. Oxidative Stress. OS resulting from imbalance of reactive oxygen species (ROS) and antioxidants, leading to disruption of cell functions, has been proposed as one of the probable modes of EMF action [2, 5, 60, 71, 196]. EMFs have also been implicated to lengthen life of free radicals particularly by Fenton reaction [33], affect enzyme activity [31], and change protein levels indicative of induction of cellular stress response pathways [14]. Fenton reaction is a process in which hydroxy free radicals are generated from hydrogen peroxide produced during mitochondrial oxidative respiration in presence of transition metals like iron [60, 64]. EMF interaction with free radicals and transitional metals has also been linked to the observed genotoxic effects [33, 64]. In this regard, cells, which are metabolically active, or have higher cellular concentrations of free iron and superparamagnetic iron particles (magnetites) in body tissues like brain cells, are more vulnerable to EMFs [60]. Several studies have demonstrated OS inducing ability of EMF including MP-RFR in different animal models [31, 152, 196–198] or in cell cultures [64, 73] paralleled with negative findings as well [5, 7]. Studies

TABLE 7: Studies showing the oxidative stress inducing ability of electromagnetic fields.

EMF characteristics	Study group	Method	Study outcome	Reference
2450 MHz pulsed (2 msec pulses, 500 pps), 2 mW/cm ² , Avg. SAR = 1.2 W/kg, 2 h, melatonin and PBN* treatment before and after exposure	Male Sprague Dawley rats	Microgel electrophoresis assay in brain cells	Involvement of free radicals in inducing DNA damage in brain cells, and protective effects of melatonin and PBN as free radical scavenger	[3]
0.1 mT, 60 Hz, 5 h and 30 min after LPS [†] administration, mice were administered with NO [‡] spin trap MGD-Fe [§]	Male BALB/C mice	EPR [§] measurement in liver	EMF increased LPS induced NO production but not alone	[194]
900 MHz, 30 min/day, 5 days/wk for 2 weeks, mel. (10 mg/kg daily orally)	Male Sprague Dawley rats in three groups	NO measurement in nasal and paranasal mucosa by Griess reaction	Increase in NO level in sinus and nasal mucosa, beneficial effect of melatonin in preventing these changes	[195]
900 MHz MW, melatonin (100 µg/kg sc before daily exposure)	Sprague Dawley rats in three groups	Lipid peroxidation in cortex brain and hippocampus tissue	Rise in MDA levels, melatonin caused decline in hippocampal MDA levels with no decrease in cortex	[2]
900 MHz RF, CW & GSM MP waves for 10 or 30 min, SAR = 0.3 & 1 W/kg, MX [#] = 500 µM	Murine L929 fibrosarcoma cells	Measurement of ROS	No ROS generation either alone or in association with MX	[5]
MP, 20, 40, 60 days, SAR = 0.043–0.135 W/kg, melatonin = 2 mg/kg body weight i.p.	Wistar rats in four groups	Biochemical estimation of MDA, carbonyl groups, XO ¹ and CAT ² activity in brain tissue	Significant rise in MDA, carbonyl groups, XO activity, and reduced CAT activity after 40 and 60 days exposure; melatonin ameliorates OS	[152]

* PBN: N-tert-butyl-a-phenylnitron, [†]LPS: lipopolysaccharide, [‡]NO: nitric oxide, [§]MGD-Fe: ferrous N-methyl-D-glucamine dithiocarbamate, [§]EPR: electron paramagnetic resonance, ^{||}MDA: malondialdehyde, [#]MX: 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone, ¹XO: xanthine oxidase, and ²CAT: catalase.

demonstrating EMF's ability to cause OS are summarised in Table 7. Given the credence of free radicals in signal transduction and EMF in boosting the free radical lifetime, there are chances of EMF influencing signalling [194].

3.3. Melatonin Diminution. Several human and animal studies conducted thus far have suggested decrease in melatonin after EMF exposure [21, 23, 24, 87]. Like all other EMF effects, melatonin diminution is also surrounded with conflicting results [87]; however, the effects have been suggested to be somewhat constant, at least in rodents [199]. Some studies have also supported the protective effect of melatonin against oxidative damage induced by EMFs [2, 3, 64, 152, 195] pointing towards the OS mechanism involved in generating negative health outcomes and melatonin's beneficial properties. The hypothesised mechanism of EMF action on melatonin concentration is through the imitation of light rays to the retina [22]. To add, Yaga et al. [86] found significant suppression of N-acetyltransferase (NAT) activity, a rate-limiting enzyme in melatonin synthesis due to MF exposure. The melatonin forming enzyme hydroxyindole O-methyl transferase has also been documented to be affected [87]. Melatonin's shielding actions counter to EMF ill effects are supposed to shoot from its direct free radical foraging and indirect antioxidant property of inhibiting free radical production at the power house of the cell and, hence, diminution

of pineal melatonin secretion could be proposed as a possible mechanism of EMF interaction with living organisms.

3.4. Calcium Flux. Calcium ion efflux/influx has also been proposed as the biological mechanism [200] and is dependent on ambient temperature, geomagnetic field intensity, direction, and signal strength [201–203]. Calcium ions are crucial for cAMP pathway as well as serotonin/melatonin conversion and their efflux from pinealocytes is supposed to cause melatonin suppression. Besides, calcium dependent signal transduction systems also have been implicated in the mediation of immune cell effects by low frequency EMF [29]. However, authors have indicated the occurrence of calcium efflux/influx at some specific exposure combinations but not at other relatively closer exposure characteristics mainly due to the “window” effect or nonlinear nature of modulation frequency and intensity effect.

3.5. Molecular Mechanisms. Similar to physiological stress response at the organ system level, there are also cellular stress responses at the cell level to impart protection to the cell from external and internal stressors. The cellular stress response is characterized by an elevation in stress protein concentration [204] in response to a stress causing damage to biomolecules like DNA and proteins [205]. EMFs at ELF, RF, and amplitude

modulated RF have been demonstrated to stimulate the same stress response [204, 206, 207]. Unlike the past assumption of absence of DNA-EMF interaction plausibility, recent investigations indicate the potential of EMF both ELF and RF to stimulate DNA and induce protein expression [14, 171, 208, 209]. Various studies have highlighted the genotoxic ability of EMF at both ELF and RF range as evidenced from DNA strand break reports post-EMF experience [33, 63–65, 68]. Recent investigations have further revealed the presence of an EMF reactive sequence in DNA [210] which acts particularly in response to EMF stimulus. These EMF reactive DNA sequences code for the production of the chief stress protein hsp70, in response to the binding of transcription factor, heat shock factor 1 (HSE-1) to heat shock element (HSE) in the promoter region [210–213]. Friedman et al. [209] delineated the molecular mechanism behind the stimulation of the ERKs in response to RFR exposure at MP frequencies. The RF-EMF through its interaction with NADH oxidase in the plasma membrane causes the formation of ROS, which further activate the MMPs (matrix metalloproteinases). Because of activation, the MMPs break into Hb-EGF [heparin-binding EGF (epidermal growth factor)] and stimulate the EGF receptor, which sequentially triggers the ERK cascade. The ERK cascade is one of the four mitogen-activated protein kinase (MAPK) signaling cascades that controls transcription and associated cellular processes like replication, cell-cycle progression, apoptosis, differentiation, metabolism, and so forth, in reaction to extracellular stimuli. The MP radiation induced overexpressed protein transcription factors have been found to regulate the cellular processes such as apoptosis [214] and replication and cell cycle progression [14, 215]. The reported findings with regard to cellular stress response post-EMF experience give critical insights into connection to harmful health-relevant potential of ELFs and RFRs in addition to their role as cellular biomarkers.

In light of several credible biointeraction processes, the OS mechanism appears to gain the maximum support. The hypothesised EMF biointeraction path may involve ROS generation, leading to diminished antioxidant capacity, affecting the antioxidant/prooxidant equilibrium and causing OS, thereby instigating adverse health effects. This sequence may be paralleled by calcium efflux, which alters serotonin conversion into melatonin thus triggering melatonin diminution, which further substantiates OS. At the same time, ROS may lead to the activation of signal transduction pathway triggering the ERK cascade. The cellular stress response mediated by hsp70 overexpression can also be considered but this effect is limited to certain group of cells while other cell types are being nonresponsive [216]. The exact mode of biointeraction mechanism still needs to be elucidated.

4. Research Needs

The limited quality of research works in bioelectromagnetics and methodological problems is an important concern [57, 155]. Until now, epidemiological investigations have failed to get the SAR value which is the most direct dosimetric measure of an individual's exposure at the tissue or organ level under study [217]. Moreover, lack of an appropriate

exposure assessment method [55] and reliable equipment for calculation of energy absorbed in the body and the intricate relation with species, frequency, power, EMF source, and modulation dosimetry has inhibited the utilization of laboratory results to human conditions [53] and the conduct of epidemiological studies [56]. Hutter et al. [34] suggested the usage of personal “exposimeter” or long-term exposure monitoring as the best way for exposure assessment. So far, errors in exposure assessment due to lack of long-term exposure monitoring by EMF dosimeters, exposure has been assessed by crude methods in most studies, such as wiring codes, occupation or residence in relation to proximity to a source, spot measurements, time-weighted average and self-reports, and hence results in underestimation of actual risk and clouds the true relationship. Absence of suitable control population for comparison as all of us are exposed to EMFs every day coming from varied sources with different degrees further complicates the understanding of literature on human EMF exposure [52, 55].

Furthermore, clear understanding is hampered by the multipart interactions of different EMF exposure factors [12, 53] and shape, size, mass, orientation, and electrical characteristics of body and individual characteristics like age, gender, activity level, incapacitation, or illness [218]. Environmental parameters like ambient temperature, wind velocity, humidity, and body insulation also affect the communication between body and the EMF vector. Anatomical differences among humans and animal models as regards size, shape, reproductive tract variations, and so forth further complicate the understanding of observed results [12].

As far as studies investigating exposure of humans to MP radiations are concerned, they have followed the standard method of EMF exposure assessment by retrospective interviews or obtaining information or self-reports of subjects on total duration of use or number of calls, number of years of use, side of use ipsilateral, or contralateral along with exposure duration estimates and billing records from service providers [52, 79]. However, these parameters have been questioned for recall bias [52]. Animal experimentation especially using primates or species closely related to humans would eliminate the chances of recall bias regarding MP use and give meaningful directions. Besides, the duration based exposure assessment is built on the postulation of equivalent power emissions per minute from all phones which may not be correct with expanding use of GSM based phones with variable power outputs ending in miscalculation of true exposure in spite of recall accuracy [217]. Besides, geographic area, physical environment, user location rural or urban, distance between user and base station antenna, handsfree use, individual characteristics of phone handset, and its use as well as technical features of provider network all have some effect on EMF emissions and consequent exposure to the individuals [12, 34, 52, 219].

A research carried out by Erdreich et al. [217] to increase the accuracy of exposure estimation in epidemiological studies of GSM-MPs found that the average power output rate in GSM phones varies with several characteristics of phone use, the largest being the site of investigation, followed by user movement and location (indoor or outdoor), use of handsfree

device, and urbanicity. The understanding is complicated further by factors like distance to the phone, holding position, position of antenna, pinna size, elasticity of ear, thickness of skull bone, type of tissue, tissue type distribution, and so forth, governing the actual amount of power absorbed [220]. In addition, lack of long-term studies also restricts our understanding. Apart from this, role of media finds significance in focusing the attention on the potential adverse health effects caused by MP radiations. This may give rise to fear or awareness forcing MP users to report more symptoms than nonusers even if the prevalence of symptoms were equal [146].

Animal and cell culture studies are surrounded with conflicting results as a consequence of the heterogeneous exposure conditions (type of EMF- RF, MW, CW, Pulsed, and so forth, SAR value, exposure duration) [5, 7] and differing assay protocols [53]. At the same time, vested interests of sponsors also influence the study outcome with quality studies having mixed funding and, hence, sponsorship should be taken into consideration while interpreting the findings [221]. We strongly advocate that with mere swelling number of studies no fruitful conclusions can be reached. If we do not address the limitations of past investigations, we may not be able to truly contribute to the domain of bioelectromagnetics. Therefore, need of the hour is to do innovative research with sound designs and appropriate methodologies rising above the demerits of past researches.

5. Conclusion

Given the ubiquitous nature of EMFs, their widespread applications, and their capability to produce deleterious effects, conclusive investigations of the health risks are critical. With the published literature on EMF, it is still not sufficient enough to reach a concrete conclusion. But the possibility of negative consequences cannot be excluded. Several studies with appropriate methodologies reflect the capacity of EMFs to cause adverse health effects. However, the absence of any established biointeraction mechanism does not diminish the reliability of these studies as there are several credible mechanisms like OS that can account for the observed effects.

Therefore, need of the hour is to restrict the swelling numbers of scientific investigations and in place activate comprehensive well-coordinated blind scientific investigations especially long-term studies overcoming all limitations and demerits of previous findings with suitable replication studies and follow-up. There is a need for standardized research methodology along with the inclusion of appropriate exposure assessment technique which is crucial for identification of dose response relation if any and the elucidation of mechanism for biological interaction. If we do not work upon the demerits of previous findings, we may remain far from any concrete conclusion. At the same time, it is critical to analyse the EMF investigations giving more weight to the similarities and dissimilarities rather than giving more importance to the endpoints reached.

For the time being, since it is difficult to protect oneself from EMFs, the only practical way to check exposures is to

distance oneself from the source. Together, the precautionary approach and ALARA (as low as reasonably achievable) principle can also be applied to save us from substantial exposures and the possible ill effects if any. The objective is to minimize EMF exposures to the greatest degree possible without significant economic cost and disturbance.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Le escribimos para pedirle que vote NO a los cambios propuestos a los Títulos 16 y 22 del Código del Condado de Los Ángeles. Estos cambios, que supuestamente cerrarán la brecha digital, solo empeorarán las cosas asegurándose de que las comunidades minoritarias obtengan conexiones inalámbricas inferiores mientras que las comunidades más acomodadas obtengan fibra óptica. Esto provocará otra brecha digital que persistirá durante muchos años.

Las conexiones inalámbricas a Internet son lentas, poco fiables, caras (si quieres cualquier tipo de conexión decente), no reguladas (por lo que las compañías inalámbricas pueden cobrar lo que quieran), y vienen con una serie de otros problemas, incluyendo incendios y peligros para la salud e impactos ambientales negativos. Wireless nunca será capaz de proporcionar las velocidades que se requerirán de las conexiones a Internet en un futuro próximo

En resumen, la banda ancha inalámbrica es una tecnología perdedora que se impone a las comunidades minoritarias en un intento bien intencionado pero inútil de compensar lo que las telecomunicaciones no han logrado hacer durante veinte años - conectar a los clientes en su área de servicio con la banda ancha de fibra óptica, como prometieron, y como se les pagó para hacer

Todo el mundo merece una conexión de fibra óptica a Internet, y eso incluye a todas las familias que viven en comunidades minoritarias en Los Ángeles. No queremos un servicio inalámbrico deficiente. Necesitamos las mismas conexiones de banda ancha de calidad que todos los demás

Por favor vote NO a los cambios a los Títulos 16 y 22 y exija que el Condado de Los Ángeles use su poder e influencia para conectar a todos con fibra óptica.

Sinceramente,
Union Binacional de Organizaciones de Trabajadores Mexicanos Exbraceros 1942-1964
Baldomero Capiz
Coordinador Binacional

BOYLE HEIGHTS COMMUNITY PARTNERS

Unity with Strength for History, Community and Historic Preservation

603 North Breed Street
Los Angeles, California 90033

BHCP

5 December 2022

Los Angeles County Supervisor Hilda L. Solis, First District
856 Kenneth Hahn Hall of Administration
500 West Temple Street
Los Angeles, CA 90012

Re: Petition Relating to Proposed Amendments to Title 16 & 22 (Vote on Final Passage Scheduled for December 6, 2022)

Dear LAC Board of Supervisors Members:

Our organization **Boyle Heights Community Partners** strongly urges that you Board of Supervisors Members vote 'No' on the above captioned matter. Our organization is focused on guiding our supervisors in the direction of listening to the voice of your constituents, and hear what is best for us, including small businesses and avoid corruption in working with lobbyist and deep pockets, which have proven to cause more harm.

We are deeply concerned that a vote in favor of amendments to Titles 16 and 22 will cause great harm to residents and businesses large and small in our Los Angeles, County. Therefore, directly undermine our mission for the following reasons.

Why Fiber:

- **Fiber is faster:** Fiber is easily capable of speeds of 100Gbps, with that fast of a connection, everyone can send emails faster, send files faster, download large attachments and upload information quickly. That saves time and money, and fiber internet is faster and more reliable than the 5G network.
- **Fiber is scalable:** Flexible bandwidth options ensure quality performance, and whatever is required, internet service delivered over a fiber network can be easily adjusted to accommodate growth needs without additional hardware.
- **Fiber is more secure and more available:** A fiber line is dedicated, which means the service is much more secure, with less opportunity for interference
- **Fiber is cost-effective:** The switch to fiber requires an up-front investment, but the long-term benefits minimize the costs over time. The increased speed alone ensures increased productivity and efficiency, and Fiber also comes with far fewer maintenance requirements than other broadband platforms. Fiber is no longer just a telecommunications industry buzzword. It's a widely available, viable internet service option. Its positive impact on the bottom line demonstrates just how valuable it is to the future.

Title 16

- Does not provide for a meaningful evaluation of the impact a contemplated wireless facility will have on historic resources. There is no requirement for notice to historic preservation authorities and groups that a wireless facility is proposed on or near to an historic resource so they will not have an opportunity to independently analyze and comment on the project or its potential impact.

www.BoyleHeightsCommunityPartners.com

Boyle Heights Community Partners is a California 501(c)(3) Nonprofit #32-0628921 (c) 2018

BOYLE HEIGHTS COMMUNITY PARTNERS

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Los Angeles, California 90033

BHCP

- Nothing in the ordinances requires any showing by the applicant that it has performed all required reviews and consultations.
- Both ordinances are inconsistent with federal requirements, in particular section 106 of the National Historic Preservation Act, as amended, 54 U.S.C. § 306108 and the regulations of the Advisory Council on Historic Preservation, 36 CFR Part 800.
- They do not comport with state CEQA obligations because the proposed ordinances purport to excuse the county from performing any impact evaluation based on a claimed “exemption” that ignores the Historic Resources Exception. See CEQA Guidelines 15300.2(f).
- The Title 16 proposal is the most egregious because it completely ignores the entire topic.
- The entire process is deemed “ministerial.” It does not require any notice to any historic preservation office or group, and it does not allow any opportunity to comment or contest.
- It does not require any notice to any historic preservation office or group, and it does not allow any opportunity to comment or contest. It is entirely possible a proposed small cell on county-owned right-of-way that is within or near an historic resource will negatively impact that resource in some way, however, including but not limited to aesthetics and ground disturbances.

Title 22

- Title 22 proposals do at least make a nod toward historic resources. By way of background, the county has a process for special recognition of historic resources. See County Code Ch. 22.124. A resource that has gone through that process it can receive special protection, and the proposed amendments would preserve any that currently exist for those resources. But there are many sites in the county that are listed or eligible for listing on the National, California, or County historic registers that have not been nominated for or gone through the Ch. 22.124 process and are therefore not procedurally or substantively protected. A wireless facility project that would affect an historic resource that has not been listed under Ch. 22.124 will be assigned to “ministerial” treatment. This means there is no required notice to any historic preservation office or group and no opportunity for any party to comment or object. Nor does the proposed ordinance require that the wireless provider or county conduct any impact review. All it says is that the Director of Regional Planning has discretion to require an Historic Resource Assessment. See proposed Ch. 22.140.700(E)(1)(b)(iv).¹ But even then, there is no express requirement that the provider or Director involve any historic preservation office or group.
- Proposed Ch. 22.140.700(E)(1)(b)(iv) does provide that “New wireless facilities shall not be installed on buildings or structures listed or eligible for listing on the National, California, or County historic registers.” This is meaningful, to be sure. It goes on to provide that “[n]ew towers and support structures installed on the grounds of properties listed or eligible for listing on the National, California, or County historic registers shall be located and designed to eliminate impacts to the historic resource.”

¹ “A Historic Resource Assessment, prepared to the satisfaction of the Director, may be required for a facility to be located on a site containing an eligible resource to identify impacts to historic resources, and identify mitigation to minimize impacts.”

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- The proposed ordinance does not, however, require notice to or collaboration with historic preservation groups or allow any participatory rights to a party that wants to contest the application. The entire process is internal and conducted in secret. Nor is there any provision for an appeal of the Director's "ministerial" determinations to the Planning Commission or Board of Supervisors if someone does manage to find out about the project. The public in general and those concerned with historic preservation are required to trust that the Director will always get it right in these no-notice, closed-door proceedings.

In addition to this grave expression of concern, we are well informed by our legal advisors that the proposed action is illegal under various federal and state statutes and infringes U.S. and state due process protections.

We deeply appreciate your consideration and support.

Thank you!

Sincerely,



Vivian M. Escalante
President & CEO

cc

Hilda L. Solis, Los Angeles County Supervisor-First District
Holly J. Mitchell, Los Angeles County Supervisor-Second District
Sheila J. Kuehl, Supervisor, Los Angeles County Supervisor-Third District
Lindsey P. Horvath, Supervisor-Elect Los Angeles County Supervisor-Third District
Janice K. Hahn, Los Angeles County Supervisor-Forth District
Kathryn A. Barger, Los Angeles County Supervisor-Fifth District
Dawyn R. Harrison, Acting County Counsel

CALIFORNIA FIRES AND FIREFIGHTERS

PO Box 1444
Lyons, CO 80540
susan.foster04@gmail.com

December 4, 2022

NO on #80 – County Code, Title 16 - Highways & Title 22 Planning & Zoning Amendments

Dear Los Angeles County Supervisors:

I'm writing to you as a Fire and Utility Consultant, an Honorary Firefighter with the San Diego Fire Department and Co-Founder of California Fires and Firefighters. I'm asking you to **vote NO on Item #80, Titles 16 and 22**, on Tuesday, December 6.

I spoke at the Board of Supervisors hearing on Wireless Ordinances in opposition to the Staff recommendation of Titles 16 & 22 on Tuesday, August 15. I had previously submitted the attached White Paper: PROTECTING LA COUNTY'S FUTURE: HOW FIRE RISKS FROM TELECOMMUNICATIONS EQUIPMENT, CLIMATE CHALLENGES & A DANGEROUS SHIFT AWAY FROM ENVIRONMENTAL REVIEW THREATEN LOS ANGELES COUNTY'S FUTURE.

Unfortunately, only my cover letter was displayed in the official record. Therefore, some of these facts were not available to you on November 15. They are available to you now. Additionally, I resubmitted this paper during the hearing on the 15th, and I am resubmitting to each supervisor and for the record ahead of Dec. 6 **because I am warning of a fire risk that is inevitable and avoidable. Why are you categorically exempting CEQA review when each new cell tower brings with it additional fire risk?**

How can you look the other way, deliberately and recklessly, when the very same telecommunications entities responsible for the Malibu Canyon Fire (2007) and the Woolsey Fire (2018) were accused by the CPUC of attempting to impede *both* fire investigations? Yet you are dropping environmental review and inviting those actors into LA County to police themselves? Why would you do that when you are responsible for the health and safety of the residents of Los Angeles County?

Why are you saying to Southern California Edison (SCE), AT&T, Verizon, Sprint (now T-Mobile) and NextG (now Crown Castle): "Come on into LA County with the same equipment, the same lack of engineering rigor and the same pattern of impeding the investigations of the fires you started. We assume that if you impede fire investigations you are not making fire prevention a priority up front, but we're still going to look the other way because we've already categorically exempted CEQA."

You have been misled by the Planning Department when advised that the FCC does not allow time for environmental review. Absolutely false. Safety still belongs to the municipality to regulate and the FCC rules do not mandate that LA County burn itself to the ground.

You can pass an ordinance similar to Malibu's, Res. 21-17 [see White Paper] and enact a robust application checklist, add staff or consultants to handle the applications, review applications and within the first 10 days toll the shot clock in writing if the application is incomplete. Charge telecom for the additional staff/consultant time to review their applications. Write an ordinance that incorporates sound electrical and structural engineering principles in cell tower design.

Your Public Works Department is not capable of doing the sort of environmental review that needs to be done when a small cell is placed a matter of inches from the canopy of a highly flammable tree. I heard your Planning Department speak of the "small footprint" left by cell towers, implying they do not actually need environmental review.

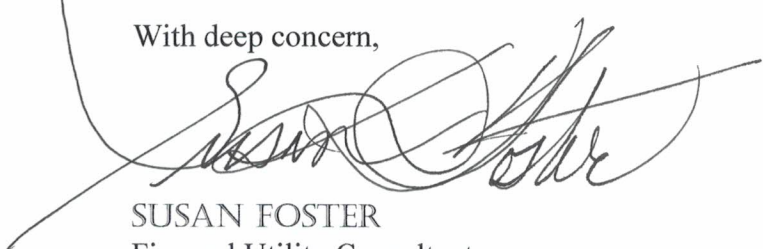
Yet when a small cell fails as happened in LA city not long ago, do your residents know this fire cannot be fought through conventional means until the grid has been cut? That can take up to an hour. In the meantime, the highly flammable tree made even more flammable by chronic drought will have caught fire. Will your residents have time to escape? Will they know that if they take a garden hose to fight the fire, they will be electrocuted if the grid has not yet been cut. Does your Public Works Department even know of the fire hazards they will be rolling out?

You are placing the cell towers close to homes, schools, daycare centers and nursing homes and this will not allow people time to escape.

Please read my attached White Paper; note the details on page 11 about the four major Southern California wildfires over the last 15 years that were started, in whole or in part, by telecommunications equipment. If you don't protect the life and property of the residents of LA County, who will? The FCC rules make life more difficult for the County because of the shot clock but look to Malibu as a model (Res. 21-17). Do not be misled by your Planning Dept.

You have an alternative. There are federal dollars on the table for fiber to the premises. Fiber offers speed, privacy, security, and a profound reduction in fire risk. For the record, small cells do not call 911 in case of fire or any other emergency. 911 calls are routed through the macro towers and the CPUC has already mandated that they be backed up. The insistence that we need more cell towers to call 911 is a false narrative. These written comments including the attached White Paper are for the record. **Vote NO on Item #80 on Tuesday, May 6.**

With deep concern,



SUSAN FOSTER
Fire and Utility Consultant
Co-Founder, California Fires in Firefighters
Honorary Firefighter, San Diego Fire Department

Cc: W. Scott McCollough, Esq.

Julian Gresser, Esq.

FiberFirst LA County

Attachment: PROTECTING LA COUNTY'S FUTURE

PROTECTING LA COUNTY'S FUTURE:
HOW FIRE RISKS FROM TELECOMMUNICATIONS EQUIPMENT, CLIMATE
CHALLENGES & A DANGEROUS SHIFT AWAY FROM ENVIRONMENTAL
REVIEW THREATEN LOS ANGELES COUNTY'S FUTURE

Susan Foster, Co-Founder
California Fires and Firefighters

November 15, 2022

INTRODUCTION TO TELECOM FIRE RISKS

Cell towers and related telecommunications equipment can cause wildfires. Each cell tower is an electrical device. When electrical devices fail, electrical fires can be triggered. Cell tower fires cannot be extinguished through conventional means. Anyone putting water on a cell tower fire before the electricity is cut, which can take up to 60 minutes,¹ will be electrocuted. Imagine a cell tower fire in a neighborhood or next to a school in the midst of a Santa Ana windstorm and there is nothing you can do until Southern California Edison (SCE) cuts the power.

Our team working in Malibu – telecommunication's attorney W. Scott McCollough, electrical engineer Tony Simmons, P.E., and Susan Foster, Fire & Utility Consultant and Honorary Firefighter with the San Diego Fire Department – linked four major fires to telecommunications equipment within the last 15 years in Southern California alone, costing well over \$6 billion in damages. These fires will be evaluated within this paper but in brief they are the Guejito Fire (2007) in San Diego which merged into the explosive Witch Creek Fire, Malibu Canyon Fire (2007), Woolsey Fire in Malibu & LA County (2018) in Supervisor Kuehl's district which burned for one month, took the lives of three people trying to escape, and the Silverado Fire in Irvine (2020). Please note three of those fires were in or adjacent to LA County.

Though these fires are always well reported in the media at the time, fire investigations can take years and very often the telecommunication industry's role in the initiation of fires is proven years down the road, so the general public and even local leaders may have no awareness of the role telecommunications plays in the initiation of these fires. The fault most often lies with telecommunications' failures in electrical engineering, structural safety, and maintenance; these faults are often understated and/or covered up.²

According to the Federal Communications Commission (FCC), safety belongs to the locality to regulate.^{3 4} That includes safety setbacks. Because of the risk of fire due to telecommunications

¹ "Protecting Malibu's Future: Preventing Electrical Fires in Cell Towers by Introducing Enhanced But Generally Accepted Engineering Design Rigor and Adequate Proof of Work in the Application," Susan Foster & Tony Simmons, P. E., Updated May 8, 2022 by S. Foster. Attachment 1 Community Memo, Memorandum from W. Scott McCollough to Malibu City Council, "Response to Planning Commission Recommendation and Staff Draft Conforming Provisions," April 8, 2021.

² Ibid.

³ 2014 Infrastructure Order ¶ 202.

⁴ 2020 Section 6409 Dec R and NPRM ¶43.

equipment, Los Angeles County leaders would be well advised to keep cell towers out of residential areas to allow residents time to escape in the event of a cell tower fire. The same caution should be used for school and daycare facilities, and in all areas where a vulnerable portion of the population has limited access to escape, which may include transportation shortcomings, and limited time in which to escape.

The use of ministerial permits should be discouraged because then electrical, structural and fire safety will be left unchecked, and the telecommunications industry will be policing telecom. We have seen the results of that with over \$6 billion worth of damage in the last 15 years alone, thousands of homes lost or damaged, dozens of casualties, lives disrupted, and the environment and wildlife threatened.

It is particularly germane to note that in the Malibu Canyon Fire, the California Public Utilities Commission (CPUC) accused all parties the CPUC found to be negligent in the initiation of the Malibu Canyon Fire to have impeded the fire investigation. These parties included: Southern California Edison (SCE), AT&T, Verizon, Sprint (now T-Mobile) and NextG, now owned by Crown Castle. Because AT&T, Verizon and Sprint admitted to their participation in the initiation of the fire without having to litigate, the CPUC and the Safety and Enforcement Division (SED) were more critical of and punitive with SCE and NextG.⁵ All of these parties conduct business in Los Angeles County and provide telecommunications services and electrical services (SCE) to Los Angeles County.

In addition to the Malibu Canyon Fire, the \$6 billion Woolsey Fire was the fault of Southern California Edison's own telecommunications company. Edison impeded the fire investigation; details will be forthcoming in this paper.

It is therefore relevant to ask all parties who participate in the safety of the residents of Los Angeles County if appropriate due diligence is being exercised by the County with respect to telecommunications equipment that already has been permitted or will be permitted in the future in Los Angeles County. If the parties who participated in causing the Malibu Canyon Fire impeded the subsequent fire investigation, what makes the leaders of Los Angeles County have any confidence whatsoever in the telecommunications industry continuing to police their own installation of telecommunications equipment?

Los Angeles County must not rely on inexperienced agencies such as the LA County Public Works Department which has never before dealt with wireless installations being in charge of the small cell buildout, for example. It is indeed possible to accomplish electrical, structural and fire and building code safety inspections with all telecom applications for permits within the constraints of the shot clock, difficult though that may be, by requiring electrical, structural and fire safety code inspections in an application checklist upfront.

If the LA County Planning Department evaluated all incoming Wireless Telecommunications Facility applications according to a posted checklist, and an applicant failed to provide required

⁵ DECISION CONDITIONALLY APPROVING THE SOUTHERN CALIFORNIA EDISON COMPANY SETTLEMENT AGREEMENT REGARDING THE MALIBU CANYON FIRE, BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA, Decision 13-09-028 September 19, 2013.

information, the shot clock could be tolled with a written letter to the carrier from the Planning Department. That stops the shot clock until the appropriate information is provided to the County of Los Angeles.

This does not guarantee that all telecommunications fires will be avoided in the future, but it does help reduce future fires by allowing an opportunity to review Wireless Telecommunications Facility designs and placement upfront, and it preserves an essential aspect of due process for the residents of Los Angeles County. Again, for emphasis, safety belongs to the municipality to regulate. Without federal, state, and county code enforcement, the telecommunications industry will be left to police itself. Any and all entities that have established a reputation with the CPUC for failing to cooperate in a fire investigation should not be left to supervise themselves.

Our team's recommendations to the Malibu Planning Commission and the Malibu City Council were accepted and passed unanimously by both bodies. We presented the facts about the Malibu Canyon Fire and the known risks at the time of the Woolsey Fire, both of them telecommunications-initiated in whole or in part, and we presented a plan we had constructed for the appropriate electrical, structural, fire and building code safety to be evaluated at the application stage. That plan is provided in this paper along with additional information that supports the need for the Los Angeles County Planning Department and its requisite safety consultants to review every application according to a very specific application checklist that has safety as its central theme.

We strongly advise against ministerial permits because this upfront evaluation will be omitted with a rubberstamp. To discard safety, and environmental review is an integral part of ensuring safety, as a "solution" to the shot clock requirement is the opposite of what is needed. The more cell towers Los Angeles County permits, the greater the fire risk. More scrutiny is needed with every cell tower that enters Los Angeles County, not less. The shot clock should not be a reason for knowingly adding to Los Angeles County's fire risk. The shot clock simply requires that Los Angeles County hire staff and/or consultants sufficient to effectively and efficiently shift the compliance requirements so that the onus is on the telecom applicants to have completed applications with design requirements upfront when they enter Los Angeles County. This can be accomplished in a reasonable and balanced manner.

For context, let us look at the Malibu Canyon Fire and the Woolsey Fire, and understand why they occurred. For the sake of the residents of Los Angeles County, we implore you to remedy what appears to be a very dangerous direction where Los Angeles County is neglecting safety and neglecting environmental review in favor of expediency and marching to the FCC and telecommunications industry's shot clock. To suggest that environmental review is no longer relevant is astonishing with the challenges faced by changing climate, rising temperatures, a drought with no end in sight, and increased fire risk with every single Wireless Telecommunications Facility permitted in Los Angeles County.

Understanding how these telecommunications fires start may help Los Angeles County appreciate that to turn away from WTF design requirements and scrutiny through use of 1) ministerial permits, and 2) by dismissing environmental review altogether invites an unmitigated

fire risk this County and its inhabitants cannot afford. It is crucial to understand that environmental review includes fire and climate challenges.

First, let us take the Malibu Canyon Fire. The fire occurred in October 2007 when three utility poles fell to the ground during a Santa Ana windstorm. The California Public Utilities Commission (CPUC) approved settlement agreements totaling \$51.5 million with Southern California Edison (SCE) and NextG Networks (now owned by Crown Castle) as both punishment and enhancement of public safety moving forward. Again, AT&T, Verizon and Sprint (now T-Mobile) admitted to their part in the fire and thus were fined though not as significantly as SCE and NextG Networks.⁶

The Woolsey Fire started on November 8, 2018. The Ventura County Fire Department received notice of a fire, soon-to-be known as the Woolsey Fire, at the Santa Susana Field Laboratory in the Simi Hills, just south of Simi Valley. The fire ignited at two points simultaneously and these two locations were designated by CalFire as Sites 1 and 2.

To quote directly from INVESTIGATION REPORT OF THE WOOLSEY FIRE: “The messenger wire extended about one quarter mile east to Site 1 between poles number 4650857E and 4557126E; these two poles supported several other communications conductors in addition to an ECS communications conductor from Site 2. Trees in this area had been growing into the communication conductors between these poles and pressing them together. This overgrowth caused the energized messenger wire and its lashing wire to make contact with another messenger wire and its lashing in the same span. The contact between the two sets of wires caused an arc, which partially melted the lashing wires and caused hot fragments of lashing wire to fall into the brush below. These hot metal fragments ignited the brush and started a second fire there at Site 1.”⁷

These two brush fires converged as they burned south and became the Woolsey Fire. The Woolsey Fire burn 96,949 acres of land, destroyed 1,643 structures, caused three fatalities, and prompted the evacuation of more than 295,000 people in the area. The total damage to property was estimated to be \$6 billion.⁸

The telecommunications role in this fire is as follows: The negligence for the Woolsey Fire was not placed at the feet of one of the telecommunications giants but rather Southern California Edison’s own telecommunications backhaul line which was SCE’s responsibility to maintain.

The Safety and Enforcement Division (SED) found that on a May 10, 2018 telecommunications inspection of their equipment, an SCE employee failed to assign a priority level to the condition associated with a broken Edison messenger wire and a broken Edison lashing wire. This condition should have been marked as urgent and it was not. The failure to repair

⁶ CPUC ENHANCES SAFETY, ISSUES \$51.5 MILLION IN PENALTIES AND REMEDIATION AGAINST SCE AND NEXTG FOR MALIBU CANYON FIRE, Docket #: I.09-01-018, Press Release, Sept. 19, 2013.

⁷ INVESTIGATION REPORT OF THE WOOLSEY FIRE, SAFETY AND ENFORCEMENT DIVISION ELECTRIC SAFETY AND RELIABILITY BRANCH LOS ANGELES.

⁸ Ibid.

telecommunications equipment went unrecognized for six months. Southern California Edison did not contest the SED's findings. In other words, telecommunications equipment belonging to Southern California Edison and a failure to maintain that equipment properly played a significant role in the initiation of the Woolsey Fire.⁹

Just as the CPUC accused all parties in the Malibu Canyon Fire of failing to cooperate fully in the fire investigation, the same failure to cooperate in the Woolsey Fire investigation conducted by the Safety and Enforcement Division (SED) was well-documented.

Wildfires by their very nature are extraordinarily destructive, which makes fire investigation observations at the earliest possible time critical to understanding the events that occurred and finding the cause or causes. Southern California Edison failed to provide a comprehensive set of data and evidence that Safety and Enforcement Division (SED) requested. Edison impeded and prolonged SED's investigation, according to the Fire Investigation Report.¹⁰ Edison's actions prevented SED from reviewing all available information from the point at which the fire had least disturbed the electric facilities.

According to the Report: "The actions of Edison's first responders cannot preemptively be under the direction of Edison counsel. Any notes, reports, or text messages that SED requested would not be generated under the direction of Edison counsel and accordingly should not be subject to attorney-client or work product privilege. For the reasons stated above, SED's investigation determined that Edison is in violation of PU Code § 316 and GO 95, Rule 19 for failing to provide: the list of evidence and records used for Edison's own investigation, as well as photographs, notes, reports, and text messages generated by first responders. In the spirit of full and transparent cooperation with the Commission and its staff, it is imperative that Edison respond to SED data requests with the most comprehensive information available. Without such comprehensive information, SED cannot conduct a thorough investigation, determine the root cause of the incident, expeditiously remedy any issues and prevent future similar incidents from occurring."¹¹

Los Angeles County leaders need only look within the geographical boundaries of their responsibilities to understand that Southern California Edison has a history of negligence in electrical safety, structural safety and maintenance of its equipment. It was the reckless disregard for safety by overloading utility poles because it is profitable to do so that triggered the Malibu Canyon Fire. It was a failure by SCE to maintain their telecommunications equipment that contributed to the initiation of the Woolsey Fire, the most destructive fire in California's history up until that point.

To compound SCE's reckless disregard for safety [Malibu Canyon Fire] and the negligence of its existing equipment [Woolsey Fire] with impeding fire investigations that they participated in

⁹ [PROPOSED] ADMINISTRATIVE CONSENT ORDER AND AGREEMENT, Issued pursuant to Commission Resolution M-4846 (adopting Commission Enforcement Policy on November 5, 2020), October 21, 2021.

¹⁰ INVESTIGATION REPORT OF THE WOOLSEY FIRE, SAFETY AND ENFORCEMENT DIVISION ELECTRIC SAFETY AND RELIABILITY BRANCH LOS ANGELES.

¹¹ Ibid.

[Malibu Canyon Fire] or were, in fact, fully responsible for [Woolsey Fire] should immediately shift the calculus for Los Angeles County planners and leaders.

The above facts should compel both planners and leaders to seriously call into question whether Los Angeles County should be trusting SCE and its telecommunications partners with policing themselves by rubberstamping applications through ministerial permits. Furthermore, the above facts should compel both planners and leaders to immediately reconsider allowing a Public Works Department that has never before dealt with wireless applications, permits, notifications or appeals to rollout small cells in front of people's homes and/or under the canopies of highly flammable trees.

The reckless disregard for safety will no longer belong to the utilities alone if environmental review is set aside in favor of bowing to shot clocks when a solution – tolling the shot clock because an application is incomplete – is available.

CLIMATE CHALLENGES COMPOUND TELECOM FIRE RISKS

The fire risk in Los Angeles County is extreme, as it is throughout most of the state. In July 2022 Gov. Gavin Newsom met with lawmakers in Washington DC in an attempt to secure better equipment to battle climate-driven fires that start for a variety of reasons, one of which, telecommunications equipment, is addressed in this paper. Gov. Newsom and Sen. Alex Padilla announced the U.S. Department of Defense will be allocating seven C-130 planes for California for purposes of fighting fires. Newsom announced that seven aircraft are officially on the Defense Department's schedule for 2023, with the expected delivery to be sometime around the end of next summer. The massive military transport planes can be retrofitted and modified to serve multiple purposes, including wildfire suppression.

In spite of the fact California is the most populated state in the nation, and one of the states with the highest fire dangers, California has often had to borrow firefighting aircraft from the federal government, other states and even other countries.¹²

Climate changes compound that fire risk, and the LA County Climate Vulnerability Assessment dated October 2021 is cautionary. Taken directly from the Executive Summary, Los Angeles County leaders were warned in these stark terms:

“In recent years, LA County has experienced record-breaking high temperatures, prolonged drought, and more intense wildfires. Each unprecedented event strains our communities, directly harming our health, infrastructure, and the natural resources we rely on. Such climate hazards are projected to become increasingly severe and frequent in the coming decades.

¹² Travis Schlepp, *California to receive 7 firefighting planes from Defense Department, Gov. Newsom says* (KTLA Los Angeles, July 16, 2022).

“This report, the LA County Climate Vulnerability Assessment (CVA), fulfills a commitment outlined in the Our County Sustainability Plan, identified by stakeholders as a top priority: to assess how people and infrastructure in LA County may be vulnerable to the changing climate. The County’s vision of sustainability demands that we work to understand increasingly dangerous threats. High climate vulnerability is generally defined as a combination of increased exposure to climate hazards; high sensitivity, or susceptibility, to negative impacts of exposure; and low adaptive capacity, or ability to manage and recover from exposure.”¹³

In his Foreword, Los Angeles County Chief Sustainability Officer Gary Gero addresses the danger in preparing a Climate Vulnerability Assessment such as the one he and colleagues prepared for LA County in that the “projected impacts could be mistaken for established facts of what will happen in the future.”

Yet Chief Gero explains the care that has been taken with this report. “In conducting this assessment,” the Chief Sustainability Officer offers, “we looked at the best available science on climate projections.” The 141-page report includes 246 Endnotes, most of them scientific in nature, as well as Staff Reports, input from the Los Angeles City/County Native American Indian Commission, multiple references to the U.S. Environmental Protection Agency, and papers on wildfires and health, many of them specific to those vulnerable members of the population who are disproportionately impacted.

According to Chief Gero: “The results are frightening but not inevitable. We still have the power to create a safer and healthier future by taking bold and aggressive action to reduce emissions today. And, doing so, we will help clean up our air and water, create good jobs, improve our neighborhoods, and address some of our most intractable environmental justice issues.”¹⁴

The wildfire references were particularly compelling in the Climate Vulnerability Assessment. Wildfires were predicted in 2021 to become larger, more frequent and more destructive – especially in the San Gabriel Mountains where “the wildfire burn area may increase up to 40% by mid-century.”¹⁵

The LA County Climate Vulnerability Assessment goes on to predict: “Although much of the additional destruction will likely occur in unpopulated areas, more than a million housing units in the wildland-urban interface will continue to be at risk. Furthermore, wildfire smoke will continue to affect people across the County, with 40 percent of residents already reporting that they have avoided going outside because of air quality impacts.”¹⁶

The LA County Climate Vulnerability Assessment emphasizes that wildfire also jeopardizes water quality and energy assets serving residents across the County, and it points out several

¹³ LA County Climate Vulnerability Assessment, October 2021, pp 4-5.

¹⁴ Ibid., p. 3.

¹⁵ Ibid., p. 6.

¹⁶ Ibid., p. 6; University of Southern California, Dana and David Dornsife College of Letters, Arts and Sciences, Center for Economic and Social Research. LABarometer: Top 5 Takeaways from The Sustainability and Resilience Report. University of Southern California, Sept. 25, 2020, cesr.usc.edu/sites/default/files/Top5_sustainability.pdf. Accessed Sept. 10, 2021.

areas of particular vulnerability including limited transportation to escape, as well as risk to the last remnants of a culture that must be honored.

With respect to escape, Santa Clarita is highlighted as being at risk of exposure to both extreme heat and wildfire, which has a high proportion of older adults living alone and low transit access.¹⁷ Low transit access can severely threaten anyone's ability to escape the wildfire, but older adults are particularly vulnerable and are thus disproportionately impacted when it comes to the ability to escape.¹⁸

The Assessment also highlights Native populations as being disproportionately impacted when it comes to events like wildfires. Not only do they add to "historical trauma and ongoing injustice that puts these populations at greater risk of negative impacts, the reduction of the region's natural biodiversity decreases access to traditional foods and culturally significant plants," wildfire can destroy irreplaceable cultural sites and sacred land.¹⁹

MALIBU'S SOLUTION: ELECTRICAL, STRUCTURAL, FIRE & BUILDING CODE EVALUATIONS AT THE APPLICATION STAGE

Wireless Communications Facility (WCF) proliferation increases the possibility of electrical fires. As such, electrical fire safety became a priority for Malibu, a city that has burned twice at the hands of telecommunications equipment in just the last 15 years alone.

A group of Malibu residents (referred to here as the Community) worked with the city to help minimize Malibu's fire risk from WCF installations. The following is taken directly from the white paper written by our team with a telecommunications attorney, a Professional Engineer (PE), and a Fire & Utility Consultant and Honorary Firefighter with the San Diego Fire Department.²⁰

"This white paper explains the Community's proposed safety design and application content requirements. These proposed requirements are tailored to Wireless Communications Facility installations in areas with dry vegetation, like Malibu. Some of the language was taken from ordinances in Encinitas and Sebastopol, while much of it is new. The new language is necessary because of the recent discovery that national, state and local electrical codes have expressed or implicit exemptions for "public utilities." *See, e.g.,* California Electric Code Section 89.101.3.3(4) and (5) and "public utility" exclusion in Los Angeles County Electric Code Sections 80-3 and 80.6. There are similar exemptions in NFPA documents. Therefore, merely adopting the Electric Code, as Staff proposes, will do nothing. Malibu will have no electrical safety standards for WCFs unless our proposals are adopted.

¹⁷ LA County Climate Vulnerability Assessment, October 2021, p, 7.

¹⁸ Ibid., p. 7.

¹⁹ Ibid.

²⁰ "Protecting Malibu's Future: Preventing Electrical Fires in Cell Towers by Introducing Enhanced But Generally Accepted Engineering Design Rigor and Adequate Proof of Work in the Application," Susan Foster & Tony Simmons, P. E., Updated May 8, 2022 by S. Foster. Attachment 1 Community Memo, Memorandum from W. Scott McCollough to Malibu City Council, "Response to Planning Commission Recommendation and Staff Draft Conforming Provisions," April 8, 2021.

“There are generally accepted standards for most other buildings and structures, including installations that house extensive and complicated electronics with similar characteristics to those employed as part of a WCF. The Community’s proposed design standards incorporate those standards. In other words, we basically eliminated the “exception” so the general standards can apply. As a result, and consistent with FCC rules, Malibu will be enforcing “generally applicable building, structural, electrical, and safety codes and other laws codifying objective standards reasonably related to health and safety.” *In the Matter of Acceleration of Broadband Deployment by Improving Wireless Facilities Siting Policies; Acceleration of Broadband Deployment: Expanding the Reach and Reducing the Cost of Broadband Deployment by Improving Policies Regarding Public Rights of Way and Wireless Facilities Siting; 2012 Biennial Review of Telecommunications Regulations*, 29 FCC Rcd 12865, 12945, ¶188 (2014).

“Separately, the Community’s proposal sets out the information that must be contained in the application. The design is important, but it is equally crucial that applicants be required to show their work, provided in a way that allows for independent verification and analysis. Only then can Malibu residents be assured that every possible step has been taken to minimize the risk of yet another wildfire caused or made worse by equipment breakdown in a WCF.

“This paper provides specific and detailed explanations for the requirements we propose to help mitigate the profound fire risks in Malibu. It explains what we need by way of engineering up-front design and what is required for the telecommunications carrier to “show its work” in the permit application. Carriers will have their own professional engineers run their equipment through basic tests or produce standard design diagrams with an engineer’s seal. Those scrutinizing the application will be able to independently verify the work was indeed done by the appropriate qualified personnel. This design and application content rigor should catch most design flaws that could, if left undetected, put Malibu at greater risk for fire.

“Malibu bears greater risk if telecom cuts corners in the engineering and design process. Our proposal requires just over a dozen documents in the Application, signed off on by a professional engineer employed by telecom. Those documents will be reviewed by Malibu’s permitting and enforcement departments and, if everything is in order, facilities will be approved for installation in the city. We are simply asking carriers to do due diligence and submit the right paperwork to the City when they apply. If they are going to come into Malibu, they must do so safely. It’s that simple.

“We present examples below of failure to scrutinize electrical equipment and utilize professional engineers to help protect life, health and property. These examples will be familiar to every member of the Planning Commission and, we trust, will serve as a reminder to all of us that engineering rigor and proof of work applied early in the process will protect the City from potentially catastrophic failures later on.

“We also provide several examples of the ways electrical fires can start in cell towers and why the new small cell infrastructure poses unique threats to Malibu. In addition, we demonstrate that setbacks and separation will accommodate telecommunications yet allow enough space and distance for residents to escape should an electrical fire still occur. Electrical fires cannot be extinguished by homeowners or even firefighters until power to the facility is cut by the utility.

“In some instances, de-energization of a cell tower has taken over 60 minutes. In such a circumstance, distance from residences, schools and other buildings may mean the difference between life and death.

“Homeowners should never fight a cell tower fire even if it is directly in front of their home. To fight an electrical fire before the tower has been de-energized by the local utility (10 to 60 minutes) risks electrocution. Residents of Malibu must flee their homes in the event of an electrical fire and that is why distance between towers and setbacks from homes is critical.

“Finally, we urge the Planning Commission and Staff to recognize that the federal government and public safety officials consider wireless infrastructure to be essential infrastructure. Therefore, any hesitation on the part of Staff to require our electric fire safety protocol may be allayed by appreciating that the infrastructure itself needs to be protected. Attempts by carriers to introduce slipshod and inferior design, materials and products in Malibu should be rejected.

“We have been asked if our electric fire safety protocol is new and if electric fire safety requirements have been adopted by other cities. The answer is yes, and the answer is no. We know some cities are beginning to write into their small cell ordinances that electric codes should be adhered to because of the growing awareness of electrical fire risk in cell towers very close to homes and schools. As such, cities have attempted to require electric fire safety protocols. But it appears most cities have not discovered the “loophole” arising from the public utility exception that renders their efforts to protect their cities ineffective. As far as we can tell, Malibu will be the first to identify this problem and actually force an objective, generally applicable standard for electric fire safety.

“Our proposed electric fire safety requirements are the result of in-depth collaboration between Tony Simmons, P.E., a professional engineer with decades of electric fire safety experience and Susan Foster, writer and an Honorary Firefighter with the San Diego Fire Department and a member of the 2001 Task Force in San Diego County that created the County’s first wireless ordinance. That ordinance survived a challenge all the way to the U.S. Supreme Court. Susan Foster has worked with rank-and-file firefighters in California and across the country over the last 20 years on the issue of RF radiation health and safety.

“Mr. Simmons is a professional electrical engineer licensed by the States of California and Nevada. He is a recognized subject matter expert on electrical safety. As an employee of NV Energy, which served customers in California and Nevada, he was responsible for ensuring that no gap existed between the safety standards for customer-owned equipment and utility-owned equipment. Mr. Simmons designed a specialized test facility that integrated electrical equipment from East Asia, Europe, and the United States. This test site incorporated grounded and ungrounded electrical systems from all three regions and required Mr. Simmons to integrate standards from three regions to adhere to the technical requirements of the U.S. National Electric Code.

“Residents and city planners in various California cities have contacted Susan Foster seeking assistance in their efforts to create safer WCF ordinances by taking electric fire safety into account. Additionally, Susan Foster has met with city councilmembers and engineering/IT

personnel in several cities in Colorado, a state that also experienced an unprecedented fire threat in 2020 and more recently the December 2021 Marshall Fire which burned 6000 urban and suburban acres in six hours in Boulder County. Similarly, Tony Simmons' expertise has been requested by several California cities regarding electric fire safety and engineering. Mr. Simmons and Susan Foster are working on electric fire safety amendments for three Colorado cities.

“As it relates to Malibu, Susan Foster and Tony Simmons have worked over the past six months with attorney W. Scott McCollough, who has an extensive 37-year career in law and policy and was the Assistant Texas Attorney General responsible for utility matters, to arrive at our proposed electric fire safety requirements so as to minimize the chances of WCF electrical fires in Malibu. We did not know, until we pooled our collective knowledge and compared federal and state laws and local ordinances and regulations, that telecom was exempt from otherwise generally applicable codes and standards. We anticipate telecom is aware of the exception but chose to remain silent. This problem has now arrived at Malibu's doorstep and must be solved. We hope it will be resolved in favor of ensuring the safety of the city and its residents. News of this issue and problem is spreading, but Malibu has the opportunity – and responsibility – to lead the way, as it is known to do in matters of great importance.

WHY ELECTRICAL FIRE SAFETY?

“We propose fire safety requirements that consider Malibu's unique geographic location, its ongoing seismic activity, a marine climate conducive to expedited corrosion of WCF equipment, an abundance of dry brush, limited escape routes out of town, and year-round tourism which can swell the population by 4,000 visitors on any given weekend – adding to the burden on access/exit roads.

“Fire risks in Malibu are not hypothetical conjecture. This city has burned twice just in the last 15 years. Over the last nine decades, at least 30 wildfires have destroyed parts of this coastal community, with the most recent Woolsey Fire (the largest in recorded history), consuming almost 100,000 acres. The ongoing, severe drought in California, along with record high temperatures, makes the focus on fire prevention more urgent than ever.

“Our team in Malibu discovered the following four (4) California wildfires had been initiated, at least in part, by telecommunications equipment:

- **Guejito Fire (2007)** in San Diego which became part of the Witch Creek Fire, the worst fire in San Diego history.
- **Malibu Canyon Fire (2007)**; three utility poles overloaded with equipment from the following carriers snapped in the wind and ignited the grass below: Sprint (now T-Mobile), AT&T, Verizon, and NextG (now owned by Crown Castle). All four carriers as well as SCE were accused by the CPUC of attempting to mislead fire investigators.
- **Woolsey Fire (2018)**; A telecommunications lashing wire came loose igniting at least one of the two ignition points for the \$6 billion fire. Southern California Edison (SCE) was cited for 28 violations by the CPUC. One critical violation involved the failure by SCE to mark as a priority the repair of a broken communications line and a

broken telecommunications lashing wire. The broken equipment was found during a May 2018 telecommunications inspection. Without priority designation for repair, this known electrical hazard remained in disrepair. In November 2018 the broken Edison telecommunications equipment was involved as part of the ignition of the month-long fire.

- **Silverado Fire in Irvine (2020)** involved SCE and a T-Mobile lashing wire. Silverado merged with a second fire causing the evacuation of 130,000 people.

“Preventing fires in Malibu has been a full-time job for Mayor Mikke Pierson since the beginning of his tenure on City Council. He was elected in 2018 two days before the Woolsey Fire broke out. Over 400 homes were lost with catastrophic impact on Malibu; many residents have still not made it through the permit stage for rebuilding. From a recent posting in Malibu’s News Carousel:

“Wildfire has always been Malibu’s number-one public safety threat, but the size, duration and severity of the Woolsey Fire was unprecedented, and showed us the dangerous new normal of drought, climate change and California mega-fires,” said Mayor Mikke Pierson. “I am proud of the progress we have made in developing strategies to be even more prepared for disasters, including this siren system, which could be a powerful step toward community-wide preparedness.”

“The documents provided to the Planning Commission by Staff do not show sufficient commitment to treating fire as Malibu’s number one public safety threat, as articulated by Mayor Pierson. Our plea, and that of the Community, is that the Planning Commission and City Council rectify this error. There must be strong and specific design, application content and inspection language in the Ordinance and Resolution. The whole point of applying electric engineering rigor is to make sure that when a device fails – and they all do at some point – it fails safely. Without this kind of rigor for WCFs, Malibu will expose itself to significant risk of yet another preventable fire.

“We have therefore been detailed and specific about what is required to reduce the risk. We are not asking for anything that is not already required of every business in Malibu that wants to install parking lot lighting, a sign in front of their place of business, or install complicated electronics inside their building. Citizens have a right to demand engineering rigor for the projects coming into Malibu extremely close to people’s homes, schools, daycare centers, parks, places of business, restaurants and in every facet of life.

“We presently have no idea what the Planning Director will require in the applications. If application content is left entirely up to the Planning Director, the form can be changed at whim, especially after a personnel change. The application, however, is not just for Staff. The Planning Commission extensively relies on it, as does anyone participating in the application process. Unlike Staff and the Commission, public participants have no right or practical ability to require additional information beyond what is in the application. Their ability to reasonably participate and provide input is entirely dependent on the quantity and quality of the information in the application. The public needs and deserves more than the Staff materials provide.

“The Community wants more rigorous requirements, particularly relating to up-front design by qualified and licensed personnel, and full disclosure in the application stage. In other words, we expect every application submitted to Malibu to have 14 documents indicating successful completion of a test, a diagram, a design schematic, and a list of any potentially hazardous substances, all signed and sealed by a licensed professional engineer. The Community’s protocol was designed by an electrical engineer with decades of experience in applying engineering rigor to protect life, health and property. He knows what is needed for both design and proof of work. He knows what is feasible and reasonable.

“To date, our fire safety proposals have been rejected by Staff/City Attorneys. We are particularly concerned that not only does our groundbreaking electric safety protocol get removed from every draft, but so does the fire safety wording we adopted from ordinances already passed by Encinitas and Sebastopol. That makes no sense for a city that has suffered two catastrophic fires in the last 15 years, and 30 over the last 90 years.

DESIGN AND PROOF OF WORK FOR THE APPLICATION

“Tony Simmons, P.E. has synthesized an electric fire safety protocol tailored to the specific needs of fire-prone Malibu. The engineering documents listed below in our 14-step electric fire safety protocol are required to demonstrate compliance with the generally applicable technical requirements of the following codes: the National Electric Code, the California Electric Code and the Los Angeles County Electric Code. Item (N) below indicates text pertaining to structural engineering requirements that, unlike the electrical safety portions, has been accepted and incorporated by Staff.

“Each of the 14 steps below represents a document to be included in each WCF application. Each document must be sealed by a professional engineer pursuant to the California Professional Engineer’s Act. Documents A through E are routinely produced by commercially available software such as E-TAP or POWER TOOLS. Documents F through H are produced with CAD programs such as AutoCAD. Document I is required by all codes. Document J is a reaffirmation that all parties understand the service entrance switch is not readily accessible. Documents K, L, and M include information all employers are required to provide to their workers. Document N has been accepted by Staff.

(v) **Electrical and Structural Safety Information.** The following engineering documents prepared under the responsible charge of and sealed by a California licensed professional engineer must be included in the application:

- (A) A short circuit and coordination study (“SCCS”) calculated pursuant to the IEEE 551-2006: Recommended Practice for Calculating AC Short-Circuit Currents in Industrial and Commercial Power Systems or the latest version of that standard. The study must demonstrate the protection devices will ensure the equipment enclosure will not be breached. The SCCS must include analysis of Voltage Transient Surges due to contact of conductors of different voltages;

REASON FOR REQUIRING THIS DOCUMENT: This study is required to demonstrate the installation complies with NEC Articles 110.9, 110.10, 110.16 and 240.

WHY THIS STUDY IS IMPORTANT: All electrical equipment will fail. This study ensures that electrical equipment will not catastrophically fail. As an example, electrical conductors may rub together and damage the insulation, allowing excessive current to flow. This study ensures that the fuse or circuit breaker de-energizes the circuit fast enough to prevent arcing or fire. This study could have identified beforehand that meters would catastrophically fail in Stockton in 2015. This study can ensure that a WCF mounted on poles with transmission and distribution circuits, like the pole on the corner of Malibu Canyon Road and Harbor Vista, does not fail like electric meters did in Stockton in 2015.

(B) A one-line diagram of the electrical system;

REASON FOR REQUIRING THIS DOCUMENT: This diagram provides a map of the electrical installation and serves as the primary reference for all the other documents.

WHY THIS DIAGRAM IS IMPORTANT: This document allows less experienced electrical workers to quickly trouble shoot electrical malfunctions and failures and to identify a de-energization point.

(C) Voltage Drop & Load Flow Study;

REASON FOR REQUIRING THIS DOCUMENT: This Study proves the electrical conductors are large enough to ensure that equipment supplied by the electricity flowing through conductors operate within the design range for that item of equipment.

WHY THIS STUDY IS IMPORTANT: If the voltage is too low or too high, electrical equipment may not operate correctly or be damaged.

(D) Load Calculation;

REASON FOR REQUIRING THIS DOCUMENT: The load calculation ensures each item of equipment is sized to safely carry the design load.

WHY THIS DOCUMENT IS IMPORTANT: This document lists all load connected to the electrical system.

(E) Panel Directories;

REASON FOR REQUIRING THIS DOCUMENT: Panel Directories are provided to show workers which switch or breaker de-energizes a specific circuit or piece of equipment.

WHY THIS DOCUMENT IS IMPORTANT: The panel directory is required by Electric Codes so that electrical workers or less experienced individuals can quickly de-energize a circuit in an emergency without a “trial and error” approach.

(F) A plot plan showing the location of the mounting structure including address, or structure designation, or GPS location;

REASON FOR REQUIRING THIS DOCUMENT: This document is necessary to quickly identify the location for prompt emergency and non-emergency response.

WHY THIS DOCUMENT IS IMPORTANT: This document shows the exact location of the WCF and the access route. Power poles are commonly assigned addresses that may be located several hundred feet from the actual location.

(G) A plot plan showing the location of the service disconnecting means;

REASON FOR REQUIRING THIS DOCUMENT: This document is necessary to demonstrate the location of the switch or circuit breaker that separates the customer electrical system from the utility electrical system. This is commonly called the “main switch” or the “main circuit breaker”.

WHY THIS DOCUMENT IS IMPORTANT: A WCF has been proposed on a streetlight pole on Cross Creek Road. The WCF is powered from one electric service. The streetlight is powered from a separate electric service. In order to suppress a fire, the power to the streetlight and the power to the WCF must both be de-energized. This plan shows both de-energization points. Service disconnects for streetlights may be several hundred feet away on a different street.

(H) An elevation drawing of the equipment and the service disconnecting means;

REASON FOR REQUIRING THIS DOCUMENT: This drawing shows how the equipment will look once installed. It is critical to ensure the workspace has adequate room to operate safely.

WHY THIS DOCUMENT IS IMPORTANT: Performing work on electrical equipment is hazardous. Workers are entitled to sufficient room to safely work and to escape if an arc develops.

- (I) A demonstration there will be signage as required by the California Electric Code or the Los Angeles County Fire Department Chief or his or her designee;

REASON FOR REQUIRING THIS DOCUMENT: The CEC requires that electric equipment be labeled.

WHY THIS DOCUMENT IS IMPORTANT: This is necessary to ensure that first responders or electrical workers safely de-energize the correct equipment.

- (J) A demonstration the service disconnecting means shall be mounted at an elevation determined by the Los Angeles County Fire Chief or his or her designee in conjunction with the electric utility;

REASON FOR REQUIRING THIS DOCUMENT: The CEC specifies that the service disconnecting means be readily accessible, which generally means operatable without a ladder. To prevent vandalism of communication systems in public right of ways, the service disconnecting means may be mounted out of reach from the ground.

WHY THIS DOCUMENT IS IMPORTANT: To prevent casual vandalism, the service disconnect may be mounted at a height not reachable from ground level.

- (K) A demonstration there will be instructions for deenergizing the equipment by First Responders.

REASON FOR REQUIRING THIS DOCUMENT: Certain electric equipment must be de-energized in a specific sequence to ensure safety.

WHY THIS DOCUMENT IS IMPORTANT: Certain electrical equipment can create an additional hazard if de-energized in the incorrect sequences.

- (L) A list of toxic substances that may develop during arcing or fire that may impede fire suppression efforts;

REASON FOR REQUIRING THIS DOCUMENT: The intense heat of an electrical arc may turn non-hazardous substances into hazardous substances. Special protective equipment may be required.

WHY THIS DOCUMENT IS IMPORTANT: Electric arcs instantly reach temperatures of thousands of degrees. Normally non-hazardous material may become hazards. Metals may vaporize and damage lungs.

- (M) A list of hazards that may develop during arcing or fire that may impede fire suppression efforts;

REASON FOR REQUIRING THIS DOCUMENT: Arcing or fire may create a pressure wave that can imperil life, health and property.

WHY THIS DOCUMENT IS IMPORTANT: Electric arcing can vaporize copper or aluminum. Copper expands 67,000 times when converted from solid to vapor, which can cause an air blast that throws an individual several feet with fatal force.

- (N) Structural Safety Information. The structural/civil engineering documents as recommended by a California licensed professional civil or structural engineer employed by Center for Municipal Solutions.

NOTE: The proposed ordinance includes a standard recommended by APCO/ANSI. This issue has been adequately addressed in the documents provided by Staff.

“Every draft we provided to Staff included the 14 documents listed above. As stated, each step represents a diagram, design schematic, or list of potentially hazardous substances that must be signed off on by a professional engineer as required in our fire safety and structural engineering protocol. Staff has persistently removed the protocol, with the notable exception of structural engineering. We do not know why.

FIRE PREVENTION LANGUAGE TAKEN FROM ENCINITAS & SEBASTOPOL SMALL CELL ORDINANCES

“The following language was offered to Staff, having been taken from ordinances previously passed in Sebastopol and Encinitas, California. Those cities’ Small Cell Ordinances expanded on fire safety language beyond basic adherence to local fire codes. Susan Foster contributed to writing the fire safety portion of the Encinitas Small Cell Ordinance passed initially in 2019 and amended in 2020. The intent of this language was to meet the needs imposed upon each city by the proliferation of small cells and the proximity of these electrical devices for the first time so close to residences, schools, hospitals, playgrounds, daycare centers and parks. Malibu Staff removed this language from the drafts provided by the Community.

APPLICATION AND REVIEW PROCEDURES

“Fire Department Review. After submittal by the applicant, the Director shall transmit the entire application packet to the Fire Prevention Division. The Fire Chief (or his or her designee) shall review the application for compliance with objective health and safety standards related to fire hazards. The Fire Chief shall inform the Director in writing of its conclusions and any recommended conditions for public health and safety. Review by the Fire Prevention Division may reasonably require additional processing time, including potentially exceeding FCC Shot Clock timelines if necessary. The Fire Chief (or his or her designee) may select and retain an independent consultant with expertise and/or specialized training in fire safety and fire hazard mitigation and prevention satisfactory to the Fire Chief in connection with any permit application. The Fire Chief may request independent consultant review on any matter committed to Fire Department review or approval. Subject to applicable law, in the event that the Fire Chief elects to retain an independent consultant in connection with any permit application, the applicant shall be responsible for the reasonable costs in connection with the services provided, which may include without limitation any costs incurred by the independent consultant to attend and participate in any meetings or hearings. The same procedures for fee deposits, cost reimbursements and refunds to the applicant as described above shall be applicable to independent consultant review required by the Fire Chief.

CONDITIONS OF APPROVAL

“**Safety Hazard Protocols.** If the Fire Chief (or his or her designee) or Board of Chiefs of the Dispatch Joint Powers Authority finds good cause to believe that the facility (including, without limitation, its accessory equipment, antenna and/or base station) presents a fire risk, electrical hazard or other immediate threat to public health and safety in violation of any applicable law, such officials may order the facility to be shut down and powered off until such time as the fire risk or electrical hazard has been mitigated. Any mitigations required shall be at the permittee’s sole cost and expense.

“**Continued Monitoring.** The permittee’s Registered Engineer shall certify in writing continued compliance with the safety standards of this policy on or before January 30th of each calendar year. The Fire Chief will continue to monitor the safety of wireless facilities in the City and publish a yearly review of fire safety considerations regarding potential risks posed by electrical components of new technologies, the presence of numerous small cell wireless facilities in the ROW and any fire events or near-miss events related to wireless facilities.

“Oversight Authority. The Fire Chief, in his or her discretion, may issue written fire safety performance directives that shall apply to all existing permits within the scope of such directives and shall be considered as though incorporated into such permits. All permittees shall be required to comply with such directives at the permittee’s sole cost and expense.

Fire Investigations.

“(i) The Fire Chief shall receive and investigate any credible fire safety complaint made by a resident of the City regarding a wireless facility in the City. Cost of such investigation shall be borne by the permittee. Permittees shall also inform the Fire Chief in writing within one business day of any fire or near-ignition event at any facility or replacement of any facility component in connection with any malfunction pertaining to excess heat, arcing or discharged current. (ii) The Fire Chief shall further investigate any fire in or around the vicinity of a small cell wireless facility. If the conclusion of the investigation is that any facility component is at fault, the Fire Chief shall immediately notify the Malibu City Council of his/her findings, and the facility at issue shall be de-energized until such time as the permittee provides assurances or undertakes precautions satisfactory to the Fire Chief that such event or similar event will not reoccur. In the event that no such assurance is received, and the Fire Chief has good cause to believe that such failure to comply constitutes a threat to health or safety, permit revocation shall be initiated by the Director.

DESIGN STANDARDS

“Electric Meters. Small cells and other infrastructure deployments shall use flat-rate electric service or other method that obviates the need for a separate above-grade electric meter. If flat-rate service is not available, applicants may install a shrouded “smart meter” that shall not exceed the width of the pole provided that such smart meter shall be placed at least 10 feet above ground level. If the proposed project involves a ground-mounted equipment cabinet, an electric meter may be integrated with and recessed into the cabinet, but the Director shall not approve a separate ground-mounted electric meter pedestal unless (1) the separate ground-mounted meter pedestal would be placed off the sidewalk and (2) the applicant’s Registered Engineer demonstrates with clear and convincing evidence that all other alternatives for the electric meter are technically infeasible.

Fire Safety Standards.

“All wireless facilities shall include:

1) a power shut off readily accessible to fire service personnel, such as by means of rapid entry Knox or similar type systems installed as required by the Fire Chief, upon arrival at the scene of a fire and/or anticipated power surge due to power being turned off or on for any reason;

(2) surge protection devices capable of mitigating a direct or partial direct lightning discharge;

(3) surge protection devices capable of mitigating significant electrical disturbances that may enter the facility via conductive cables;

(4) at least one-hour fire resistant interior surfaces to be used in the composition of all structures and

(5) monitored automatic fire notification and extinguishing systems for all wireless facilities approved by the Fire Chief.

LEARN FROM PAST MISTAKES

“The 14 documents must be included because past failures to employ them caused mistakes that put people and their homes in harm’s way.

“Four of the six tragedies below occurred in California. The California Public Utilities Commission (CPUC) has deferred to the utilities to have independent engineering review performed. In other words, the utilities have been policing themselves. The utilities have been remiss in overall engineering design as demonstrated by the following:

- In 2007, the Malibu Canyon Fire started when three Southern California Edison power poles overloaded with wireless transceivers from Verizon, AT&T, Sprint (now T-Mobile) and NextG (now Crown Castle), in violation of state regulations, snapped in Santa Ana winds, igniting the tall grass at the base of the power poles. Southern California Edison (SCE) agreed to pay \$37 million. AT&T, Verizon and Sprint shared equal parts in a \$12 million fine. NextG was fined \$14.5 million. All five parties were accused by the CPUC of attempting to mislead fire investigators.
- In 2015, nearly 5000 PG&E smart meters exploded and caused over 80 fires when a transmission line contacted a distribution line, sending a surge through the city that exceeded the smart meters’ capacity.
- In Canada and the US between 2012 and 2015, 17 utilities removed 790,000 Sensus smart meters as a safety precaution because of a fire hazard.
- In 2018, the Woolsey Fire was started by utility owned equipment, including a telecommunications wire, that led to the most destructive fire in Malibu in the last 100 years. It burned over 400 homes, killing two people in Malibu, and cost over \$6 billion.
- In June 2020, the head of PG&E pled guilty to 84 counts of manslaughter in the deaths of residents caused by the 2018 Camp Fire in Paradise, California. A nearly 100-year-old

electrical transmission line owned and operated by PG&E was identified as the cause of the Camp Fire.

- In February 2021, the electric grid in Texas collapsed because electricity and natural gas providers had not winterized their equipment despite warnings 10 years earlier. Thousands of homes were damaged due to water leaks caused by freezing pipes, and so far, 69 deaths have been attributed to the energy grid collapse. Damages are estimated at \$18 billion.

“We believe a higher level of professionalism and a coming together of multiple disciplines will enhance the chances for a less hazardous outcome as largely untested small cell technology exponentially increases within Malibu’s city limits.

WIRELESS FIRES ARE ELECTRICAL FIRES & THEY DO HAPPEN

“Three fire officials, including Battalion Chief Drew Smith, recently stated they have not specifically fought 5G tower fires and claimed data is not available on 5G tower fires. It is early for data to be available on 5G cell tower fires and it is worth noting that no agency or industry in the United States, except those who have done so on a private basis, has kept track of cell tower fires from the installation of the first cell tower to the present. Yet proof of electrical fires in cell towers after the 1990s is available. This evidence has been collected in media reports and by some firefighters who have personal records and photographs; some have willingly shared that information. Additionally, we have obtained fire incident reports on cell tower fires around the country and confirmed arcing as a frequent heat source and “electrical” as a frequent cause.

“Thanks to the pioneering work of retired Los Alamos Laboratory physicist Dr. David Stupin, we have a reasonable sense of how often cell tower fires were occurring up to the point where he stopped keeping statistics in 2015. Dr. Stupin’s research led him to believe that approximately one cell tower fire happens every month somewhere in the United States. The majority occurred because of electrical malfunction or because there was a deficiency of structural integrity and the collapse itself triggered a fire. We now face an exponential increase in small cell WCFs in the US. The CTIA is the telecommunications industry lobbying entity. They recently commissioned a study focusing on the increase in small cells in the United States. From the CTIA website:

“The Accenture analysis commissioned by CTIA also found that the United States will see a **550% rise in small cells by this year**, underscoring the timeliness of the FCC’s action to jumpstart broadband investment. Small cell deployments will escalate rapidly from roughly 13,000 deployed in 2017 to over 800,000 cumulatively deployed by 2026, according to the analysis.” [2018]

“We urge you not to wait for the data on 5G cell tower fires before protecting Malibu from what we consider to be an inevitable increase in cell tower fire risks. If the industry has not been keeping track of cell tower fires during the last four generations of wireless, there is no foundation on which to place our hope that they will keep track of 5G cell tower fires. We choose to act with the knowledge of how electrical devices fail, and the fact there is nothing about small cells – the 5th generation of wireless that is being brought into our communities in

greater numbers and in closer proximity to people – that can lead us to any conclusion other than the fact the risk of wireless fires in Malibu is increasing with the installation of every small cell.

“From the December 16, 2020, Community Meeting, we feel the impression was left, based upon statements by fire officials, that 5G towers are not fire risks. Yet for fire officials of the Malibu section of the Los Angeles County Fire Department to state they have not fought 5G fires does not mean 5G tower fires do not exist. 5G WCFs *are* fire risks in the same way that 2G, 3G, 4G WCFs are fire risks. They are electrical devices. They will fail. Our goal is to put the WCFs through no more engineering rigor than would be required of the signage and electrical lighting in front of Malibu restaurants, gas stations and other commercial establishments in hopes of catching design flaws that could eventually result in fire. And if they do result in fire, we want the diagrams in place with the city of Malibu to show the First Responders the most pertinent information with respect to design features and chemicals involved so that our First Responders can respond as expeditiously and safely as possible.

FIRE RISKS WITH WIRELESS COMMUNICATION FACILITIES

“The 2015 Stockton, CA fires (multiple homes) were caused by smart meters used to measure electric use on the sides of homes. Smart/AMI meters may be deficient in suppressing transients/surges and the catastrophic failure of smart meters to handle a massive surge in the City of Stockton demonstrates that electronics close to the home, which many WCFs are and will be in the future, may pose a threat to life, health and property if not screened initially through our recommended Short Circuit and Coordination Study (SCCS). What happened in Stockton can happen in Malibu. If the utility pole on the corner of Malibu Canyon Road and Harbor Vista is hit by a car, and the transmission line contacts the distribution line, we could expect the electric meter and possibly the WCF to catastrophically fail. It would be necessary to de-energize the transmission line and thereby de-energize the area from City Hall and Cross Creek Road to Pepperdine and beyond. Using the Coordination Study will make it clear what the appropriate fuse size should be. If the WCF is utilizing the appropriate fuse size, the fuse will instantly de-energize the circuit and prevent catastrophic failure.

“For metered WCFs, SCE uses electronic meters that may have the same susceptibility as the meters in Stockton. Metered wireless facilities must go through the Community’s electric fire safety protocol to determine if they have adequate surge protection against the type of fault that occurred in Stockton.

“Lightning strikes can contain more energy than the electrical mishap that occurred in Stockton. California is experiencing more lightning strikes due to the evolving climate. Therefore, electrical installations in Malibu must mitigate the increased frequency of lightning.

“The January 28, 2019, edition of The Los Angeles Times reported that [California utility equipment sparked more than 2,000 fires in over a three-year period](#). Cal Fire determined 17 of 21 California fires in 2018 were attributed to pole issues. The deadly [Campfire was confirmed to be started by power lines](#) and pole loading. In order to accommodate the newest wireless facilities, companies like Verizon are requiring an increase of pole height by 20-25% (adding 10-

ft extension onto 40-ft or 50-ft pole) significantly lengthening the pole while decreasing the force of wind required to topple a pole.

“No community outside Paradise, California has been more devastated by wildfire than Malibu. The overloading of three SCE utility poles by four different telecommunications carriers sparked the Malibu Canyon Fire in 2007 and in November 2018, a downed telecommunications lashing wire ignited the Woolsey Fire, forever scarring Malibu by taking out over 400 homes and costing over \$6 billion. With the exponential increase of WCFs and the administrative exemptions offered to telecom, our concern is that this problem will increase rather than decrease. Thus, electric fire safety protocol and structural site hardening are essential for Malibu.

EXAMPLES OF WCF FIRES

“There is a common misperception that WCF fires are primarily caused by arson. While there are documented cases of arson in 2020 related to misinformation about 5G and COVID-19, these cases were a short-term phenomenon. The examples below are representative of WCF fires that have occurred through the years as documented by the news media. Electrical malfunction and welding on WCFs for routine maintenance are the cause of the vast majority of cell tower fires. The examples below are representative of the genuine risks that could be facing Malibu.

July 2013 – Besalem, Pennsylvania: An AT&T cell tower fire was sparked when welders were working 70 feet in the air on a tower; sparks set off an intense fire ten feet above them. They tried to put it out but ended up having to race down to get help. The fire spread quickly and left the 10-story tower leaning over precariously. Initially, firefighters could not throw water on the fire because electricity was still surging through the tower and it took utility crews longer than expected to get it turned off. Essentially the fire was allowed to burn itself out.

July 2014 – Columbus, Ohio: Black smoke poured from a light pole with a WCF in Grandview Heights around 10:00 AM. The pole held lights for the football field as well as cell phone equipment. Streets were blocked off while emergency crews were on the scene. Homes within a one-block radius of the school were evacuated. Suspected electrical fire.

September 2014 – Thurston, Oregon: A cell tower fire at Thurston High School sent up a smoky plume above the Colts sport field. The cause of this fire was undetermined but Battalion Chief Marcus Lay explained, referring to the fire, that “It is contained and basically under control, but we have to wait until Springfield Utility Board gets here to get the power completely shut off to finish extinguishing it.” Cause undetermined.

June 26, 2020 – Hanover, Virginia: A cell tower caught on fire overnight; a heavy storm with lightning moved through the area shortly before the call. Hanover Fire was able to extinguish flames on top of a cell phone tower. When they arrived around 11:15 PM, they saw a cell tower completely covered in flames. The fire was safely put out and officials believe that it was an accidental fire as the result of electrical/mechanical issues.

October 2020 – Irvine, California: Silverado Fire Southern California Edison Co. may seek contributions from T-Mobile as it is suspected the company’s lashing wire touched an adjacent power line and sparked the fire. On October 26 SCE told the CPUC that a lashing wire attached to a telecommunications line running under the utility’s 12-kV power line may have ignited the wildfire. The blaze seriously injured two firefighters and scorched more than 12,000 acres in Orange County and forced the evacuation of over 60,000 people, according to the California Department of Forestry and Fire Protection. In general, multiple companies can use the same utility poles, but each is responsible for managing its own equipment. Utilities are supposed to regularly look for any threats from telecom equipment installed on shared poles. This is not a foolproof system of governance.

November 2020 – Lapeer, Michigan: Wiring in a 197-foot-tall cell tower caught fire shortly after 9 p.m. Flames were visible shooting from the top of the hollow tower, while near the base of the structure the interior fire was so hot the metal glowed orange and pink. As a result of the fire that weakened the strength of the tower, there was a visible lean to the structure — the height of a 15-story building. The tower was dismantled and replaced.

March 2021 – Chula Vista, California: An AT&T cell tower partially concealed in a light fixture around a track at Otay Ranch High School burst into flames at 7:30 PM on a Tuesday evening. The Fire Incident Report was obtained through a public records request. The area of origin was within the equipment; the heat source was “electrical arcing”. When the fire department arrived the 100-ft pole appeared to have an internal fire that traveled up the pole to the cell phone equipment and stadium lighting at the top of the pole. The fire department requested utility SDG&E to respond to the location. Firefighters maintained a safe distance until they could verify all power supply to the pole had been secured. As they were waiting for the representative from SDG&E to arrive to confirm the power had been cut, the heat of the fire due to arcing caused the steel pole to become molten plasma. It collapsed onto the bleachers near the football field, burning the track and destroying the bleachers. Once the rep from SDG&E arrived on scene and verified the power had been secured and that there was no electrical hazard, firefighters extinguish the fire using a water and foam combination.

WHY DOES 5G INFRASTRUCTURE POSE A GREATER FIRE RISK TO RESIDENTS

“It is not the frequency of cell tower fires that concerns us the most. It is the severity of what a single cell tower fire can do. The biggest risk is that WCFs have been brought much closer to local populations and those installations are much more densely situated. Every electrical device including every WCF must be deenergized before a fire can be fought. On a good day that can happen in 10 minutes. Some cities find that it is 30 minutes or more before the electric company cuts the power. If the firefighters fight the fire before the tower is deenergized, they can be electrocuted. A lightning strike is a type of transient event that may lead to WCF catastrophic failure. Malibu residents will recall in May of 2019, just before Memorial Day weekend, several beaches were closed in Malibu because of a lightning storm that created unsafe conditions. **Thus, the placement of WCFs must allow time and space for escape because a fire originating in a WCF must not be fought by residents or by firefighters until SCE has turned off the power. This is why we propose separation and setback requirements as strategies to mitigate risk to residents.**

“One firefighter who is accustomed to fighting fires under Santa Ana conditions in California understood the extreme risk posed by a cell tower fire near a populated area. He described how he would fight such a fire:

“If the fire involves energized equipment, do not put water on it. Use water only to extinguish anything like trees, grass, vegetation, etc. that it may spread to, and then use water in short bursts if it's adjacent to the pole. Call the utility company immediately so they can de-energize. Keep people back for 2 spans in either direction and make sure all personnel and equipment stay out from under the power lines. Focus on public safety and exposure protection until it's confirmed that the power has been shut off.”

“We firmly believe the greater the distance between WCFs, the more likely an individual(s) would be able to escape homes, schools, hospitals, nursing homes. Distance between towers and from property lines will be critical to escape. Distance from WCFs and property lines may mean the difference between life and death. Due to the length of time it can take to cut the electricity and subsequently fight a fire, particularly one that has spread, we feel it is not worth the very real potential for loss of life if cell towers, small cells or macro towers, are located within residential neighborhoods. Additionally, care should be taken to keep cell towers away from roots of entrance and egress for neighborhoods. The same caution should be taken with densely populated facilities like schools, daycare centers and special zones as designated by the city.

“The scars from the 2007 Malibu Canyon Fire and the 2018 Woolsey Fire are still evident on the land. The human toll appears greater. The residents speak openly about PTSD, particularly on those days when the winds blow as they did during the Malibu Canyon Fire and the Woolsey Fire. The winds remind residents of the Santa Anas that carried burning embers sideways, whipped flames such that they consumed many residents’ homes, blocked exit routes out of the city and literally terrorized the whole of Malibu – the land, the air, and most of all the residents, their animals and wildlife.

“**FALL ZONE:** We would like to add that we believe expansion of the fall zone should be carefully considered. It must be at least the height of the tower with 50% or at least 25% added onto that because of the falling debris field.

UNIQUE FIRE RISKS TO MALIBU & GERMANE TO OTHER PARTS OF CALIFORNIA, AS WELL AS OTHER STATES

“**VERY HIGH FIRE HAZARD SEVERITY ZONE:** The City of Malibu is designated as a Very High Fire Hazard Severity Zone. The City was devastated by major fires in 2007 and 2018 due to power pole failures. In each instance the utility structures supported wireless communications facilities that either initiated or significantly contributed to the ignition. The 2018 Woolsey Fire consumed over 96,000 acres, destroyed at least 1,643 structures, killed three people, and prompted the evacuation of more than 295,000 people. It was one of several fires in California that ignited on the same day. Malibu has still not recovered. The 2007 fire burned 3,836 acres, 36 vehicles and 14 structures, including Castle Kashan and the Malibu Presbyterian Church, and damaged 19 other structures. It is essential that wireless communications facilities be engineered to prevent fire and withstand fire events as much as possible, and at least in a

manner comparable to other commercial facilities with extensive, complicated electronics and wiring, as well as flammable, sometimes hazardous and toxic, materials on site.

“SEISMICALLY ACTIVE: Malibu is geographically defined by the Santa Monica Mountains to the North, the Pacific Ocean to the South, the Santa Monica Fault to the East and Ventura County to the West. Malibu is a seismically active area with five active faults in the general vicinity. These nearby faults include Malibu Coast Fault, Las Flores Thrust Fault, Santa Monica Fault, Palos Verdes Hills Fault, and the Newport-Inglewood Fault. There are also potential seismic hazards and soil hazards in Malibu. Seismically-induced soil hazards include liquefaction – a temporary, but substantial loss of strength in granular solids, such as sand, silt, and gravel, usually occurring during or after a major earthquake. Seismic activity can also induce subsidence and settlement. Subsidence is deep settlement due to the withdrawal of fluid (oil, natural gas, or water). Seismically-induced settlement occurs in loose to medium dense unconsolidated soil above groundwater. These soils compress or settle with seismic shaking. Settlement can also result from human activities including improperly placed artificial fill, and/or structures built on bedrock or soil with differential settlement rates. There is also risk from expansive soils such as clay; it can swell when wetted and shrink when dried. Wetting can occur from rainfall, groundwater fluctuations, lawn watering, broken water or sewer lines. Expansive soils can result in cracks in foundations. Expansive soils located on slopes can cause slope failure. Unstable soils can produce landslides, debris flows, and rock falls. Hill slopes, which occur in Malibu, have a tendency to fail. Unless engineered properly, development in hillside areas tends to increase the potential for slope failure.

“MARINE ENVIRONMENT: Malibu is a marine environment. Thus, there are accelerated corrosion issues due to the combination of increased moisture and salt in the air. Metal parts within wireless facilities fail faster in this corrosive environment. This corrosion may adversely affect the structural and electrical integrity of a wireless facility. In addition, corrosion may pose a risk to internal parts which, if corroded and not replaced on a very conservative maintenance schedule, may become fire risks themselves. Therefore, the failure rate of wireless facilities is higher and the need for stricter standards in the very beginning is essential.

“GREATER NEED FOR STRUCTURAL INTEGRITY: Because of seismic and soil displacement and/or settlement risks as well as the potential for fires, heavy rains, mudslides and landslides, all wireless facility sites must be built to the standards of ANSI/APCO Public Safety Grade Site Hardening Requirements. This standard represents public safety requirements regarding various characteristics to make mission critical communications network sites sufficiently robust to meet the service availability requirements of public safety. These safety standards can be found in APCO ANSI 2.106.1–2019, or their replacements. Collapsed WCFs are a cause of multiple wireless facility fires. Structural integrity is paramount to keeping Malibu safe from fire started by collapsed wireless equipment.

“This confluence of geographic and climate characteristics means that Malibu needs greater fire safety regulations than non-marine, low fire hazard, seismically stable regions. Malibu is the first local government to be informed that the exemption for telecom utilities render the National Electric Code, the California Electric Code, and the Los Angeles County Electrical Code

insufficient to protect the public from the electrical risks of WCFs. Malibu can protect itself and its residents by adopting the safety provisions we propose.

WIRELESS CELLULAR FACILITIES AS CRITICAL INFRASTRUCTURE

“This final subsection recognizes that the Federal government and state public safety organizations have declared that wireless networks are critical infrastructure for national security and public safety purposes – often at the urging of the wireless industry. Critical infrastructure must be protected too, through appropriate fire and structural safety requirements. We are not aware of any evidence indicating telecom objects to a stronger electric safety protocol. If such an objection exists, it should be made on the record and the basis fully explained.

“Cell towers are considered critical infrastructure to maintain communication during times of natural and man-made disasters. Pandemics are one example, as illustrated by the timing of the US Department of Homeland Security, Cybersecurity & Infrastructure Security Agency’s (CISA) March 28, 2020 Guidance on the Essential Critical Infrastructure Workforce: Ensuring Community and National Resilience in COVID-19 Response Version 3.0 (updated on April 17, 2020), available at https://www.cisa.gov/sites/default/files/publications/Version_3.0_CISA_Guidance_on_Essential_Critical_Infrastructure_Workers_1.pdf. The Wireless Infrastructure Association applauded the designation. See <https://wia.org/wia-applauds-dhs-action-for-access-to-critical-infrastructure/>.

“In Malibu, we are simply asking telecommunications carriers to treat their facilities like the essential infrastructure that it is. Anything less is counterintuitive and ill-advised.

“Further, even before the DHS guidance the Association of Public-Safety Communications Officials (APCO) International received final approval from the American National Standards Institute (ANSI) in 2019 for an American National Standard (ANS) that identifies hardening requirements for public safety grade sites. In other words, structural engineering for WCF sites has gone from the concept practiced by some to a standard that should be followed by all.

“APCO ANSI 2.106.1-2019 was developed by the Public Safety Grade Site Hardening Working Group. This standard was derived from the 2014 National Public Safety Telecommunications Council (NPSTC) report (Chapter 9) and the work of the original APCO Broadband Committee. The document is intended to assist public-safety communications network builders with the guidelines necessary to build hardened public safety grade networks.

“With five (5) active earthquake faults running through Malibu, this is a welcome standard. It reads, in part:

This standard represents public safety requirements regarding various characteristics to make mission critical communications network sites sufficiently robust to meet the service availability requirements of public safety. In other words, what it takes to make network sites “public safety grade” or the extent to which they are “hardened.”

The document is intended to assist public safety communications network builders with the guidelines necessary to build hardened public safety grade networks. This document addresses hardening for wireless transmission and reception sites. Specifically, it addresses the hardening requirements to provide the appropriate site conditions and characteristics

for wireless system electronics (e.g., transmitters and receivers) and wireless passive components (e.g., coaxial cables and antennas).

These sites need to withstand the onslaught of natural or manmade conditions and consider the distinct requirements for different geographic locations of the United States, including their likelihood to be subject to severe storms, earthquakes, tornadoes, and other disasters.

“In the face of increasing federal emphasis on WCFs as essential to Public Safety and no record of opposition from the telecom industry, we question why anyone would be reluctant about embracing our safety protocol and application content requirements.”

End Malibu White Paper

CONCLUSION

The Malibu solution is not a guarantee that telecommunications equipment evaluated through established design criteria at the application stage will never cause another fire. Yet it is a workable solution within the challenging confines of the FCC promoted and telecom-preferred shot clocks.

Two very important takeaways are: 1) safety belongs to the municipalities to regulate; 2) shot clocks may be tolled with a written letter to the carrier if an application is deemed incomplete. A tolling letter must be sent to the carrier or the carriers’ representative(s) expeditiously. Sufficient staff needs to be in place to process applications.

We strongly recommend adding sufficient planners including outside consultants capable of evaluating code compliance to assess incoming applications. Los Angeles County would be well advised to effectively and efficiently shift the compliance requirements so that the onus is on the telecom applicants to have completed applications in accordance with design requirements listed by the Planning Department when they enter Los Angeles County. This can be accomplished in a reasonable and balanced manner.

It is not enough to evaluate safety at the backend. Safety must be evaluated upfront. Code compliance must be evaluated upfront. Specifying and posting design criteria as part of the application checklist for the telecommunications applicants is essential.

To discard environmental review – which includes climate change and the synergistic effect of climate and fire, further compounded by the fact that telecommunications equipment can and does cause wildfires – in order to comply with the confines of the shot clock is a failure of the most precious responsibility entrusted to our local leaders. This is indeed a dangerous cocktail in any location but particularly California. Some of the most vulnerable members of our community will be at the greatest risk.

We are imploring the leaders of Los Angeles County and the Planning Staff to include environmental review and forgo the temptation to utilize ministerial permits. The future of Los Angeles County and the safety of your residents’ lives, their property, the County’s wildlife, and the County’s yet dwindling remnants of our rich Native American heritage rest in the decisions you are about to make.



To: Los Angeles County ("LAC") Board of Supervisors Members:
Hilda L. Solis, Holly J. Mitchell, Janice Hahn, Kathryn Barger, Lindsay Horvath

Cc: Chair LA County Regional Planning Department ("LACRPD"): Yolanda Duarte-White,
Director of Public Works: Mark Pestrella, Dawyn R. Harrison, Acting County Counsel

From: (Insert organization name)

Re: Petition Relating to Proposed Amendments to Title 16 & 22 (Vote on Final Passage
Scheduled for December 6, 2022)

Date: December 5, 2022

Dear LAC Board of Supervisors Members (and Other Concerned with the above captioned matter):

Our organization (insert name) is strongly urges that you Board of Supervisors Members vote 'No' on the above captioned matter. Our organization is focused on (insert mission in one line). We are deeply concerned that a vote in favor of amendments to Titles 16 and 22 will cause great harm to our members and therefore directly undermine our mission for the following reasons (insert by a few bullets).

In addition to this grave expression of concern, we are well informed by our legal advisors that the proposed action is illegal under various federal and state statutes, and infringes U.S. and state due process protections.

We deeply appreciate your consideration and support.

Sincerely,

Julie Levine

Executive Director

As a molecular biologist and geneticist that has worked in academic research at UCLA, published peer reviewed papers and was a founding member of AGRE (The Autism Genetic Resource Exchange), I oppose L.A. County's proposed amendments to TITLES 16 and 22 of the L.A. County Code. Please vote NO.

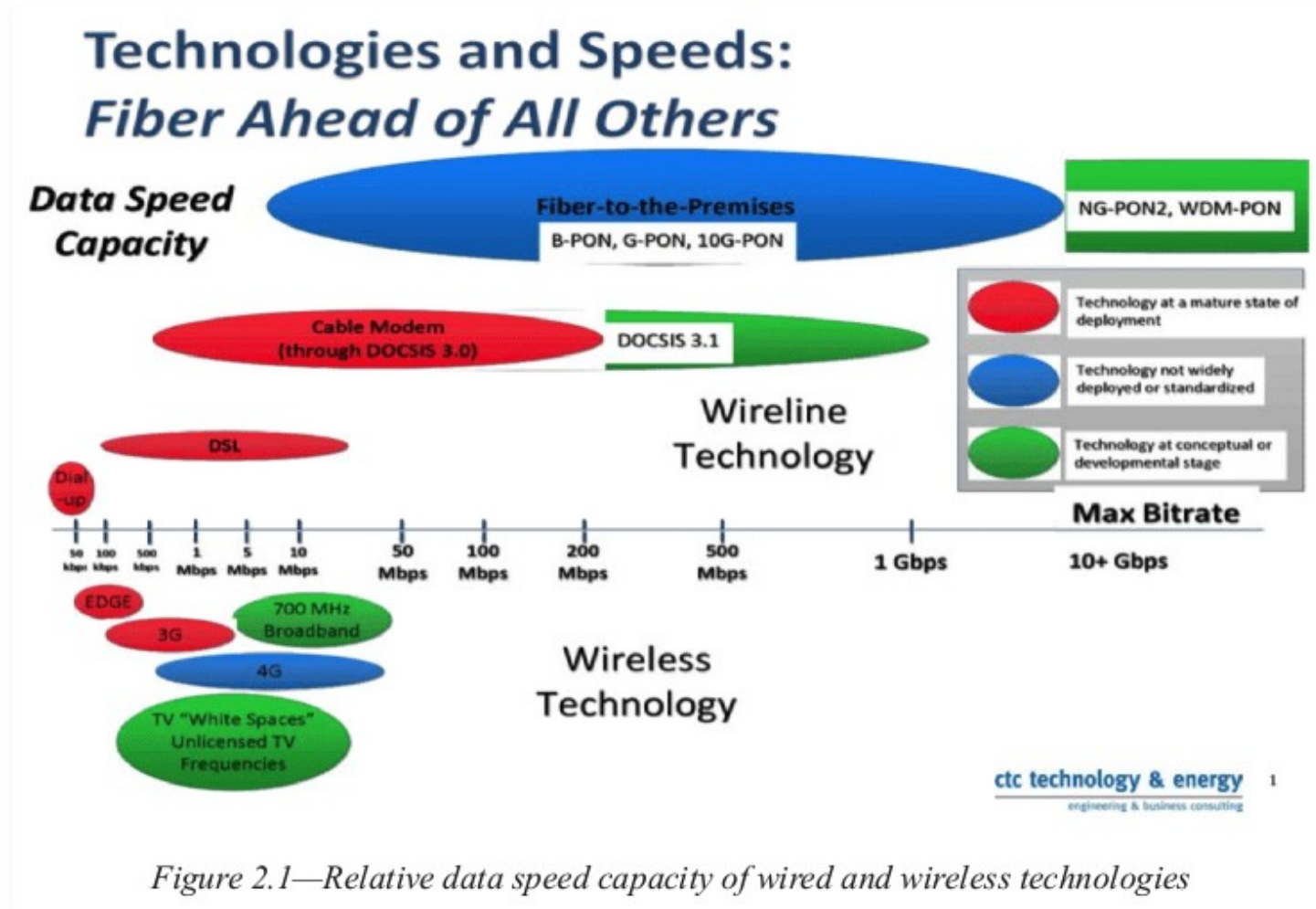
I have worked alongside scientists and researchers to address neurodevelopmental disorders and the data is clear - there is a statistical correlation to children with neurodevelopmental disorders (now 1 in 5 children) and exposure to electrical, magnetic and RF radiation.

You have the ability right now to stop this. The decisions made in Los Angeles County affects other major cities in Ca. Where Ca goes related to these decisions so goes the rest of the nation. This vote is significant.

I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections that keep us all safe.

Due to the lack of safety requirements, I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.

Fiber is Faster



Minimum Time Required for Downloading and Uploading a 5 GB File

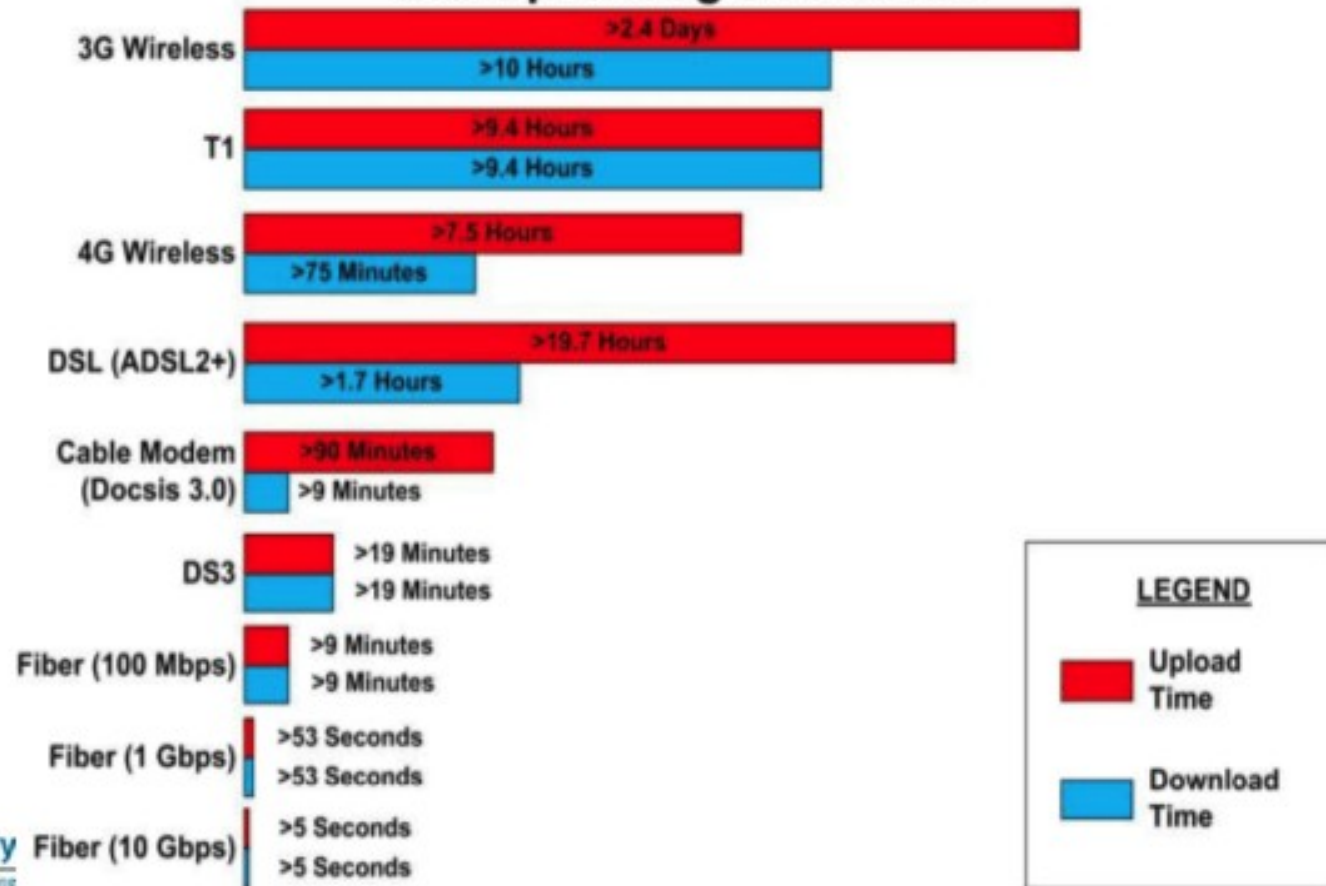


Figure 2.2—Comparison of download and upload times

Dear LA County Supervisors,

I request my written comments below be part of the public record for Amendments to Titles 16 and 22 of LA County Code at the December 6th B.O.S. meeting.

I oppose L.A. County's proposed amendments to Titles 16 and 22 of the L.A. County Code. Please vote NO.

I urge the Board of Supervisors to adopt instead the proposed redlined changes to Titles 16 and 22 that were submitted by Fiber First L.A.

Due to the lack of safety requirements, I also urge a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22. Because of fire hazards, wireless infrastructure needs to be located at safe distances from homes, schools, hospitals, long-term care facilities, and any other place that would be difficult to evacuate.

I do not want the Supervisors to pursue a build-out of inferior Wireless Broadband that has a short 5-year life span, is much slower, is less reliable, is more hackable, has unsafe levels of radiation, and has a **proven track record of causing terrible wildfires**.

I have been evacuated from my home in Topanga twice in the last few years, both times for wildfires caused by electrical equipment that failed (Woolsey and another one).

I urge the Supervisors to take advantage of federal dollars and invest our resources in superior Fiber-Optic Broadband Infrastructure that will last 15 to 20 years, **is fire resistant**, is much faster, is much more reliable, is much harder to hack, generates minimal EMF radiation, supports land line phone service in emergencies when the power goes out, and that we already paid for in fees added to telephone bills over the last 2 decades.

If you are not familiar with fire hazards of wireless infrastructure, please listen to this presentation by Susan Foster, Fire & Utility Consultant and Honorary Firefighter, beginning at timestamp 47:15.

<https://www.bitchute.com/video/55CHKLtksnSk/>

Key points from Susan Foster beginning at timestamp **50:35** –

- Fires caused by wireless equipment are electrical fires, and cannot be put out until the electricity is shut off by the electric company, which can take up to 60 to 90 minutes. **Anyone trying to spray water on an electrical fire with live electricity will be electrocuted.**

- Cell towers are made of steel, and steel parts corrode rather rapidly in marine environments, and the California coast is a marine environment, with more corroded steel closer to beaches.
- Wireless infrastructure fires can also be caused by lashing wires blown loose in Santa Ana winds.
- There have been 3 major wildfires in LA County in recent years caused by telecom equipment, causing over \$6 Billion in damages.
- There were many smaller electrical fires during the pandemic lockdown with so many people telecommuting/tele-learning; wireless infrastructure was overloaded and failed.

Please also see this page for more information about the superior technology of fiber-optic broadband compared to wireless:

<https://5gfreecalifornia.org/science/wired-networks-safer-faster-technology/>

Thank you for considering my comments.

Kindest regards,
Andrea Sea Namaste

December 6, 2022

Board of Supervisors
Los Angeles County
500 West Temple Street
Los Angeles, CA 90012

Re: Hearing On Wireless Facilities Ordinance – Titles 16 & 22 – Oppose

Dear Board of Supervisors:

Due Process Concerns

I support Fiber First LA's Model Legislation for Title 16 & 22 as submitted to the Board of Supervisors. I strongly oppose all other opposing revisions to Title 16 & 22.

The corporate placement of wireless infrastructure within the community must become public knowledge and be subject to public comment in every instance.

The changes proposed remove due process rights of everyone concerned with the amplified microwave frequencies issued by 5G, which includes a growing number of people who do not yet know they are affected by 5G. Under the proposed Title 16 & 22, wireless antennas and towers will be constructed in affected neighborhoods with NO corporate disclosure, no public notification, NO public hearings and NO opportunity to complain to the governing 5G regulator. Affected persons literally wake up one morning and see a 5G tower or array being put up right next to the affected house or apartment. These 5G installations are corporate overreach into individual health opportunities decisions and is undemocratic!

Second, we all live in a shared, single, fragile atmospheric environment. Wireless technology transmits amplified microwave energy through the atmosphere containing air necessary for human consumption. 5G infrastructure, the amplified microwave repeating electric transformers, intrude concentrated electron fields within the everyday personal living space of a community faced with the overuse of 5G. Safe, grounded fiber optic infrastructure connections are being ignored, and corporate 5G atmospheric radiation increases and now reaches within the walls of the community. This increases the combined carbon footprint of us all and puts vulnerable people at risk.

Balancing Test of Cellular Data Benefits to Environmental Health Hazards

Wireless technology is not safe for our natural world. We need our atmosphere to be healthy.

Cell towers and antennas are prone to fire. Cell towers, antennas and repeaters since 2007 have been found to have caused, in whole or in part, four major California wildfires at a cost of billions in losses.

The 5G plastic fake trees being used to camouflage the high-output 5G cell antennas discharge environmentally dangerous microplastics, with lead, and other California Prop 65 chemicals into the shared atmospheric environment in which we breathe. Birds, bees, plants and trees are the first to uptake the 5G plastic into the food chain where we live and where it enters our lives.

Since 2009, repeated scientific studies confirmed that radiofrequency radiation (RFR) emissions from 5G infrastructure contributes to the further decline in bee populations and have adversely affected navigation of migratory birds, their habitat, growth and reproductive cycles. Trees 5G radiation has harmed trees by causing thinner cell walls to grow and increases volatile terpenes in tree sap which makes trees more flammable, especially in drought.

In 2019 a ten-year study by the National Toxicology Program of the National Institutes of Health, found "clear evidence" of increased cancer risk among lab animals exposed to RF radiation, as well as evidence of DNA damage and other biological impacts. Increasingly, peer-reviewed studies which demonstrate biological harm from exposure to RF radiation now appear with radiation above threshold levels considered safe by the FCC.

5G will be radiating this community, and in communities across the country, after a threshold is crossed, and lives move from voluntary 5G exposure to involuntary 5G exposures. Highly concerned and sensitized residents feel forced to fortify their living spaces with EMF-blocking materials or abandon their homes and apartments to seek safe refuge from amplified radiation fields in their homes caused by 5G.

Corporate Overreach Into Public Regulation Governing Radiation Outputs By Communications Industry

Since 2007, the California Public Utilities Commission has faulted telecom companies for their role in fires caused by their infrastructure neglect in rural areas. The Board of Supervisors has this information, so how can BOS justify giving the CPUC-sanctioned telecom companies an unregulated right to build new amplified wireless cellular radiation sites without strict governmental oversight?

5G infrastructure is rated at a 5-year life cycle with no cradle-to-cradle design for reuse. It is the same e-waste disposable product cycle adding to disposal costs. I want the Supervisors to invest our time and resources in superior Fiber Optic Broadband Infrastructure that will last 15 to 20 years. I do not want the Supervisors to pursue a build out of inferior Wireless Broadband that has a short 5 year life span. The telecom companies have already been paid to install fiber optics communication transmission infrastructure.

For these reasons I urge you to vote NO on the proposed changes.

Jack Neff
600 ½ N. Beachwood Dr.



Empowering People to make Safer Technology Choices

Los Angeles Board of Supervisors
Hilda Solis, Holly J. Mitchell, Lindsey Horvath, Janice Hahn, and Kathryn Barger
856 Kenneth Hahn Hall of Administration
500 West Temple Street
Los Angeles, CA 90012

Re: Proposed changes to Titles 16 and 22 to the Los Angeles County Code

Dear Board of Supervisors:

I'm urging the L.A. Board of Supervisors to vote NO on Title 16 & 22 or at minimum delay the vote so that the newly elected Board member, Lindsay Horvath, can become apprised of the issues surrounding Title 16 & 22.

I also strongly urge the Board of Supervisors to engage with Fiber First L.A. Attorneys to obtain an objective understanding of the legal requirements the Board must consider. These legal obligations are outlined in the redline ordinance submitted by [Fiber First L.A.](#) for Titles 16 and 22. Currently the ordinance (Title 16 & 22), as written, does not uphold specific legal & procedural requirements, especially those that pertain to CEQA.

As well the ordinance as written:

DOES NOT - Safeguard Due Process Rights

The radiation emitted from cell towers is not safe for humans or the environment — therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.

DOES NOT - Protect Us From Telecom Induced Wildfires

In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires and they cannot be fought until the grid has been cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of fire. The proposed revisions allow cell towers to be too close to homes, schools and daycare centers.

DOES NOT - Consider Important Facts About Safety

The Board of Supervisors are **being misled to believe this infrastructure is necessary for 911 calls**. This is NOT true. In an emergency, like during an earthquake with loss of power, 911 calls would depend solely upon the **macro towers** that are already backed up [per the California Public Utilities Commission \(CPUC\) Order](#). Claims that hundreds of new small cell antennas are required for 911 calls is false and should **not** be used as an argument for the amendments to Title 16 & 22.

DOES NOT – Solve the Digital Divide



Empowering People to make Safer Technology Choices

Fiber should be prioritized, per NTIA. **This is a once in a lifetime opportunity as these federal dollars to upgrade to fiber will not be available in the future and will extend the digital divide into the next decade.** The Board should take advantage of these funds to provide futureproof, superior fiber optic broadband connections to the home rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods.

DOES NOT Consider Energy Consumption or Carbon Footprint

[Wireless technology utilizes at least ten times more power](#) compared to wired technologies and significantly increases our carbon footprint. Therefore, we should try to mitigate the use of these technologies and use them only when fiber to the home (FTTH) can't be accomplished.

DOES NOT Fully Consider or Understand FCC Orders and Law

The Board is being misled into believing that the ordinance as written is necessary in order to stay within the FCC wireless rules and laws. FCC rules and federal laws do not supersede other laws. The FCC, Congress and the courts all agree that local control is necessary. Congress explicitly preserved to local governments the general authority to regulate the placement, construction, and modification of wireless facilities within their jurisdiction, subject to five (5) finite constraints as outlined by 47 U.S.C.A. §332 (C)(7) subparagraph (B) entitled "*Limitations*." These smart planning provisions were designed to enable wireless carriers the ability to **(a)** saturate the local jurisdiction with personal wireless coverage (*not for gaming and streaming but for the ability to make a phone call also known as significant gap in coverage*), **(b)** minimizing the number of wireless facilities necessary to provide such coverage and **(c)** minimize, the greatest extent possible, adverse impacts upon residential developments, individual homes, and communities in general.

Instead, the L.A. Board of Supervisors are throwing away all local control and handing over their powers to "Big Telecom," thereby buying into and propping up telecom's disinformation machine! Giving Big Telecom carte blanche, and betting on a temporary broadband band-aid to triage the digital divide will only extend it into the next decade. You have one chance to get this right and end the digital divide once and for all by using the powers given to you by our federal government and prioritizing fiber to the home (FTTH)! **There is no meaningful justification for not doing this.**

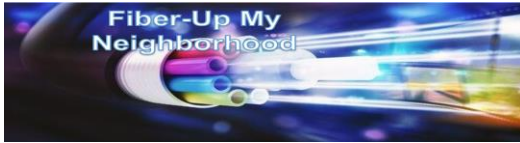
Local governments, like the LA Board of Supervisors, are the only protection from Big Telecom for unserved, underserved and vulnerable populations. You are the line that is supposed to be protecting your constituents.

Doing the right thing might be hard, but in the long run, it serves those you purport to want to protect. The unserved and underserved of L.A. County.

Regards,

Jodi Nelson

Director of Californians for Safe Technology



The Next Phase in Local and Regional Economic Development

December 5, 2022

Dear Los Angeles County Board of Supervisors:

Fixed wireless is NOT an option for the following reasons:

1. Lost investment in fiber optic connectivity to the regions for which the billions of dollars were designated to serve,
2. Subject the lives of millions of uninformed people to significant health threats to themselves, animal and plant(food),
3. Further a wireless industry agenda that 2 separate CA Governors (Brown and Newsom) have previously vetoed legislation asking for unfettered access to poles, wires and other structures for wireless proliferation,
4. Lock digital divide communities into ten-year blocks of inferior technology,

The only methodology that has worked to free a region or city from the harms of monopolistic power is a duplicative build of a fiber optic network where one exists, which is the case in Pomona or new build where none exists. We must work to understand the history and other extenuating circumstances which frame the solution around a fiber-first protocol. This requires us to recognize and work to fix the wrong committed to date by the telecommunication industry, legislators and the regulators as I articulate here in this article, not give them more deference and power:

- [Los Angeles County Supervisors Put Corporate Interests Ahead of the Peoples' Under the Guise of Closing the Digital Divide – L. A. Ortega](#)

Currently, pricing, monopolistic power and ignorance to the level of harm that exist with wireless build-outs in the name of closing the digital divide frame our conclusions. These actions provide no pathway forward for our communities. If you don't know the history or have the courage to attempt to incorporate a look to history as a matter of solving the future (fiber-optics an economic and moral imperative) then we have limited our solutions unnecessarily. This is not what we should be doing with the depth and breadth of intellect, courage, and accomplishments we have collectively.

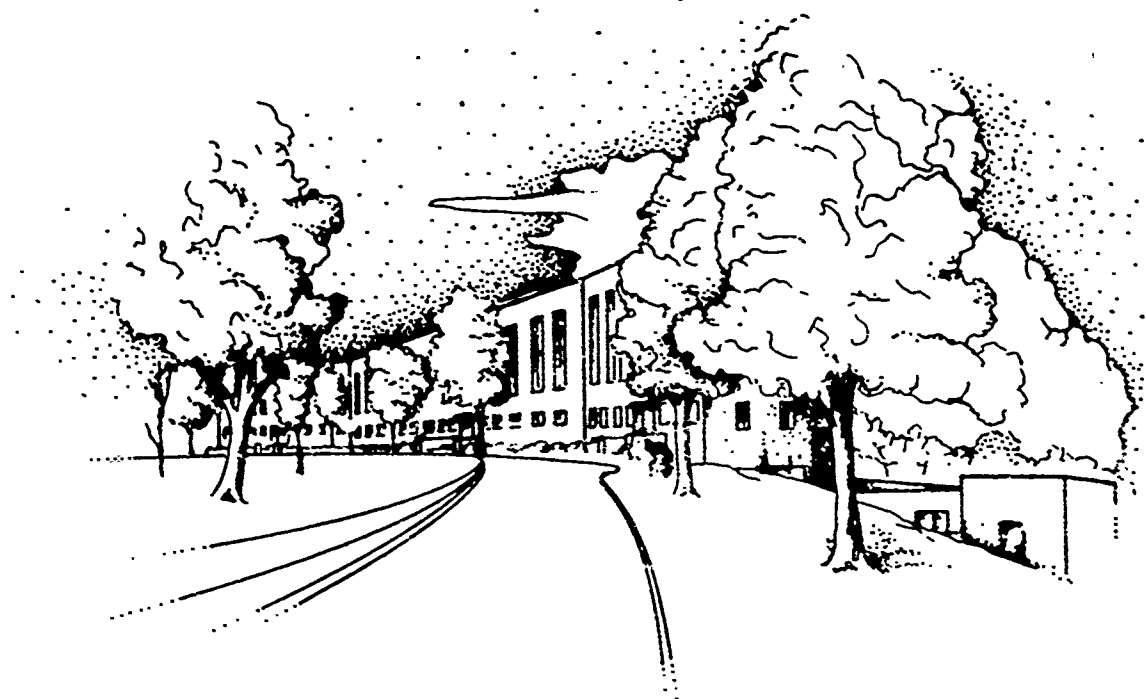
Please vote NO on Agenda Item #80.

Larry Ortega
President and Founder
Community Union, Inc. and Fiber-Up My Neighborhood

AD 750271

NMRI

NAVAL MEDICAL RESEARCH INSTITUTE



**BIBLIOGRAPHY OF REPORTED BIOLOGICAL PHENOMENA ('EFFECTS') AND CLINICAL
MANIFESTATIONS ATTRIBUTED TO MICROWAVE AND RADIO-FREQUENCY RADIATION**

RESEARCH REPORT

MF12.524.015-0004B

**REPORT NO. 2
REVISED**

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Springfield, VA 22151

**BIBLIOGRAPHY OF REPORTED BIOLOGICAL PHENOMENA ('EFFECTS') AND CLINICAL
MANIFESTATIONS ATTRIBUTED TO MICROWAVE AND RADIO-FREQUENCY RADIATION**

**Zorach R. Glaser, Ph.D.
LT, MSC, USNR**

Research Report

Project MF12.524.015-0004B, Report No. 2

**Naval Medical Research Institute
National Naval Medical Center
Bethesda, Maryland 20014, U.S.A.**

4 October 1971

**Second Printing, with Revisions,
Corrections, and Additions: 20 April 1972
(Supersedes AD No. 734391)**

ABSTRACT

More than 2000 references on the biological responses to radio frequency and microwave radiation, published up to June 1971, are included in the bibliography.* Particular attention has been paid to the effects on man of non-ionizing radiation at these frequencies. The citations are arranged alphabetically by author, and contain as much information as possible so as to assure effective retrieval of the original documents. An outline of the effects which have been attributed to radio frequency and microwave radiation is also part of the report.

*Three supplementary listings bring the number of citations to more than 2300.

Key Words

Biological Effects
Non-Ionizing Radiation
Radar Hazards
Radio Frequency Radiation
Microwave Radiation
Health Hazards
Bibliography
Electromagnetic Radiation Injury

The comments upon and criticisms of the literature made in this report, and the recommendations and inferences suggested, are those of the author, and do not necessarily reflect the views of the Navy Department or of the Naval Service.

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BETHESDA, MARYLAND 20014

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BUREAU OF MEDICINE AND SURGERY (NAVY)
WASHINGTON, D.C. 20390

13. ABSTRACT

More than 2300 references on the biological responses to radio frequency and microwave radiation, published up to April 1972, are included in this bibliography of the world literature. Particular attention has been paid to the effects on man of non-ionizing radiation at these frequencies. The citations are arranged alphabetically by author, and contain as much information as possible so as to assure effective retrieval of the original documents. Soviet and East European literature is included in detail. An outline of the effects which have been attributed to radio frequency and microwave radiation is included as Chapter 1. The revised report (which supersedes DDC report AD#734391) is updated with the inclusion of three supplementary listings, and has incorporated many corrections and additions to the original 2100 citations.

UNCLASSIFIED

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Biological effects Non-ionizing radiation Kadar hazards Radio frequency radiation Microwave radiation Health hazards Bibliography Electromagnetic radiation injury radiation adverse effects						

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Foreword

It is the hope of the author that this bibliography will provide guidance to the diffuse and conflicting literature on the biological responses to electromagnetic radiation at radio- and microwave-frequencies, with particular reference to the effects of concern to man. Such guidance is needed in the formulation and appraisal of criteria and limits of human exposure to "non-ionizing" radiation, and in the planning and conduct of future research.

The original plans were to categorize and key the literature citations to the "outline of biological and clinical effects" (Chapter 1). This proved to be a much more difficult and time-consuming task than anticipated, and was actually completed only for about 400 papers. Thus, the letter-number combinations given in square brackets for some of the "A" through "C" citations refer to the outline. [NV] indicates the citation was "not verified".

The standard format used throughout the bibliography is: author, (date), journal, volume, (issue): page, "title". The authors are alphabetized, and in chronological order. Multiple authors are also alphabetically ordered according to the second, third, etc., author. Inclusive pagination is given where possible, as is the original language of the citation. Report accession and translation numbers (some of which are cited in Appendix A), and alternate sources are listed when known. The title of books is underlined. When the title of the report was not available (or not given), a short (one line) description of the paper is listed whenever possible. Reports in which the name of the author was not given are listed chronologically using the format, "title", reference, source, (date). In many cases the citation was obtained from secondary (and tertiary) sources. For this reason it was impossible to put every citation into a consistent format.

In a few cases, papers have been cited which were presented at symposia or meetings devoted to the present topic, even when the report title suggests that it does not pertain directly to the topic. This has been done to show the wide range of items considered relevant (at least at the time of the meeting, and by the organizing chairman) in past years. An example is "electroanesthesia".

A few citations of marginal and/or peripheral relationship have also been included so that the reader may judge the applicability to his individual research needs. Examples are reports dealing with the biological effects of static and alternating magnetic fields, experimental techniques using radio frequency and microwave radiation (e.g., electron spin resonance, and nuclear magnetic resonance spectroscopy), and microwave exposure limits, regulations, and standards.

References for a few limited-distribution government reports are available upon request.

The author welcomes information which will correct errors and omissions (both of which no doubt exist). Copies of new papers would be greatly appreciated, and would encourage updating and revising the bibliography periodically.

ACKNOWLEDGMENTS

The assistance and support received during the preparation of this bibliography have been considerable, and I am happy to acknowledge my indebtedness and gratitude. Drs. John Keesey and Dennis Heffner, former and present Heads of the Biophysics Division, and Dr. Seymour Friess, Director of the Environmental Biosciences Department of the Naval Medical Research Institute, permitted me the opportunity to work on the bibliography, and offered frequent encouragement.

Acknowledgment is also due to many friends and associates for their helpful suggestions, comments, and loans and/or gifts of reports or other material, which have been invaluable in the course of the work. Mr. Glenn Heimer of the Naval Ship Engineering Center contributed an extensive collection of government reports and documents, many of which had not previously been cited in the open literature.

Special help in tracing and in the acquisition of relevant papers has been received from the librarians and staff members of the NMRI library: Mrs. Thelma Robinson, Mrs. Ernestine Gendleman, Mrs. Eleanor Capps, and Miss Deborah Grove. Their diligence and resourcefulness in tracing and obtaining copies of a large number of papers and reports, often in spite of incomplete and/or inaccurate citations given in other sources, enabled me to include many relevant items in the bibliography.

Mr. Christopher Dodge of the Scientific and Technical Center, Department of the Navy, provided much of the Soviet Bloc literature, linguistic and other technical assistance, and in addition offered valuable comments and encouragement throughout the preparation of this report. Especially noteworthy were the corrections and improvements suggested by Chris following his reading of the entire manuscript.

Helpful also in locating some of the Soviet literature was Mr. E. S. Serebrennikov, of the Science and Technology Division, The Library of Congress.

Credit is due Mrs. Anna Woke (of this Institute) for translating many of the German papers; to Dr. Emilio Weiss, who translated from the Italian, and to Mrs. Edith Pugh who typed many "first drafts"; also to Mrs. Rhoda Glaser for her help in many aspects of the work.

Mrs. Fannie Epstein deserves special mention for her outstanding editorial assistance, and especially for the heroic typing, organization, and checking of the entire report.

The Outline of Reported Biological Phenomena ('Effects') and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation, is patterned after that given by R. Murray, et al., in an article entitled, "How safe are microwaves", which appeared in Non-Ionizing Radiation 1(1):7-8 (1969). Some of the "effects" were listed in the report by S. F. Cleary and W. T. Ham, Jr., entitled, "Considerations in the evaluation of the biological effects on exposure to microwave radiation", (Background document, Part I, 1969, for the Task Force on Research Planning in Environmental Health, Subtask Force on Physical Factors in the Environment). The discussion and suggestions offered by Byron McLees, Edward Finch, Lewis Gershman, and Christopher Dodge relating to the Outline are also gratefully acknowledged.

Preparation of the bibliography was supported by the Bureau of Medicine and Surgery, Department of the Navy, under work unit MF12.524. 015-0094B.

CHAPTER 1

Reported Biological Phenomena ("Effects") and Some Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation (See Note)

A. Heating of Organs* (Applications: Diathermy, Electrosurgery, Electrocoagulation, Electrodesiccation, Electrotomy)

1. Whole Body (temperature regulation defects), Hyperpyrexia
2. Skin
3. Bone and Bone Marrow
4. (a) Lens of Eye (cataractous lesions - due to the avascular nature of the lens which prevents adequate heat dissipation.)
(b) Corneal damage also possible at extremely high frequencies.
5. Genitalia (tubular degeneration of testicles)
6. Brain
7. Sinuses
8. Metal Implants (burns near hip pins, etc.)

The effects are generally reversible except for 4a.

B. Changes in Physiologic Function

1. Striated Muscle Contraction
2. Alteration of Diameter of Blood Vessels (increased vascular elasticity), Dilation
3. Changes in the Oxidative Processes in Tissues and Organs
4. Liver Enlargement
5. Altered Sensitivity to Drug Stimuli
6. Decreased Spermatogenesis (decreased fertility, to sterility)
7. Altered Sex Ratio of Births (more girls!)
8. Altered Menstrual Activity
9. Altered Fetal Development
10. Decreased Lactation in Nursing Mothers
11. Reduction in Diuresis (Na^+ excretion, via urine output)
12. Altered Renal Function (decreased filtration by tubules)
13. Changes in Conditioned Reflexes
14. Decreased Electrical Resistance of Skin
15. Changes in the Structure of Skin Receptors of the (a) Divergent, and (b) Blood-Carrying Systems
16. Altered Blood Flow Rate

* It is also reported that low levels of irradiation produce a cooling effect - "hypercompensation".

Note: These effects are listed without comment or endorsement since the literature abounds with conflicting reports. In some cases the basis for reporting an "effect" was a single or a non-statistical observation which may have been drawn from a poorly conceived (and poorly executed) experiment.

17. Alterations in the Biocurrents (EEG?) of the Cerebral Cortex (in animals)
18. Changes in the Rate of Clearance of Tagged Ions from Tissue
19. Reversible Structural Changes in the Cerebral Cortex and the Diencephalon
20. Electrocardiographic (EKG) Changes
21. Alterations in Sensitivity to Light, Sound, and Olfactory Stimuli
22. Functional (a) and Pathological (b) Changes in the Eyes:
(a) decrease in size of blind spot, altered color recognition, changes in intraocular pressure, lacrimation, trembling of eyelids; (b) lens opacity and coagulation, altered tissue respiration, and altered reduction-oxidation processes
23. Myocardial Necrosis
24. Hemorrhage in Lungs, Liver, Gut, and Brain
25. Generalized Degeneration of all Body Tissue
26. Loss of Anatomical Parts
27. Death
28. Dehydration
29. Altered Rate of Calcification of Certain Tissue

} At Fatal Levels
of Radiation

C. Central Nervous System Effects

1. Headaches
2. Insomnia
3. Restlessness (Awake and During Sleep)
4. Electroencephalographic (EEG) Changes
5. Cranial Nerve Disorders
6. Pyramidal Tract Lesions
7. Conditioned Reflex Disorders
8. Vagomimetic Action of the Heart; Sympathomimetic Action
9. Seizures, Convulsions

D. Autonomic Nervous System Effects

1. Neuro-vegetative Disorders (e.g., alteration of heart rhythm)
2. Fatigue
3. Structural Alterations in the Synapses of the Vagus Nerve
4. Stimulation of Parasympathetic Nervous System (Bradycardia), and Inhibition of the Sympathetic Nervous System

E. Peripheral Nervous System Effects

Effects on Locomotor Nerves

F. Psychological Disorders ("Human Behavioral Studies") - the so-called "Psychophysiologic (and Psychosomatic) Responses"

1. Neurasthenia - (general "bad" feeling)
2. Depression
3. Impotence
4. Anxiety
5. Lack of Concentration
6. Hypochondria
7. Dizziness
8. Hallucinations
9. Sleepiness
10. Insomnia
11. Increased Irritability
12. Decreased Appetite
13. Loss of Memory
14. Scalp Sensations
15. Increased Fatigability
16. Chest Pain
17. Tremor of the Hands

G. Behavioral Changes (Animal Studies)

Reflexive, Operant, Avoidance, and Discrimination Behaviors

H. Blood Disorders

(V = in vivo)
(v = in vitro)

Changes in:

1. Blood and Bone Marrow
2. Phagocytic (polymorphs) and Bactericidal Functions of Blood (v)
3. Hemolysis rate (increase), (a shortened lifespan of cells)
4. Sedimentation rate (increase), (due to changes in serum protein levels or amount of fibrinogen. (??))
5. Number of Erythrocytes (decrease), also number of lymphocytes
6. Blood Glucose Concentration (increase)
7. Blood Histamine Content
8. Cholesterol and Lipids
9. Gamma (also α and β) Globulin, and Total Protein Concentration
10. Number of Eosinophils
11. Albumin/Globulin Ratio (decrease)
12. Hemopoiesis (rate of formation of blood corpuscles)
13. Leukopenia (increase in number of white cells), and Leukocytosis
14. Eritrocytosis

I. Vascular Disorders

1. Thrombosis
2. Hypertension

J. Enzyme and Other Biochemical Changes

Changes in activity of:

1. Cholinesterase (V,v)
2. Phosphatase (v)
3. Transaminase (v)
4. Amylase (v)
5. Carboxydismutase
6. Protein Denaturation
7. Toxin, Fungus, and Virus Inactivation (at high radiation dose levels), Bacteriostatic Effect
8. Tissue Cultures Killed
9. Alteration in Rate of Cell Division
10. Increased Concentration of RNA in Lymphocytes, and Decreased Concentration in Brain, Liver, and Spleen
11. Changes in Pyruvic Acid, Lactic Acid, and Creatinine Excretions
12. Change in Concentration of Glycogen in Liver (Hyperglycemia)
13. Alteration in Concentration of 17- Ketosteroids in Urine

K. Metabolic Disorders

1. Glycosuria (sugar in urine; related with blood sugar?)
2. Increase in Urinary Phenol (derivatives? DOPA?)
3. Alteration of Rate of Metabolic Enzymatic Processes
4. Altered Carbohydrate Metabolism

L. Gastro-Intestinal Disorders

1. Anorexia (loss of appetite)
2. Epigastric Pain
3. Constipation
4. Altered Secretion of Stomach "Digestive Juices"

M. Endocrine Gland Changes

1. Altered Pituitary Function
2. Hyperthyroidism
3. Thyroid Enlargement
4. Increased Uptake of Radioactive Iodine by Thyroid Gland
5. Altered Adrenal Cortex Activity
6. Decreased Corticosteroids in Blood
7. Decreased Glucocorticoidal Activity
8. Hypogonadism (usually decreased testosterone production)

N. Histological Changes

1. Changes in Tubular Epithelium of Testicles
2. Cross Changes

O. Genetic and Chromosomal Changes

1. Chromosome Aberrations (e.g., linear shortening, pseudochiasm, diploid structures, amitotic division, bridging, "sticky" chromosomes, irregularities in chromosomal envelope)
2. Mutations
3. Mongolism
4. Somatic Alterations (changes in cell not involving nucleus or chromosomes, cellular transformation)
5. Neoplastic Diseases (e.g., tumors)

P. Pearl Chain Effect (Intracellular orientation of subcellular particles, and orientation of cellular and other (non-biologic) particles)

Also, orientation of animals, birds, and fish in electromagnetic fields

Q. Miscellaneous Effects

1. Sparking between dental fillings
2. Peculiar metallic taste in mouth
3. Changes in Optical Activity of Colloidal Solutions
4. Treatment for Syphilis, Poliomyelitis, Skin Diseases
5. Loss of Hair
6. Brittleness of Hair
7. Sensations of Buzzing Vibrations, Pulsations, and Tickling About the Head and Ears
8. Copious Perspiration, Salivation, and Protrusion of Tongue
9. Changes in the Operation of Implanted Cardiac Pacemakers
10. Changes in Circadian Rhythms

Dear Board of Supervisors;

Fiber should be prioritized, per NTIA. This is a once in a lifetime opportunity as these federal dollars will not be available in the future. The Board should take advantage of these funds to provide futureproof, superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. [Wireless technology utilizes at least ten times more power:](#)

https://www.researchgate.net/publication/224240247_Energy_Consumption_in_Wired_and_Wireless_Access_Networks compared to wired technologies and significantly increases our carbon footprint



Date: October 15, 2019

To: The Secretariat of the U.N. Human Rights Council Advisory Committee
OHCHR – United Nations Office at Geneva, Switzerland

Re: Comments on the U.N. Human Rights Commission's Resolution entitled,
“New and Emerging Digital Technologies and Human Rights” – adopted
July 11, 2019

From: These comments are being transmitted on behalf of the Advisors to the
International EMF Scientist Appeal¹.

The International EMF Scientist Appeal was initiated in May 2015 and is addressed to the U.N. Secretary General, the World Health Organization Director General, the Executive Director of the U.N. Environment Programme and to all Member States. It is now signed by over 240 scientists in 43 nations who have published peer-reviewed papers on the biological or health effects of non-ionizing electromagnetic fields (EMF), part of the electromagnetic spectrum that includes extremely-low frequency (ELF) electromagnetic fields emitted by electrical power delivery networks and electrical devices; and radiofrequency radiation (RFR) used for wireless communications. Scientists who have published peer-reviewed papers in related fields and have been significantly engaged in EMF education, are recognized as Supporting Scientists.²

The Appeal urgently calls upon the United Nations, the WHO, UNEP and the UN Member States to address the global public health concerns related to exposure to cell phones, power lines, electrical appliances, wireless devices, wireless utility meters and wireless infrastructure in residential homes, schools, communities and businesses. The greatest concerns of these scientists are for the protection of children, pregnant women and for those who are electromagnetically hypersensitive.

- The World Health Organization (WHO) is encouraged to exert strong leadership in fostering the development of more protective EMF-exposure guidelines, to call for precautionary measures, and to educate the public about health risks, particularly risks

¹ International Appeal: Scientists call for protection from non-ionizing electromagnetic field exposure, European Journal of Oncology, Vol. 20, 2015/12/01, pp. 180-182

² See <https://emfscientist.org>

posed to children and fetal development. By not acting, the WHO is failing to fulfill its role as the preeminent international public health agency.

- The United Nations Environmental Programme (UNEP) is the U.N.'s "voice for the environment" and is uniquely positioned to take a planetary view of the potential for harm that EMF pollution presents to living organisms world-wide including well-being, health, reproduction, survival and evolution. We encourage the U.N. to ask UNEP to evaluate the scientific evidence and initiate an assessment of alternative exposure standards and practices that could substantially lower environmental exposures to non-ionizing electromagnetic fields. This request was restated in a letter to Inger Andersen, UNEP's Executive Director, on July 9, 2019, but there has been no formal reply to date.
- In September 2017, the Advisors to the Appeal recommended that—in keeping with the U.N. Guiding Principles on Business and Human Rights to "Protect, Respect and Remedy"—5G wireless communications technologies should be subjected to an independent health and safety assessment before they are deployed. It is required for newly-developed drugs and should be mandatory for all non-ionizing electromagnetic fields to which a large population is or is going to be exposed.

Technological innovation offers social and economic benefits to society. Wireless communication technologies are rapidly becoming an integral part of every economic sector. But there is a rapidly growing body of scientific evidence of harm to people, plants, animals, and microbes caused by exposure to these technologies. It is our opinion that adverse health consequences of chronic and involuntary exposure of people to non-ionizing electromagnetic field sources are being ignored by national and international health organizations despite our repeated inquiries as well as inquiries made by many other concerned scientists, medical doctors and advocates. This constitutes a clear violation of human rights, as defined by the United Nations:

"Human rights are rights inherent to all human beings, regardless of race, sex, nationality, ethnicity, language, religion, or any other status. Human rights include the right to life and liberty, freedom from slavery and torture, freedom of opinion and expression, the right to work and education."

We strongly urge the U.N. Human Rights Council to be a strong voice for the human rights of all people and an effective catalyst within the United Nations with regards to seeking greater health protection for humankind and both flora and fauna from serious harm and increased health risks posed by non-ionizing electromagnetic fields.

Sincerely,

Elizabeth Kelley, MA
Director, EMFScientist.org

On behalf of Scientific Advisors to the International EMF Scientist Appeal:
Annie Sasco, MD, DrPH; Ronald L. Melnick, PhD.; Magda Havas, PhD; Henry Lai, PhD; and,
Joel M. Moskowitz, PhD.



BOYLE HEIGHTS COMMUNITY GARDEN

To: Los Angeles County ("LAC") Board of Supervisors Members:

Hilda L. Solis, Holly J. Mitchell, Janice Hahn, Kathryn Barger, Lindsay Horvath

Cc: Chair LA County Regional Planning Department ("LACRPD"): Yolanda Duarte-White,
Director of Public Works: Mark Pestrella, Dawyn R. Harrison, Acting County Counsel

From: 5G Free California, Inc.

Re: Petition Relating to Proposed Amendments to Title 16 & 22 (Vote on Final Passage
Scheduled for December 6, 2022)

Date: December 5, 2022

Dear LAC Board of Supervisors Members (and Other Concerned with the above captioned matter):

Our organization Boyle Heights Community Garden strongly urges that you Board of Supervisors Members vote 'No' on the above captioned matter. Our organization is focused on sustainability, our environment and the communities' wellbeing. We are deeply concerned that a vote in favor of amendments to Titles 16 and 22 will cause great harm to our members and all the residents of Los Angeles, County.

Communities in East Los Angeles, have been victims of environmental racism for decades, being environmentally impacted by many contaminants. Our soil is contaminated by lead and arsenic from EXIDE (battery recycling center). Our air is polluted by the car smog of heavy traffic from six major freeways that surrounds us. The racism has expanded to even the number of trees planted in our streets. Our water is contaminated. We have been victimized and being lack of our basic human rights, clean air, water and soil!!

Now the Board of Supervisors, advice by the Planning Commission, in an effort to make a buck is willing to risk the wellbeing of our communities once again. This ordinance, as drafted, eliminates requirements regarding distance between cell towers; advance notice or provide to our residents the opportunity to appeal. There are no fire (specially electrical fires) setbacks in front of homes, schools, daycare and hospitals allowing little to no time to escape in the event of fires and earthquakes.

Not allowing for fire setbacks could potentially set us up for severe or even deadly fires. California has suffered devastating fire losses due to telecom equipment, yet no wireless carrier or their agents carry liability insurance for claims of injury or death* In fact since 2007 four major Southern California fires were caused by telecommunication equipment failures including the Woosley fire, which caused \$6 billion worth of damages and devastated Los Angeles County. The criminal investigation by Attorney General found that "Consistent with the scientific findings contained in the report issued by Cal Fire and the Ventura County Fire Department, investigators determined that electrical and communication

equipment owned by Southern California Edison caused the Woolsey Fire”**. This fire claimed many lives, displaced approximately 295,000 people,(** <https://oag.ca.gov>)

These ordinances will not close the “Digital Divide.” We have an abundance of cell service in our neighborhood and yet many cannot afford safe, inexpensive and reliable internet access. A viable solution to closing the “digital divide” is fiber optics. This proposed wireless build-out is depriving low income and minority communities of an immediately viable, safe, fast, cyber-secure, energy efficient alternative. According to a research from the USC study, “Who gets access to Fast Broadband? Evidence from Los Angeles County,” by Dr. Hernan Galperin, *“The findings indicate that competition and fiber-based services are less likely in low-income areas and communities of color, with the most severe deficits observed in census block groups that combine poverty and a large percentage of people of color.”*

Other Concerns:

The Board of Supervisors is overriding federal statutes/protections: Public entities such as counties must comply with the Historic Preservation Act, the Endangered Species Act, the Americans with Disabilities Act, and the Fair Housing Amendments Act. In its search for a balanced solution for cell towers, it will be beneficial for the Board of Supervisors to consider these federal statutes they preempted by the 1996 Telecommunications Act.

No environmental assessments: California Environmental Quality Act (CEQA) and federal National Environmental Policy Act (NEPA). No residential setbacks between homes/towers. Antennas and cell tower will be set in their front yard may also violate FCC guidelines and no Environmental Impact Report will be required.

California Consumer Privacy Act: These ordinances will deny millions of constituents and stakeholders in Los Angeles County their right to opt out from the most personal and private information being packaged, sold, and resold without their consent. The California Consumer Privacy Act established in 2018, new amended protections in 2020, in the areas of privacy, technology and consumer rights ensure that consumer’s privacy and data rights are safeguarded.

We look to your support to oppose these ordinances and encourage the option of municipal fiber-optic, wired broadband. Los Angeles County could follow the example of the city of Chattanooga, TN, their Community Fiber Optic network proved to be energy efficient, reduced power outages, bridged digital divide, decreased environmental damage, enable job creations and retentions. There are so many illegalities in the proposed amendments, really think about WHO will benefit from this changes!!!

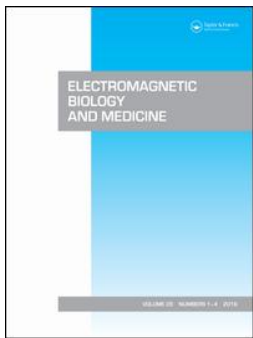
Adopt the redline provided by Fiber First LA. Oppose these ordinances; let’s explore safer, protective practices that reflect heightened vigilance, care, and precaution by our publicly elected Board of Supervisors.

We deeply appreciate your consideration and support.

Sincerely,

Brenda Trujillo-Martinez

Director of BHCG



Genetic effects of non-ionizing electromagnetic fields

Henry Lai

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REVIEW



Genetic effects of non-ionizing electromagnetic fields

Henry Lai

Department of Bioengineering, University of Washington, Seattle, WA, USA

ABSTRACT

This is a review of the research on the genetic effects of non-ionizing electromagnetic field (EMF), mainly on radiofrequency radiation (RFR) and static and extremely low frequency EMF (ELF-EMF). The majority of the studies are on genotoxicity (e.g., DNA damage, chromatin conformation changes, etc.) and gene expression. Genetic effects of EMF depend on various factors, including field parameters and characteristics (frequency, intensity, wave-shape), cell type, and exposure duration. The types of gene expression affected (e.g., genes involved in cell cycle arrest, apoptosis and stress responses, heat-shock proteins) are consistent with the findings that EMF causes genetic damages. Many studies reported effects in cells and animals after exposure to EMF at intensities similar to those in the public and occupational environments. The mechanisms by which effects are induced by EMF are basically unknown. Involvement of free radicals is a likely possibility. EMF also interacts synergistically with different entities on genetic functions. Interactions, particularly with chemotherapeutic compounds, raise the possibility of using EMF as an adjuvant for cancer treatment to increase the efficacy and decrease side effects of traditional chemotherapeutic drugs. Other data, such as adaptive effects and mitotic spindle aberrations after EMF exposure, further support the notion that EMF causes genetic effects in living organisms.

ARTICLE HISTORY

Received 22 September 2020
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KEYWORDS

Radiofrequency radiation;
static/extremely low
frequency EMF; genetic
effects; genotoxicity; gene
expression

Introduction

This is a review on studies on the genetic effects of non-ionizing electromagnetic fields (EMF). We will concentrate on two parts of the EMF spectrum which are common in our environment: static and extremely low-frequency electromagnetic fields (ELF-EMF) and radio-frequency radiation (RFR).

Studies are summarized in Supplements 1 (RFR) and 2 (static/ELF-EMF). Basically, there are two types of studies: genetic damages and gene expression. The research covers a wide area of biological systems: both in vitro and in vivo involving many animal and cell models, and various exposure conditions. First, a few words have to be said on the exposure set-ups used in these studies. It is relatively easy to set up a reliable exposure system for static and ELF-EMF. Most exposure systems used these studies are generally satisfactory. However, it is difficult to set up good exposure systems for RFR studies. In my opinion, most set-ups are relatively satisfactory, considering that there is no perfect guideline on what is a good system. However, preferably, incident power density and specific absorption rate should be provided in each study. These are generally lacking when telecommunication devices, such as cellular phones, are used in a study. It becomes difficult to

compare the results of these studies with other studies using exposure systems. It is not totally without merit to use these devices for studies. If properly set up, these devices provide more realistic exposure parameters. A general problem is that some researchers generally showed ignorance on the independent variable, i.e., EMF, that they worked on.

Regarding biological measurements, with few exceptions, the researcher are generally knowledgeable in the methodology used. However, there are studies that showed that the researchers are not familiar with the methodology that they used in their studies. An example is the use of the “Comet assay” to determine DNA strand breaks. 31% of the studies listed in Supplements 1 and 2 used the “Comet assay”. A few words have to be said on it. Different versions of the assay have been developed. These versions have different detection sensitivities and can be used to measure different aspects of DNA strand breaks. A comparison of data from experiments using different versions of the assay may be misleading. Another concern is that most of the ‘comet assay’ studies were carried out by experimenters who had no prior experience on the assay. My experience with the ‘Comet assay’ is that it is a very sensitive assay and requires great care in performing. Thus, different detection sensitivities could result from different

experimenters, even following the same procedures. One way to solve this experimental variation problem is for each researcher or laboratory to report their sensitivity of the ‘Comet assay’, e.g., threshold of detecting strand breaks in human lymphocytes exposed to x-rays. This information is generally not available from the EMF-genotoxicity studies. However, in one incidence, an incredibly high sensitivity was even reported (Malyapa et al., 1998), suggesting the inexperience of the researchers on the assay.

Supplements 1 and 2 show that the majority of studies reported genetic effects of EMF (66% for RFR and 79% for static/ELF-EMF). Thus, it is safe to conclude that genotoxic effects of EMF have been reported. The most common effects found are: DNA strand breaks, micronucleus formation, and chromosomal structural changes. There are not many studies on mutation. Thus, it is not known whether these genotoxic effects transform into mutation and involved in carcinogenesis. Interestingly, available data do not suggest mutagenic effect after RFR exposure (Chang et al., 2005; Meltz et al., 1990; Ono et al., 2004; Takahashi et al., 2002); whereas most static/ELF-EMF studies (Chahal et al., 1993; Mairs et al., 2007; Miyakoshi, 1997; Miyakoshi et al., 1998, 1996; Potenza et al., 2004; Wilson et al., 2015) suggested some mutagenic effects. Another interesting speculation is that ELF EMF acts as a promoter of cancer in the presence of an initiator by modulation of signaling pathways involved free radicals and apoptosis (Lacy-Hulbert et al., 1998). Such a possibility has not been well investigated.

There are similarly many studies that showed changes in gene expression after EMF exposure (Supplement 3). Changes in expression of many different genes have been reported. Studies in gene expression by static/ELF-EMF are far more diversified than those of RFR. The most interesting results are the expression of genes related to stress response both in vitro and in vivo in plants and animals. Another important finding is the expression of heat shock proteins, particularly HSP70, which is an important protein involving in protein misfolding and protecting cells from environmental stress.

The data point to four areas of interest: involvement of free radicals, effects at low-intensity of exposure, contributions of exposure parameters and biological system being studied, and interaction with other entities. Let us look at each of these four topics.

Involvement of free radicals (Citations of references in *italic* in this section are in Supplements 1 and 2)

Effects of EMF on cellular free radical processes have been reported in many experiments (cf. Lai, 2019; Yakymenko et al., 2016). It is conceivable that an

increase in free radicals in cells could cause macromolecular damages including DNA. There are many reports on involvements of free radicals in genetic processes, including both reactive oxygen species and reactive nitrogen species: **RFR** – Agarwal et al., 2009; Alkis et al., 2019a, b, 2021; Bektas et al., 2020; Bourdineaud et al., 2017; Burlaka et al., 2013; De Iuliis et al., 2009; Duan et al., 2015; Gajski and Garaj-Vrhovac 2009; Garaj-Vrhovac et al., 2009, 2011; Guler et al., 2010; Gürler et al., 2014; Houston et al., 2019; Kesari et al., 2011, 2014; Khalil et al., 2012; Kumar et al., 2010; Lai and Singh, 1997; Li et al. 2018; Liu et al., 2013a, b; Luukkonen et al., 2009; Manta et al. 2017; Magha et al., 2015b; Meena et al. 2014; Millenbaugh et al., 2008; Odaci et al., 2016; Pandey et al., 2017; Pandey and Giri, 2018; Qin et al., 2019; Sahin et al., 2016; Shahin et al., 2013, 2019; Sharma and Shukla, 2020; Sokolovic et al., 2015; Sun et al. 2017; Tkalec et al., 2013; Vafaei et al. 2020; Varghese et al., 2018; Veerachari and Vasan, 2012; Vilić et al., 2017; Wang et al., 2015; Wu et al., 2008; Xu et al., 2010; Yakymenko et al., 2018; Yao et al., 2008; Zong et al. 2015; Zothansiana et al., 2017; **Static and ELF EMF** – Alcaraz et al., 2014; Amara et al., 2007b; Ashta et al., 2020; Hosseinabadi et al., 2020; Berteau et al., 2015; Buldak et al., 2012; Consales et al., 2018; Dong et al. 2019; Jajte et al., 2001; Jouni et al., 2012; Kimsa-Dudek et al. 2018; Kindzelskii and Petty, 2000; Lai and Singh, 1997b, 2004; Li et al., 2001; Luukkonen et al., 2014; Rageh et al., 2012; Shokrollahi et al., 2018; Solek et al., 2017; Wang et al., 2020; Wolf et al., 2005; Yin et al., 2016; Yokus et al., 2008; Yuan et al., 2020; Zhang et al., 2016. Brief descriptions of these reports are in Supplements 1 and 2. However, changes in cellular free radical and genetic processes do not imply a cause–effect relationship. A convincing argument on direct involvement of free radicals on EMF-induced genetic changes comes from data showing that the effects could be blocked by free radical scavengers (e.g., antioxidants) e.g., see Lai and Singh (1997; 2004). The free radicals involved probably include both reactive oxidative species (ROS) and reactive nitrogen species (RNS) (Lai and Singh, 2004). RNS (e.g., nitric oxide) have longer mean free path than ROS (e.g., hydroxyl radical) and could cause more widespread cellular molecular damages. Nitric oxide can further enhance iron-mediated free radical formation via its effects on iron metabolism and release of iron from ferritin (Reif and Simmons 1990; Richardson and Ponka 1997) that generates ROS via the Fenton reaction. Nitric oxide can either be mutagenic or cytotoxic. It is mutagenic when the intracellular level of reduced glutathione is low, but cytotoxic (leading to

apoptosis and inhibition of tumor growth) in a thiol-rich environment that favors the formations of toxic nitrosothiols (Felley-Bosco 1998). These situations could occur under EMF exposure.

The mechanisms on how EMF affects free radicals in cells are not known. There are various speculations. Readers may be interested to take a look at these publications: Barnes and Greenebaum (2015); Binhi and Prato (2017); Davila et al. (2005); Dodson et al. (2013); Hore (2019); Hore and Mouritsen (2016); Kirschvink et al. (2001); Landler and Keays (2018); Sheppard et al. (2017); Sherrard et al. (2018); and Sisakht et al. (2020).

Furthermore, it has to be pointed out that EMF-induced genetic effects have been observed without free radical changes (Alcaraz et al., 2014; Ferreira et al., 2006; Furtado-Filho et al., 2014) and free radical changes without genetic effects (Frahm et al., 2006; Senturk et al., 2019; Tiwari et al., 2015; Tomruk et al., 2010) have also been reported. This may imply that mechanisms other than free radicals are involved,

Effects at low exposure intensities

There are many reports of genetic effects induced by low intensities of EMF. The studies are listed in Supplement 4. This is an important topic to consider since living organisms are being constantly exposed to low levels of EMF in the occupational and public environments. This is particularly true for ELF-EMF, since intensities of ELF-EMF in the environment are in microtesla (μT) levels, even exposure to fields from electrical appliances rarely exceed 10 microtesla (i.e., 0.01 mT). However, most laboratory cell and animal studies in ELF-EMF used fields in the millitesla (mT) level.

A survey of level of RFR in the environment of various countries (Amoako et al., 2009; Aris et al., 2020; Bhatt et al., 2016; Dhama, 2012; Dode et al., 2011; Estenberg and Augustsson, 2014; Firlarer et al., 2003; Frei et al., 2009; Hardell et al., 2016, 2017; Henderson and Bangay, 2006; Joseph et al., 2008, 2010; Kim and Park, 2010; Kurnaz and Aygun, 2020; Lahham and Hammash, 2012; Lahham et al., 2015, 2017; Sagar et al., 2018; Tell and Kavet, 2014; Thuroczy et al., 2006; Urbinello et al., 2014; Viel et al., 2009; Waldmann-Selsam et al., 2016) gave a mean power density level of 0.00259 mW/cm^2 and median of 0.000545 mW/cm^2 . Reports (Abuasbi et al. 2018; Al-Badi, 2012; AL-rajhi, 2014; Eskelinen et al., 2002; Ilonen et al., 2008; Lindgren et al., 2001; Rösli et al., 2011) on the levels of magnetic fields in the human environment came up with a mean level of 0.0036 mT and median level of 0.00062 mT. Much higher exposure levels could be found in occupational situations. Operators and technicians in a power plant could be exposed to 0.0126 mT, whereas the

magnetic field level in the vicinity of a power transmission line could be as high as 0.0482 mT (Hosseinsbadi et al., 2020).

Besides genetic effects, other physiological processes have also been reported to be affected by low-intensity EMFs, e.g., **RFR**: retarded development of frog (Balmori, 2010; 88.5–1873.6 MHz cell phone base station emission; $0.00859\text{--}0.00325 \text{ mW/cm}^2$); slowing of circadian rhythm in cockroach (Bartos et al., 2019; broadband RF noise; 0.000429 mT); changes in electrical activities in rat sciatic nerve (Comelekoglu et al., 2018, 1800-MHz RFR; 0.00421 W/kg); delayed growth in rose (Grémiaux et al., 2016; 900 MHz RFR; 0.00072 W/kg); retarded memory in rat (Nittby et al., 2008; 900 MHz GSM signal; 0.0006 W/kg); adrenal gland stimulation in rat (Perov et al., 2019; 171 MHz RFR; 0.0006 W/kg); human blood mononucleus cells showed higher immunological activates (Szymanski et al., 2020; 0.024 W/kg) (see also the Table in Lai, 2018 on low-intensity effect on neurological functions); **static and ELF-EMF**: decreased number of living and quality of movement of sperms of mouse (de Bruyn and de Jager, 2010; 50-Hz MF $0.0005\text{--}0.077 \text{ mT}$) and free radicals (see Table 1: „Free radical effects observed at low intensities of static and ELF-EMF” in Lai, 2019, effects have been observed with exposure to a 50 Hz MF of 0.0005 mT). In addition, mechanisms have evolved for organisms to detect very low levels of static EMF, e.g., 26 nT (i.e., 0.000026 mT) in honey bees (Kirschvink et al., 1992); 20 microV/cm in platypus (Manger and Pettigrew, 1996); and 2–3 nT in songbird (Pakhomov et al., 2017). These capabilities of detecting very low-intensity static/ELF EMF fields is actually not surprising because they are results of evolution over millions of years to enable the survival of the species. On the other hand, these functions are much vulnerable to disturbance from recent man-made EMF. However, it is a little surprising that RFR at very low intensity could also cause biological effect. The RFR studied are mostly man-made and have only existed in the environment in the last several decades. This points to a possibility that EMFs (RFR and static/ELF EMF), in general, act on some common unknown basic biological mechanisms.

Interaction effects (citations of references in italic in this section are in supplements 1 and 2)

Another important observation of the studies is that EMF can interact with other entities and synergistically cause genetic effects. These entities include:

RFR: Chemical mutagens (Baohong et al., 2005); ultra-violet ray (Baohong et al., 2007); 17- β -estradiol (Cervellati et al., 2013); bee venom (Gajski and Garaj-Vrhovac, 2009);

garlic (Gurler et al., 2014); γ -radiation (He et al., 2017; Ji et al., 2016; Jiang et al., 2013); clastogens (Kim et al., 2008); incoherent electromagnetic noise (Lai and Singh, 2005; Wu et al., 2008; Yao et al., 2008); lipopolysaccharide (Lameth et al., 2020; Zuo et al., 2015); mitomycin C (Maes et al., 1996; Sannino et al., 2011, 2017; Zeni et al., 2012a; Zhang et al., 2002); x-rays (Manti et al., 2008; Gapeyev et al., 2014; Sannino et al., 2014); aphidicolin (Tiwari et al., 2008); picrotoxin (López-Martín et al., 2009); bleomycin (Koyama et al., 2003; Zong et al., 2015) and doxorubicin (Zhijian et al., 2010).

Static – and ELF-EMF: Zinc (Amara et al., 2007); Tremozolomide (Ashta et al., 2020); Cisplatin (Buldak et al., 2012; El-Bialy et al., 2013; Chen et al., 2010; Mahmoudinasab and Saadat, 2018a; Sanie-Jahromi and Saadat, 2017; Sanie-Jahromi et al., 2016); Bleomycin (Cho et al., 2007; Sanie-Jahromi and Saadat, 2017); Gadolinium (Cho et al., 2014); alkaline-ph (Fan et al., 2018); natural radioactivity in soil (Jouni et al., 2012); sodium fluoride (Kimsa-Dudek et al., 2018, 2020); gamma radiation (Arruda-Neto et al., 2009; Kubinyl et al., 2010; Lagroye and Poney, 1997; Mairs et al., 2007); hydrogen peroxide and methyl methane sulfonate (Koyama et al., 2008); menadione (Luukkunan et al., 2011, 2014, 2017; Markkanen et al., 2008), morphine (Mahmoudinasab and Saadat, 2018b); X-ray (Miyakoshi et al., 1996b; 1999, 2000; Teodori et al., 2014; Udroui et al., 2015); Xenobiotics (Moretti et al., 2005); lipopolysaccardide (Nakayama et al., 2016); heat (Robison et al., 2002); N-methyl-N'-nitro-N-nitrosoguanidine, 4-nitroquinoline N-oxide, benzene, 1,4-benzenediol, 1,2,4-benzenetriol (Scassellati Sforzolini et al., 2004; Villarini et al., 2000); mineral oil (Skyberg et al., 2001); Paclitaxel (Sun et al., 2012); IR (Yoon et al., 2014); FeCl₂ (Zmyslony et al., 2000); UV (Zmyslony et al., 2000).

Most of the compounds that have been shown to interact with EMF are mutagens. This is important because in real-life situations, a person is usually exposed simultaneously to EMF and many different environmental factors, including mutagens. On the other hand, some of these entities are drugs used in cancer chemotherapy. EMF can possibly be used as an adjuvant in chemotherapy to enhance the anticancer efficacy of these drugs and decrease their side-effects. Thus, synergism of these entities with EMF should be further studied.

However, it is important to point out that are reports (listed below) that showed no significant interaction effects.

RFR: Mitomycin C (Hansteen et al., 2009; Kerbacher et al., 1990; Maes et al., 1997, 2000, 2001, 2006; Zhijian et al., 2009); Adrimycin (Kerbacher et al., 1990); x-ray

(Maes et al., 2000; Stronati et al., 2006); proflavin (Meltz et al., 1990); 3-Chloro-4-(dichloromethyl)-5-Hydroxy-2 (5 H)-furanone (an environmental mutagen) (Sannino et al., 2009; Verschaeve et al., 2006).

Static – and ELF-EMF: Methylmethane sulfonate, chromate (Cantoni et al., 1996); UV (Cantoni et al., 1996; Mizuno et al., 2014); ionizing radiation, H₂O₂, mitomycin C (Jin et al., 2011, 2014); IR and H₂O₂ (Jin et al., 2015; Yoon et al., 2014); chemical mutagens (Verschaeve et al., 2011); heat (Williams et al., 2006).

Effects of waveform

Two other important findings of recent studies are that the effects of EMF are waveform specific and cell-type specific (Supplement 5). These findings underscore the complicity of interaction of EMF with biological tissues and may partially explain why effects were observed in some studies and not others. It is essential to understand why and how certain wave-characteristics of an EMF are more effective than other characteristics in causing biological effects, and why certain types of cells are more susceptible to the effect of EMF? The fact that “there are different biological effects elicited by different EMF wave-characteristics” is a critical proof for the existence of non-thermal effects.

Wave-form dependency is one of the major puzzles of Bioelectromagnetics research. In the 1970s, research in the laboratories of Ross Adey (Bawin et al., 1975; 1978) and Carl Blackman (Blackman et al., 1979) showed the importance of modulations on the EMF-carrier frequency on calcium efflux from cells. Other biological effects of EMF also showed wave-form dependency, e.g., see discussion in Lai (2018) on neurological effects of RFR. And, research presented here also showed similar dependency in EMF-induced genetic effects. So far, there has not been a credible unifying explanation for the “wave-form dependency effect”.

Regarding cell-type specificity, one can speculate that:

1. Cells that are metabolic active are more susceptible to EMF effects with an increase in generation of free radical in the mitochondria;
2. Cells that have higher anti-oxidative activities are less susceptible;
3. Transitional elements, e.g., iron, may play a role in the effect via the Fenton reaction (see Lai, 2019). Brain cells contain a relatively high concentration of free iron, particularly intercalated in the DNA molecules, and are more susceptible;
4. Cell cycle arrests are common in cells exposed to EMF. It may be a response to repair genetic damages caused by EMF. If damage could not be repaired, cell death occurs, particularly via apoptosis, which is a common outcome after EMF exposure. These effects are consistent with the gene expression

studies, showing activation of genes involved in both cell death and repair. 5. If genetic damaged cells are allowed to survive, cancer may occur. However, if they die, the risk of cancer would actually be reduced. But, other detrimental health outcomes may occur, e.g., death of brain cells could lead to neurodegenerative diseases. Increased incidences of degenerative diseases (including Alzheimer's disease, amyotrophic lateral sclerosis, dementia, and motor dysfunctions) after EMF exposure, particularly under occupational conditions, have been reported (Gervasi et al. 2019; Gunnarsson and Bodin 2018, 2019; Huss et al. 2018; Koeman et al. 2017; Jalilian et al. 2018; Pedersen et al. 2017; Sorahan and Mohammed 2014).

Discussion

The main question is whether EMF exposure could cause genetic effects? It is pertinent here to quote a recent statement made by two prominent bioelectromagnetic researchers (Barnes and Greenebaum, 2020): "The evidence that weak radiofrequency (RF) and low-frequency fields can modify human health is still less strong, but the experiments supporting both conclusions are too numerous to be uniformly written off as a group due to poor technique, poor dosimetry, or lack of blinding in some cases, or other good laboratory practices." All in all, in the studies reviewed in Supplements 1 and 2, approximately 70% of them showed effects. One could say that EMF exposure can lead to genetic changes. Some genetic damages could eventually lead to detrimental health effects. However, the mechanisms remain to be uncovered. But, knowing the mechanism is not necessary to accept that the data are valid. It is also a general criticism that most EMF studies cannot be replicated. I think it is a conceptual and factual misstatement. Replication is also not a necessary and sufficient condition to believe that certain data are true. Scientific studies are hardly replicated. Rational funders do not generally fund replications. All scientists should know that it is very difficult to replicate exactly an experiment carried out by another lab. This is particularly true when the effects of EMF depend on many unknown factors. By the way, not many replication experiments have been carried out in EMF genetic-effect research to justify the statement that "data from EMF are not replicable". In some cases, the experimenters deliberately changed the procedures of an experiment that they were supposed to be replicating and claimed that their experiment was a replication, for example, compare the experimental procedures of Lai and Singh (1995) and Malyapa et al. (1998).

To prove an effect, one should look for consistency in data. Genetic damage studies have shown similar effects with different set-up and in various biological systems. And, the gene expression results (Supplement 3) also support the studies on genetic damages. Expression of genes related to cell differentiation and growth, apoptosis, free radical activity, DNA repair, and heat-shock proteins have been reported. These changes could be consequences of EMF-induced genetic damages. In addition, other effects of EMF, such as mitotic-spindle disruption (De Amicis et al., 2015; Hintzsche et al., 2011; Li et al., 2013; Schrader et al., 2011, 2008; Tkalec et al., 2009) and "adaptive" effects, i.e., the ability of concomitant exposure of RFR to decrease the genotoxic effects of other agents, such as ionizing radiation (He et al., 2017; Ji et al., 2016; Jiang et al., 2012, 2013; Sannino et al., 2014, 2017, 2011; Sun et al., 2016; Zeni et al., 2012; Zong et al., 2015) also support the notion that EMF exposure could affect genetic processes in cells. In conclusion, there are enough reasons to believe that genetic effects of EMF are real and possible.

During cell phone use, a relatively constant mass of tissue in the brain is exposed to the radiation at relatively high intensity (peak specific absorption rate (SAR) of 4–8 W/kg). Many papers have reported genetic effect/DNA damage at much lower SAR (or power density) (see Supplement 4). This questions the wisdom of the several exposure standard-setting organizations in using the obsolete data of 4 W/kg (whole-body averaged SAR) as the threshold for exposure-standard setting. Furthermore, since critical genetic mutations in one single cell are sufficient to lead to cancer and there are millions of cells in a gram of tissue, it is inconceivable that some standards have changed the SAR from averaged over 1 gm to 10 gm of tissue. (The limit of localized tissue exposure has been changed from 1.6 W/kg averaged over 1 gm of tissue to 2 W/kg over 10 gm of tissue. Since distribution of radiofrequency energy is non-homogenous inside tissues, this change allows a higher peak level of exposure.) What actually needed is a better refinement of SAR calculation to identify 'peak values' of SAR inside the brain.

Any effect of EMF has to depend on the energy absorbed by a biological entity and on how the energy is delivered in space and time. Aside from influences that are not directly related to experimentation (Huss et al., 2007), many factors could influence the outcome of an experiment in bioelectromagnetics research. Frequency, intensity, exposure duration, and the number of exposure episodes can affect the response, and

these factors can interact with each other to produce different effects. In addition, in order to understand the biological consequences of EMF exposure, one must know whether the effect is cumulative, whether compensatory responses result, and when homeostasis will break down. A drawback in the interpretation and understanding of experimental data from bioelectromagnetic research is that there is no general accepted mechanism on how EMF affects biological systems. Since the energy level is not sufficient to cause direct breakage of chemical bonds within molecules, the effects are probably indirect and secondary to other induced chemical changes in the cell. The mechanisms by which EMF causes genetic effects are unknown. This author suspects that biological effects of EMF exposure are caused by multiple inter-dependent biological mechanisms.

Disclosure of Interest

The author declares no conflict of interest

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Supplement 1

Genetic effects of radiofrequency electromagnetic radiation (*study with no effect observed)
Study reported effect =237 (66%); study reported no effect = 124 (34%) (Literature up to January 2021).

	Exposure conditions	Results
*Agarwal et al. (2009)	Human semen sample to cell phone radiation in talk mode for 1 h	No significant DNA damage, increase in reactive oxygen species; decrease in sperm motility and viability.
Aitken et al. (2005)	Mice to 900-MHz RFR for 7 days at 12 h/day; SAR 0.09 W/kg	Significant damage to Mitochondrial genome and nuclear β -globin locus in epididymal spermatozoa.
Akdag et al. (2016)	Male Wistar-Albino rats to 2400 MHz RFR from a Wi-Fi signal generator for a year; SAR 0.000141 (min)- 0.007127 (max) W/kg	No significant change in DNA single strand breaks (Comet assay) in brain, kidney, liver, and skin tissues, increased in testes.
Akdag et al. (2018)	Men who used cell phone for different durations per day; peak head SAR 0.45-0.79 W/kg	Increased DNA single strand breaks (Comet assay) in ear canal hair follicle cells; a dose-response relationship was observed.
Akhavan-Sigari et al. (2014)	Resected Glioblastoma multiforme (GBM) brain tumors from human patients	Increased mutant type of p53 expression in the peripheral zone of GBM in patient who use cell phone form ≥ 3 h/day; the increase was significantly correlated with shorter overall survival time.
Alkis et al. (2019a)	Rats exposed to 900 MHz (brain SAR 0.0845 W/kg), 1800 MHz (0.04563 W/kg), and 2100 MHz (0.03957 W/kg) RFR 2 h/day for 6 months	Increased DNA single strand break (Comet assay), oxidative DNA damage, and oxidative stress in brain frontal lobe.
Alkis et al. (2019b)	Rats exposed to 900 MHz, 1800 MHz, and 2100 MHz RFR 2 h/day for 6 months; maximum SAR over the rat 0.017 W/kg	Increased DNA single strand beak (Comet assay), oxidative DNA damage and oxidative stress in testicular tissue.
Alkis et al. (2021)	Rats exposed to 1800	Significant increases in liver in 8-hydroxydeoxyguanosine, DNA single strand

	MHz (SAR 0.62 W/kg), 1800 MHz (0.04563 W/kg), or 2100 MHz (0.2 W/kg) RFR 2 h/day for 7 months	breaks (Comet assay), malondialdehyde, total oxidant status, oxidative stress index,
*Al-Serori et al. (2017)	Human U87 (wild-type) and U251 (mutated) glioblastoma cells exposed to intermittent (5 mi ON/10 min OF) UMTS 1750 MHz signal for 16 h, SAR 0.25, 0.5, and 1 W/kg	No effect on micronucleus frequency. Apoptosis was induced in U231 cells.
Al-Serori et al. (2018)	Ten human cell types exposed to intermittent (5 mi ON/10 min OF) UMTS 1750 MHz signal for 16 h, SAR 0.25, 0.5, and 1 W/kg	Increased in single strand breaks (Comet assay) in U87 p52- proficient glioblastoma cells grew under serum free condition; no effect on double strand breaks (γ H2AX foci); nucleotide excision repair induced.
*Antonopoulos et al. (1997)	Human blood samples exposed to 380 MHz (17.65 Hz modulation, 0.08 W/kg); 900 MHz (217 Hz modulation, 0.208 W/kg); or 1700 MHz (217 Hz modulation, 1.7 W/kg) for 48-68 h	No significant effect on cell cycle progression and frequency of sister-chromatin exchange in lymphocytes.
Atasoy et al. (2013)	Male Wister rats exposed to 2437 MHz (Wi-Fi) RFR; 24 h/day for 20 weeks; maximum SAR 0.091 W/kg	Increased oxidative DNA damage and decreased catalase and glutathione activities in blood and testes.
Atlı Şekeroğlu et al (2013)	Immature (whole body SAR 0.38-0.78 W/kg) and mature (0.31-0.52 W/kg) rats exposed to 900 MHz RFR 2 h/day for 45 days	Increased bone marrow cell chromosome aberration, micronucleus frequency, mitotic index and ratio of polychromatic erythrocytes. Cytogenetic damages in immature rats were significantly higher than in the mature rats. No recovery on day 15 post-exposure.
Balode (1996)	Blood samples from female Latvian Brown cows lived close to and in front of the Skrundra	Significantly higher micronucleus concentration was found in the erythrocytes of the exposed cows.

	Radars and from a control area	
Banerjee et al. (2016)	Buccal mucosal cells from subjects who used their cellular phone less than five years and less than three hours a week (low), and those who used more than five years and more than 10 hours a week comprised of the second group.	Micronucleated frequency in buccal mucosal cells was found to be significantly increased in longer cellular phone users.
Baohong et al. (2005)	Human lymphocytes exposed in vitro to 1800 MHz RFR (SAR 3 W/kg) for two hours and also co-treated with various mutagens	DNA strand break assayed (Comet assay) at 0 and 21 h after treatment. No effect when cells were exposed to RFR alone. But, RFR co-exposure enhanced the DNA damage induced by mitomycin C and 4-nitroquinoline-1-oxide.
Baohong et al. (2007)	Human lymphocytes exposed in vitro to 1800 MHz RFR (SAR 3 W/kg) for 0, 1.5, and 4 h. Cells were also co-treated with ultraviolet ray C	DNA damage as assayed by the Comet assay showed no significant effect with RFR alone. But, RFR co-exposure reduced DNA damage induced by ultraviolet C.
Beaubois et al. (2007)	Tomato plant leaves exposed to a 900-MHz RFR or 10 min at 0.066 mW/cm ²	Evoked rapid and substantial accumulation of basic leucine-zipper transcription factor (bZIP) mRNA in the terminal leaf with kinetics very similar to that seen in response to wounding. (Effect attenuated by calcium antagonist.)
Bektas et al (2020)	Pregnant women who used cell phone and Wi-Fi; placenta and cord blood samples were analyzed	Samples from cell phone users showed increased oxidative DNA damage and oxidative stress; Wi-Fi users showed increased oxidative DNA damage but no oxidative stress; more DNA single strand breaks (Comet assay) in cell phone users than in control (did not use cell phone nor Wi-Fi) and Wi-Fi users; Wi-Fi and cell phone uses were synergistic.
Belyaev et al. (1992)	X-irradiated E. coli cells exposed to 51.62-51.84 GHz and 41.25-41.50 GHz millimeter-wave	Power density of 1 μ W/cm ² was sufficient to suppress X-radiation-induced repair of genome conformational state.

	RFR	
Belyaev et al. (2005)	Lymphocytes from human subjects exposed to GSM 915 MHz RFR for 2 h ; SAR 0.037 W/kg;	Increased condensation of chromatin; no significant difference between responses of blood samples of healthy and electro-hypersensitive subjects.
Belyaev et al. (2006)	Rats exposed to GSM 915 MHz RFR for 2 h, SAR 0.4 W/kg	Affected gene expression in brain cells; no significant effect on chromatin conformation and double strand DNA breaks.
Belyaev et al. (2009)	Human lymphocytes exposed to UMTS cell phone signal(1947.4 MHz, 5 MHz band width) for 1 h; SAR 0.04 W/kg	Chromatin affected and inhibition of DNA double-strand break co-localizing 53BPI/gamma-H2AX DNA repair foci; lymphocytes from electro-hypersensitive subjects responded differently to UMTS and GSM signals in the formation of DNA repair foci than in healthy subjects.
*Bisht et al. (2002)	Mouse embryo sarcoma fibroblast C3H 10T½ cells exposed to FDMA (835.62 MHz; SAR 3.2 or 5.1 W/kg) and CDMA (847.74 MHz; SAR 3.2 or 4.8 W/kg) RFR for 3, 8, 16 or 24h	No significant effect on micronucleus formation.
Bourdineaud et al. (2017)	earthworms (<i>Eisenia fetida</i>) exposed to 900 MHz for 2 h; SAR 0.00013-0.00933 W/kg	DNA genotoxic effect persisted for at least 24 h; gene expressions up regulated for HSP70 (heat shock protein), MEKK1 (signal transduction); oxidative stress; and chemical and immune defenses.
*Bourthoumieu et al. (2010)	Human amniotic cells exposed to GSM-900 MHz RFR for 24 h; SAR 0.25 W/kg	No significant genotoxic effect was observed at 0 and 24 h after exposure by visual examination of chromosomal rearrangement.
*Bourthoumieu et al. (2011)	Human amniotic cells exposed to GSM-900 MHz RFR for 24 h; SAR 0.25, 1,2, and 4 W/kg	No significant change in the rate of aneuploidy of chromosomes 11 and 17 was found.
*Bourthoumieu et al. (2013)	Human amniotic cells exposed to GSM-900 MHz RFR for 24 h; SAR 0.25, 1,2, and 4 W/kg	No significant change in the expression and activation of the p53 protein was found. (p53 can cause cell cycle arrest and allow time for DNA repair or apoptosis.)
Burlaka et al. (2013)	Male Wister rats exposed to 245 MHz RFR for 2 h a day. 7 days a week for 2, 8, 15, or 30 days at 5-	Increased micronucleus formation was found in bone marrow erythropoietic cells after 15- day exposure; erythrocyte count, haemoglobin and haematocrit were

	10 mW/cm ² .	increased in peripheral blood after 8 and 15 days of exposure.
Buttiglione et al. (2007)	Human SH-SY5Y neuroblastoma cells exposed to modulated 900 MHz RFR for 24 h; SAR 1 W/kg	Increased Egr-1 gene expression paralleled with activation of the MAPK subtypes ERK1/2 and SAPK/JNK, and decrease in mRNA of Bcl-2 and surviving genes. RFR has anti-proliferative effect and causes cell cycle arrest at G2-M.
Cam and Seyhan (2012)	Hair root cells of human subjects after 15-30 min use of a 900-MHz GSM cell phone	Increased in DNA single strand breaks (Comet assay) was observed; more damages resulted after 30 min than after 15 min use.
Campisi et al. (2010)	Rat neocortical astroglial to 50 Hz-modulated or CW 900 MHz RFR for 5, 10, or 20 min; incident power density 0.0265 mW/cm ²	Significant increases in DNA fragmentation and reactive oxygen species were observed at 20 min only after exposure to the modulated RFR.
Cervellati et al. (2013)	Human placenta trophoblast-derived HTR-8/SVneo cells exposed to 1.8 GHz GSM RFR amplitude modulated by rectangular pulses of 217 Hz for 1 h; SAR 2 W/kg	Increased connexin Cx40 and Cx43 mRNA expression; decreased Integrin alpha1 and β 1 mRNA levels but enhanced Int alpha5 mRNA expression.
Chandel et al. (2019a)	Onion roots (<i>Allium cepa</i> L.) were exposed to 2350 MHz RFR for 1, 2, or 4 h, SAR 0.313 W/kg	Increased in mitotic index and chromosomal aberration; significant increase in DNA single strand break (Comet assay) at 2 and 4 h.
Chandel et al. (2019b)	Onion roots (<i>Allium cepa</i> L.) were exposed to 2100 MHz RFR for 1 or 4 h, SAR 0.282 W/kg	Increased mitotic index, chromosomal aberration, and DNA single-strand breaks (Comet assay) after 4 h of exposure.
*Chang et al. (2005)	<i>Escherichia coli</i> and <i>Salmonella typhimurium</i> exposed to 835 MHz RFR for 48h; SAR 4W/kg	835-MHz RFR neither affected the reverse mutation frequency nor accelerated DNA degradation in vitro. (Some interaction effects with mutagens were observed.)
Chaturvedi et al. (2011)	Male mice exposed to 2450 MHz RFR, 2 h/day for 30 days; SAR 0.03561 W/kg	Increased DNA single strand breaks (Comet assay) in brain cells.
*Chauhan et al. (2006a)	Human lymphoblastoma cells (TK6) exposed to pulsed-modulated,	No evidence of a general stress response with proto-oncogene and heat-shock protein gene transcriptions.

	intermittent (5 min ON, 10 min OFF) 1900-MHz RFR for 6 h; SAR 1 or 6 W/kg	
*Chauhan et al. (2006b)	Human –derived immune cell-lines HL-60 and MM6 cells exposed to pulsed-modulated, intermittent (5 min ON, 10 min OFF) 1900-MHz RFR for 6 h; SAR 1 or 10 W/kg	No evidence of detectable change in stress-related gene expression.
*Chauhan et al. (2007)	Human glioblastoma-derived cell-line (U87MG) and human monocyte-derived cell-line (MM6) exposed to pulsed-modulated, intermittent (5 min ON, 10 min OFF) 1900-MHz RFR for 24 and 6 h; SAR 0.1-10 W/kg	No evidence that the RFR exposure altered late onset gene expression in either cultured cell-lines.
Chavdoula et al. (2010)	Drosophila melanogaster flies exposed to GSM-900 MHz and DCS-1800 MHz cell phone radiation; 6 min per day for 5 days	Decreased insect's reproductive capacity with fragmented DNA (apoptosis) in the egg chamber.
*Chemeris et al. (2004)	Frog (<i>Xenopus laevis</i>) erythrocytes exposed to high peak power pulsed RFR (8.8 GHz, 180 ns pulse width, peak power 65 kW, repetition rate 50 Hz) for 40 min; SAR 1.6 kW/kg (peak SAR 300 MW/kg)	Increased DNA single strand breaks (Comet assay) caused by temperature rise.
*Chemeris et al. (2006)	Human whole blood leukocytes and isolated lymphocytes exposed to pulsed 8.8 Hz RFR (180 ns pulse width, peak power 65 kW, pulse repetition frequency 50 Hz) for 40 min: average SAR 1.6 kW/kg (peak	No change in DNA single strand breaks (Comet assay)

	300 mW/kg)	
Chen et al. (2012)	Saccharomyces cerevisiae yeast cells exposed to 1800 MHz RFR for 6 h; SAR 4.7 W/kg	Expression of several genes.
*Choi et al. (2020)	Human adipose tissue-derived stem cells (ASCs), Huh7 and Hep3B liver cancer stem cells (CSCs), HeLa and SH-SY5Y cancer cells, and normal fibroblast IMR-90 cells exposed to WCDMA-signal 1.7-GHz RFR for 72 h, SAR 1 and 2 W/kg	No significant effect on double strand breaks; increased intracellular reactive oxygen species and decreased proliferation.
*Ciaravino et al. (1991)	Chinese hamster ovary cells exposed to 2450-MHz pulsed RFR (SAR 33.8 W/kg) simultaneously with adriamycin for 2 h	RFR did not affect changes in cell progression and number of sister chromatid exchanges induced by adriamycin.
d'Ambrosio et al. (1995)	Human blood exposed to 9 GHz RFR (continuous-wave or 50-Hz amplitude modulated) for 10 min; SAR 90 W/kg	Increased in micronucleus frequency in lymphocytes after exposure to the amplitude modulated RFR.
d'Ambrosio et al. (2002)	Human blood cultures exposed to 1748 MHz RFR (continuous –wave or phase modulated (GMSK)) for 15 min: SAR ~5 W/kg	Micronucleus frequency in lymphocytes was increased only after exposure to phase-modulated RFR.
Danese et al. (2017)	Human whole blood exposed to 900 MHz RFR from a cell phone for 30 min	No change in frequency of γ -H2AX foci (double strand DNA breaks) in lymphocytes.
De Amicis et al. (2015)	Human fetal fibroblasts exposed to THz radiation (0.1-0.15 THz) for 20 min; SAR 15-20 W/kg	Increased total number of micronuclei and centromere positive micronuclei that could lead to chromosome loss. No significant effect on DNA strand breaks (Comet assay), phosphorylation of H2AX histone and apoptosis.
De Iuliis et al. (2009)	Human spermatozoa exposed to 1800-MHz	Increased oxidative DNA damage and fragmentation (apoptosis) and reactive

	RFR; SAR 0.4 – 27.5 W/kg for 16 h	oxygen species; sperm motility and vitality were reduced.
*de Oliveira et al. (2017)	Human buccal cells from cell phone users; Averaged years of use 11.4 yrs; mean duration of daily use 2.8 min	Cells ipsilateral to cell phone use did not have a statistically significantly higher micronucleus frequency, compared to cells contralateral to exposure.
Del Re et al. (2019)	Human HeLa, BE2C and SH-SY5Y cells exposed to 900 MHz 217-Hz pulse-modulated RFR for 48 h; SAR 1 W/kg	Increased transcription of repetitive DNA, type of transcription depended on cell type. (Alteration of repetitive DNA transcription can be induced by environmental stress conditions, causing human pathological effects.)
Del Vecchio et al. (2009)	Murine SN56 cholinergic cell line (48 and 72 h) and rat primary cortical neurons (24, 72, 120 h) exposed to GSM-modulate 900 MHz RFR; SAR 1 W/kg	Increased expression of beta-thymosin (cytoskeleton regulating factor) m-RNA, and reduced neurite generation.
Demsia et al. (2004)	Rats exposed to 910-MHz RFR 2 h/day for 30 days; SAR 0.42 W/kg.	Increased of micronuclei in polychromatic polymorphonuclear cells in bone marrow smears. Effects less in female rats.
Deshmukh et al. (2013)	Male Fischer rats exposed to 900 MHz (0.0005953 W/kg), 1800 MHz (0.0005835 W/kg), and 2450 MHz (0.0006672 W/kg) RFR for 2 h/day, 5 days/week for 30 days.	Increased DNA single strand breaks (Comet assay) in brain tissues.
Deshmukh et al. (2015)	Male Fischer rats exposed to 900 MHz (0.0005953 W/kg), 1800 MHz (0.0005835 W/kg), and 2450 MHz (0.0006672 W/kg) RFR for 2 h/day, 5 days/week for 180 days.	Increased DNA single strand breaks (Comet assay) in brain tissues; elevated heat-shock protein-70 level.
Deshmukh et al. (2016)	Male Fischer rats exposed to 900 MHz (0.0005953 W/kg), 1800 MHz (0.0005835 W/kg), and 2450 MHz (0.0006672 W/kg) RFR for 2 h/day, 5 days/week	Increased DNA single strand breaks (Comet assay) in brain tissues; elevated heat-shock protein-70 level.

	for 90 days.	
Diem et al.(2005)	Human diploid fibroblasts and cultured rat granulosa cells exposed to 1800 MHz intermittent (5 min On/10 min Off) or continuous –wave; SAR 1.2 or 2 W/kg	Increased in DNA single and double strand breaks (Comet assay) in both cell types after 16 h exposure. Intermittent wave showed a higher effect than continuous wave.
Duan et al (2015)	Mouse spermatocyte-derived GC-2 cells exposed to intermittent (5 min On/10 min Off) 1800 MHz RFR (from a GSM cell phone in talk mode) for 24 h; SAR 1.2 , or 4 W/kg	Increased oxidative DNA damage a 4 W/kg; no significant with Comet assay.
*Durdik et al. (2019)	Umbilical cord blood (UCB) cells exposed to a GSM900 (1-17 h, 0.004 or 0.04 W/kg) or UMTS-1947.4 MHz (3 h, 0.04 /kg) cell phone signals fed to a TEM cell	No changes in DNA single and double strand breaks (Comet assay), and apoptosis; increased reactive oxygen species was observed.
Eker et al. (2018)	Female Wistar-albino rats exposed to 1800-MHz RFR for 2h/day for 8 weeks; SAR 0.06 W/kg	Caspase-3 and p38MAPK gene expressions increased in eye tissues.
Engelmann et al. (2008)	Cell suspension cultures of Arabidopsis thaliana exposed to 1900 MHz UMTS-modulated RFR for 24 h; SAR peak 2 W/kg, average 0.75 W/kg	Significant changes in transcription of 10 genes.
Esmekaya et al. (2011)	Human peripheral blood lymphocytes exposed to 1800 MHz GSM- (217 HZ) modulated RFR for 6, 8, 24, or 48 h; SAR 0.21 W/kg	Chromatin changes and increase in sister chromatin exchange.
*Falzone et al. (2010)	Human spermatozoa exposed to pulse-modulated 900-MHz RFR for 1 h; SAR: 2.0 and 5.7 W/kg	No significant effects on DNA fragmentation, reactive oxygen species, and capase-3 activity.

Ferreira et al. (2006)	Pregnant rats exposed to a cell phone at 834 MHz for 8.5 h/day from conception to birth; SAR 0.55-1.23 W/kg	Increased erythrocyte micronucleus frequency but no significant effects in oxidative parameters in blood and liver of newborn pups.
Figueiredo et al. (2004)	Human whole blood exposed to 2.5 GHz RFR (from a microwave oven) for 40 sec (SAR 626.67 W/kg) or 10.5 GHz RFR for 5 min (SAR 0.25 W/kg)	No chromosomal aberrations observed in lymphocytes; no alteration in radiosensitivity to gamma radiation; cell mortality increased markedly after RFR exposure.
*Finnie et al. (2006)	Pregnant mice exposed to 900-MHz RFR (modulated at 217 Hz with pulse-width of 0.6 ms) for 60 min per day from day 1-19 of gestation; SAR 4 W/kg	No significant effect on c-fos expression in brain of offspring.
Fragopoulou et al. (2018)	C57BL/6 adult male mice exposed to 2 hr to GSM 1800-MHz RFR (from a phone) for 2 h at an average power density of 0.0049-0.081 mW/cm ²	In the hippocampus, the expression of 178 genes changed significantly, revealing an impact on genes involved in critical biological processes, such as cell cycle, DNA replication and repair, cell death, cell signaling, nervous system development and function, immune system response, lipid metabolism, and carcinogenesis.
Franchini et al. (2018a)	Human fetal and adult fibroblasts exposed to 25 GHz RFR for 20 min; SAR 20W/kg	Increased total number of micronuclei and centromere positive micronuclei in exposed samples. No significant effect on DNA single strand break (Comet assay).
Franchini et al. (2018b)	Human adult fibroblasts exposed to 0.15 THz (150 GHz) RFR (4 μ s pulses at 25 Hz) for 20 min; SAR 15-20 W/kg	Increased centromere-positive micronuclei frequencies and chromosomal nondisjunction events, indicating induction of aneuploidy and not by DNA breakage.
Franzellitti et al. (2008)	Human trophoblasts HTR-8/SVneo exposed to 1800 MHz continuous-wave, GSM-217-Hz, and GSM-Talk signals for 4-24 h, time averaged SAR 2 W/kg	Levels of the inducible HSP70C transcript were significantly enhanced after 24 h exposure to GSM-217Hz signals and reduced after 4 and 16 h exposure to GSM-Talk signals. No effect on inducible HSP70A, HSP70B and the constitutive HSC70 transcripts.
Franzellitti et al. (2010)	Human trophoblast HTR-8/SVneo cells exposed to 1800 MHz	GSM signals increased DNA single strand breaks (Comet assay) after 16 and 24 h exposure; recovered within 2 h post-

	continuous –wave. GSM (217 Hz modulated) and GSM intermittent (5 min on/10 min off) RFR for 4, 16, or 24 h: SAR 2 W/kg	exposure; continuous-wave RFR was without effect.
*Fritze et al. (1997)	Rats expose to GSM 90 MHz RFR for 4 h, brain average SAR 0.3- 1.5 W/kg	No effect on C-jun and GFAP expression in brain.
Fucic et al. (1992)	Lymphocytes from humans occupationally exposed to RFR; 1250-1350 MHz, 10 μ W/cm ² -20 mW/cm ²	Showed preferentially clastogenic effect measured by micronucleus. Effect on genetic material similar to both of a chemical agent and of ionizing radiation.
Furtado-Filho et al. (2014)	Rats of different ages (0-30 days) exposed 950 MHz RFR for 0.5 h/day for 51 days (21 days of gestation and 6-30 days old): SAR pregnant rat 0.01-0.03 W/kg; neonate 0.88 W/kg, 6-day old 0.51 W/kg, 15-day old 0.18 W/kg, 30-day old 0.06 W/kg.	Decreased DNA single strand breaks (Comet assay) in liver of 15-day old and increased breaks in 30-day old rats, no oxidative stress detected.
*Furtado-Filho et al. (2015)	At exposed to 950 MHz RFR. 0.5 h/day to 27 days (throughout pregnancy and 6 days postnatal); SAR 0.44-0.35 W/kg, neonatal rat 1.32 W/kg, 6-day old 1.14 W/kg	Right cerebral cortex showed an increase in DNA single strand breaks (Comet assay), but no significant effect in the left cerebral cortex in RFR-exposed 6-day old rats. No oxidative effects observed.
Gadhia et al. (2003)	Blood samples of cell phone and non-cell phone users	Increased dicentric chromosomes and sister chromatid exchange in lymphocytes of cell phone users.
Gajski and Garaj-Vrhovac (2009)	Blood samples from Wistar rats exposed to GSM-modulated 915 MHz RFR for 30 min, SAR 0.6 W/kg	Increased basal (single strand) and oxidative DNA damage (Comet assay) in lymphocytes.
Gandhi and Anita (2005)	Blood from cell phone users (most for 2-5 yrs)	Increased DNA single strand breaks (Comet assay) and micronucleus found in cell phone users.
Gandhi and Singh	Blood and buccal cells	Increased micronucleated buccal cells and

(2005)	from cell phone users (3-4,5 yrs); controls never used cell phone	chromosomal aberration in peripheral lymphocytes.
Gandhi et al. (2015)	People lived within 300 m of a cell phone base station (average power density= 1.149 mW/cm ²) for an average of 7.45 yrs, controls average power density = 0.0045 mW/cm ² .	Increased DNA single strand breaks (Comet assay) in peripheral blood leukocytes. Daily cell phone usage, location of residence, and power density are significant predictor of DNA damage.
Gapeyev et al. (2014)	Mouse blood samples exposed to 1-Hz pulse-modulated 42.2 GHz RFR for 20 min, SAR 1.5 W/kg; and x-rays	Pre-exposure to pulse-modulated RFR (not continuous-wave) reduced x-ray-induced DNA single strand breaks (Comet assay) in lymphocytes Effect may be related induction of reactive oxygen species by RFR.
Garaj-Vrhovac et al. (1990)	V79 Chinese hamster cells exposed to 7.7 GHz RFR for 15, 30, or 60 min; power density 30 mW/cm ²	Inhibited [³ H]thymidine into DNA with stoppage of cell cycle at S phase; chromosome aberration observed.
Garaj-Vrhovac et al. (1991)	V79 Chinese hamster fibroblast cells exposed to 7.7 GHz RFR for 15, 30, or 60 min; power density 0.5 mW/cm ²	Increased chromosome aberration (dicentric and ring chromosomes) and micronucleus.
Garaj-Vrhovac et al. (1992)	Human whole blood samples exposed to 7.7 GHz RFR for 10, 30, or 60 min; power density 0.5, 10, or 30 mW/cm ²	Increased chromosome aberration (dicentric and ring chromosomes) and micronucleus in lymphocytes.
Garaj-Vrhovac and Fucic (1993)	Air traffic controllers who did repair on radar devices two days ago and exposed to 1250-1350 MHz RFR of unknown intensity (pulse power 100 kW). (presumably higher than normal exposure of 10 µW/cm ² -20 mW/cm ²)	Lymphocytes showed increased number of chromosome breaks, acentric fragments, dicentric and polycentric chromosomes with accompanying fragments, ring chromosomes and chromatid interchange. Most aberrations returned to normal after 30 weeks, except dicentrics and ring chromosomes.
Garaj-Vrhovac. (1999)	Peripheral blood lymphocytes of workers on radar equipment and antenna system service, 1250-1350 MHz; power	Exposed subjects shows an increase in the number of micronucleus and number of micronucleus per cell; disturbance of cells in the cell cycle.

	density 10 $\mu\text{W}/\text{cm}^2$ -20 mW/cm^2 ; average employment duration 13.3 yrs	
Garaj-Vrhovac and Orescanin (2009)	Peripheral blood lymphocytes of workers on radar equipment and antenna system service, 1250-1350 MHz; power density 10 $\mu\text{W}/\text{cm}^2$ -20 mW/cm^2 ; average employment duration 13.3 yrs	Increased DNA single strand breaks (Comet assay) and bleomycin-induced chromatid breakage.
Garaj-Vrhovac et al. (2009)	Wistar rats exposed to 915 MHz RFR 1 h/day for two weeks, SAR 0.6 W/kg	Increased basal DNA single strand break and oxidative DNA damages (Comet assay) in blood leukocytes.
Garaj-Vrhovac et al. (2011)	Workers occupationally exposed to marine radar pulsed RFR (3, 5.5, and 9.4 GHz)	Increased DNA single strand break (Comet assay) and micronucleus in blood lymphocytes; increased oxidative stress.
*Garson et al. (1991)	Blood samples of radio- linemen occupationally exposed to 400 kHz – 20 GHz	No increase in chromosomal damage in lymphocytes.
Ghatei et al. (2017)	Mice exposed pre- and post-natally to radiation from a cellular phone jammer (900 and 1800 MHz)	At 8-10 weeks old, in the cerebellum, no effect on expression level of bcl-2 and p53 genes, but gene expression level of <i>bax</i> was decreased and gene expression level of <i>p21</i> was increased.
*Glaser et al. (2016)	Human hematopoietic stem cells and leukemia HL-60 cells exposed to GSM (900 MHz), UMTS (1,950 MHz) and LTE (2,535 MHz) for 4, 20 or 66 h; SAR 0-4 W/kg	No effect on apoptosis, oxidative stress, cell cycle, DNA damage (DNA single strand breaks (Comet assay)) and DNA repair. A significant decrease in DNA breaks was found in hematopoietic stem cells exposed for 4 h to GSM signal.
Gökçek-Saraç et al. (2020)	Rats exposed to UMTS 2100 MHz RFR 2h/day for 7 days; whole body average SAR 0.47 or 2.17 W/kg	Decreased RNA expressions of acetylcholinesterase (AChE), choline acetyltransferase (ChAT), and vesicular acetylcholine transporter (VACHT) in the hippocampus; deficit in object location and Y-maze tests.
*Görlitz et al. (2005)	B6C3F1 mice exposed to GSM900 or DCS 1800 signals for 2 h/day for 1	No effect on micronucleus frequency in erythrocytes of the bone marrow or peripheral blood, in keratinocytes, or in

	week (SAR 0-33.2 W/kg) or 6 weeks (SAR 0-24.9 W/kg)	spleen lymphocytes.
Gorpinchenko et al. (2014)	Human sperms exposed to a cell phone in stand-by/talk mode for 5 h	Increased DNA fragmentation (apoptosis) and decreased motility in spermatozoa.
Gulati et al. (2016)	Blood and buccal cells of people lived close (<400 meters) to a cell tower; 1800 MHz, Maximum power density (at 150 meters) $1.22 \mu\text{W}/\text{cm}^2$, some subjects lived in the area for more than 9 yrs	Increased DNA single strand breaks (Comet assay) in lymphocytes and micronucleus in buccal cells. Female subjects had significantly higher effects than males.
Gulati et al. (2018)	Blood samples from subjects lived 400 m from cell towers for 8-9 years, power density $0.037\text{-}12.20 \text{ mW}/\text{cm}^2$	A significant association of genetic polymorphism of antioxidant genes (for MnSOD and CAT) with oxidative damage has been observed in human population exposed to radiations emitted from mobile towers. Decreased MnSOD and CAT activities and increased lipid peroxidation observed in blood serum.
Gulati et al. (2020)	Human lymphocytes exposed to UMTS signals at 1923, 1947.47, and 1977 MHz for 1 or 3 hr; SAR 40 mW/kg	Observed DNA damage (Comet assay) depending on UMTS frequency with maximal effect at 1977 MHz; no effects on ROS, apoptosis, preleukemic fusion genes, and mutations in TP53 gene.
Guler et al (2010)	Pregnant and non-pregnant New Zealand white rabbit exposed to GSM 1800-MHz RFR for 15 min/day for 7 days (15 th to 22 nd days of gestation); power density $0.052 \text{ mW}/\text{cm}^2$	Increased oxidative DNA damage and lipid peroxidation in brain tissues in adult rabbits, no significant effect in newborn rats
Guler et al. (2012)	New Zealand white rabbits exposed to GSM 180-MHz RFR for 15 min/day in utero between 15 th to 22 nd days of gestation and at 1-month old 15 min/day 7 days for female and 14 days for male; SAR 1.8 W/kg	Increased DNA oxidative damage in liver of female rabbits (not in male) and increased lipid peroxidation in liver of both male and female rabbits.
*Gurbuz et al. (2010)	Female Wistar rats	No significant effect on micronucleus

	exposed to GSM 1800-MHz RFR 20 min/day, 5 days/week for 1 month; power density 0.0054 mW/cm ²	frequency in bladder cells.
*Gurbuz et al. (2014)	Male Wistar rats exposed to 1800- or 2100-MHz RFR 30 min/day, 6 days/week for 1 or 2 months; SAR 0.23 W/kg	No significant effect on micronucleus frequency in bladder cells.
*Gurbuz et al. (2015)	Normal and diabetic rats exposed to a 2100-MHz RFR 30 min/day, 5 days/week for 1 month; SAR 0.24 W/kg	No effect on micronucleus frequency in exfoliated bladder cells in both normal rats and rats with chronic disorder.
*Gurisik et al. (2006)	Two human cell lines (neuronal SK-N-SH) and monocytoid U937) exposed to a GSM 900-MHz RFR for 2 h; SAR 0.2W/kg	No significant effects on gene expression, heat shock protein level, and cell cycle distribution in SK-N-SH cells; and no effects on cell viability and cell cycle in U937 cells.
Gürler (2014)	Wistar rats exposed to 2450 MHz RFR 1 h/day for 30 consecutive days; power density 0.0036 mW/cm ²	Increased oxidative DNA damage in brain and blood, and oxidative protein products in blood.
Gustavino et al. (2016)	Secondary roots of Vicia faba (broad bean) seedlings exposed to continuous-wave 915-MHz RFR for 2 h; SAR 0.4-1.5 W/kg	Increased micronucleus frequency up to 7-fold.
Habauzit et al. (2014)	Human keratinocytes exposed to 60.4 GHz RFR for 3 hr, incident power density of 20 mW/cm ² : SAR 594 W/kg (average), 1233 M/kg (peak)	7 gene expressions showed specific electromagnetic effect under hyperthermia condition (i.e., not mimicked by heat-shock controls).
* Habauzit et al. (2020)	Male hairless rats exposed to 94 GHz RFR 3 h/day, 3 days/week for 5 months, incident power density 10 mW/cm ²	No significant modification of gene expression in skin cells.
Haider et al. (1994)	Plant cutting bearing young flower buds	Increased micronucleus was found in all conditions (compared to lab controls).

	exposed for 30 h to short-wave 10-21 MHz RFR on both sides of a slewable curtain antenna (0.424-7.67 mW/cm ²), at 15 m (2.15 mW/cm ²) and 30 m (1.3 mW/cm ²) from a cage antenna; and 200 m from a broadcasting station (0.00027-0.0024 mW/cm ²)	
Hanci et al. (2013)	Pregnant rats exposed 1 h/day on days 13-21 of pregnancy to 900-MHz RFR at power density 0.0265 mW/cm ² .	Testicular tissue of 21-day old offspring showed increased DNA oxidative damage, apoptotic index, and lipid peroxidation.
*Hansteen et al. (2009a)	Human lymphocytes exposed to 18 GHz or pulsed 16.5 GHz RFR for 53 h	No significant effect on chromosomal aberration frequency.
*Hansteen et al. (2009b)	Human lymphocytes exposed to 2.3 GHz continuous-wave or pulsed (200 Hz, 50% duty cycle) RFR	No significant effect on chromosomal aberration frequency.
Hao et al. (2010)	Murine N9 microglial cells were exposed to pulsed 2450-MHz RFR for 20 min, SAR 6.2 W/kg	Significant induced phosphorylation of STAT3, increased transcription levels of the inflammation-associated genes, iNOS and TNF-alpha, which are reported to contain STAT-binding elements in their promoter region. (STAT3 is a transcription activator that mediates the expression of a variety of genes in response to cell stimuli, and thus plays a key role in many cellular processes such as cell growth and apoptosis.)
He et al. (2016)	Mouse bone marrow stromal cells exposed to a 900 MHz RFR 3 h/day for 5 days; peak and average SAR 4.1×10^{-4} and 2.5×10^{-4} W/kg	Increased expression of PARP-1 mRNA. (PARP-1 involved in DNA repair, genomic stability and apoptosis and is activated by DNA single strand breaks.)
He et al. (2017)	Mouse bone marrow stromal cells exposed to a 900 MHz RFR 3 h/day for 5 days; peak and average SAR 4.1×10^{-4}	Induced PARP-1. Cells exposed to RFR and gamma ray showed significantly decreased genetic damage (DNA single strand break (Comet assay)) as well as faster kinetics of repair compared with those exposed to GR

	and 2.5×10^{-4} W/kg, some cells were challenged with one dose of gamma ray.	alone.
Hekmat et al. (2013)	Calf thymus exposed to 940 MHz RFR for 45 min; SAR 0.04 W/kg	Altered DNA structure at 0 and 2 h after exposure; conformational changes and disaggregation caused by increment in surface charge and size of DNA.
*Hintzsche and Stopper (2010)	Oral cavity mucosa cells from human subjects who used cell phones for different durations weekly (0, <3 h, and > 3h)	No significant change in micronucleus frequency in mucosa cells with cell phone use.
*Hintzsche et al. (2012a)	Human HaCaT cells and A(L) human-hamster hybrid cells exposed to continuous-wave or GSM-modulated 900 MHz RFR for 30 min or 22 h; power density 0.0066-2.15 mW/cm ²	No significant effect on micronucleus frequency.
*Hintzsche et al. (2012b)	Human keratinocytes (HaCaT) and human dermal fibroblasts (HDF) exposed to 0.106 THz (106 GHz) RFR for 2, 8, 24 h; 0.88 -2 mw/cm ² (2mw/cm ² gave a SAR of 13.34 W/kg)	No effect on micronucleus frequency and DNA single strand breaks (Comet assay).
*Hirose et al. (2006)	Human glioblastoma A172 cells exposed to 2.1425 GHz W-CDMA radiation at SARs of 0.08, 0.25, and 0.8 W/kg, and continuous-wave radiation at 0.08 W/kg for 24 or 48 h; and human IMR-90 fibroblasts from fetal lungs exposed to both W-CDMA and continuous-wave RFR at a SAR of 0.08 W/kg for 28 h	No significant changes in induction of p53-dependent apoptosis, DNA damage, or other stress response
*Hirose et al. (2007)	Human glioblastoma	No significant induction of phosphorylation

	A172 cells were exposed to W-CDMA radiation at SARs of 0.08 and 0.8 W/kg for 2-48 h, and continuous-wave 2.1425 GHz RFR at 0.08 W/kg for 24 h, and human IMR-90 fibroblasts from fetal lungs were exposed to W-CDMA at 0.08 and 0.8 W/kg for 2 or 28 h, and continuous-wave at 0.08 mW/kg for 28 h.	of hsp27 or expression of heat shock protein gene family.
*Hook et al. (2004)	Human Molt-4 T lymphoblastoid cells exposed to 847.74 MHz code-division multiple-access (CDMA) (SAR 3.2 W/kg), 835.62 MHz frequency-division multiple-access (FDMA) (3.2 W/kg), 813.56 MHz iDEN(R) (iDEN) (0.0024 or 0.024 W/KG), and 836.55 MHz time-division multiple-access (TDMA) (0.0026 or 0.026 W/kg) for up to 24 h	No significant changes in DNA single strand breaks (Comet assay) and apoptosis.
*Hou et al. (2015)	Mouse embryonic fibroblasts (NIH/3T3) exposed to intermittent (5 min on/10 min off) 1800-MHz GSM-talk mode RFR from 0.5 to 8 h; SAR 2 W/kg.	No effect on γ H2AX foci frequency (Increased reactive oxygen species and late apoptotic cells).
Houston et al. (2019)	Male mice exposed to 906 MHz RFR for 12 h/day for 1, 3, or 5 weeks; SAR 2.2 W/kg	Increased DNA oxidative and fragmentation (Comet assay) in spermatozoa across all exposure periods, increased mitochondrial reactive oxygen species.
*Huang et al. (2008a)	Jurkat human T lymphoma cells exposed for 24 h to 1763 MHz RFR; SAR 10 W/kg	Alterations in cell proliferation, cell cycle progression, DNA integrity (Comet assay) or global gene expression were not detected.
*Huang et al. (2008b)	HEI-OC1 immortalized mouse auditory hair cells	No significant effects on cycle distribution, DNA damage (Comet assay), stress response

	exposed to 1763 MHz (CDMA) RFR for 24 or 48 h; SAR 20 W/kg	and gene expression.
*Jeong et al. (2018)	14-month old C57BL/6 mice exposed to 1950 MHz RFR for 2 h/day, 5 day/wk, 8 months; SAR 5 W/kg	No significant effects on levels of oxidative stress, oxidative DNA damage, apoptosis, astrocyte, or microglia markers in brain tissues.
Jeong et al. (2020)	2 and 12-month old C57BL/6 mice exposed to 1950-MHz RFR 2h/day, 5 day/wk for 8 months; SAR 5 W/kg	Increased expression of Epha8 and Wnt6 genes in the hippocampi at 20 months after exposure, although 13 additional genes showed no significant changes. Cognitive enhancement detected in 1-month mice after exposure may be associated with increases in neurogenesis-related signals.
Ji et al (2004)	Human subjects used cell phones for 4 h.	DNA single strand breaks (Comet assay) increased in peripheral blood cells (T-cells, B-cells, granulocytes).
Ji et al. (2016)	Mouse bone-marrow stromal cells (BMSC) exposed to 900-MHz RFR for 4 h/day for 5 days; power density 0.12 mW/cm ² ; some cells were also irradiated with 1.5 Gy γ -radiation after RFR exposure	RFR followed by γ -radiation exposure significantly decreased number of DNA strand breaks (Comet assay) and resulted in faster kinetics of repair of DNA strand breaks compared to γ -radiation alone. Thus, data suggest that RFR preexposure protected cells from damage induced by γ -radiation.
Jiang et al. (2012)	Mice were pre-exposed to a 900-MHz RFR for 4 h/day for 1, 3, 5, 7, and 14 days; power density 0.12 mW/cm ² and then subjected to an acute dose of 3 Gy γ -radiation	DNA single strand breaks (Comet assay) in blood leukocytes from mice pre-exposed to RFR for 3, 5, 7, and 14 days showed progressively decreased damage and was significantly different from those exposed to γ -radiation alone.
Jiang et al. (2013)	Mice exposed to a 900-MHz RFR 4/day for 7 days, SAR 0.548 W/kg and also γ -radiation	Pre-exposure to RFR decreased micronucleus frequency induced by γ -radiation in immature erythrocytes in peripheral blood and bone marrow.
*Juutilainen et al. (2007)	Female CBA/S mice were exposed for 78 weeks (1.5 h/day, 5 day/week) to either a continuous 902.5-MHz signal similar to that emitted by analog NMT (Nordic Mobile	No significant effects of RFR on micronucleus frequency in polychromatic or normochromatic erythrocytes.

	Telephone) phones at a whole-body SAR of 1.5 W/kg, or to a pulsed 902.4-MHz signal similar to that of digital GSM phones at 0.35 W/kg and also 4 Gy of X-ray on the first three weeks; female transgenic mice (line K2) and their nontransgenic littermates were exposed for 52 weeks (1.5 h/day, 5 day/week) to two digital mobile phone signals, GSM and DAMPS at SAR 0.5 W/kg, and repeated ultraviolet radiation	
Karaca et al. (2012)	Mouse brain cells exposed to a 10.715 GHz RFR for 6 h/day for three days, SAR 0.725 W/kg	Increased micronucleus apoptosis and necrosis, and decreased expression of the STAT3 genes.
*Kerbacher et al. (1990)	Chinese Hamster Ovary cells exposed for 2 h to pulsed 2450 MHz RFR; SAR 33.8 W/kg	No significant effect on chromosome aberration; no interactions with Mitomycin C and Adriamycin.
Kesari and Behari (2009)	Male Wistar rats exposed to 50-GHz RFR 2 h/day for 45 days; SAR 0.0008 W/kg	Increased in brain tissue DNA double strand breaks (Comet assay); decreased antioxidant enzymes superoxides dismutase and glutathione peroxidase, and increased catalase activity.
Kesari et al. (2010)	Male Wistar rats exposed to 2.45-GHz RFR 2 h/day for 35 days; SAR 0.11 W/kg	Increased in brain tissue DNA double strand breaks (Comet assay); decreased antioxidant enzymes superoxides dismutase and glutathione peroxidase, and increased catalase activity.
Kesari et al. (2011)	Male Wistar rats exposed to 900 MHz-GSM signal 2 h/day for 35 days; SAR 0.9 W/kg	Decreased micronucleus frequency, change in cell cycle and increased oxidative stress in sperm cells.
Kesari et al. (2014)	Male Wistar rats exposed to a 3D cell phone. 2h/day for 60 days; SAR 0.26 W/kg	Increased DNA double strand breaks (comet assay), micronuclei, Caspase 3 and apoptosis in brain cells; activation of hsp27/p38MAPK stress pathway.
*Khalil et al (2011)	Mice exposed to 900	No effects on plasma, brain, and spleen 8-

	MHz-GSM signal 30 min/day for 30 days; SAR 1 W/kg	oxo-7, 8-dihydro-2'- deoxyguanosine and oxidative stress.
Khalil et al. (2012)	Male Sprague-Dawley rats exposed for 2 h to 1800-MHz GSM signal, SAR 1 W/kg	Urine samples collected 0.5, 1, 2, and 4 h from the beginning of exposure showed elevated 8-oxo-7, 8-dihydro-2'-deoxyguanosine (from repair of oxidative DNA damage) level.
*Khalil et al. (2014)	Saliva of cellular phone users collected before as well as after 15 and 30 min use of phones.	No change in 8-oxo-7,8-dihydro-2'-deoxyguanosine (8-Oxo-dG). There was no relationship between cell phone use and changes in the salivary oxidant/antioxidant profile.
Kim et al. (2008)	Mouse lymphoma cells and Chinese hamster lung cells exposed to 835-MHz RFR for 48 h; SAR 4W/kg	RFR increased clastogens-induced DNA single strand breaks (Comet assay).
*Komatsubara et al. (2005)	Mouse m5S cells exposed for 2 h to 2450 MHz CW RFR (SAR 5,10, 20, 50 and 100 W/kg) or pulsed RFR (SAR mean 100W/kg, peak 900 W/kg)	No chromosomal aberration observed.
Korenstein-Ilan et al (2008)	Human dividing lymphocytes exposed to 0.1 THz RFR (0.031 mW/cm ²) for 1, 2, or 24 h	Change in chromosomes number in chromosomes 11 and 17 were most vulnerable (about 30% increase in aneuploidy after 2 and 24 h of exposure), while chromosomes 1 and 10 were not affected, and in the asynchronous mode of replication of centromeres 11, 17 and 1 (by 40%) after 2 h of exposure. 0.1 THz radiation induces genomic instability. It is speculated that these effects are caused by radiation-induced low-frequency collective vibration modes of proteins and DNA.
Koyama et al. (2003)	Chinese hamster ovary (CHO)-K1 cells exposed to 2450 MHz RFR for 18 h; SAR 13-100 W/kg	Higher micronucleus frequency after exposure at 78 W/kg and higher. Synergistic with bleomycin in micronucleus formation.
Koyama et al. (2004)	Chinese hamster ovary K1 cells exposed to 2450 MHz RFR for 2h; SAR5-200 W/kg	Increased micronucleus formation above 50 W/kg (May be related to temperature rise).

*Koyama et al. (2016a)	Human corneal epithelial (HCE-T) cells exposed to 0.12 THz radiation at 5 mW/cm ² for 24 h	No effect on micronucleus formation, morphological change and heat shock protein expression (Hsp27, Hsp70, and Hsp90α).
*Koyama et al. (2016b)	Human corneal epithelial (HCE-T) and human lens epithelial (SRA01/04) cells exposed to 60 gigahertz (GHz) RFR for 24 h; 1 mW/cm ²	No effect on micronucleus formation DNA single strand breaks (Comet assay) and heat shock protein expression.
Kumar A. et al. (2020)	Allium cepa (onion) root meristematic cells exposed to 900- (0.0902 W/kg) and 1800-MHz (0.169 W/kg) RFR for 0.5, 1, 2, and 4 h	Increased chromosomal aberrations and increased DNA single strand breaks (Comet assay).
*Kumar G. et al. (2011)	Long bone (femur and tibia) of male Sprague – Dawley rats exposed to 900-MHz continuous-wave RFR for 30 min; SAR 2 W/kg	No significant effect on DNA single-strand breaks (Comet assay) in bone marrow lymphocytes.(Assayed at 72 h after exposure.)
*Kumar G. et al. (2015)	Long bone (femur and tibia) of male Sprague – Dawley rats exposed to 900 and 1800 MHz continuous-wave and pulsed RFR; 900-MHz CW at 2 and 10 W/kg for 90 min and 1800-MHz CW and PW at 2.5 and 12.4 W/kg for 120 min	No significant effect on DNA single-strand breaks (Comet assay) in bone marrow lymphoblasts. (Assayed at 1 h after exposure.)
Kumar R. et al. (2020)	male Wistar rats exposed to 900 MHz, 1800 MHz and 2450 MHz RFR at a specific absorption rate (SAR) of 5.84×10^{-4} W/kg, 5.94×10^{-4} W/kg and 6.4×10^{-4} W/kg, respectively for 2 h per day for 1-month, 3-month and 6-month periods.	RFR exposure caused significant epigenetic modulations (DNA and histone methylation) which alter gene expression in the hippocampus.
Kumar S. et al. (2010)	Male Wistar rats exposed to 10-GHz RFR 2 h a day for 45 days, SAR	Increased micronucleus and reactive oxygen species in blood cells.

	0.014 W/kg	
Kumar S. et al. (2013)	Male Wistar rats exposed to a 10 GHz RFR 2h/day for 45 days; SAR 0.014 W/kg	Increased micronucleus frequency in blood lymphocytes and increased single strand breaks (Comet assay) in spermatozoa. Decreased testosterone and testicular size.
Kumar S. et al. (2014)	Male Wistar rats exposed to 1910.6 MHz RFR from a cell phone in “talk mode” for 60 days (2 h/day, 6 days a week); SAR 0.28 (Max.) and 0.0226 (Min.)	Increased DNA single strand breaks (Comet assay) and lipid peroxidation in spermatozoa,
*Lagroye et al. (2004a)	Sprague-Dawley rats exposed to pulsed 2450-MHz RFR for 2 h; SAR 1.2 W/kg	No significant change in DNA single strand breaks (Comet assay) (with or without proteinase-k treatment of samples-for detection of DNA-protein crosslinks) in brain cells.
*Lagroye et al. (2004b)	Clonal mouse embryo C3H 10T(1/2) cells exposed 2450-MHz continuous-wave RFR for 2 h; SAR 1.9 W/kg	No significant change in DNA single strand breaks (Comet assay) (with or without proteinase-k treatment of samples.)
Lai and Singh (1995)	Male Sprague-Dawley rats exposed to pulsed or continuous-wave 2450-MHz RFR for 2 h; SAR 0.6 and 1.2 W/kg	Increased DNA single strand breaks (Comet assay) in brain cells was observed at 4 h after exposure to pulsed RFR and at 0 and 4 h after continuous-wave exposure.
Lai and Singh (1996)	Male Sprague-Dawley rats exposed to pulsed or continuous-wave 2450-MHz RFR for 2 h; SAR 1.2 W/kg	Increased DNA single- and double-strand breaks (Comet assay) in brain cells was observed at 4 h after exposure to pulsed or continuous-wave RFR.
Lai and Singh (1997)	Male Sprague-Dawley rats exposed to pulsed 2450-MHz RFR for 2 h; SAR 1.2 W/kg	Increased DNA single- and double-strand breaks (Comet assay) in brain cells at 4 h after exposure. Effects blocked by melatonin or the spin-trap compound N-tert-butyl-alpha-phenylnitron. (Free radicals are involved in the effects).
Lai and Singh (2005)	Male Sprague-Dawley rats exposed to continuous-wave 2450-MHz RFR for 2 h; SAR 0.6 W/kg	Increased DNA single- and double-strand breaks (Comet assay) in brain cells at 4 h after exposure. Effects blocked by a temporally incoherent magnetic field.
Lai et al. (1997)	Male Sprague-Dawley rats exposed to pulsed 2450-MHz RFR for 2 h;	Increased DNA double-strand breaks (Comet assay) in brain cells at 4 h after exposure. Effect blocked by naltrexone. (Involvement

	SAR 1.2 W/kg	of endogenous opioids in the effects).
Lakshmi et al. (2010)	Human subjects professionally using VDTs	No effect on DNA single strand break (comet assay) and micronucleus frequency in blood cells of subjects exposed for 2 years; increased in long-term (>10 years) users.
Lameth et al. (2020)	Healthy rats, rats undergoing an acute neuroinflammation triggered by a lipopolysaccharide (LPS) treatment, and transgenic hSOD1 ^{G93A} rats that modeled a presymptomatic phase of human amyotrophic lateral sclerosis (ALS) exposed head only to a GSM-1800 MHz RFR for 2 h, SAR 3.22 W/kg.	Cortical cell gene modulations triggered by GSM-RFR in the course of an acute neuroinflammation and indicate that GSM-induced gene responses can differ according to pathologies affecting the CNS.
*Lamkowski et al. (2018)	Human peripheral blood cells exposed to 900 MHz RFR for 30, 60, and 90 min; SAR 9.3 W/kg	No significant effect on gene expression.
Le Quément et al. (2012)	Primary human skin cells exposed to a 60.4-GHz RFR for 1, 6, or 24 h, SAR 42.4 W/kg.	Expression of 130 transcripts was found to be potentially modulated. PCR confirmed 5 genes as differentially expressed after 6 h of exposure.
*Lerchl et al. (2020)	Pregnant mice exposed to UMTS ~1960 MHz RFR from day 7 post-conception (p.c.) at SAR 0.04 and 0.4 W/kg (24 h/day, 7 days/week); at day 14 p.c., injected with ethylnitrosoures(ENU)	No DNA adenyl adduct formation was observed in the brain of fetuses at 24, 36, and 72 h after ENU injection.
Lee et al. (2005)	Human HL-60 cells exposed to a pulsed 2450 MHz RFR for 2 or 6 h; SAR 10 W/kg	Many genes apoptosis-related genes were affected. Apoptosis- related genes were among the upregulated ones and the cell cycle genes among the downregulated ones.
*Li et al. (2001)	Murine C3H 10T(1/2) fibroblasts exposed to 847.74 MHz code-division multiple access (CDMA) and 835.62 frequency-division	No significant effect on DNA single strand breaks (Comet assay).

	multiple access (FDMA) RFR for 2, 4, or 24 h; SAR 3.2 - 5.1 W/kg	
Li et al. (2018)	Mouse spermatocyte-derived cells (GC-2) were exposed to 1800-MHz RFR for 24 h, SAR 1, 2 or 4 W/kg	No effect on DNA double strand break, increased DNA single strand breaks (Comet assay); free radicals involved.
Li et al. (2020)	Pregnant female rats exposed to 1800 (1 mW/cm ²) and 2400 (0.1 mW/cm ²) MHz RFR during the 21st day of pregnancy (8 pm- 8 am). Offspring tested from 3-9 weeks postnatal	Up- and down-regulation expressions of different forms (NR1, NR2A, NR2B, NR2C, NR2D, NR3A, NR3B) of methyl-D-aspartate receptors (NMDARs) in the hippocampus were observed; animals showed behavioral and cognitive development effects which may be associated with altered mRNA expression of NMDARs.
Lin et al. (2016)	Budding yeast exposed to 2-GHz RFR for 96 h, SAR 0.12 W/kg	Upregulation of the expression of genes involved in glucose transportation and the tricarboxylic acid (TCA) cycle.
Liu et al. (2013a)	Mouse spermatocyte-derived GC-2 cell line exposed to 1800-MHz Global System for Mobile Communication (GSM) signals (5 min on and 10 min off) for 24 h; SAR 1, 2, or 4 W/kg	Increased DNA single strand breaks (comet assay) and DNA adduct 8-oxoguanine at SAR of 4 W/kg; increased reactive oxygen species generation.
Liu et al. (2013b)	Mouse spermatocyte-derived GC-2 cell line was exposed to a commercial mobile phone handset once every 20 minutes in standby, listen, dialed or dialing modes for 24 h; power density 0.0059-0.0122 mW/cm ²	Increased DNA single strand breaks (Comet assay) (attenuated by melatonin).
Lixia et al. (2006)	Human lens epithelial cells exposed to GSM-1.8 GHz RFR for 2 h, SAR 1, 2, 3 W/kg	Increased DNA single strand breaks (comet assay) at 3 W/kg at 0 and 30 min post-exposure; Increased mRNA and protein expression of Hsp70.
López-Martín et al. (2009)	Picrotoxin-pretreated male Sprague-Dawley rats exposed to 900-MHz GSM-modulated or unmodulated RFR for 2	Increased c-fos expression in brain areas.

	h, SAR modulated RFR 0.03 W/kg average— peak 0.14 W/kg in brain; unmodulated RFR average 0.26 W/kg- peak 1.4 w/kg in brain	
Luukkonen et al. (2009)	Human SH-SY5Y neuroblastoma cells exposed to 872-MHz (CW and GSM) RFR for 1 h; SAR 5 W/kg	CW RFR increased DNA single strand breaks (Comet assay) and reactive oxygen species in cells treated with menadione (a chemical that induces intracellular ROS production and DNA damage) compared to cells treated with menadione alone. GSM- modulated RFR had no significant effect.
*Luukkonen et al. (2010)	Human SH-SY5Y neuroblastoma cells exposed to 872-MHz (CW and GSM) RFR for 3 h (DNA damage) and 1 h (reactive oxygen species) ; SAR 5 W/kg	CW and modulated RFR had no significant effect on DNA single strand breaks (Comet assay) and reactive oxygen species production in cells treated with ferrous chloride,
Maes et al (1993)	Human peripheral blood lymphocytes exposed to pulsed 2450-MHz RFR for 30 or 120 min, SAR 75 W/kg	Increase in the frequency of chromosome aberrations (including dicentric chromosomes and acentric fragments) and micronuclei.
Maes et al (1996)	Human whole blood samples exposed to GSM 954- MHz emitting antenna for 2 h, SAR 1.5 W/kg, some samples also incubated with mitomycin C after exposure	Synergistic effect between RFR and mitomycin C was observed the frequencies of sister chromatid exchanges in metaphase figures.
Maes et al. (1995)	Human whole blood cells exposed to 954 MHz RFR from an antenna for 2 h; SAR 1.5 W/kg. Blood from maintenance workers of transmission antenna (450, 900 MHz) exposed at least 1 h/day for a year.	Increased chromosome aberration (dicentric chromosome) in lymphocytes. No effect found in blood of antenna maintenance workers.
*Maes et al. (1997)	Human whole blood cells exposed to 935.2 MHz RFR alone and in	No significant effects of RFR on chromosome aberration, sister chromatid exchange, and DNA single strand breaks

	combination with mitomycin C for 2 h; SAR 0.3-0.4 W/kg	(comet assay). No synergistic effect with mitomycin C.
*Maes et al (2000)	Human lymphocytes exposed to 455.7 MHz RFR from antenna of a car phone for 2 h; SAR 6.5 W/kg	No significant effects of RFR on chromosome aberration and sister chromatid exchange. No synergistic effect with mitomycin C.
*Maes et al (2001)	Human lymphocytes exposed to 900-MHz RFR for 2 h, SAR 0-10 W/kg	No significant effects of RFR on chromosome aberration and sister chromatid exchange. No synergistic effect with mitomycin C.
*Maes et al (2006)	Peripheral blood lymphocytes from subjects who were professionally exposed to cell phone RFR	No evidence of RFR-induced genetic effects: DNA single strand breaks (Comet assay), chromosome aberration, and sister chromatid exchange.
*Malini (2017)	Blood and semen samples from subjects who used cellular phones for 1-5, 6-10, and >10h/day.	No DNA damages (ladder assay) and oxidative changes observed.
*Malyapa et al. (1997a)	U87MG and C3H 10T1/2 cells exposed to 2450-MHz continuous-wave RFR for 2 h; SAR 0.7 and 1.9 W/kg	No significant effects on DNA single strand breaks (Comet assay).
*Malyapa et al. (1997b)	Mouse C3H 10T1/2 fibroblasts and human glioblastoma U87MG cells exposed to 835.62 MHz (FMCW) and 847.74 MHz (CDMA) RFR up to 24 h; SAR 0.6 W/kg	No significant effects on DNA single strand breaks (Comet assay).
*Malyapa et al. (1998)	Male Sprague-Dawley rats exposed to 2450 MHz continuous-wave (CW) RFR for 2 h; SAR 1.2 W/kg	No significant effects on DNA single strand breaks (Comet assay) in cerebral cortex or hippocampus.
Manti et al. (2017)	Four days-old adult female flies (<i>Drosophila melanogaster</i>) exposed to GSM-1800 talk mode RFR emitted by a commercial cellular	168 genes were differentially expressed associated with multiple and critical biological processes, such as basic metabolism and cellular subroutines related to stress response and apoptotic death. Free radicals may be involved.

	phone for 30 min; SAR 0.15 W/kg	
Manti et al. (2008)	Human peripheral blood lymphocytes exposed a UMTS 1.95 GHz signal for 24 h; SAR 0.5 and 2.0 W/kg; some samples also exposed to x-ray	X-ray induced chromosome exchange per cell was increased by RFR exposure. (RFR may either influence the repair of X-ray-induced DNA breaks or alter the cell death pathways of the damage response.)
Marinelli et al. (2004)	acute T-lymphoblastoid leukemia cells exposed to 900 MHz RFR for 2-48 h, SAR 0.0035 W/kg	Increased DNA damage (DNA ladder) and activation genes involved in pro-survival signaling.
Markova et al. (2005)	Human lymphocytes exposed to 905 and 915 MHz GSM signals for 1 h. SAR 0.037 W/kg	RFR from GSM cell phone affected chromatin conformation and 53BP1/gamma-H2AX foci similar to heat shock. No significant difference between lymphocytes from healthy and electro-hypersensitive subjects.
Markova et al. (2010)	Human diploid VH-10 fibroblasts and human adipose-tissue derived mesenchymal stem cells exposed to GSM (905 MHz or 915 MHz) or UMTS (1947.4 MHz, middle channel) RFR for 1, 2, or 3 hr; SAR 0.037-0.039 W/kg	915 MHz and 1947.4 MHz signals inhibited tumor suppressor TP53 binding protein 1 (53BP1) foci that are typically formed at the sites of DNA double strand break location in both cell types. 905 MHz RFR did not inhibit 53BP1 foci in differentiated cells but in stem cells. (Inability to form DNA repair foci has been correlated to radiosensitivity, genomic instability, and other repair deficits.)
Martin et al. (2020)	Human neonatal foreskin keratinocytes (HEK-3N, HEK-1N, and NHEK-3N) and human skin keratinocytes HeCAT exposed to a 60-GHZ RFR for 3 h, Average SAR 513 W/kg and peak SAR 1233 W/kg	Different cell types showed different patterns of expreson of ADAMTS6, IL7R, and NOG genes.
Mashevich et al. (2003)	Human peripheral blood lymphocytes exposed to 830 MHz RFR for 72 hr, SAR 1.6-8.8 W/kg	A linear increase in chromosome 17 aneuploidy (loss and gain of chromosome) and abnormal chromosome-17 replication were observed as a function of the SAR value, demonstrating that this radiation has a genotoxic effect.
Mazor et al. (2008)	Human lymphocytes exposed to continuous-wave 800 MHz for 72 hr;	Increased levels of aneuploidy depending on the chromosome studied as well as on the level of exposure. In chromosomes 1 and 10,

	SAR 2,9 and 4,1 W/kg	there was increased aneuploidy at the higher SAR, while for chromosomes 11 and 17, the increases were observed only for the lower SAR.
*McNamee et al. (2002a)	Human blood cultures exposed to continuous-wave 1900 MHz RFR for 2 h; SAR 0-10 W/kg	No effect on DNA single strand breaks (Comet assay) in leukocytes.
*McNamee et al. (2002b)	Human blood cultures exposed to pulsed 1900 MHz RFR for 2 h; SAR 0-10 W/kg	No effect on DNA single strand breaks (Comet assay) and micronucleus formation in leukocytes.
*McNamee et al. (2003)	Human blood cultures exposed to continuous-wave or pulsed 1900 MHz RFR for 24 h; SAR 0-10 W/kg	No effect on DNA single strand breaks (Comet assay) and micronucleus formation in leukocytes.
*McNamee et al. (2016)	Male C57BL/6 mice exposed to pulse-modulated or continuous-wave 1900 MHz RFR for 4 h/day for 5 consecutive days; whole body average SAR ~0.2 W/kg and ~1.4 W/kg.	No differentially expressed gene expressions were identified in various regions of the brain.
Meena et al. (2014)	Wistar rats exposed to 2.45 MHz RFR 2 h/day for 45 days; SAR 0.14 W/kg. Rats also treated with melatonin.	Increased in DNA single strand breaks (Comet assay) and oxidative stress in testicular tissue. Effects attenuated by melatonin.
Megha et al. (2015a)	Fischer rats exposed to 900 and 1800 MHz RFR for 30 days (2 h/day, 5 days/week); SAR 0.00059 and 0.00058 W/kg	Reduced levels of neurotransmitters dopamine, norepinephrine, epinephrine, and serotonin, and downregulation of mRNA of tyrosine hydroxylase and tryptophan hydroxylase (synthesizing enzymes for the transmitters) in the hippocampus.
Megha et al. (2015b)	Fischer rats exposed to 900, 1800, and 2450 MHz RFR for 60 days (2 h/day, 5 days/week); SAR 0.00059, 0.00058, and 0.00066 W/kg	Increased DNA single-strand breaks (Comet assay) in hippocampus, increased oxidative stress and pro-inflammatory cytokines (IL-2, IL-6, TNF- α , and IFN- γ)
*Meltz et al. (1990)	Mouse leukemic cells exposed to pulsed 2450	No evidence in any mutagenic action by the RFR exposure alone or interaction with

	MHz RFR for 4 h, SAR 40 W/kg	proflavin, a DNA-intercalating drug.
Mildažienė et al. (2019)	Sunflower seeds exposed to 5.28 MHz RFR for 5, 10, 15 min, 12.7 kV/m	RFR exposure induced a long-term effect on gene expression in leaves, mostly stimulating expression of proteins involved in photosynthetic processes and their regulation.
Millenbaugh et al. (2008)	Rats exposed to 35 GHz RFR at 75 mW/cm ² until colonic temperature reached 41-41°C, skin was assayed	Changes were detected in 56 genes at 6 h and 58 genes at 24 h post-exposure. Genes associated with regulation of transcription, protein folding, oxidative stress, immune response, and tissue matrix turnover were affected at both times. At 24 h, more genes related to extracellular matrix structure and chemokine activity were altered.
*Miyakoshi et al. (2002)	Human brain tumor derived M54 cells exposed to 2450 MHz RFR for 2 h; SAR 50 or 100 W/kg	No effect on DNA single strand breaks (Comet assay) observed.
*Mizuno et al. (2015)	WI38VA13 subcloned 2RA human fibroblast cells exposed to wireless power transfer (WPT) 12.5 MHz resonant frequency for 48, 96, or 144 h; SAR 21 W/kg	No effects on cell growth, cell cycle distribution, DNA single strand breaks (Comet assay), micronucleus formation, and hypoxanthine-guanine phosphoribosyltransferase (HPRT) gene mutation.
*Nakatani-Enomoto et al. (2016)	Human spermatozoa exposed to 1950 MHz Wideband Code Division Multiple Access (W-CDMA)-like RFR for 1 h; SAR 2.0 or 6.0 W/kg	No effect on percentage of 8-hydroxy-2'-deoxyguanosine positive spermatozoa.
Narasimhan and Huh (1991)	Lambdaphage DNA exposed to short pulses of RFR	Observed conformational anomalies in DNA probably resulting from single strand breaks and localized strand separations induced by RFR.
Nikolova et al. (2005)	Mouse embryonic neural progenitor stem cells exposed to 1710-MHz GSM RFR for 6 or 48 h; SAR 1.5 W/kg	Exposure for 6 h, but not for 48 h, resulted in a low and transient increase of DNA double-strand breaks and the transcript level of genes related to apoptosis and cell cycle control..
Nittby et al. (2008)	Fischer 344 rats exposed to 1800 MHz GSM RFR	Expression in cortex and hippocampus of genes connected with membrane functions.

	for 6 h; SAR whole body average 0.013 W/kg, head 0.03 W/kg	
Nylund and Leszczynski (2006)	Human endothelial cell line: EA.hy926 and EA.hy926v1 exposed to 900-MHz GSM RFR for 1 h; SAR 2.8 W/kg	Gene and protein expression were altered dependent on the cell type.
Odaci et al. (2016)	Pregnant Sprague - Dawley rats exposed to 900 MHz RFR 1 h each day during days 13 - 21 of pregnancy; SAR whole body average 0.024 W/kg	Testis and epididymis of offspring showed higher DNA oxidation and lipid peroxidation at 60 days postnatal.
Ohtani et al. (2016)	Sprague-Dawley rats exposed to wideband code division multiple access 2140 MHz RFR for 6 h or 3 or 6 h/day for 4 days, SAR 4 or 0.4 W/kg	Exposure at 4 W/kg (at 6 h/day) increased core temperature and upregulation of some stress markers, heat-shock proteins and heat-shock transcription factors family, in the cerebral cortex and cerebellum.
*Ohtani et al. (2019)	Mice exposed to 85 kHz (for charging electrical vehicles) EMF at 25.3 mT, 1 h/day for 10 days	No significant change in gene transcriptional expression in brain and liver.
*Ono et al. (2004)	Pregnant lacZ-transgenic mice exposed intermittently (10 sec On, 50 sec OFF) 16 h/day to 2450-MHz RFR from embryonic days of 0 to 15; SAR whole body average 0.71 W/kg	No significant effects on mutation frequencies at the lacZ gene in spleen, liver, brain, and testis in offspring. The RFR is not mutagenic in utero.
Ozgur et al. (2014)	Hepatocarcinoma cells exposed to intermittent (15 min ON, 15 min OFF) GSM 900- and 1800-MHz RFR for 1, 2, 3, or 4 h; SAR 2 W/kg	Cells showed irregular nuclei pattern and DNA damage (apoptosis).
Pacini et al. (2002)	Human skin fibroblasts exposed to GSM 904.2-MHz RFR for 1 h (from a cell phone); SAR 0.6 W/kg	Increased the expression of mitogenic signal transduction genes (e.g., MAP kinase kinase 3, G2/mitotic-specific cyclin G1), cell growth inhibitors (e.g., transforming growth factor-beta), and genes controlling apoptosis (e.g., bax).

Panagopoulos et al. (2007)	Flies (<i>Drosophila melanogaster</i>) exposed to either GSM 900-MHz or DCS 1800-MHz signals from a digital cell phone, for few minutes per day during the first 6 days of their adult life.	Degeneration of large numbers of egg chambers after DNA fragmentation (apoptosis) of their constituent cells, induced by both types of mobile telephony radiation.
Panagopoulos (2019)	Human peripheral blood lymphocytes exposed to UMTS signal (1900-2200 MHz) using a cell phone for 15 min	Chromatid-type aberrations (gaps and breaks) observed.
Panagopoulos (2020)	Human lymphocytes (in G2/M phase) exposed to UMTS (3G) 1920-1960 MHz RFR emitted from a smart phone on talk mode for 15 min; peak power density $92 \pm 27 \mu\text{W}/\text{cm}^2$; averaged over 6 min $29 \pm 14 \mu\text{W}/\text{cm}^2$	Chromatid-type aberrations were observed. Effect synergistic with caffeine.
Pandey et al. (2017)	Swiss albino mice exposed to 900-MHz RFR for 4 or 8 h per day for 35 days; SAR 0.0054-0.0516 W/kg	RFR exposure-induced oxidative stress causes DNA single-strand breaks (Comet assay) in germ cells, with altered cell cycle progression leading to low sperm count in mice (depolarization of mitochondrial membranes resulting in destabilized cellular redox homeostasis). Larger effect with longer exposure time, and recovery at 35 days post-exposure.
Pandey and Giri (2018)	Swiss albino mice exposed to GSM 900-MHz RFR 3h twice/day for 35 days, SAR 0.0516-0.0054W/kg	Increased DNA single strand breaks (Comet assay) and free radicals in testis and germ cells, effects attenuated by melatonin.
*Paparini et al. (2008)	Mice exposed to GSM 1800-MHz signal for 1 h; SAR whole body average 1.1 W/kg, brain 0.2 W/kg	No significant modulation in gene expression in whole brain.
Paulraj and Behari (2006)	35-day old male Wistar rats exposed 2 h/day for 35 days to 2450 MHz or 16.6 GHz RFR; SAR 1.0 and 2.01 W/kg,	Increased in DNA single strand breaks (Comet assay) in brain cells for both frequencies.

	respectively.	
Pesnya and Romanovsky (2013)	Onion (<i>Allium cepa</i>) exposed to GSM 900-MHz RFR from a cell phone for 1 h/day or 9 h/day for 3 days; incident power density 0.05 $\mu\text{W}/\text{cm}^2$	Increased the mitotic index, the frequency of mitotic and chromosome abnormalities, and the micronucleus frequency in an exposure-duration manner.
Phillips et al. (1998)	Human Molt-4 T-lymphoblastoid cells exposed to pulsed signals at cellular telephone frequencies of 813.5625 MHz (iDEN signal) and 836.55 MHz (TDMA signal) for 2 or 21 h. SAR 0.0024 and 0.024 W/Kg for iDEN and 0.0026 and 0.026 W/kg for TDMA)	Changes in DNA single strand breaks (increase and decrease depending on exposure parameters) (Comet assay) were observed.
*Port et al. (2003)	Human leukaemia cells (HL-60) exposed to pulsed (1 Hz) 400 MHz RFR for 6 min; 50 kV/m-25 times higher than the ICNIRP reference levels for occupational exposure	No significant effects on apoptosis, micronucleation, abnormal morphologies and gene expression assayed at 9, 24, 48, and 72 h post-exposure.
Qin et al. (2018)	Male mice exposed to 1800-MHz RFR 2 h/day for 32 days, SAR 0.0553 W/kg	Inhibition of testosterone synthesis might be mediated through CaMKI/ROR α signaling pathway.
Qin et al. (2019)	Mouse Leydig cells exposed to a 1800-MHz RFR for 1, 2 or 4 h, SAR 0.116 W/kg	Cells showed downregulated of testosterone synthase genes (<i>Star</i> , <i>Cyp11a1</i> , and <i>Hsd-3β</i>) and clock genes (<i>Clock</i> , <i>Bmal1</i> , and <i>Rora</i>), also reduced level of testosterone and increased oxidative stress.
*Qutob et al. (2006)	Human U87MG glioblastoma cells exposed to pulse-modulated 1900 MHz RFR for 4 h; SAR 0.1, 1.0, and 10 W/kg	No significant effect on gene expression.
Racuciu (2009)	Zea mays root tips exposed to continuous-	Increased mitotic index and chromosomal aberration frequency linear with increased

	wave 900 MHz RFR for 1 – 36 h; SAR < 1 W/kg)	exposure time.
Rago et al. (2013)	Human subjects with different daily durations of cell phone use (no use, < 2 h, 2-4 h, > 4 h) and “trouser users” and “shirt users”	>4 h daily use and “trouser users” had higher sperm DNA fragmentations.
Rammal et al. (2014)	Lycopersicon esculentum (tomato) exposed to 1250 MHz RFR for 10 days at 0.0095 mW/cm ²	Increased expression of proteinase inhibitor (Pin II) and Lycopersicon esculentum basic leucine Zipper1 (lebZIP1), two wound-plants genes.
*Regalbuto et al. (2020)	Human fibroblasts exposed to 2450 MHz continuous-wave or pulsed (1 ms square ouluses, 50% duty cycle) RFR; SAR 0.7W/kg	No significant effect on γ -H2AX/53BP1 foci, differential gene expression, micronucleus formation, and cell cycle.
Remondini et al. (2006)	Six human cell types exposed to 900 and 1800 MHz RFR; three exposure systems were used, exposure time 1, 24, or 44 h, SAR 1 - 2.5 W/kg (Details in Table 1 of paper.)	Some but not all human cells reacted to RFR with an increase in expression of genes encoding ribosomal proteins and therefore up-regulating the cellular metabolism.
Romano-Spica et al. (2000)	Human hemopoietic and testicular cell types exposed to 50 MHz RFR modulated (80%) with a 16-Hz frequency for 0.5-24 h; the exposure system generates a 0.2 microT magnetic field parallel to the ground and a 60 V/m electric field orthogonal to the earth's magnetic field.	Overexpression of the proto-oncogene ets1 mRNA in Jurkat T-lymphoblastoid and Leydig TM3 cell lines only in the presence of the 16-Hz modulation.
*Ros-Lior et al. (2012)	Cells collected from cheeks of human subjects	Comparing control area with the side cell phone was placed; no significant genotoxic effect was found (DNA damage and cytokinetic defects, proliferative potential, and cell death).

*Roti-Roti et al (2001)	C3H 10T(1/2) cells exposed to 835.62 MHz FDMA or 847.74 MHz CDMA for 7 days and then one-dose X-ray followed by RFR for 42 days; SAR 0.6 W/kg	No significant effect of RFR on neoplastic transformation (induced by X-ray) was observed.
Roux et al. (2006)	Tomato plants exposed to a 900-MHz RFR for 2-10 min at 0.0066 mW/cm ²	Increased stress-related transcripts (calmodulin, protease inhibitor and chloroplast mRNA-binding protein) in leaves. (Increased at 15 min after the end of electromagnetic stimulation, dropped to close to initial levels by 30 min, and then increased again at 60 min.)
Roux et al. (2008)	Tomato plants exposed to a 900-MHz RFR for 10 min at 0.0066 mW/cm ²	Induction of stress gene expression; similar to wound responses suggesting that the radiation is perceived by plants as an injurious stimulus.
Sagripanti and Swicord (1986)	Purified DNA solution exposed to 2.55-GHz RFR for 20min; SAR _{min} and SAR _{max} ranges: 0, 2-8-5 and 21-85 W/kg,	Structural changes in DNA suggested that exposure to RFR can cause single as well as double-strand breaks in DNA in solution.
Sagripanti et al. (1987)	Purified plasmid DNA exposed to RFR in the frequency range from 2.00 to 8.75 GHz for 20 min; SAR 0, 8.5, or 85 W/kg	Induced dose- and exposure-duration-dependent DNA single and double strand breaks depends on the presence of small amounts of cuprous ions.
Sahin et al. (2016)	Rats exposed to 3-G 2100 MH RFR 6 h/day for 10 or 40 days	Oxidative DNA damage (8-hydroxy-2'deoxyguanosine) in brain increased after 10-day exposure but decreased after 40 day exposure.
Said-Salman et al. (2019)	Escherichia coli K-12 DH5α exposed to 2.4 GHz RFR for 5 h	Expression of 101 genes was differentially affects (up- and down-regulation).
*Sakuma et al. (2006)	Human glioblastoma A172 cells exposed to W-CDMA 2.1426 GHz radiation at SARs of 80, 250, and 800 mW/kg and CW radiation at 0.08 W/kg for 2 and 24 h; normal human IMR-90 fibroblasts from fetal lungs exposed to W-	No significant effect on DNA single strand breaks (Comet assay).

	CDMA and CW radiations at a SAR of 0.08 W/kg for 2 and 24 h.	
*Sakurai et al. (2011)	Human glial cell line, SVGp12, exposed to continuous-wave 2450 MHz RFR for 1, 4, and 24 h; SAR 1, 5, and 10 W/kg	No evidence of effect on gene expression.
*Salmen et al. (2018)	<i>S. aureus</i> , <i>S. epidermidis</i> , and <i>P. aeruginosa</i> . Exposed to exposed to 900 and 1800 MHz RFR for 2 h using a cell phone	No significant effects on DNA, growth rate and antibiotic susceptibility.
*Sannino et al. (2006)	Human blood leukocytes exposed to UMTS-1950 MHz signal for 24 h; SAR 0.5 or 2 W/kg	No effect on DNA single strand breaks (Comet assay) and cell viability.
*Sannino et al. (2009a)	Human dermal fibroblasts from a healthy subject and from a subject affected by Turner's syndrome exposed to GSM 900 MHz.RFR for 24 h; SAR 1 W/kg	No significant effect on DNA single strand breaks (Comet assay)
*Sannino et al. (2009b)	Human dermal fibroblasts from one subject exposed to 900 MHz RFR for 24 h; SAR 1 W/kg	No significant effect on DNA single strand breaks (Comet assay) and micronucleus frequency.
Sannino et al. (2011)	Phytohemagglutinin activated human blood lymphocytes exposed to a 900-MHz RFR for 20 h; SAR 1.25 W/kg, and then to mitomycin C	RFR attenuated micronucleus induced by mitomycin c at S-phase, and not at G(0)- and G(1)-phases of the cell cycle. (Adaptive response)
Sannino et al. (2014)	Phytohemagglutinin activated human blood lymphocytes exposed to a 900-MHz RFR for 20 h; SAR 0.3 W/kg, and then to x-ray	RFR attenuated micronucleus induced by x-ray.
Sannino et al. (2017)	Chinese hamster lung fibroblasts exposed to 1950 MHz, Universal	Increased micronucleus frequency at 0.15 and 0.3 W/kg, no effect at 0.6 and 1.25 W/kg; attenuated micronucleus induced by

	Mobile Telecommunication System signal for 20 h; SAR 0.15 – 1.25 W/kg	mitomycin-C at 1.25 W/kg.
Sarimov et al. (2004)	Human lymphocytes exposed to GSM 895-915 MHz signals for 30 min; SAR 0.0054 W/kg	Condensation of chromatin was observed. (Stronger effect at 1 h exposure.)
Sarkar et al. (1994)	Mice exposed to 2450 MHz RFR 2 h/day for 120, 150, and 200 days; SAR 1.18 W/kg	Rearrangements of DNA segments were observed in brain and testis.
Scarfi et al (1996)	Bovine lymphocytes exposed to 9 GHz RFR for 10 min, SAR 70 W/kg	Increased micronucleus frequency.
*Scarfi et al. (2003)	Human peripheral blood lymphocytes exposed to pulsed 120-130 GHz (pulse rate 2 Hz, pulsed duration 4 μ s) field for 20 min; delivered energy 1.2 and 0.72 J for the two frequencies, respectively.	No effect on micronucleus frequency and cell proliferation.
*Scarfi et al (2006)	Human lymphocytes exposed to GSM 900 MHz RFR for 24 h, SAR 1, 5, and 10 W/kg).	The results provided no evidence for the existence of genotoxic (micronucleus) or cytotoxic effects
* Schuermann et al. (2020)	Human MRC-5 lung fibroblasts, human osteosarcoma cells, HTR-8/SVneo human trophoblasts, and GFP-tagged XRcc1 cells exposed to intermittent (5/10 min ON/FF) or continuous 1950 MHz, 2450 MHz (GSM or unmodulated) RFR for 1-24 h; SAR 0.5-4.9 W/kg.	No significant effect on DNA single strand breaks (Comet assay).
Schwarz et al. (2008)	Human fibroblasts and lymphocytes exposed to UMTS 1950 MHz RFR for 4-48 h; SAR 0.05 to 2.0 W/kg	Increased DNA single strand breaks (comet assay) and micronucleus were observed in fibroblasts but not in lymphocytes either unstimulated or stimulated with phytohemagglutinin.

Sekeroğlu et al. (2012)	Immature (2 week old) and mature (10 weeks old) Wistar rats exposed to continuous-wave 1800 MHz RFR for 2 h/days for 45 days; SAR 0.38-0.78 W/kg (immature rats), 0.31-0.52 W/kg (mature rats)	Bone marrow cells showed chromosome aberrations, micronucleus frequency, mitotic index and ratio of polychromatic erythrocytes (PCEs) in all exposed groups. Immature group showed more effect and less recovery at day 15 post-exposure. The cytogenotoxic damage in immature rats was statistically higher than the mature rats.
Sekeroglu et al. (2013)	Immature and mature rats exposed to 900 MHz RFR for 2 h/days for 45 days; SAR immature rats, 0.38-0.78 W/kg; mature rats 0.31-0.52 W/kg	Bone marrow cells showed chromosome aberrations, increases in micronucleus frequency, mitotic index, and ratio of polychromatic erythrocytes. Effects persisted for 15 days after exposure.
*Sekijima et al. (2010)	Human A172 (glioblastoma), H4 (neuroglioma), and IMR-90 (fibroblasts from normal fetal lung) cells exposed to continuous-wave and W-CDMA 2.1425 GHz RFR up to 96 h; SAR 0.08, 0.25, 0.8 W/kg	No significant effects on gene expression and cell proliferation.
Semin et al. (1995)	DNA in glycine and formaldehyde exposed to 10 different 4 to 8 GHz RFR 25 ms pulses, 1-6-Hz repetition rate, 0.4 to 0.7 mW/cm ² peak power density	3 or 4 Hz pulses and 0.6 mW/cm ² peak power increased the accumulated damage to the DNA secondary structure. However, changing the pulse repetition rate to 1, 5, 6 Hz, as well as changing the peak power to 0.4 or 0.7 mW/cm ² had no effect (“window effect”).
*Senturk et al. (2019)	Lymphocytes from patients received radiofrequency treatment on inferior turbinate as they were diagnosed with inferior turbinate hypertrophy	No significant effect on DNA single strand breaks (Comet assay) on Day 15 post-treatment. Increase in oxidative stress was observed.
Shah et al. (2015)	Human blood samples exposed to 916-MHz RFR at two power densities and 1-8 hr using an antenna	Chromosomal damage observed in lymphocytes at higher power density and longer exposure duration.

Shahin et al. (2013)	Female mice (<i>Mus musculus</i>) exposed to continuous-wave 2.45 GHz RFR 2 h/day for 45v days; SAR 0.023 W/kg	Increased DNA strand breaks (Comet assay) observed in the brain. Changes in oxidative mechanisms and oxidative stress were observed in liver, kidney and ovary. Increased embryo implantation/resorption and abnormal pregnancy were observed.
Shahin et al. (2019)	Male Wistar rats exposed to 900 MHz RFR for 2 h/day for 8 weeks, SAR 1.075 W/kg	Increased DNA single strand breaks (Comet assay) in testis and increased oxidative stress.
Sharma ad Shukla (2020)	Male Wistar rats exposed to 900 MHz RFR for 1, 2, or 4 h/day for 90 days; SAR brain 0.231 W/kg	Increased DNA single strand breaks (Comet assay) and increased oxidative stress in brain.
Shckorbatov et al. (2009)	Human buccal epithelium cells exposed to 35 GHz RFR for 10 sec; SAR 0.75 W/kg	Caused condensation of chromatin. Left circularly polarised radiation induced less effect than linearly polarised radiation. Cell membrane damage observed.
Shckorbatov et al. (2010)	Human fibroblasts exposed to 36.65 GHz RFR at incident power densities of 1, 10, 30 and 100 microW/cm ² for 10 sec	Chromosome condensation observed at 10 and 100 $\mu\text{W}/\text{cm}^2$ exposure. Right-handed elliptically polarized radiation was more biological activity than the left-handed polarized one.
*Shi et al (2014)	Cultured human lens epithelial cells (HLECs) exposed to 90 kHz magnetic field for 2 and 4 h; 93.36 μT	No significant effects on DNA single strand break (comet assay) and double strand breaks.
*Silva et al. (2016)	Human primary thyroid cells exposed to 895 and 900 MHz RFR for 3-65 h, SAR 0.082-0.170 W/kg	No effect on expressions of Ki-67 (involved in cell proliferation) p53 (tumor suppression) HSP-70 (stress biomarker), and reactive oxygen species.
Smith-Roe et al. (2020)	Male and female Hsd:Sprague Dawley rats and B6C3F1/N mice exposed from Gestation day 5 or Postnatal day 35, respectively, to code division multiple access (CDMA) or global system for mobile modulations over 18 hr/day, at 10-min	Significant increases in DNA single strand breaks (Comet assay) observed in the frontal cortex of male mice (both modulations), leukocytes of female mice (CDMA only), and hippocampus of male rats (CDMA only). No significant increases in micronucleated red blood cells were observed in rats or mice.

	intervals for 19 (rats) or 14 (mice) weeks; SAR 1.5, 3, or 6 W/kg (rats, 900 MHz) or 2.5, 5, or 10 W/kg (mice, 1,900 MHz).	
Sokolovic et al. (2015)	Wistar rats exposed to RFR (4 h/day, for 20, 40, and 60 days) from a Nokia 3110 cell phone:SAR 0.043-0.135 W/kg; some rats treated with melatonin (2 mg/kg, ip)	Melatonin reduced DNA fragmentation in testicular tissues also reversed oxidative changes caused by RFR (malondialdehyde, xanthine oxidase, and acid-DNase)
Soubere Mahamoud et al. (2016)	Human keratinocyte exposed to a 60.4-GHz RFR at an incident power density of 20 mW/cm ² for 3 hours	No keratinocyte transcriptome modifications were observed. Co-treatment with a glycolysis inhibitor slightly alter the transcriptome of 6 genes encoding transcription factors or inhibitors of cytokine pathways. Thus, the RFR exposure may affect metabolically stressed cells
Souza et al. (2014)	Exfoliated cells from the oral epithelium from human subjects who spent different time using cell phones (group I, t > 5 h; group II, t > 1 h and ≤ 5 h; and group III, t ≤ 1 h).	Structures that may be associated with gene amplification were significantly greater in the individuals in group I. No significant effects on micronucleus frequency and apoptosis and necrosis were observed.
*Speit et al. (2007)	Human fibroblasts (ES1 cells) and Chinese hamster cells (V79) exposed to intermittent (5 min ON/10 min OFF)1800-MHz for 1, 4, 24 h; RFR; SAR 2 W/kg	No significant effects on DNA single strand break (Comet assay) and micronucleus frequency.
*Speit et al. (2013)	Human HL-60 exposed to intermittent (5 min ON/10 min OFF) 1800 MHz RFR for 24 r; SAR 1.3 W.kg	No significant effects on DNA single strand break (Comet assay) and micronucleus frequency.
*Stronati et al. (2006)	Human blood samples exposed to GSM 935-MHz signal for 24h; SAR 1 and 2 W/kg	Lymphocytes showed no changes in DNA single strand breaks (Comet assay), chromosomal aberrations, sister chromatid exchanges, micronuclei frequency and cell cycle. No significant interaction with x-ray.
*Su et al (2017)	Neurogenic A172, U251, and SH-SY5Y cells	No significant DNA damage (γH2AX foci)

	exposed to an intermittently (5 min ON/10 min OFF) 1800 MHz RFR at SAR of 4.0 W/kg for 1, 6, or 24 h.	
*Su et al. (2018)	Primary cultured astrocytes, microglia and cortical neurons were exposed to intermittent (5 min ON/10 min OFF) GSM 1800 MHz RFR for 1, 6 or 24 h; SAR 4.0 W/kg.	The RFR did not elicit DNA double strand breaks (γ H2AX foci) but inhibited the phagocytic ability of microglia and the axon branch length and branch number of cortical neurons.
Sun C. et al. (2016)	Mouse embryonic fibroblasts (MEFs) with proficient ($Atm^{+/+}$) or deficient ($Atm^{-/-}$) ataxia telangiectasia mutated, which is critical to initiation of DNA repair, to GSM 1800-MHz RFR for 1, 12, 24, or 36 h; SAR 4 W/kg.	Increased DNA single-strand breaks (SSBs) (Comet assay) and activated the SSB repair mechanism. This effect reduced the DNA damage to less than that of the background level after 36 hours of exposure. In the $Atm^{-/-}$ MEFs, the same RF-EMF exposure for 12 h induced both DNA single and double-strand breaks (Comet assay) and activated the two repair processes, which also reduced the DNA damage to less than the control level after prolonged exposure. (compensatory effects) (Conclusion from interpretation of different results from ($Atm^{+/+}$) and ($Atm^{-/-}$) cells.
Sun, LX et al. (2006a)	Human lens epithelial cells exposed to 217 Hz-modulated 1800 MHz RFR for 2 h; SAR 1, 2, 3, 4 W/kg	No or repairable DNA single strand breaks (Comet assay) was observed after 2 hour irradiation of 1.8 GHz microwave on LECs when SAR \leq 3 W/kg. The DNA damages caused by 4 W/kg irradiation were irreversible.
Sun, LX et al. (2006b)	Human lens epithelial cells exposed to 217 Hz-modulated 1800 MHz RFR for 2 h; SAR 1, 2, 3, 4 W/kg	No DNA single strand breaks (comet assay) was induced using comet assay after 2 hours irradiation of 1.8 GHz microwave on hLECs at the dose SAR \leq 3.0 W/kg. 4.0 W/kg irradiation caused significantly DNA damage and inhibition of hLECs proliferation.
Sun Y. et al. (2017)	HL-60 cells from human leukemia exposed to a 900-MHz RFR for 4 h/day for 5 days, Peak and average SAR 4.1x	Increased oxidative DNA damage, decreased mitochondrial transcription, and increased oxidative stress.

	10^{-4} and 2.5×10^{-4} W/kg	
Sykes et al. (2001)	pKZ1 mice exposed daily for 30 min to 217-Hz modulated 900 MHz RFR 1, 5, or 25 days; SAR 4 W/kg	After 25 days of exposure, RFR could lead to a perturbation in recombination frequency which may have implications for recombination repair of DNA.
*Takahashi et al. (2002)	Male Big Blue mice (BBM) exposed to 1.5 GHz RFR in the head region for 90 min/day, 5 days/week, for 4 weeks; SAR 0.67 and 2 W/kg	There was no significant variation in the frequency of independent mutations of the lacItrans gene and deletion mutation in the brain.
Tice et al. (2002)	Human blood leukocytes and lymphocytes exposed to voice modulated 837 MHz produced by an analog signal generator or by a time division multiple access (TDMA) cellular telephone, 837 MHz generated by a code division multiple access (CDMA) cellular telephone (not voice modulated), and voice modulated 1909.8 MHz generated by a global system of mobile communication (GSM)-type personal communication systems (PCS) cellular telephone for 3 or 24 h, SAR 1-10 W/kg	No significant effect on DNA single strand break (Comet assay). Exposure to each of the four RF signal technologies for 24 h at an average SAR of 5.0 or 10.0 W/kg resulted in a significant and reproducible increase in the frequency of micronucleated lymphocytes.
Tiwari et al. (2008)	Blood samples from male human subjects exposed to a CDMA cell phone for 1 h	In vitro exposure to RFR induces reversible DNA single strand breaks (Comet assay) in synergism with aphidicolin, a DNA repair inhibitor,
Tkalec et al. (2009)	Allium cepa L root meristematic cells from seeds exposed to 400 and 900 MHz RFR for 2 h, power density 10, 23, 41 and 120 V/m).	Lagging chromosomes, vagrants, disturbed anaphases and chromosome stickiness were observed.

Tkalec et al. (2013)	Earthworm (<i>Eisenia fetida</i>) exposed to continuous-wave and AM-modulated 900-MHz RFR for 2 - 4 h; SAR 0.00013, 0.00035, 0.0011, and 0.00933 W/kg	Increased DNA single strand breaks (Comet assay) in earthworms coelomocytes and oxidative stress (lipid and protein oxidation)
Tohidi et al. (2020)	Male BALB/c mice exposed to RFR from a cell phone jammer that emits 900- and 1800 MHz CDMA and GSM signals) for 0.5, 1, 2, or 4 h twice a day for 30 days.	Apoptotic genes Bax and Bcl2 expression in the hippocampus were upregulated for 1- and 2-h exposures and down-regulated with longer exposure.
*Tomruk et al. (2010)	Nonpregnant and pregnant New Zealand White rabbits exposed to GSM 1800 MHz RFR 15 min/day for a week	No oxidative damage in liver of exposed adult and offspring, increased lipid peroxidation.
Trivino Pardo et al (2012)	T-lymphoblastoid leukemia cells exposed to 900 MHz RFR for 2 or 48 h; SAR 9.0035 W/kg	Changes in gene expressions (e.g., an early activation of genes involved in DNA double- and single-strand breaks repair).
Trosic (2001)	Rats exposed to 2450 MHz RFR for 2, 8, 13 and 22 irradiation treatments of two hours each; power density 5-15 mW/cm ² , SAR 20 W/kg	Increased multinucleated alveolar macrophages- the elevation of the number of nuclei per cell was exposure time- and dose-dependent.
Trosic and Busljeta (2005)	Wistar rats exposed to continuous-wave 2450 MHz RFR 2 h/day 7 days /week for a total of 4, 16, 30, and 60 h. power density 5-10 mW/cm ² SAR 1-2 W/kg	The frequency of micronucleated bone marrow erythrocytes was significantly increased after 15 irradiation treatments. No effect after 2, 8, and 30 exposure treatments.
Trosic and Busljeta (2006)	Rats exposed to 2450 MHz RFR 2 h/day, 7 days/week; SAR 1.24 W/kg	Bone marrow cell micronucleus frequency increased on experimental day 15, and micronucleated polychromatic erythrocytes in peripheral blood increased on day 8.
Trosic et al. (2002)	Male Wistar rats exposed for 2 h/day, 7 days a week for up to 30 days to continuous-wave 2450	Increased micronuclei in peripheral blood polychromatic erythrocytes on the 2nd, 8 th , and 15 th day of exposure. It is likely that an adaptive mechanism, both in

	MHz RFR; power density 5-10 mW/cm ² SAR 1-2 W/kg	erythrocytopoiesis and genotoxicity occurred.
Trosic et al. (2004)	Male Wistar rats exposed for 2 h/day, 7 days/week for 4, 16, 30, and 60 h to continuous-wave 2450 MHz RFR; power density 5-10 mW/cm ² SAR 1.25 W/kg	The frequency of micronucleated polychromatic erythrocytes in bone marrow was significantly increased on experimental day 15, but not on 2, 8, and 30 days.
Trosic et al. (2011)	Male Wistar rats exposed to GSM 915 MHz RFR for 1 h /day 7 days/week for 2 weeks; SAR 0.6 W/kg	Increased DNA single strand breaks (Comet assay) in brain, renal, and liver cells.
Tsybulin et al. (2013)	Japanese Quail embryos exposed in ovo to GSM 900 MHz signal from a cell phone intermittently (48 sec ON/12 sec OFF) during initial 38 h of brooding or for 158 h (120 h before brooding plus initial 38 h of brooding): SAR 0.000003 W/kg	The lower duration of exposure led to a significant decrease in DNA single strand breaks (Comet assay) in cells of 38-h embryos, while the higher duration of exposure resulted in a significant increase in DNA damage.
Usikalu et al., (2013)	Sprague-Dawley rats exposed to 2450 MHz RFR for 10 min: SAR 0-4.3 W/kg	Increased DNA single strand breaks (Comet assay) found in ovary and testis.
Vafaei et al. (2020)	Pregnant mice exposed to 2400 MHz RFR from a D-link Wi-Fi router from 5 days after mating to 1 day before delivery for 2-4 h/day, head SAR at 30 cm from router 0.09 W/kg	Placenta tissue showed increased superoxide dismutase mRNA, CDKN1A, and Gadd 45a expression. (CDKN1A, and Gadd 45a are involved in DNA repair, cell cycle arrest, apoptosis, and cellular responses to environmental stressors.) Also, increased BAX mRNA and decreased Bcl-2 mRNA leads to apoptosis.
*Valbonesi et al. (2008)	Human trophoblast cell line HTR-8/SVneo exposed to pulsed 1817 MHz RFR or 1 h; SAR 2 W/kg	No significant change in either HSP70 or HSC70 protein or gene expression, or DNA single strand breaks (Comet assay).
Valbonesi et al. (2014)	Rat PC12 cells exposed to continuous-wave 1.8 GHz RFR or GSM-	After PC12 cells exposure to the GSM-217 Hz signal for 16 or 24 h, HSP70 mRNA transcription significantly increased, whereas

	217Hz and GSM-Talk signals for 4, 6, or 24 h, SAR 2 W/kg	no effect was observed in cells exposed to the CW or GSM-Talk signals.
*Valbonesi et al. (2016)	Rat PC12 cells exposed to 1.8 GHz 217-GSM signal for 24 h. SAR 2 W/kg	Acetylcholine esterase transcriptional or translational pathways not affected, whereas acetylcholine esterase enzymatic activity increased.
Vanishree et al. (2018)	Buccal cells from low and high cellular phone users	There was a significant increase in micronucleus counts in subject who use the phone longer. There was highly significant difference in the mean micronucleus count of participants using (code division multiple access) CDMA than (global system for mobiles) GSM cellular phones.
Varghese et al. (2018)	Female Sprague-Dawley rats exposure 2450 MHz RFR, 4/day. For 45 days; SAR 0.23 W/kg	Increased caspase-3 gene expression in brain tissues; decreased antioxidant enzymes and increased lipid preoxidation. Rat showed lowering of learning and memory and expression of anxiety behavior.
Veerachari and Vasan (2012)	Human elected semen exposed to a 900-GSM cellular phone in talk mode for 1 h; power density 1-40 $\mu\text{W}/\text{cm}^2$ at 2.5 cm from antenna.	Increased DNA fragmentation index and reactive oxygen species, and decreased sperm motility and viability.
*Verschaeve et al. (2006)	Female rats exposed to RF fields for 2 h per day, 5 days per week for 2 years; SAR 0.3 or 0.9 W/kg. the mutagen and carcinogen 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone (MX) was given in the drinking water. at a concentration of 19 $\mu\text{g}/\text{ml}$.	No significant genotoxic activity of MX in blood and liver cells measured by micronucleus and DNA single strand breaks (comet assay). However, MX induced DNA damage in rat brain. Co-exposures to MX and RF radiation did not significantly increase the response of blood, liver and brain cells. (no data on RFR alone.)
Vian et al. (2006)	Tomato plants exposed to a 900-MHz RFR for 10 min at 0.0066 mW/cm^2	Induction of mRNA encoding the stress-related bZIP transcription factor.(3.5 folds at 5-15 min post-exposure)
Vijayalaxmi et al. (1997a)	C3H/HeJ mice exposed to for 20 h/day, 7 day to continuous-wave 2450 MHz RFR MHz for 20 h/day. 7 days/week, over	Significant increases in micronucleus formation in peripheral blood and bone marrow cells were observed.

	18 months: SAR 1.0 W/kg	
Vijayalaxmi et al. (1997b)	Human peripheral blood exposed to 2450 MHz RFR either continuously for 90 min or intermittently (30 min on and 30 min off, repeated three times); SAR 12.46 W/kg	No effect on several genotoxic indexes including chromosome damage, exchange aberrations, and micronucleus frequency.
*Vijayalaxmi et al. (1999)	CF-1 male mice exposed to ultra-wideband electromagnetic radiation (UWBR) for 15 min; SAR 0.037 W/kg	No significant effects on micronucleus frequency and polychromatic erythrocytes in peripheral blood and bone marrow cells at 16 and 24 h post-exposure.
*Vijayalaxmi et al. (2000)	3 human peripheral blood samples exposed to pulsed 2450-MHz RFR for 2 h; SAR 2.135 W/kg	No significant effect on DNA single strand breaks (Comet assay) was observed in lymphocytes immediately and at 4 h post-exposure.
*Vijayalaxmi et al. (2001a)	4 human peripheral blood samples exposed to 835.62 MHz (FDMA) RFR for 24 h, SAR 4.4 or 5.0 W/kg	Lymphocytes were stimulated with a mitogen, phytohemagglutinin. No significant effects at 48 and 72 h post-exposure in mitotic indices, incidence of exchange aberrations, excess fragments, binucleate cells, and micronucleus frequency.
*Vijayalaxmi et al. (2001b)	Male Sprague-Dawley rats exposed to continuous-wave 2450 MHz RFR for 24 h; SAR 12 W/kg	Peripheral blood and bone marrow smears showed no effects on frequency of micronuclei in polychromatic erythrocytes at 24 h post-exposure.
*Vijayalaxmi et al. (2001c)	4 human peripheral blood samples exposed to continuous-wave 847.74 MHz (CDMA) RFR for 24 h; SAR 4.9 or 5.5 W/kg	No significant effects on mitotic indices, frequencies of exchange aberrations, excess fragments, binucleate cells, and micronuclei in lymphocytes at 48 and 72 h post-exposure.
*Vijayalaxmi et al. (2003)	Timed-pregnant Fischer 344 rats (from nineteenth day of gestation) and their nursing offspring (until weaning) exposed to a far-field 1.6 GHz Iridium wireless communication signal for 2 h/day, 7 days/week	No significant effects on micronuclei in polychromatic erythrocytes in bone marrow.

	for 2 years; SAR 0.036 to 0.077 W/kg	
*Vijayalaxmi et al. (2004)	Mice exposed to 42.2 GHz RFR applied to the nasal region 30 min/day for 3 days; peak SAR 622 W/kg	No effect on micronucleus frequency in polychromatic erythrocytes of peripheral blood and bone marrow cells collected 24 h after exposure.
*Vijayalaxmi et al. (2006)	Human peripheral blood samples exposed to 2.45 GHz or 8.2 GHz pulsed-wave RFR for 2 h; SAR 2.13 W/kg (245 MHz) or 20.71 W/kg (8.2 GHz),	No significant effects on chromosomal aberrations and micronuclei in lymphocytes.
Vilic et al. (2017)	Honey bee (<i>Apis mellifera</i>) larvae exposed to 900 MHz at field levels of 10, 23, 41 and 120 V m ⁻¹ for 2 h. At a field level of 23 V m ⁻¹ the effect of 80% AM 1 kHz sinusoidal and 217 Hz modulation was investigated as well.	DNA single strand break (Comet assay) increased significantly in honey bee larvae exposed to modulated (80% AM 1 kHz sinus) field at 23 V m ⁻¹ . Oxidative changes also observed. Modulated RF-EMF produced more negative effects than the corresponding unmodulated field.
*Waldmann et al. (2013)	Human peripheral blood samples exposed to GSM 1800 MHz RFR for 28 h; SAR 0.2, 2, and 10 W/kg	No significant effects on lymphocytes on chromosome aberration, micronucleus frequency, sister chromatid exchange and DNA single strand break (comet assay).
Wang et al. (2015)	Neuro-2a (mouse neuroblastoma) cells exposed to GSM 900 MHz RFR for 24 h; SAR 0.5, 1 or 2 W/kg	Increased DNA oxidative damage (comet assay) and reactive oxygen species. OGG1(a base excision DNA repair enzyme) may be involved.
Wu et al. (2008)	Human lens epithelial cells exposed to 1800 MHz mobile phone radiation for 24 h; SAR 4 W/kg	Increased DNA single strand breaks (Comet assay) and reactive oxygen species.
Xu et al. (2010)	Sprague-Dawley rat primary cultured cortical neurons exposed to intermittent (5 min ON/10 min OFF) 217-Hz pulsed 1800 MHz RFR for 24 h; SAR 2 W/kg	Increased in the levels of 8-hydroxyguanine, a common biomarker of DNA oxidative damage, in the mitochondria of neurons, levels of mitochondrial RNA (mtRNA) transcripts showed a reduction.
Xu et al. (2013)	Six different types of cells intermittently (5	RFR induced DNA damage (γ H2AX foci and alkaline and neutral comet assay) in a

	min ON/10 min OFF) exposed to pulsed GSM 1800 MHz RFR for 1 or 24 h: SAR 3.0 W/kg	cell type-dependent manner.
Yadav and Shama (2008)	Buccal-mucosa cells from 85 regular cell phone users (exposed) and 24 non-users (controls)	A positive correlation between 0-1, 1-2, 2-3 and 3-4 years of exposure and the frequency of micronucleated cells and total micronuclei.
Yakymenko et al. (2018)	Quail embryos exposed to GSM 1800 GHz signal from a smart phone (48 s ON/12 s OFF) for 5 days before and 14 days during incubation, power density 0.00032 mW/cm ²	Increased DNA single strand breaks (comet assay), oxidative DNA damage, reactive oxygen species, and mortality.
Yan et al. (2008)	Adult Sprague-Dawley rats exposed to a cell phones 1.9 GHz (PCE CDMA) for 6 h per day for 126 days (18 weeks).	Significant mRNA up-regulation of injury- related proteins in the brain of rats exposed to cell phone radiation
Yao et al. (2004)	Rabbit lens epithelial cells exposed to continuous-wave 2450- MHz RFR for 8 h, power densities 0.10, 0.25, 0.50, 1.00, and 2.00 mW/cm ²	The RFR higher than 0.50 mW/cm ² can inhibit lens epithelial cell proliferation, and increase the expression of P27Kip1.
Yao et al. (2008)	Human lens epithelial cells intermittently (5 min ON/10 min OFF) exposed to GSM 1.8 GHz RFR for 2 h; SAR 1, 2, 3, and 4 W/kg	Increased DNA single strand breaks (Comet assay), no change in double strand breaks (γ H2AX foci), and increased reactive oxygen species.
Ye et al. (2016)	Chicken embryos exposed to GSM 900 MHz RFR from cell phones 3 h/day from day 2 to day 21 of incubation	Increased DNA single strand breaks (Comet assay) from blood cells and mortality.
*Yildirim et al. (2010)	People who lived around cell phone base stations and healthy controls	There was no significant difference in micronucleus frequency and chromosomal aberrations in blood lymphocytes between the two study groups
Zalata et al. (2015)	Human semen samples exposed to 850-MHz	Significant increase in sperm DNA fragmentation percent, clusterin gene

	RFR from a cell phone for 1 h; SAR 1.46 W/kg at 10 cm	expression and clusterin protein (associated with clearance of cellular debris and apoptosis) levels in the exposed semen samples.
*Zeni et al. (2003)	Human peripheral blood exposed to continuous wave 925 MHz RFR or GSM 925 MHz (6 min ON/ 3 h OFF for 44h (SAR 1.6 W/kg); or GSM signal 1 h/day for 3 days (SAR 0.2 W/kg).	No statistically significant differences were detected in micronucleus frequency in lymphocytes.
*Zeni et al. (2005)	Human peripheral blood lymphocytes exposed to GSM 900 MHz signal for 2 h; SAR 0.3 and 1 W/kg	No significant effects on DNA single strand breaks (Comet assay), chromosome aberration, or sister chromatid exchange.
*Zeni et al. (2007)	Human whole blood samples exposed to 120 GHz (SAR 0.4 W/kg) and 130 GHz (SAR 0.24, 1.4, or 2 W/kg) RFR for 20 min.	No effects in leukocytes on micronucleus frequency and DNA single strand breaks (comet assay).
*Zeni et al. (2008)	Human peripheral blood exposed intermittently (6 min ON/2 h OFF) to 1945 MHz RFR for 24 – 68 h; SAR 2.2 W/kg	No significant effects on DNA single strand breaks (Comet assay) and micronucleus frequency in leukocytes.
Zeni et al. (2012a)	Human peripheral blood lymphocytes exposed to 1950-MHz RFR UMTS (universal mobile telecommunication system) signal for 20 h; SAR 1.25, 0.6, 0.3, or 0.15 W/kg. and then to mitomycin C	Cells pre-exposed to RFR at 0.3W/kg (less consistent at the other SARs) and then treated with MMC showed a significant reduction in the frequency of micronucleus, compared with the cells treated with MMC alone
*Zeni et al. (2012b)	Rat neuron-like pheochromocytoma (PC12) cells exposed to 1950-MHz 3G Universal Mobile Telecommunications System (UMTS) signal for 24 h; SAR 10 W/kg	No effect on DNA single strand break (Comet assay), cell viability, and apoptosis.

Zhang et al. (2006)	Chinese hamster lung cells exposed intermittently (5 min ON/10 min OFF) to GSM 1800 MHz RFR for 1 or 24 h; SAR 3 W/kg	Cells exposed for 24 h showed increased DNA double strand breaks (γ H2AX foci).
Zhang et al. (2002)	Human whole blood exposed to 2450 MHz RFR for 2 h; Power density 5 mW/cm ²	2450-MHz RFR cannot induce DNA and chromosome damage, but can increase DNA single strand breaks (Comet assay) induced by mitomycin C .
Zhang et al. (2008)	Primary culture of rat neurons exposed to a 1.8 GHz RFR for 24 h; SAR 2 W/kg.	Changes (up- and down-regulation) of many genes transcription (involving cytoskeleton, signal transduction pathway, metabolism, etc.) were observed.
Zhao J. et al. (2020)	Escherichia coli exposed to 3.1 THz RFR for 8 h at 33 mW/cm ² and 10 Hz repetition frequency	Plasmid copy number, protein expression and fluorescence intensity of bacteria from the irradiated area were 3.8-, 2.7-, and 3.3 times higher than in bacteria from the un-irradiated area, respectively.
Zhao R. et al. (2007)	Rat neurons exposed to pulsed 217-Hz modulated 1800 MHz RFR for 24 h; SAR 2 W/kg	up- and down-regulation of genes transcriptions were observed.
Zhao TY. et al. (2007)	Primary cultured neurons and astrocytes exposed to a GSM 1900 MHz cell phone for 2 h;	Up-regulation of caspase-2, caspase-6 and Asc (apoptosis associated speck-like protein containing a card) gene expression in neurons and astrocytes. Additionally, astrocytes showed up-regulation of the Bax gene. Neurons appeared to be more sensitive to this effect than astrocytes.
*Zhijian et al. (2009)	Leukocytes from four young healthy donors exposed intermittent (5 min ON/10 min OFF) to 1800 MHz RFR for 24 h; SAR 2 W/kg; Cell also exposed x-ray	No significant effect on DNA single strand breaks (Comet assay) and no synergistic effect with x-ray.
*Zhijian et al. (2010)	Human B-cell lymphoblastoid cells exposed to 1800 GHz RFR for 2 h; SAR 2 W/kg	RFR did not directly induce DNA single strand breaks (Comet assay)
*Ziemann et al. (2009)	Peripheral blood erythrocytes of B6C3F1	No significant effect on micronucleus frequency.

	mice exposed to GSM 900 or DCS 1747 MHz RFR 2 h/day, 5 days /week for 2 years; SAR 0.4, 1.3 and 4 W/kg	
Zong et al. (2015)	Mice exposed to 900 MHz RFR 4 h/day for 7 days; SAR 0.05 W/kg	RFR alone had no effect on DNA single strand breaks (Comet assay) and oxidative damage in blood leukocytes. It attenuated bleomycin-induced DNA breaks and repair, and oxidative damage.
Zothansiam et al. (2017)	Blood samples from people lived closed to cell phone base station	The exposed group, residing within a perimeter of 80 m of mobile base stations, showed significantly higher frequency of micronuclei in lymphocytes when compared to the control group, residing 300 m away from the mobile base stations.
Zotti-Martelli et al. (2000)	Human peripheral blood lymphocytes exposed to 2.45 and 7.7 GHz RFR for 15, 30, or 60 min; power density 10, 20, or 30 mW/cm ²	Increased micronucleus frequency at a power density of 30mW/cm ² and after an exposure of 30 and 60 min.
Zotti-Martelli et al. (2005)	Human whole blood samples exposed to continuous-wave 1800 MHz RFR for 60, 120 and 180 min; power density 5, 10, or 20 mW/cm ²	A statistically significant increase of micronucleus was observed in lymphocytes dependent on exposure time and applied power density.
*Zuo et al. (2015)	Sprague-Dawley rat spiral ganglion neurons exposed intermittently (5 min ON/10 min OFF) to GSM 1800 MHz RFR for 24 h; SAR 2 and 4 W/kg	The RFR could not directly induce DNA single strand breaks (Comet assay) in normal spiral ganglion neurons, but it could cause the changes of cellular ultrastructure at SAR 4.0 W/kg when cells are in fragile or micro-damaged condition.

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Supplement 2

Genetic effects of static and ELF EMF (*study with no effect observed) Study reported effect =168 (79%); study reported no effect = 45 (21%). (literature up to January 2021)

	Exposure conditions	Results
Agliassa et al. (2018)	Arabidopsis thaliana (thale cress) exposed to 0.00004 mT static magnetic field for 38 days after sowing.	Changes in gene expression in leaf and floral meristem (cryptochrome-related gene involved); delayed flowering time and a significant reduction of leaf area index and flowering stem length, with respect to controls under geomagnetic field.
Ahuja et al. (1999)	Human peripheral blood samples exposed to 50 Hz EMF at 2, 3, 5, 7, or 10 mT	Increased DNA single strand breaks (Comet assay) in lymphocytes.(Damage levels higher in female than in male subjects.)
*Albert et al. (2009)	Human subjects exposed to exposed to 60-Hz magnetic field at 0.2 mT for 4 h	No significant effect on DNA single strand breaks (Comet assay) and micronucleus frequency in lymphocytes.
Alcaraz et al. (2013)	Swiss mice exposed to 50-Hz magnetic field at 0.2 mT for 7, 14, 21, or 28 days	Increased micronucleus frequency in bone marrow. Effect not affected by antioxidants.
Al-Huqail and Abdelhaliem (2015)	Maize seedlings exposed to 50-Hz electric field at 6 kV/m for 1, 3, or 5 days	Increased DNA single strand breaks (comet assay)
Amara et al. (2006)	Male rats exposed to a static magnetic field at 128 mT, 1 h/day for 30 days	Increased 8-oxo-dG concentration and oxidative damage in testis.
Amara et al. (2007a)	Human monocytic leukemia THP-1 cells exposed to static magnetic field at 250 mT for 1, 2, or 3 h	Lower level of DNA single strand breaks (Comet assay) at 3 h of exposure, no effect on oxidative damages and enzymes and oxidative DNA damage.
Amara et al. (2007b)	Rats exposed to a static magnetic field at 128 mT, 1 h/day for 30 days	Increased 8-oxo-7,8-dihydro-2'-desoxyguanosine in kidney but not in liver. Also decreased anti-oxidative enzymes and increased lipid peroxidation. Zinc supplementation attenuated DNA oxidation induced by static magnetic field in kidney to the control level.

*Amara et al. (2009)	Rats exposed to a static magnetic field at 128 mT, 1 h/day for 30 days	No significant effect on 8-oxo-7,8-dihydro-2'-deoxyguanosine in frontal cortex and oxidative stress induced. However, there was an increase in metallothioneins level which might have protected DNA from oxidative damage.
*Amara et al. (2011)	Rats exposed to a static magnetic field at 128 mT, 1 h/day for 30 days, also treated with cadmium (Cd)	Magnetic field had no interaction on Cd-induced increase in 8-oxo-7,8-dihydro-2'-deoxyguanosine in the frontal cortex and hippocampus. However, static magnetic field enhanced Cd-induced increase in oxidative damage in the rat brain.
Arruda-Neto et al. (2009)	<i>Microcystis panniformis</i> , the eukaryote <i>Candida albicans</i> and human MRC5 lung cells exposed to gamma radiation and then to static electric field for 2-20 h at 20- 1250 V/cm	Static electric field caused suppression of DNA repair in <i>C. albicans</i> . It decreased cell growth in <i>M. panniformis</i> when compared with gamma radiation alone. The electric field increased number of nuclei with γ -H2AX foci in the irradiated MRC5 cells. Electric field interferes mostly in the DNA repair mechanisms.
Ashta et al. (2020)	Human glioblastoma cells (A172) exposed to 10 Hz or static magnetic field at 5 mT, up to 96 h	Increased p52 gene expression, cytotoxicity and free radical formation; effects enhanced by Temozolomide.
Back et al. (2019)	Mouse embryonic stem cells exposed to hypomagnetic field (<0.005 mT) up to 12 days	Induced abnormal DNA methylation through the dysregulation of DNA methyltransferase3b (Dnmt3b) expression, eventually resulting in incomplete DNA methylation during differentiation.
Bagheri Hosseinabadi et al. (2019)	Blood samples from 102 thermal power plant workers as the exposure group and 136 subjects as the unexposed group.	Increased DNA single strand breaks (Comet assay) in lymphocytes of exposed subjects.
Bagheri Hosseinabadi et al. (2020)	Blood samples from thermal power plant workers; mean levels of exposure to ELF magnetic and electric fields were .0165 mT (± 6.46) and 22.5 V/m (± 5.38), respectively,	DNA single strand breaks (Comet assay) in lymphocytes decreased by antioxidants.

Balamuralikrishnan et al. (2012)	Blood from electrical workers exposed to ELF EMF occupationally	Increased chromosome aberrations and micronucleus in lymphocytes.
Baraúna et al. (2015)	Chromobacterium violaceum bacteria cultures exposed to ELF-EMF for 7 h at 0.00066 mT	Five differentially expressed proteins detected including the DNA-binding stress protein, which may help to prevent physical damage to DNA.
Belyaev et al. (2005)	Human lymphocytes exposed to 50 Hz magnetic field at 0.015 mT (peak) for 2 h (measurements made at 24 and 48 h after exposure).	Induced chromatin conformation changes and decreased background 53BP1 (protein co-localized with DNA double strand breaks and involves in DNA damage signaling pathway.)
Bertea et al. (2015)	Arabidopsis thaliana (thale cress) exposed to artificially reversed geomagnetic field conditions for 10 days at .0419 mT	Significant effects on plant growth and gene expression observed. This supports the hypothesis that GMF reversal contributes to inducing changes in plant development that might justify a higher selective pressure, eventually leading to plant evolution.
Borhani et al. (2011)	Female NMRI mice exposed to a 50-Hz EMF at 0.5 mT for 4 h/day, 6 days/week for 2 weeks. Mated on day 8 after exposure, on day 4, blastocysts were obtained by flushing the uterus horns.	DNA fragmentation index increased and decrease in blastocytes in exposed group.
*Brix et al. (2020)	Young volunteers allocated to three study arms were exposed to [¹⁸ F] fluoro-D-glucose alone, to a 3-T SMF alone or to both combined over 60 min at a PET/CT or a PET/MRI system.	No significant change in lymphocyte DNA double strand breaks (γH2AX) to static magnetic field or interaction with [¹⁸ F] fluoro-D-glucose.
Buddak et al. (2012)	Murine AT478 carcinoma cells cultured with cisplatin exposed to 50-Hz EMF for 16 min at 1 mT	Exposure to ELF-EMF alone resulted in an increase in DNA single strand breaks (Comet assay) compared to control cells. ELF-EMF lessened the effects of oxidative stress and DNA damage that were induced by cisplatin;

		however, ELF-EMF alone was a mild oxidative stressor and DNA damage inducer. The addition of ELF-EMF exposure to cisplatin treatment resulted in decreased ROS levels and antioxidant enzyme activity.
Burgos-Molina et al (2020)	DNA double strand breaks were induced in <i>Saccharomyces cerevisiae</i> yeast and exposed to a 50-Hz magnetic field for 21 days at 2.45 mT	Long-term magnetic field exposure increased the DNA repair activity.
Calabro et al. (2011)	Human neuronal-like cells exposed to static (2 mT) and 50 Hz (1 mT) for 3 h.	Fourier self deconvolution spectroscopic analysis showed alteration in DNA/RNA and increased beta-sheet.
Calabro et al. (2020)	Human Neuronal-like cells and roots of <i>Allium sativum</i> and <i>Vicia faba</i> exposed to a static and 50 Hz magnetic fields at intensities ranging from 1 mT to 0.8 T	Exposure to both low- and high-intensity magnetic fields in typical human and plant cells induces uncoiling and unpackaging of chromatin constituents, followed by chromosome alignment towards the direction of applied magnetic field, providing further demonstration that magnetic fields can induce the orientation of organic macromolecules even at low-intensity values.
*Cantoni et al.(1996)	Cultured mammalian cells exposed to 50 Hz electric (0.2 - 20 kV/m), magnetic (0.0002-0.2 mT), or combined electric and magnetic fields.	Repair of DNA single strand breaks (Comet assay) induced by the carcinogens methylmethane sulphonate (MMS), chromate, and 254 U.V. radiation not affected by ELF EMF exposure.
Celikler et al. (2009)	Workers from transformer and distribution line stations. The electric field was in the range from 130–8310 V/m and from 300–15,000 V/m, the magnetic field was between 0.5 and 1.7 A/m and 0.25–17 A/m around and inside transformer buildings. Average time of exposure was 19 years.	Increased chromosomal aberrations and micronucleus in peripheral lymphocytes. The frequency of chromosomal aberration in exposed groups correlated with the years of exposure.

*Cellini et al. (2008)	<i>Escherichia coli</i> ATCC 700926 exposed to 50-Hz EMF (0.1, 0.5, 1.0 mT); 20-120 min	No changes among DNA finger-printings. Other measurements indicates 50 Hz EMF acts as a stressing factor on bacteria
*Chahal et al. (1993)	<i>Escherichia coli</i> strain AB1157 exposed to a frequency of 1 Hz with field strengths of 1 or 3 kV m ⁻¹	Low frequency electromagnetic fields do not increase spontaneous mutation, induce DNA repair or increase the mutagenic effects of UV or mitomycin C.
Chen GD et al. (2008)	Human MCF-7 breast cancer cells exposed to a 50-Hz magnetic fields for 24 h at 0.4 mT	Identified three 50 Hz MF responsive genes in MCF-7 cells.
*Chen G et al. (2012)	<i>Saccharomyces cerevisiae</i> yeast cells exposed to a 50-Hz magnetic field at 0.4 mT for 6 h	Yeast cells did not alter gene expression in response to 50 Hz magnetic field.
Chan J. et al. (2020)	Human choriocarcinoma cells exposed to DC electric field (150 mV/mm) for 8 h	Increased gene expressions of ErbB and HIF-1 signaling pathways involved in cell migration/motility, cell cycle progression and proliferation.
Chen WF et al. (2010)	Human myelogenous leukemia K562 cells exposed to static magnetic field at 8.8 mT with or without cisplatin	Static magnetic field exposure induced DNA to become thicker than controls, and enhanced DNA breakage (Comet assay) induced by cisplatin.
Cho S et al. (2014)	Human lymphocytes exposed to 60-Hz EMF at 0.8 mT for 12-72 h with or without gadolinium.	ELF-EMF increased cell death, micronucleus frequency, DNA single strand break (Comet assay), and apoptosis induced by gadolinium.
Cho YH et al. (2007)	Human fibroblasts exposed to 60-Hz EMF at 0.8 mT plus bleomycin for 28, 88, and 240 h	The co-exposure of cells to bleomycin and EMF led to a significant increase in the frequencies of micronucleus and aneuploidy compared to the cells treated with bleomycin alone.
Chow and Tung (2000a)	<i>Escherichia coli</i> strain XL-1 Blue exposed a 50-Hz magnetic field at 0.1-1.2 mT for 1 h	This result was indicative that the efficiency of DNA repair had been improved. The improvement was found to be mediated by the induced overproduction of heat shock proteins DnaK/J (Hsp70/40).
Chow and Tung (2000b)	<i>Escherichia coli</i> strain XL-1 Blue (transformed by plasmid pUC8 that had been mutagenized by	Improved efficiency of DNA repair mediated by the induced overproduction of heat shock proteins DnaK/J (Hsp70/40).

	hydroxylamine exposed a 50-Hz magnetic field at 0.1-1.2 mT for 1 h	
Collard et al. (2013)	Epidermis cultures harvested from human abdominoplasty exposed to ELF electric fields (a biphasic, asymmetric, charge-balanced current stimuli, with a repetition frequency of 40 Hz modulated by a fundamental frequency of 0.125 Hz. The exposure was repeated during 4 s followed by a 4 s break for 40 min/day for 11 days	Observed a significant change in genes expression after 4 days and change in expression in another group of genes at day 4 and 7. Genes are involved in cell proliferation or differentiation, mitosis, cell cycle or in the DNA replication transcription and translation.
Consales et al. (2018)	Human SH-SY5Y neuroblastoma cells and mouse primary cortical neurons exposed to a 50-Hz magnetic field at 1 mT for 4-72 h	Expressions of microRNA miR-34b/c that caused mitochondrial oxidative stress, also altered α -synuclein expression involved in synaptic functions. These effects may be related to neuro-degeneration.
Cuccurazzu et al. (2010)	Mice exposed to 50 Hz EMF at 1 mT for 1-7 h/day for 7 days	Induced increases in the transcription of pro-neuronal genes (Mash1, NeuroD2, Hes1) and genes encoding Ca(v)1.2 channel α 1C subunits in the hippocampus. Generation of new granule cells in the dentate gyrus.
Del Re et al. (2006)	Escherichia coli exposed to sinusoidal or pulsed square wave 50-Hz magnetic field at 1 mT for 40 min	Sinusoidal magnetic field exposure induced a significantly higher level of DnaK and GroEL, whereas a lower level was observed after pulsed magnetic field exposure. When bacterial cells were exposed to heat shock (HS) after ELF-magnetic field exposure: again sinusoidal and pulsed fields resulted in an increase and in a reduction of HSP amount.
Delimaris et al. (2006)	Human lymphocytes exposed to 50-Hz pulsed electric fields (10-Hz carrier frequency) at 4×10^5 V/m for 120 min	Increased in DNA single strand breaks (Comet assay).
Di Campli et al. (2010)	Helicobacter pylori biofilm exposed to 50-	No changes in DNA patterns were recorded, whereas a modulation in amiA gene

	Hz EMF at 1 mT for 2 days	expression was detected; phenotypic changes induced.
Dominici et al. (2011)	Lymphocytes from welders (average magnetic field exposure from personal dosimeters 0.00781 mT (general environmental level 0.00003 mT)	Higher micronucleus frequency correlated with EMF exposure levels; decreased in sister chromatid exchange frequency.
Dong et al. (2019)	Human pre-osteoclast RAW264.7 cells exposed to a 16 T static magnetic field for 2-4 days	HiSMF markedly blocked the expression of osteoclast-associated transcription factors and osteoclast marker genes and inhibited iron absorption and iron storage-related protein expression. Mitochondrial concentration and oxidative stress levels in osteoclasts were decreased under magnetic field exposure.
Du et al. (2008)	Cultured human lens epithelial cells exposed 50-Hz magnetic field at 0.4 mT for 2 h, 6 h, 12 h, 24 h and 48 h	Increased DNA doubled strand breaks (γ -H2AX foci) after 24 h exposure.
Duan et al. (2015)	A mouse spermatocyte-derived GC-2 cell line intermittently (5 min on and 10 min off) exposed to a 50 Hz EMF at 1, 2 or 3 mT for 24 h	Increased DNA strand breaks (Comet assay and γ -H2AX foci) at 3 mT exposure.
El-Bialy and Rageh (2013)	Mice with Ehrlich tumors exposed to a 50-Hz magnetic field 1 h/day for 2 weeks at 10 mT	Exposure cause DNA single strand breaks (Comet assay) in tumor cells and increased micronucleus frequency in bone marrow cells. ELF-MF enhanced the effects of cisplatin.
Erdal et al. (2007)	Wistar rats exposed to 50 Hz magnetic field at 1 mT for 4 h or 4h/day for 45 days	Micronucleus frequency higher in bone marrow cells of long-term exposed rat. Mitotic index decreased in both exposed groups.
*Fairbairn and O'Neill (1994)	Human cells exposed to ELF-EMF	No significant effect on DNA single strand breaks (Comet assay)
Fan et al. (2005)	Rat bone marrow derived-mesenchymal stem cells exposed to a 50-Hz EMF at 1 mT for 4 h/day for 3 days	Increased cell viability, DNA synthesis and proportion of cells in S phase and up-regulated the expressions of hematopoietic growth factors.

Fan et al. (2018)	<i>Enterococcus faecalis</i> (isolated from dental infection) exposed to a static magnetic field at 170 mT for 24 or 72 h.	Static magnetic field up-regulated the expression of stress gene (dnaK) and virulence genes (efaA and ace). Synergistic with alkaline pH induced by calcium hydroxide (a major dental antimicrobial) in antimicrobial action and up-regulation of stress and virulence genes.
Fatigoni et al. (2005)	Tradescantia (a perennial wildflower) exposed to a 50-Hz magnetic field at 1 mT for 6 or 24 h	Caused a time-dependent increase in micronucleus frequency.
Fedrowitz and Loscher (2012)	Female F344 and Lewis rats exposed to a 50-Hz magnetic field at 0.1 mT 24 h/day for two weeks	F344 breast tissue showed alterations in gene expression, which were absent in Lewis rats, particularly, α -amylase, a stress marker.
*Fiorani et al. (1992)	Human immortalized myelogenous leukemia K562 cells exposed to 50-Hz electric (0.2-20 kV/m) or magnetic (0.0002-.2 mT) or combination of electric and magnetic fields, for 24 h	No detectable DNA lesions (measured by filter elution technique).
Focke et al. (2010)	Human fibroblasts exposed to intermittent (5 min ON/10 min OFF) 50-Hz EMF at 1 mT for 15 h	Increased DNA single strand breaks (Comet assay) caused by magnetic and not electric field, No oxidative DNA damage. Could be caused by minor disturbances in S-phase processes and occasional triggering of apoptosis rather than by the generation of DNA damage.
*Frahm et al. (2006)	Mouse macrophages exposed to a 50-Hz magnetic field for 45 min, 12, 24, or 48 h; 0.05 – 1 mT	No genotoxic effect (micronucleus formation); increased phagocytic activity, free radicals, and IL-1 beta production.
*Frazier et al. (1990)	Human lymphocytes induced with DNA damage with ionizing radiation were exposed to 60-Hz magnetic field at 1 mT, electric field at 1 or 20V/m, or combinations of magnetic and electric	EMF exposure did not affect repair of DNA single strand breaks (Comet assay).

	fields (0.2 V/m and 0.05 mT, 6 V/m and 0.6 mT, or 20 V/m and 1 mT) up to 180 min	
Frisch et al. (2013)	Transfected rat primary fibroblast (RAT1) cells exposed to 10 Hz electric fields at 20-500 V/m for 2 h	Induced HSP70 heat shock expression, with peak responses obtained at 8 h following exposure.
Giorgi et al. (2011)	Two Escherichia coli model systems were exposed to sinusoidal or pulsed-square wave magnetic fields of various frequencies (20, 50, 75 Hz) and for different exposure times (15 and 90 min). at 1 mT	ELF-MF exposure affected transposition activity (transposon (Tn) mobility) and the effects critically depended on the wave shape of the field, but not on the frequency and the exposure time.
*Giorgi et al. (2014)	Human neuroblastoma BE(2)C cells treated with hydrogen peroxide exposed to 50-Hz pulsed magnetic field at 1 mT for 1-72 h	Pulsed magnetic field exposure did not interfere with genotoxicity (DNA double strand breaks measured by γ -H2AX foci) and cytotoxicity induced by oxidative stress.
Giorgi et al. (2017)	Human neural cells (BE(2)C) exposed to pulsed 50-Hz magnetic field at 1 mT for 24 and 48 h in combination with oxidative stress (hydrogen peroxide)	Pulsed magnetic field and oxidative stress induced weak decreases and increases of DNA methylation levels; combined exposure led to significant transient decrease of DNA methylation levels at different genome loci.
Heredia-Rojas et al. (2010)	Human non-small cell lung cancer cells (INER-37) and mouse lymphoma cells (RMA E7) (transfected with a plasmid with hsp70 expression when exposed to magnetic field and contains the reporter for the luciferases gene) exposed to a 60-Hz magnetic field at 0.008 and 0.00008 mT for 20 min.	An increased in luciferase gene expression was observed in INER-37 cells exposed to magnetic field, but similar exposure had no effect on the RMA E7 cell line.

Hong et al. (2005)	Mice exposed to a 50-Hz EMF at 0.2 or 6.4 mT for 4 weeks	EMF induced DNA single strand breaks (Comet assay) in testicular cells and chromatin condensation in spermatozoa.
*Huwiter et al. (2012)	Escherichia coli K-12 MG1655 exposed at 50-Hz magnetic fields generated by three signal types (sinusoidal continuous, sinusoidal intermittent, and power line intermittent) at 1 mT for 8 min, 2.5 h, or 15 h	No effect on transcription of 4358 gene studied.
Ivancsits et al. (2002)	Human diploid fibroblasts exposed to continuous or intermittent (5 min ON/10 min OFF) 50-Hz EMF at 1 mT for 24 h	Intermittent exposure induced DNA single and double strand breaks (Comet assay).
Ivancsits et al. (2003a)	Human diploid fibroblasts exposed to intermittent (5 min ON/10 min OFF) 50-Hz EMF at 0.02- 1 mT for 1-24 h	DNA Single and double strand breaks (Comet assay) observed at 0.035 mT at 15 h; recovered within 9 h.
Ivancsits et al.(2003b)	Fibroblasts from human subjects of different ages exposed to intermittent (5 min ON/10 min OFF) 50-Hz EMF at 1 mT for 1-24 h	Increased DNA Single and double strand breaks (Comet assay) at 15 h; more pronounced in cells from older donors
Ivancsits et al. (2005)	Various cell types exposed to intermittent (5 min ON/10 min OFF) 50-Hz EMF at 1 mT for 1-24 h	Effects on DNA Single and double strand breaks (Comet assay) showed three responder (human fibroblasts, human melanocytes, rat granulosa cells) and three non-responder cell types (human lymphocytes, human monocytes, human skeletal muscle cells).
Jajte et al. (2001)	Rat peripheral blood lymphocytes exposed to a 50-Hz magnetic field at 7 mT for 3 h	Increased DNA single strand breaks (Comet assay) in cells treated with ferrous chloride; melatonin attenuated the effect.
*Jin H. et al. (2015)	Non-tumorigenic human lung epithelial L132 cells exposed to a 60-Hz magnetic field at 1 or 2 mT for 9 h	No G2/M arrest or aneuploidy nor interaction with gamma radiation and H ₂ O ₂

*Jin et al, (2012)	Mouse embryonic fibroblast NIH3T3 cells and human lung fibroblast WI-38 cells exposed to a 60 Hz magnetic field at 1 mT for 4 h	No significant effect on micronucleus frequency and interaction with ionizing radiation, H ₂ O ₂ , or c-Myc activation.
*Jin et al, (2014)	NIH3T3 mouse fibroblast cells, WI-38 human lung fibroblast cells, L132 human lung epithelial cells, and MCF10A human mammary gland epithelial cells exposed to a 60-Hz magnetic field at 1 mT for 4 or 16 h	No significant effect on DMA single strand breaks (Comet assay), and interaction with ionizing radiation, H ₂ O ₂ , or c-Myc activation.
Jin et al. (2019)	Arabidopsis young seedlings exposed to a static magnetic field at 600 mT	Increased auxin (a plant growth hormone) from expression of PIN3 and AUX1 genes in root tips; cryptochromes (cry1 and cry 2) are also involved. Root growth enhanced. Effects occurred when static magnetic field was parallel and perpendicular not opposite, to geomagnetic field.
Jouni et al. (2012)	<i>Vicia faba</i> (broad bean) culture in soil with high background radioactivity and exposed to static magnetic field at 15 mT for 8h/day for 8 days	Increased chromosomal aberration and DNA damage in root tip cells with lowering of antioxidant defense; soil radioactivity enhanced the effects.
Kesari et al. (2015)	Human neuroblastoma SH-SY5Y cells exposed to a 50-Hz 100 μ T magnetic field for 24 h.	Micronucleus formation was observed at 15 and 30 days postexposure. Effect not related to oxidative changes.
Kesari et al. (2016)	Human glioblastoma SH-SY5Y and rat glioma C6 cells exposed to a 50-Hz magnetic field at 0.01 and 0.03 mT for 24 h with menadione as a cofactor	Micronuclei were significantly increased in SH-SY5Y cells at 0.03 mT Increased cytosolic and mitochondrial superoxide levels were observed in C6 cells. The results indicate that the threshold for biological effects of ELF magnetic field is 0.01 mT or less.
Khalil and Qassem (1991)	Human lymphocytes exposed to a pulsing 50-Hz EMF at 1.05 mT for 24, 48 and 72 h	Suppression of mitotic activity and a higher incidence of chromosomal aberrations. Delay in cell proliferation index and an increase in the baseline frequency of sister-chromatid

		exchanges occurred only after 72 h f exposure.
Ki et al. (2020)	Human hair follicle dermal papilla cells, a type of cells involved in hair growth, exposed to a 70 Hz EMF at intensities ranging from 0.5 to 10 mT over four days	Increased the expression of anagen-related molecules, including collagen IV, laminin, ALP, and versican, and increased β -catenin and Wnt3 α expression and GSK-3 β /ERK/Akt phosphorylation. Cell proliferation enhanced.
Kim HJ. et al. (2013)	Bone marrow derived mesenchymal stem cells (BM-MSCs) were subjected to a 50-Hz EMF	Increased levels of neuronal differentiation marker (MAP2), while early neuronal marker (Nestin) was down-regulated; increased differentially expression of 8 proteins; notably, a significantly increased expression of the ferritin light chain.
Kim J. et al. (2010)	IMR90 (human lung fibroblast) primary cells and HeLa (human cervical carcinoma) cells exposed to a time-varying (rotating) 60-Hz magnetic field at 6 mT for 60 min or 30 min/day for 3 days	Repeated exposure showed DNA double strand breaks (γ -H2AX foci) and decreased cell viability and increased apoptosis through p38 activation.
Kim J. et al. (2012)	Human primary fibroblast and cervical cancer cells exposed to a time-varying 60-Hz magnetic field at 7 mT for 10-60 min	DNA double strand breaks (γ -H2AX foci and Comet assay) detected (intracellular reactive oxygen species not affected).
Kimsa-Dudek et al. (2018)	Normal human dermal fibroblasts exposed to static magnetic field at 0.65 T for 24 h and sodium fluoride	Static magnetic field attenuated expression of antioxidant defense genes (SOD1, PLK3, CLN8, XPA, HAO1) induced by sodium fluoride.
Kimsa-Dudek et al. (2020)	Normal human dermal fibroblasts exposed to static magnetic field at 0.45, 0.55 and 0.5 T for 24 h and sodium fluoride	The field reduced fluoride-induced apoptosis and affected apoptosis gene expression; reduced fluoride-induced increases in reactive oxygen species and lipid peroxidation and decrease in antioxidant enzymes.
Kimura et al. (2008)	<i>Caenorhabditis elegans</i> exposed to 2, 3, or 5 T static magnetic field for 4-24 h	Genes involved in motor activity, actin binding, cell adhesion, and cuticles are transiently and specifically induced; also hsp (heat shock protein) 12 and 16 family genes.

Kindzelskii and Petty (2000)	Human neutrophils exposed to pulsed square-wave (20 msec) DC electric field at 0.2 V/m for 30, 45, 60 min	Increased DNA single strand breaks (Comet assay).
*Kirschenlohr et al. (2012)	Male human subjects exposed to 50-Hz EMF at 0.062 mT for 2 h (Exposure repeated two more times.)	No genes or gene sets in blood samples showed consistent response profiles to repeated ELF-EMF exposures (including immediate early genes, stress response, cell proliferation and apoptotic genes).
Koyama et al. (2008)	Human glioma A172 cells exposed to a 60-Hz magnetic field at 5 mT for 2, 4, 8, 16, 24 h	The number of apurinic/apyrimidinic sites induced by genotoxic agents methyl methane sulfonate and H ₂ O ₂ was enhanced by exposure to ELF magnetic fields. (Apurinic/apyrimidinic sites are common DNA lesions arise from spontaneous depurination or by base excision repair of oxidized, deaminated or alkylated bases.)
Kubinyi et al. (2010)	Human lymphocytes exposed to an inhomogeneous static magnetic field with a lateral magnetic flux density gradient of 47.7, 1.2, or 0.3 T/m by 10 mm lateral periodicity, or a homogeneous SMF of 159.2 mT magnetic flux density for a time period of 0.5 min, 1, 2, 4, 6, 18, 20, or 24 h.	Increased DNA single strand breaks (Comet assay); affected DNA repair induced by gamma ray when exposure occurred after ionizing radiation treatment.
Kumari et al. (2017)	Mice exposed continuously for 5 weeks to 7.5 KHz MF at 120 μ T	Expression of the pro-inflammatory cytokine tumor necrosis factor alpha mRNA was significantly increased in the hippocampal region; impairment of memory observed.
*Lacy-Hulbert et al. (1995)	Human leukemic cells (HL60) exposed to a 60-Hz EMF for 20 min at 0.00057, 0.0057, or 0.057 mT	No change in MYC and beta-actin gene expression observed.
Lagroye and Poncy (1997)	Rat tracheal epithelial cell lines were first exposed to gamma rays and then cultured in a 50-Hz magnetic field at 0.1 mT for 24 h.	Increased binucleated cells with micronuclei in cells exposed to gamma rays and magnetic field, compared with gamma irradiation alone. Magnetic field alone had no significant effect on micronucleus frequency.

Lai and Singh (1997a)	Male Sprague-Dawley rats exposed to a 60-Hz magnetic field at 0.1, 0.25, or 0.5 mT for 2 h	Increased DNA single and double strand break (Comet assay) in brain cells.
Lai and Singh (1997b)	Male Sprague-Dawley rats exposed to a 60-Hz magnetic field at 0.5 mT for 2 h	Increased DNA single and double strand break (Comet assay) in brain cells. Effects blocked by melatonin and a spin-trap compound.
Lai and Singh (2004)	Male Sprague-Dawley rats exposed to a 60-Hz magnetic field at 0.01 mT for 24 or 48 h	Increased DNA single and double strand break (Comet assay) in brain cells. More effect with 48-h than 24-h exposure. Effects blocked by Trolox (a vitamin E analog) and 7-nitroindazole (a nitric oxide synthase inhibitor).
Laramée et al. (2014)	Transfected rat primary fibroblast (RAT1) cells exposed to static magnetic fields of 1 to 440 mT for 16, 24, or 48 h starting at 24 and 48 h post transfection	Induction of heat shock protein (HSP70) expression showed a dependency on flux density, exposure duration, and start time post transfection.
Lee et al. (2010)	<i>Caenorhabditis elegans</i> exposed to exposed to a static magnetic field at 200 mT	Expression of genes involved in development and aging. Accelerated development and shorten lifespan.
Lee et al. (2016)	MCF10A, MCF7, Jurkat, and NIH3T3 cells exposed to a 60 Hz magnetic field at 1 mT for 4 or 16 h	MCF10A and MCF7 cells showed consistent and significant decreases in cell number, cell viability, and DNA synthesis rates (cell cycle delay), whereas Jurkat and NIH3T3 cells showed no effect. MCF7 cells (2 mT for 16 h) showed up-regulation of PMAIP1 gene (involved in apoptosis).
Lee et al. (2011)	Human lymphocytes exposed to EMF generated during MRI scanning (clinical routine brain examination protocols: three-channel head coil) for 22, 45, 67, and 89 min	Significant increases in DNA single-strand breaks (Comet assay), and frequencies of both chromosome aberrations and micronuclei in a time-dependent manner.
Leone et al. (2014)	Neural stem cells isolated from hippocampi of newborn mice exposed to a 50-Hz EMF at 1 mT for 10 days	Histone acetylation-related chromatin remodeling leading to enhanced proliferation and neuronal differentiation.

Li and Chow (2001)	E. coli XL-1 Blue transformed with plasmid pUC18 and DNA samples exposed to a 50-Hz magnetic field at 1.2 mT for 1-5 h, with heat shock response suppressed	Without the protection of the heat shock response, magnetic field exposure induced DNA degradation, which could be attenuated by the presence of an antioxidant,
*Li L. et al (2015)	Workers from a power supply bureau (inspection workers vs. logistic staff); The average time-weighted average was 0.0073 mT (0.00156-0.02633 mT) and the subjects were subgrouped by cumulative ELF-magnetic field exposure dose: low (<0.0156 mT), middle (0.0156-0.073 mT) and high (> 0.073 mT)	No significant effect on the frequency of micronucleus lymphocytes or micronuclei frequency; no changes in antioxidant enzymes and cellular oxidative damage.
Li SS et al. (2013)	Male <i>Drosophila melanogaster</i> fruit flies exposed to a 50-HZ EMF at 3 mT for 72 or 312 h	Different sets of genes were up- and down-regulated after short- or long-term exposure. Short-term exposure may decrease the reproductive ability of males, whereas long-term exposures had no effect on reproductive ability.
Li Y. et al. (2014)	Fertilized embryos of zebra fish (<i>Danio rerio</i>) exposed to a 50-Hz magnetic field at 0.1 - 0.8 mT for 96 h	The transcription of apoptosis-related genes (caspase-3, caspase-9) was significantly up-regulated in exposed embryos. Delayed hatching and apoptosis observed.
Li, Y. et al. (2015)	Rat oligodendrocyte precursor cells exposed to DC electric field at 50, 100. Or 200 mV/mm for 1.5 h	Mitogen-activated protein kinase pathway that signals cell migration was significantly upregulated in cells treated with an EF of 200 mV/mm compared with control cells and downregulation of differentially expressed genes in chemotaxis.
Li Y. et al. (2019)	Dementia rats induced by streptozotocin (STZ) intracerebroventricular injection exposed to a 10 mT 20-Hz pulsed EMF,	Pulsed EMF increased expression of insulin growth factor 2 (IGF-2) in the hippocampus and improved the ability of learning and memory in STZ-treated rats.

	2 h/day, 10 days	
Lin et al. (2016)	Budding yeast exposed to a 50-Hz EMF at 6 mT for 96 h	The transcription levels of 28 genes were upregulated and those of four genes were downregulated. Exposure can upregulate the expression of genes involved in glucose transportation and the tricarboxylic acid (TCA) cycle, but not the glycolysis pathway.
Liu et al. (2015)	Mouse spermatocyte-derived GC-2 cell line exposed to an intermittent (5 min ON/10 min OFF) 50-Hz EMF at 1, 2, or 3 mT for 72 h	Exposure decreased genome-wide methylation at 1 mT, but global methylation was higher at 3 mT. Expression of DNMT1 and DNMT3b (DNA methyltransferases) was decreased at 1 mT, and increased at 3 mT.
*Lopucki et al. (2005)	Cotyledons dissected from placentas obtained immediately after physiological labors exposed to a 50-Hz magnetic field at 2 or 5 mT for 3 h	No significant effect on level of 8-hydroxy-2'-deoxyguanosine in DNA (oxidative DNA damage).
Lourencini da Silva et al. (2000)	SnCl ₂ -treated pBR322 plasmids exposed to a 3400Hz square-wave EMF with peak power of 4V for 2 h	An EMF-dependent potentiation of DNA scission (i.e. the appearance of relaxed plasmids) was observed. The results indicate that the EMF, in the presence of a transition metal, is capable of causing DNA damage.
*Luceri et al. (2005)	Human peripheral blood lymphocytes and DBY747 <i>Saccharomyces cerevisiae</i> exposed to a 50-Hz magnetic field at 0.001, 0.01 or 0.1 mT for 18 h	No significant effects on DNA single strand breaks (Comet assay), oxidated DNA base, and gene expression.
Lupke et al (2006)	Human umbilical cord blood-derived monocytes exposed to a 50-Hz magnetic field at 1 mT for 45 min	Alteration of 986 genes involved in metabolism, cellular physiological processes, signal transduction and immune response.
Luukkonen et al. (2011)	Human SH-SY5Y neuroblastoma cells. Exposed to a 50-Hz magnetic field at 0.1 mT for 24 hours, followed by chemical (menadione) exposure for 3 h	Magnetic field enhanced menadione-induced DNA damage, DNA repair rate, and micronucleus formation. No effects were observed after magnetic field exposure alone.

Luukkonen et al. (2014)	Human SH-SY5Y neuroblastoma cells. Exposed to a 50-Hz magnetic field at 0.1 mT for 24 hours, followed by menadione exposure for 3 h	Persistently elevated levels of micronuclei were found in the progeny of magnetic field (alone)-exposed cells at 8 and 15 days after exposure, indicating induction of genomic instability. (No magnetic field x menadione interaction effect). Magnetic field disturbed oxidative balance immediately after the exposure, which might explain the previous findings on MF altered cellular responses to menadione-induced DNA damage.
Luukkonen et al. (2017)	Human SH-SY5Y neuroblastoma cells. Exposed to a 50-Hz magnetic field at 0.1 mT for 24 hours, followed by menadione exposure for 1 or 3 h	Decreased p21 protein (a DNA damage response-related proteins) level after 1-h menadione treatment, as well as increased proportion of cells in the G1 phase and decreased proportion of S phase cells after 3-h menadione treatment. Magnetic field exposure decreased DNA single strand breaks (Comet assay) caused by 1 h treatment with menadione.
Ma et al. (2014)	Mouse embryonic neural stem cells exposed to a 50-Hz EMF at 2 mT for 3 days	Expression of genes regulating neuronal differentiation was altered.
Mahaki et al. (2019)	Rats exposed to a 50-Hz EMF at 0.001-2 mT for 2 h/day for 60 days	In the spleen, gene expression levels of ROR α (retinoid-related orphan receptor alpha) and c-Maf (transcription factor Maf) were significantly down-regulated at 0.001 and 0.1 mT, while the expression of STAT6 (signal transducer and activator of transcription 6) was only significantly decreased at the density of 0.1 mT. No effect on thymus.
Mahmoudinasab and Saadat (2016)	Human MCF-7 cells exposed to a 50-Hz magnetic field at 0.25 and 0.5 mT (5 min ON/5 min OFF, 15 min ON/15 min OFF, or 30 min field-on continuously) for 30 min	Alterations in the <i>NQO1</i> and <i>NQO2</i> (NAD(P)H: quinone oxidoreductase) mRNA levels seen at the "5 min ON/5 min OFF" condition.
Mahmoudinasab and Saadat (2018a)	MCF-7 and SH-SY5Y cells exposed to 50-Hz EMF at 0.5 mT (15 min ON/ 15 min OFF), and treated with morphine and cisplatin.	EMF exposure could protect SH-SY5Y cells from the cytotoxicity of cisplatin and morphine, whereas it has no significant change in MCF-7 cells. Expression patterns of antioxidant genes are different in both cell lines.

Mahmoudinasab and Saadat (2018b)	SH-SY5Y cells exposed to 50-Hz EMF at 0.5 mT ("15 min ON/ 15 min OFF" and "30 min ON") for 30 min, and treated with morphine and beta-lapachone	NQO1 mRNA level decreased in the "15 min field-on/15 min field-off" condition, the expression level of NQO2 was increased. Morphine and EMF reduced the cytotoxicity of beta-lapachone.
Mahmoudinasab et al. (2016)	Human MCF-7 cells exposed to a 50-Hz magnetic field at 0.25 and 0.5 mT (5 min ON/5 min OFF, 15 min ON/15 min OFF, or 30 min field-on continuously) for 30 min	Significant changes in mRNA levels of seven antioxidant genes for "the 15 min field-on/15 min field-off condition".
Mairs et al. (2007)	UVW human glioma cells to a 50-Hz EMF at 1 mT for 12 h	Induced 0.011 mutations/locus/cell, which was equivalent to a 3.75-fold increase in mutation induction compared with unexposed controls. The field also potentiated the mutagenic capacity of gamma-irradiation.
Manzella et al. (2015)	Human dermal fibroblasts exposed to a 50 Hz magnetic field at 0.1 mT for 1 h	Changes in expression of clock genes.
Mariucci et al. (2010)	CD1 mice exposed to a 50-Hz magnetic field at 1 mT for 1 or 7 days (15 h/day)	Increased DNA single strand breaks (Comet assay) in brain areas detected immediately after 7-day exposure. No effect on HSP-70 expression.
Markkanen et al. (2008)	Murine L929 fibroblasts exposed to a 50-Hz magnetic field at 0.1 or 0.3 mT for 24 h, with or without ultraviolet B (UVB, wavelength 280-320 nm) radiation or menadione (MQ)	Pre-exposure to magnetic field can alter cellular responses to other agents, and indicate that magnetic field as low as 0.1 mT has measurable impacts on cancer-relevant cellular processes such as DNA-damage.
Mastrodonato et al. (2018)	Mice exposed to a 50 Hz, 1 mT EMF 3.5 h/day for 12 days	Increased Wnt3 (neurogenesis gene) mRNA expression and nuclear localization of its downstream target β -catenin in subventricular zone of the lateral ventricle. Mice showed enhanced olfactory memory at 30 days post-exposure.

*McNamee et al. (2002)	10-day-old mice exposed to a 60-Hz magnetic field at 1 mT for 2 h, cerebellum assayed at 0, 2, 4, and 24 h after exposure	DNA single strand breaks (Comet assay): “While increased DNA damage was detected by tail ratio at 2h after MF exposure, no supporting evidence of increased DNA damage was detected by the other parameters.” “Taken together, these results do not support the hypothesis that acute MF exposure causes DNA damage in the cerebellums of immature mice.” No change in apoptosis.
*McNamee et al. (2005)	Rodents (adult rats, adult mice, and immature mice) exposed to a 60-Hz magnetic field at 0.1, 1 or 2 mT for 2 h. Assayed at 0, 2 and 4 h after exposure	This study provided no evidence of magnetic-field-induced DNA single strand breaks (Comet assay) in the brain.
Mercado-Sáenz et al. (2019)	<i>Saccharomyces cerevisiae</i> wild type strain (WS8105-1C) exposed to sinusoidal magnetic field (2.45 mT, 50 Hz, continuous) or pulsed magnetic field (1.5 mT, 25 Hz, 8 h/day). Chronological aging was evaluated during 40 days	Decreased spontaneous frequency of mitochondrial mutation during aging was observed in pulsed magnetic field-treated samples.
*Miyakoshi et al. (1996a)	Chinese hamster ovary (CHO) cells exposed to a 60-Hz magnetic field at 5 mT for 130 h	No significant effect on c-myc expression and cell growth rate.
Miyakoshi et al. (1996b)	Human melanoma MeWo cells exposed to a 50-Hz magnetic field at 400 mT up to 20 h	Induced mutations in the hypoxanthine-guanine phosphoribosyl transferase gene, synergistic with X-ray. No significant increase in mutant frequency occurred when DNA replication was inhibited during magnetic field exposure. DNA replication error is suspected of causing the mutations produced by ELFMF exposure.
Miyakoshi et al. (1997)	Human melanoma MeWo cells exposed to a 50-Hz magnetic field at 400 mT for 2 h	Induced mutations in the hypoxanthine-guanine phosphoribosyl transferase gene, DNA replication errors and/or disturbance of the mismatch repair systems caused by exposure to ELF-MF may be involved in the

		mutagenic effect.
Miyakoshi et al. (1998)	Human osteosarcoma cells (Saos-LP-12), with deleted 53 gene, exposed to a 50-Hz magnetic field at 400 mT for 4 h	Induced mutations in the hypoxanthine-guanine phosphoribosyl transferase gene. Introduction of the wild-type (wt) p53 expression plasmid (pOPRSVp53) suppressed the magnetic induced mutation. The findings suggest that wt p53 has a function in suppression of DNA replication errors and/or in maintenance of genomic stability after high-density magnetic field exposure.
Miyakoshi et al. (1999)	Chinese hamster ovary K1 (CHO-K1) cells exposed to a 60-Hz magnetic field at 5 mT for up to 6 weeks	No effect on mutant frequency of the hypoxanthine-guanine phosphoribosyl transferase but enhanced the effect of x-ray.
Miyakoshi et al. (2000)	Human glioma MO54 cells exposed to a 50-Hz magnetic field at 55, 50, or 400 mT at 4°C or on ice, for 30 min	Exposure to magnetic field at more than 50 mT potentiated X-ray-induced DNA single strand breaks (Comet assay).
*Mizuno et al. (2014)	Human fibroblast WI38VA13 subcloned 2RA and XP2OS(SV) cells exposed to a 60-Hz magnetic field at 5 mT for 24 h	Magnetic field exposure did not have modification effect on cell survival after UV-B irradiation and on repair process of DNA damage induced by UV-B irradiation.
Moraveli et al. (2016)	dermal papilla mesenchymal cells exposed to 50-Hz EMF at 1 mT for 5-14 days	Increased expression of MAP gene with decreased cell proliferation (cell differentiation occurred.) (MAP2 protein involves in neuritogenesis to stabilize microtubules.)
Moretti et al. (2005)	Jurkat cells exposed to a 50-Hz magnetic field at 1 mT for 1 h with added xenobiotics	Magnetic field exposure enhanced genotoxic effects (DNA single strand breaks (Comet assay)) of xenobiotics.
Mouhoub et al. (2017)	<i>Salmonella hadar</i> grown under static magnetic field of 200 mT for 3, 6, or 9 h	Increased expression of gene involved in the production of acdiolipin and phosphatidylethanolamine (both components of bacteria cell membrane).
Nakayama et al. (2016)	Macrophages stimulated with the bacterial endotoxin, lipopolysaccharide and	Increased DNA single strand breaks (Comet assay) and decreased viability.

	posed to a 50-Hz magnetic field at 0.5 mT for 24 h	
Nasrabadi et al. (2018)	Neonatal human retinal pigment epithelial cells exposed to pulsed 50-Hz EMF at 1 mT for 8 h daily for 3 days	Both gene and protein expressions of retinal progenitor cell markers were reduced.
Nikolova et al. (2005)	Mouse embryonic stem (ES) cells exposed to an intermittent (5 min ON/30 min OFF) 50-Hz EMF at 2 mT for 6 or 48 h	Significantly affected transcript levels of the apoptosis-related bcl-2, bax, and cell cycle regulatory "growth arrest DNA damage inducible" GADD45 genes, No effect on DNA single and double strand breaks (Comet assay).
*Okudan et al. (2010)	Swiss mice exposed to a 50-Hz EMF at 0.001 - 0.005 mT for 40 days	The results suggest that ≤ 0.005 mT intensities of 50 Hz EMFs did not cause genotoxic effect in the mouse. (However, The number of micronucleus per peripheral blood lymphocytes in the 0.004 and 0.005 mT-exposure groups were significantly higher than those of the lower intensity exposure groups. The males in 0.004 mT-exposure group displayed the highest micronucleus number per lymphocyte).
Panagopoulos et al. (2013)	Newly eclosed <i>Drosophila melanogaster</i> exposed to 50-Hz magnetic field (0.1, 1.1, and 2.1 mT) continuously during the first 5 days of their adult lives	Severe DNA damage (DNA fragmentation by TUNEL assay) and consequent cell death induction in the reproductive cells.
Pesqueira et al. (2017)	Human tendon-derived cells exposed to a 2 Hz magnetic field at 350 mT for 4 or 8 h, or 8 h every 24 or 48 h up to 14 days	8-h exposure significantly upregulated the expression of tendon-associated genes SCX, COL1A1, TNC and DCN. 8 h every 24 h exposure significantly upregulated COL1A1, COL3A1 and TNC at day 14.
Pilger et al. (2004)	Human fibroblasts exposed to an intermittent (5 min ON/10 min OFF) 50-Hz EMF at 1 mT for 15 h	Exposure resulted in an increase in DNA single strand breaks (Comet assay) unlikely to be caused by intracellular changes that affect intracellular $[Ca^{2+}]$ or mitochondrial membrane potential.
Potenza et al. (2004a)	<i>E. coli</i> XL-1Blue exposed to static	Increased cell proliferation and changes in gene expression observed. The field

	magnetic field at 300 mT up to 50 h	magnetic field may stimulate transposition activity.
Potenza et al. (2004b)	Escherichia coli DNA, plasmid, and amplification products of different lengths exposed to static magnetic field at 200-150 mT for 5 h	The in vitro assays displayed interactions between the magnetic field and DNA, revealing principally that magnetic field exposure induces DNA alterations in terms of point mutations.. This genotoxic effect of the magnetic field, however, is minimized in living organisms due to the presence of protective cellular responses.
Rageh et al. (2012)	Newborn rats (10 days after delivery) exposed continuously to a 50 Hz magnetic field at 0.5 mT for 30 days	Increased DNA single strand breaks (Comet assay) in brain cells and micronucleus frequency in bone cells. Changes in anti-oxidative enzymes and increased lipid peroxidation.
*Reese et al. (1998)	Chinese hamster ovary (CHO) cells exposed to 60-Hz magnetic fields (0.1 or 2 mT), electric fields (1 or 38 V/m), or combined magnetic and electric fields (2 mT and 38 V/m, respectively) for 1 h	No significant effect on DNA single strand breaks (Comet assay) from exposures.
Reyes-Guerrero et al. (2010)	Adult male and female Wistar rats exposed to a 60-Hz magnetic field at 1 mT for 2 h/day for 9 days	ELF EMF modulates estrogen receptor- beta gene expression in the olfactory bulb of female adult rats but not in males.
Robison et al. (2002)	HL-60, HL-60R, and Raji cell lines exposed to a 60-Hz EMG at 0.15 mT for 24 h	EMF exposure offers significant protection from apoptosis (DNA double strand breaks (Comet assay)) and significantly decreased DNA repair rates in HL-60 and HL-60R cell lines but not in the Raji cell line.
*Ross et al. (2018)	Human mesenchymal stromal cell exposed to a 5-Hz EMF at 0.4 mT for 20 min/day, 3 times a week for 2 weeks	No chromosome breaks, viability and proliferation rate detected.
*Ruiz-Gómez et al. (2010)	Wild type (wt) and radiation sensitive mutant yeast strains (Saccharomyces cerevisiae) exposed to a	The exposure did not induce alterations in cell cycle and cause DNA damage.

	50 Hz magnetic field at 2.45 mT for 96 h	
Sadri et al. (2017)	Human mesenchymal stem cells derived from human newborn cords exposed to a static magnetic field of 12, 18, or 24 mT for 2 h	Induced differentiation and decreased expression of Sox-2, Nanog, and Oct-4 genes (These genes are involved in embryonic organ development, maintenance of multipotency and self renewal of undifferentiated embryonic stem cell.)
Sanie-Jahromi et al. (2016)	Human breast adenocarcinoma MCF-7 and neuroblastoma SH-SY5Y cells exposed to 50-Hz EMF at 0.25 and 0.5 mT (5 min ON/5min OFF; 15 min ON/15min OFF, or 30 ON continuously) for 30 min	mRNA levels of seven genes involved in DNA repair pathways down regulated in MCF-7 cells. Synergistic with cisplatin in MCF-7 and SH-SY5Y cells.
Sanie-Jahromi and Saadat (2017)	MCF-7 and SH-SY5Y cells exposed to an intermittent (15 min ON/15-min OFF) 50-Hz EMF at 0.5 mT for 30 min. Cells were also treated with cisplatin and bleomycin	EMF exposed MCF-7 cells treated with cisplatin and bleomycin showed more effects on some DNA repair gene expression compared with “cisplatin and bleomycin” treatment alone, while SH-SY5Y susceptibility was not changed between the two treatments.
Sanie-Jahromi and Saadat (2018)	MCF-7 and SH-SY5Y cells were treated with 5.0 μ M morphine and exposed to an intermittent (15 min ON/15 min OFF) 50-Hz EMF at 0.50 mT for 30 min	Morphine treatment showed significant down-regulation of expression of genes involved in DNA repair pathways, while in "Morphine + EMF" treatment, the genes were not significantly changed.
Sarimov et al. (2011)	Human lymphocytes exposed to 50-Hz magnetic field at 0.005-0.02 mT for 15-180 min	Magnetic field condensed relaxed chromatin and relaxed condensed chromatin.
*Scarfi et al (2005)	Human diploid fibroblasts exposed to an intermittent (5 min ON/10 min OFF) 50-Hz EMF or a 50-Hz field plus its harmonics for 24 h (1,2,4-BT) also studied	No significant effects on DNA single strand breaks (Comet assay) and micronucleus frequency.

Scassellati Sforzolini et al. (2004)	Cells exposed to a 50-Hz magnetic field at 5 mT; co-genotoxic effects with N-methyl-N'-nitro-N-nitrosoguanidine (MNNG), 4-nitroquinoline N-oxide (4NQO), benzene, 1,4-benzenediol (1,4-BD), or 1,2,4-benzenetriol	Magnetic field showed genotoxic (micronucleus test) and co-genotoxic (comet assay) capabilities.
Schmitz et al. (2004)	Male adult mice exposed to a 50-Hz magnetic field at 1.5 mT for 8 weeks	A significant increase in both unscheduled DNA synthesis and in situ nick translation was only found for epithelial cells of the choroid plexus. Mitochondrial DNA synthesis was exclusively increased in renal epithelial cells of distal convoluted tubules.
Seong et al. (2014)	Human bone marrow-mesenchymal stem cells exposed to a 50 Hz EMF at 1 mT for 8 days	Increased expression of early growth response protein 1 (Egr1).
*Shen et al. (2016)	Chinese Hamster Lung cells exposed to a 50-Hz EMF at 0.4mT for 30 min or 24 h	Increase in LC3-II expression and increased autophagosome formation; no significant effect on γ H2AX foci.(EMF-induced autophagy may balance the cellular homeostasis to protect the cells from severe adverse biological consequences.)
Shokrollahi et al. (2018)	Soybean plants exposed to static magnetic field at 20 and 30 mT for 5 h/day for 5 days	Exposure to 20 mT decreased gene expression of Fe transporter, ferrous and H ₂ O ₂ contents and gene expression, content and activity of ferritin and catalase. Opposite responses were observed at 30 mT exposure. Tertiary structures of ferritin, apoferritin and catalase altered by static magnetic field.
Singh and Lai (1998)	Rats exposed to a 60-Hz magnetic field at 0.5 mT for 2 h	Data suggested that both DNA-protein and DNA-DNA crosslinks (Comet assay) were formed in brain cells.
Skyberg et al. (2001)	Blood samples from high voltage laboratory workers exposed to electromagnetic fields and mineral oil	In inhibited (hydroxyurea-inhibits DNA synthesis, and caffeine-inhibits DNA repair) lymphocyte cultures, there were indications that electromagnetic fields in combination with mineral oil exposure may produce chromosomal aberrations. No effect on un-inhibited cells.

Solek et al. (2017)	Mouse spermatogenic cell lines (GC-1 spg and GC-2 spd) exposed to pulsed (1sec on/off) or continuous-wave 2, 50, 120 Hz EMF at 2.5- 8 mT for 2 h	EMF activated oxidative and nitrosative stress-mediated DNA damage pathways, resulting in p53/p21-dependent cell cycle arrest and apoptosis
*Song et al. (2018)	HeLa and primary IMR-90 fibroblasts exposed to a 60-Hz EMF at 1, 3, 6, or 10 or mT continuously for up to 168 h or 30 min every 24h for 3 days	No effect on DNA damage (gamma-H2AX foci).; promoted cell proliferation (probably due to decreased reactive oxygen species).
Stankevičiūtė et al. (2019)	Rainbow trout (<i>Oncorhynchus mykiss</i>) exposed to a 50-Hz EMF at 1 mT for 40days; and the common ragworm (<i>Hediste diversicolor</i>) and the Baltic clam (<i>Limecola balthica</i>) for 12 days	Trout and ragworm erythrocytes and clam gill cells showed elevated micronucleus frequency, nuclear buds, nuclear buds on filament cells, and cells with blebbed nuclei.
*Stronati et al. (2004)	Human whole blood exposed to a 50-Hz magnetic field at 1 mT for 2 h	No significant effects on DNA single strand breaks (Comet assay), sister chromatid exchanges, chromosome aberrations, and micronucleus frequency in lymphocytes. A slight decrease in cell proliferation observed.
*Sun C et al. (2018)	ATM-proficient (Atm ^{+/+}) and ATM-deficient (Atm ^{-/-}) mouse embryonic fibroblasts exposed to a 50-Hz magnetic field at 2 mT for 15 min.(Ataxia telangiectasia mutated (ATM) plays a central role in DNA damage repair.)	No effect on γ -H2AX foci in both types of cells.
Sun L et al. (2019)	Irpex lacteus, a white-rot fungus, exposed to a 50-Hz magnetic field at 3.5 mT for 3 h/day for 4 days	Global gene expression changes were observed.
Sun RG et al.(2012)	K562 human leukemia cells exposed to	The potency of the combination of SMF and paclitaxel was greater than that of SMF or

	paclitaxel in the presence or absence of 8.8 mT static magnetic field for 24 h	paclitaxel alone on K562 cells, and these effects were correlated with DNA single strand breaks (Comet assay).
Suzuki et al. (2001)	Mouse exposed to high intensity static magnetic fields (3.0 T for 48 and 72 h and 4.7 T for 24, 48 and 72 h).	Increased micronucleus frequency in bone marrow cells.
Svedenstal et al. (1999)	Brain cells of CBA mice exposed to a 50 Hz magnetic field at 0.5 mT 2 h, 5 days or 14 days	DNA single strand breaks (Comet assay) increased after 14 days of exposure,
*Szerencsi et al. (2013)	Peripheral blood samples from men exposed to EMF produced by 3T magnetic resonance imaging equipment for 0, 22, 45, 67, and 89 min during the scanning procedure	No significant effect on DNA single strand breaks (Comet assay) and DNA integrity in lymphocytes.
Teodori et al. (2014)	Human glioblastoma cells exposed to static magnetic field at 80 mT for 6,12, or 24 h, also in combination with X-ray	Increased in DNA single strand breaks (Comet assay) after 24 h of exposure; x-ray induced DNA strand breaks significantly reduced by post-irradiation exposure to static magnetic field. Further data suggested that static magnetic field modulated DNA damage and/or repair, possibly through a mechanism that affects mitochondria.
*Testa et al. (2004)	Human blood samples exposed to a 50-Hz magnetic field at 1 mT for 48 h	No significant effect on micronucleus frequency and proliferation of lymphocytes. No interaction with x-ray.
*Tiwari et al. (2015)	Blood samples of human subjects occupationally exposed to 132 kV high-voltage substations (mean duration on job 9.27 years, range 2-30 years).	No significant effect on DNA single strand breaks (Comet assay) in lymphocytes, increased oxidative stress observed.
Udroiu et al. (2006)	Liver and peripheral blood sampled from newborn mice exposed to a 50-Hz magnetic field of 0.65 mT during the	Data obtained in newborn mice showed a significant increase in micronuclei frequencies. No significant effect was recorded on exposed adults.

	whole intra-uterine life (21 days), and on bone marrow and peripheral blood from adult mice exposed to the same magnetic field for the same period	
Udroiu et al. (2015)	Mice exposed to 50-Hz, 0.065 mT magnetic field, 24 hours/day, for a total of 30 days, starting from 12 days post-conception	Magnetic field induced a slight genotoxic damage (micronucleus formation) and no interaction with x ray in erythrocytes, but modulate the response of male germ cells to X-rays with an impact on proliferation/differentiation processes. Magnetic field exposure decreased DNA single and double strand breaks (Comet assay) in germ cells at 42 days after birth.
*Verschaeve et al. (2011)	<i>Salmonella typhimurium</i> exposed to a 50-Hz magnetic field at 0.1 or 0.5 mT for 1 or 2 h	The magnetic field did not induce mutagenicity in <i>S. typhimurium</i> bacteria and did not show any synergetic effect when combined with chemical mutagens.
*Verschaeve et al. (2016)	<i>Salmonella typhimurium</i> exposed to 50 Hz magnetic field at 0.1 mT for 1 h	The magnetic field did not damage DNA and had no influence on the DNA damaging capacity of several mutagens.
Villarini et al. (2006)	Human leukocytes exposed to a 50-Hz magnetic field at 3 mT for 30, 60, or 120 min and treated with mutagens	Magnetic field exposure increased N-methyl-N'-nitro-N-nitrosoguanidine and decreased 4-nitroquinoline N-oxide-induced DNA single strand breaks (Comet assay).
Villarini et al. (2013)	Male CD1 mice exposed to a 50-Hz magnetic field at 0.1, 0.2, 1 or 2 mT for 7 days (15 hours/day) and sacrificed either at the end of exposure or after 24 h	Magnetic field exposure induced DNA single strand breaks (Comet assay) and did not affect hsp70 expression in the brain.
Villarini et al. (2015)	Blood leukocytes from electric arc welders presumably exposed to 50-Hz EMF (mean 0.0078 mT; range: 0.00003-0.171 mT)	Decreased DNA single strand breaks (Comet assay), may be caused by DNA-protein crosslinks by metal exposure.
*Villarini et al. (2017)	SH-SY5Y and SK-N-BE-2 human neuroblastoma cells	or AlCl ₃ alone induced DNA single strand breaks (Comet assay), changes in GSH/GSSG ratio or variations in Hsp70

	exposed to a 50-Hz magnetic field at 0.01, 0.1, or 1 mT for 1 h continuously or 5 h intermittently (15 min ON/15 min OFF), and also aluminum	expression. Co-exposure to ELF-MF and AlCl ₃ did not have any synergic toxic effects.
Wahab et al. (2007)	Human peripheral blood lymphocytes exposed to 50 Hz sinusoidal (continuous or pulsed) or square (continuous or pulsed) magnetic fields at 0.001 or 1 mT for 72 h	A significant increase in the number of sister chromatid exchange /cell observed.
*Wang Y et al. (2019)	Human ventricular cardiomyocytes exposed to a 50-Hz magnetic field at 0.1 mT for 1 h continuously or 75 min intermittently (15 min ON/15 min OFF). Sprague-Dawley rats exposed to 50 Hz magnetic field at 0.1 mT for 15 h/day for 7 days	Magnetic field exposure did not cause DNA single strand breaks (Comet assay) in heart cells in both in vitro and in vivo experiments.
Wang Y. et al. (2020)	<i>Caenorhabditis elegans</i> exposed to 50-Hz, 3 mT EMF for 15 generations	Expression levels of the <i>r53.4</i> , <i>hpo-18</i> , <i>atp-5</i> , and <i>atp-3</i> genes encoding ATPase and <i>sod-1</i> , <i>sod-2</i> , and <i>sod-3</i> genes encoding superoxide dismutase (SOD) were significantly upregulated.
Wang Z et al. (2009)	Human embryoid body derived (hEBD) LVEC cell line exposed to 0.23-0.28 T static magnetic field for 24 h	Gene expression in cells showed nine signaling networks responded to static magnetic field
*Williams et al. (2006)	Salmonella bacteria cultures exposed to a 60-Hz intermittent magnetic field (5 min ON/10 min OFF) at 14.6 mT for 4 h	No significant increase in recombination events and DNA single and double strand breaks (assayed using a recombination event counter). However, magnetic field exposure induced protection from heat stress.
Wilson et al. (2015)	BALB/c×CBA/Ca F1 hybrid males exposed to 50Hz magnetic fields at 0.01, 0.1 or 0.3 mT for 2 or 15 h	There was a marginally significant increase in a non-dose-dependent mutation frequency in sperm, and not in blood cells.

Winker et al. (2005)	Human fibroblasts exposed to a 50-Hz intermittent (5 min ON/10 min OFF) EMF at 1 mT for 2-24 h	Increased micronucleus frequency and chromosomal aberration.
Wolf et al. (2005)	HL-60 leukemia cells, Rat-1 fibroblasts, and WI-38 diploid fibroblasts exposed to a 50-Hz EMF at 0.5-1 mT for 24-72 h	Dose-dependent increases in DNA single strand breaks (Comet assay) and formation of 8-hydroxy-2'-deoxyguanosine adducts were observed in all cell lines. There were increases in cell proliferation and reactive oxygen species.
Yagci and Kesim (2016)	Human gingival fibroblasts exposed in vitro to static magnetic fields produced by dental magnetic attachments for 10-12 days. (The maximum magnetic flux densities measured at the magnet centers of 4 types of attachment were 95.6-148.1 mT and became almost zero at 10 mm away)	Increased micronucleus frequency.
Yaguchi et al. (1999)	Mouse embryonic skin m55 cells exposed to a 60-Hz magnetic field at 5, 50, or 400 mT for 42 h	Increase in sister chromatid exchanges after 400 mT exposure.
Yaguchi et al. (2000)	Mouse embryonic skin m55 cells exposed to 60-Hz (5 or 50 mT) or 50-Hz (400 mT) magnetic fields for 40 h. Some cells also treated with mitomycin C or X-ray	Increased chromosomal aberration, synergistic with mitomycin C and X-ray.
Yao et al. (2015)	Rat Schwann cells exposed to DC electric field for 36-72 h at 50, 100, or 200 mV/mm	Differential expression of genes participate in multiple cellular signaling pathways involved in the regulation of cell migration, including pathways of regulation of actin cytoskeleton, focal adhesion, and PI3K-Akt cell cycle regulation).
Yin et al. (2016)	Primary cultured rat hippocampal neurons exposed to a 50-HZ EMF at 1 mT for 90 min	Increase in DNA single strand breaks (Comet assay); free radicals involved.

Yokus et al. (2005)	Female Wistar rats exposed to a 50-Hz magnetic field at 0.97 mT for 3 h/day for 50 and 100 days	Increased 8-hydroxy-2'-deoxyguanosine in blood cells.
Yokus et al. (2008)	Male Sprague-Dawley rats exposed to a 50-Hz magnetic field at 0.1 or 0.5 mT for 2 h/day for 10 months	Increased DNA base modifications in leucocytes [8-hydroxyguanine (8-OH-Gua), 2,6-diamino-4-hydroxy-5-formamidopyrimidine (FapyGua), and 4,6-diamino-5-formamidopyrimidine (FapyAde)]
Yoon et al. (2014)	Human lung fibroblast WI38 cells and human lung epithelial L132 cells exposed to a 60-Hz magnetic field at 2 mT for 6 h	2 mT field induced increased γ -H2AX expression, as well as γ -H2AX foci production. Interacted with gamma radiation but not H ₂ O ₂ .
Yuan et al. (2020)	Tumor cell lines including lung cancer, gastric cancer, pancreatic cancer and nephroblastoma exposed to a 50-Hz EMF modulated by static MF with time-average intensity of 5.1 mT, for 2 h/day for 3 days	Induced DNA single strand breaks (Comet assay), gamma-H2AX and activation of DNA repair pathways, increased reactive oxygen species and ferroptosis, and decreased proliferation.
Zendehdel et al. (2019)	Peripheral blood cells of male power line workers in a power plant. The median value of the magnetic field at the working sites was 0.00085 mT	Increased in DNA single strand breaks (Comet assay).
Zhang H et al. (2016)	ICR mice exposed to a 50-Hz EMF at 8 mT for 4 h/day for 28 days	Declined DNA content and increased expression of apoptosis genes in spleen. Free radical may be involved.
Zhang Y et al. (2016)	Workers with or without exposure to ELF-EMF (50 Hz) of 110-420kV power lines	Significant increased urinary 8-isoprostane and 8-OHdG were observed in workers with EMF exposure. Free radical may be involved.
Zheng et al. (2018)	dental pulp stem cells exposed to a static magnetic field of 1, 2, 4 mT for 15 min, 30 min, 1 h or 24 h	Increased expression of several growth factors (FGF-2, TGF- β , and VEGF), migration genes (MMP-1 and MMP-2), and upregulated the two YAP/TAZ-regulated genes, CTGF and ANKRD1. (YAP/TAZ are transcriptional activators particularly

		involved in cancer cell proliferation, therapy resistance and metastasis. Increased cell proliferation, osteo/odontogenesis and mineralization observed in the stem cells.
*Zhu et al. (2016)	Human lens epithelial cells exposed to a 50-Hz magnetic field at 0.4 mT for 2, 6, 12, 24, or 48 h	No effect on DNA single strand breaks (Comet assay) and gamma-H2AX foci.
Zmyslony et al. (2000)	Rat exposed to a static or 50-Hz magnetic field at 7 mT for 3 h	In combination with FeCl ₂ , increases in DNA single strand breaks (Comet assay) observed for both static and 50-Hz field exposure in lymphocytes.
Zmyslony et al. (2004)	Rat lymphocytes exposed first to ultraviolet radiation and then to a 50-Hz magnetic field at 0.04 mT for 5 or 60 min	60-min magnetic field exposure (plus UVA) caused an increase in DNA single strand breaks (Comet assay). MF may affect the radical pairs generated during the oxidative or enzymatic processes of DNA repair.

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Supplement 3

Gene expressions after RFR and static/ELF EMF exposure (literature up to January 2021)

<i>RFR</i>	<i>Exposure effects</i>
Akhavan-Sigari et al. (2014)	Increased risk for the mutant type of p53 gene expression in the peripheral zone of the glioblastoma, and that this increase was significantly correlated with shorter overall survival time.
Beaubois et al. (2007)	Accumulation of basic leucine-zipper transcription factor (bZIP) mRNA in the exposed terminal leaf of tomato plant.
Belyaev et al. (2006)	Expression of genes encode proteins with diverse functions including neurotransmitter regulation, blood-brain barrier (BBB), and melatonin production in rat brain.
Buttiglione et al. (2007)	Affected both Egr-1 gene expression and cell regulatory functions, involving apoptosis inhibitors like Bcl-2 and surviving in human neuroblastoma cells.
Cervellati et al. (2013)	Induced 17- β -estradiol modulates connexins and Integrins as well as estrogen receptor (ER- β) expression in trophoblast cells, suggesting an influence on cell differentiation and migration.
Chen et al. (2012)	Expression was limited to only a very small number of genes in yeast. (Expressions of structural maintenance of chromosomes 3 (SMC3) and aquaporin 2 (AQY2 (m)) while halotolerance protein 9 (HAL9), a kinase 1 (YAK1) and one function-unknown gene showed opposite changes in expression.
Del Vecchio et al. (2009)	Increased expression of beta-thymosin gene, a cytoskeleton regulating factor in murine cortical neurons, correlated to reduced number of neurites generated.
Deshmukh et al. (2015)	Increased heat shock protein 70 (HSP70) in rat brain.
Eker et al. (2018)	Caspase-3 and p38 mitogen-activated protein kinase (p38MAPK) (a kinase responsive to stress stimuli, and involved in cell differentiation, apoptosis and autophagy) gene expressions were significantly up-regulated in the ocular tissues of rat.
Engelmann et al. (2008)	Significant changes in transcription of 10 genes in <i>Arabidopsis thaliana</i> (thale cress) cells.
Fragopoulou et al. (2018)	Expression of 178 genes changed significantly mouse hippocampus
Franzellitti et al. (2008)	Levels of the inducible HSP70C transcript were significantly enhanced after 24 h exposure to GSM-217Hz signals and reduced after 4 and 16 h exposure to GSM-Talk signals in human trophoblasts.
Ghatei et al. (2017)	No effect on expression level of bcl-2 and p53 genes, but gene expression level of <i>bax</i> decreased and gene expression level of <i>p21</i> increased in cerebellum of mice exposed pre-and postnatally to RFR.
Gökçek-Saraç et al. (2020)	Decreased RNA expressions of acetylcholinesterase (AChE), choline acetyltransferase (ChAT), and vesicular acetylcholine transporter (VACHT)

	in the hippocampus of rats exposed to 2100 MHz RFR.
Gulati et al. (2018)	A significant association of genetic polymorphism of antioxidant genes (for MnSOD and CAT) with oxidative damage has been observed in human population exposed to radiations emitted from mobile towers.
Habauzit et al. (2014)	7 genes were differentially expressed in human keratinocytes, associated to the cellular response to hyperthermia.
Hao et al. (2010)	Significant induced phosphorylation of STAT3, increased transcription levels of the inflammation-associated genes, iNOS and TNF-alpha murine N9 microglial cells. (Signal transducer and activator of transcription 3 (STAT3) is a transcription activator that mediates the expression of a variety of genes in response to cell stimuli, and thus plays a key role in many cellular processes such as cell growth and apoptosis.)
He et al. (2016)	Mouse bone marrow stromal cells showed increased PARP-1 mRNA expression.(PARP-1 involves in differentiation, tumor transformation and DNA repair.)
He et al. (2017)	Mouse bone marrow stromal cells showed increased PARP-1 mRNA expression. Gamma radiation decreased RFR-induced PARP-1 expression.
Karaca et al. (2012)	Decreased STAT3 expression in mouse brain. (STAT3 acts as transcription activator).
Kumari et al. (2017)	Increased expression of the pro-inflammatory cytokine tumor necrosis factor alpha mRNA in the hippocampal region.
Kumar, R. (2020)	Altered expression of DNA (epigenetic) methylating enzymes, DNA methyltransferase1 (DNMT1) and histone methylating enzymes euchromatic histone methyltransferase1 (EHMT1) in hippocampus.
Jeong et al. (2020)	Increased expression of EphA8 and Wnt6 genes in the hippocampi of mice. (Both genes are involved in development, particularly, EphA8 coded protein mediates developmental events in the nervous system in axonal guidance).
Lameth et al. (2020)	Altered gene expressions in rat cerebral cortex in an acute neuroinflammation. Gene responses to RFR can differ according to pathologies affecting the CNS.
Le Quément et al.(2012)	Human skin cells showed differential expression of genes involved in functions such as cardiovascular development, facilitate pathogen recognition by macrophages, inhibition of angiogenesis, nonspecific ion channels, etc.
Lee et al. (2005)	Many genes were affected in human HL60 cells. Apoptosis-related genes were among the upregulated ones and the cell cycle genes among the downregulated ones.
Li et al. (2020)	Offspring of pregnant female rats exposed to RFR showed differential expression of methyl-D-aspartate receptors

	(NMDARs) genes in the hippocampus.
Lin et al. (2016)	Upregulated the expression of genes involved in glucose transportation and the tricarboxylic acid (TCA) cycle, but not the glycolysis pathway. Transcription levels of 29 genes were upregulated and 24 genes were downregulated.
López-Martín et al. (2009)	c-Fos expressions in brain of picrotoxin-treated and untreated rats.
Manta et al. (2017)	168 genes differentially expressed in the house fly <i>Drosophila melanogaster</i> , associated with multiple and critical biological processes, such as basic metabolism and cellular subroutines related to stress response and apoptotic death.
Martin et al. (2020)	Four different types of human keratinocytes showed different patterns of expression of ADAMTS6, IL7R, and NOG genes
Megha et al. (2015)	Downregulation in mRNA expression of enzymes involved in monoamine transmitter synthesis in rat hippocampus.
Mildažienė et al. (2019)	Leaves from exposed common sunflower (<i>Helianthus annuus</i> L.) seeds showed gene expression mostly of proteins involved in photosynthetic processes and their regulation.
Millenbaugh et al. (2008)	Genes associated with regulation of transcription, protein folding, oxidative stress, immune response, and tissue matrix turnover were affected in rat skin.
Nittby et al. (2008)	Altered gene expression in both cortex and hippocampus of the rat: extracellular region, signal transducer activity, intrinsic to membrane, and integral to membrane.
Nylund and Leszczynski (2006)	Gene and protein expressions altered differentially in two human endothelial cell lines.
Ohtani et al. (2016)	Heat-shock proteins (Hsp) and heat-shock transcription factors (Hsf) gene expression levels were significantly upregulated in the cerebral cortex and cerebellum of the rat.
Ohtani et al. (2019)	No change in transcription gene expression in brain and liver of mice exposed to a 85-kHZ field.
Pacini et al. (2002)	Human skin fibroblasts showed increased expression of mitogenic signal transduction genes (e.g., MAP kinase kinase 3, G2/mitotic-specific cyclin G1), cell growth inhibitors (e.g., transforming growth factor-beta), and genes controlling apoptosis (e.g., bax).
Qin et al. (2018)	Altered the expression of genes involved in testosterone synthesis (<i>Star</i> , <i>P450scc</i> , <i>P450c17</i> and 3β - <i>Hsd</i>) in mouse testicular tissue.
Qin et al. (2019)	Exposed Leydig cells showed downregulated of testosterone synthase genes (<i>Star</i> , <i>Cyp11a1</i> , and <i>Hsd-3β</i>) and clock genes

	(<i>Clock</i> , <i>Bmal1</i> , and <i>Rora</i>),
Rammal et al. (2014)	Increased expression of two wound-plant gene in tomato.
Remondini et al. (2006)	Different human cell types responded differently in gene expression. Affected gene families did not point towards a stress response, but suggested upregulating of cellular metabolism.
Romano-Spica et al. (2000)	Overexpression of the proto-oncogene <i>ets1</i> mRNA in Jurkat T-lymphoblastoid and Leydig TM3 cell lines
Roux et al. (2006)	Leaves of tomato plants showed increased stress-related transcripts (calmodulin, protease inhibitor and chloroplast mRNA-binding protein).
Roux et al. (2008)	Tomato plant showed increase in stress-related mRNA (calmodulin, calcium-dependent protein kinase and proteinase inhibitor), similar to wound responses.
Said-Salman et al. (2019)	101 genes were differentially expressed in <i>Escherichia coli</i> . Up-regulated genes are involved in metabolic pathways, transposition, response to stimuli, motility, chemotaxis, and cell adhesion, while the down-regulated genes are associated with metabolic pathways and localization of ions and organic molecules.
Silva et al. (2016)	No effect on expressions of Ki-67 (involved in cell proliferation) p53 (tumor suppression) HSP-70 (stress biomarker), and reactive oxygen species in human thyroid cells.
Soubere Mahamoud et al. (2016)	Exposed human keratinocytes treated with the glycolysis inhibitor, 2-deoxyglucose showed changes in genes encode transcription factors or inhibitors of cytokine pathways,
Souza et al. (2014)	Cells from oral mucosa of individual used cellular phones more than 5 h/week high number of broken egg which may be associated with gene amplification.
Sun Y. et al. (2017)	Decreased gene expression in mitochondria of HL-60 human leukemia cells. Free radicals involved.
Tohidi et al. (2020)	Apoptotic genes Bax and Bcl2 expression in the hippocampus were upregulated in mice exposed to RFR from a cell phone jammer for 1, 2, twice a day for 30 days and down-regulated with longer exposure schedule.
Trivino Pardo et al. (2012)	Gene expression affected in acute T-lymphoblastoid leukemia cells. Genes which act as sensors of DNA damage (<i>ATM</i> , <i>RAD17</i> , <i>RAD50</i> , and <i>PRKDC</i>) are activated. This over-expression could produce a signal cascade that causes the activation of the main DNA repair signaling. Some of the genes that were defined as essentials in double-strands repair

	(<i>BRCA1</i> , <i>LIG4</i> , <i>XRCC2</i>) and single-chain DNA repair process (<i>XPC</i> , <i>MSH5</i>) were found to over-express. More cells in S-phase.
Vafaei et al. (2020)	Increased superoxide dismutase, CDKN1A, GADD45a, Bax mRNA, and decreased Bcl-2 mRNA. (CDKN1A and GADD45a are involved in DNA repair and cellular responses to stressors.)
Valbonesi et al. (2014)	HSP70 transcription was significantly increased in rat neuronal-like PC12 cells.
Varghese et al. (2018)	Increased caspase-3 gene expression in brain tissues of rats exposed to 2450 MHz RFR
Vian et al. (2006)	Rapid induction of mRNA encoding the stress-related bZIP transcription factor in plants.
Yan et al. (2008)	Brain of exposed rat showed mRNA up-regulation of several injury-associated proteins. RFR exposure may result in cumulative injuries that could eventually lead to clinically significant neurological damage.
Yao et al. (2004)	Rabbit lens epithelial cells showed increased expression of P27kip1 protein, also G/G1 cell cycle arrest. (p27kip1 is a cyclin-dependent kinase inhibitor which binds to cyclinE/cdk2, blocking the G1/S transition.)
Zhang et al. (2008)	Primary culture neurons showed gene up- and down-regulation. Genes are associated with multiple cellular functions (cytoskeleton, signal transduction pathway, metabolism, etc.)
Zhao et al. (2007)	Up-regulation of caspase-2, caspase-6 genes occurred in both GSM 1900-MHz "on" and "stand-by" modes in neurons, but only in "on" mode in astrocytes. Additionally, astrocytes showed up-regulation of the Bax gene.
<i>Static/extremely-low frequency EMF</i>	
Agliassa et al. (2018)	Near-null MF condition (i.e., <100 nT) delayed transition to flowering in <i>Arabidopsis thaliana</i> and changes in expression of several genes in leaf and floral meristem.
Ashta et al. (2020)	Temozolomide (TMZ) with static MF or ELF MF (10 Hz) together increased p53 protein expression in the human glioblastoma cell line (A172) and increased cytotoxicity.
Baraúna et al. (2015)	The bacteria <i>Chromobacterium violaceum</i> , exposed to ELF MF, showed differential expression of 5 proteins. Expression of the protein, DNA-binding stress protein, may help to prevent DNA damage.
Bertea et al. (2015)	Exposing <i>Arabidopsis thaliana</i> to artificially reversed

	geomagnetic field conditions induced gene expressions.
Chen et al. (2008)	Human breast cancer MCF-7 cells exposed to a 50-Hz MF induced expression of three responsive genes.
Chen et al. (2020)	Human choriocarcinoma cells exposed to DC electric field showed increased gene expressions of ErbB and HIF-1 signaling pathways
Collard et al. (2013)	Epidermis cultures harvested from human abdominoplasty exposed to ELF electric fields induced expression of various genes. Some genes are involved in cell proliferation or differentiation, mitosis, cell cycle, or in the DNA replication transcription and translation.
Consales et al. (2018)	Exposure to a 50-Hz magnetic field in vitro. We demonstrate that ELF-MFs drive an early reduction of the expression level of miR-34b and miR-34c in SH-SY5Y human neuroblastoma cells, as well as in mouse primary cortical neurons, by affecting the transcription of the common pri-miR-34. Data also indicate epigenetic control of gene expression in vitro and shed light on the possible mechanism(s) producing detrimental effects and predisposing neurons to degeneration.
Cuccurazzu et al. (2010)	Exposure to a 50-Hz MF in vivo induced increases in the transcription of pro-neuronal genes (Mash1, NeuroD2, Hes1) and genes encoding Ca(v)1.2 channel α (1C) subunits in the hippocampus of the mouse. Hippocampal neurogenesis also observed.
Del Re et al. (2006)	ELF-MF influenced the synthesis of heat shock proteins in <i>E. coli</i> in a way that critically depends on the signal characteristics (static or pulsed MF).
Di Campli et al. (2010)	<i>Helicobacter pylori</i> biofilm exposed to a 50-Hz EMF showed <i>amiA</i> gene expression and decreased cell adhesion. (AmiA protein is responsible for transition of <i>H. pylori</i> from bacillary to coccoid forms. These coccoid forms can escape detection by the immune system and therefore could participate in the persistence of <i>H. pylori</i> infection during the lifetime of its human host.)
Dong et al. (2019)	16 T static magnetic field markedly blocked the expression of osteoclast-associated transcription factors and osteoclast marker genes and inhibited iron absorption and iron storage-related protein expression.
Fan et al. (2015)	Rat bone marrow derived-mesenchymal stem cells and mesenchymal stem cells exposed to a 50-Hz EMF induced expressions of various genes. Expressions of hematopoietic growth factors increase proliferation and migration of macrophagocytes.
Fan et al. (2018)	Static magnetic field up-regulated the expression of stress gene (<i>dnaK</i>) and virulence genes (<i>efaA</i> and <i>ace</i>).
Fedrowitz and Loscher	50-Hz MF-exposed F344 rat breast tissue showed alterations in

(2012)	gene expression, which were absent in Lewis rats.
Frisch et al. (2013)	Rat primary fibroblasts exposed to a 10-Hz electric fields induced HSP70 expression.
Heredia-Rojas et al. (2010)	“Electromagnetic field” plasmid transfected into INER-37 and RMA E7 cell lines exposed to a 60-Hz MF. An increased luciferase gene expression was observed in INER-37 cells but had no effect on the RMA E7 cell line.
Jin et al. (2019)	Arabidopsis seedling exposed to static magnetic field showed increased auxin (a plant growth hormone) from expression of PIN3 and AUX1 genes in root tips; cryptochromes (cry1 and cry 2 genes) are also involved.
Ki et al. (2020)	Human hair follicle dermal papilla cells exposed to a 70-Hz EMF enhance cell activation and proliferation via the GSK-3 β /ERK/Akt signaling pathway. Various genes were activated.
Kim et al. (2010)	Human normal and cancer cells exposed repeatedly to a 60-Hz MF showed p38 gene expression and induction of checkpoint kinase 2 critical to the DNA damage checkpoint pathway.(P38 mitogen-activated protein kinases are a class of mitogen-activated protein kinases (MAPKs) that are responsive to stress stimuli, and are involved in cell differentiation, apoptosis and autophagy.)
Kimsa-Dudek et al. (2018)	Static magnetic field attenuated expression of antioxidant defense genes (SOD1, PLK3, CLN8, XPA, HAO1) induced by sodium fluoride.
Kimsa-Dudek et al. (2020)	Exposure of human fibroblast cultures that had been co-treated with fluoride ions to a static MF caused specific genes expression that were involved in apoptosis.
Kimura et a. (2008)	Caenorhabditis elegans exposed to high intensity (2, 3, 5 T) static magnetic fields showed induction of genes involved in motor activity, actin binding, cell adhesion, and cuticles; also upregulation of hsp (heat shock protein) 12 and 16 family genes.
Lacy-Hulbert et al. (1995)	No effect on MYC and beta-actin gene expression in human leukemic cells.
Laramée et al. (2014)	Transfected rat primary cells in monolayer were exposed to a static MF caused HSP expression.
Lee et al. (2010)	C. elegans exposed to a 200 mT static magnetic field showed up-regulation of genes involved in development and aging (clk-1,unc-3, age-1,daf-2, lim-7).
Lee et al. (2016)	MCF7 cells showed up-regulation of PMAIP1 gene (gene involved in apoptosis) after 60-Hz magnetic field exposure.
Leone et al. (2014)	ELF-EMF enhanced proliferation and neuronal differentiation of hippocampal neural stem cells by regulation of epigenetic mechanisms leading to pro-neuronal gene expression.
Li et al. (2013)	Male Drosophila melanogaster exposed to ELF-EMF showed changes in gene expression. Differentially expressed genes following short-term exposures were involved in metabolic processes, cytoskeletal organization, mitotic spindle organization,

	cell death, protein modification and proteolysis. Long-term exposure led to changes in expression of genes involved in metabolic processes, response to stress, mitotic spindle organization, aging, cell death, and cellular respiration.
Li et al. (2014)	Zebra fish embryos exposed to a 50-Hz MF showed transcription of apoptosis-related genes (caspase-3, caspase-9) was significantly upregulation.
Li et al. (2015)	Rat oligodendrocyte precursor cells exposed to DC electric field showed upregulated mitogen-activated protein kinase pathway that signals cell migration and downregulation of differentially expressed genes in chemotaxis.
Li et al. (2019)	Pulsed EMF (20 Hz) increased expression of insulin growth factor 2 (IGF-2) in the hippocampus of streptozotocin-induced dementia rats.
Lin et al. (2016)	Budding yeast exposed to a 50-Hz EMF caused upregulation expression of genes involved in glucose transportation and the tricarboxylic acid (TCA) cycle, but not the glycolysis pathway. (A response to environmental stress.)
Lupke et al. (2006)	Human umbilical cord blood-derived monocytes exposed to ELF-MF caused expression of 5 genes.
Ma et al. (2014)	Mouse embryonic neural stem cells exposed to a 50-Hz EMF induced expression of genes regulating neuronal differentiation although cell proliferation and the percentages of neurons and astrocytes differentiated from eNSCs were not affected which might be compensation by post-transcriptional mechanisms to support cellular homeostasis.
Mahaki et al. (2019)	A 50-Hz EMF reduced the expression levels of c-Maf, STAT6, and ROR α genes in the spleen of rats.
Mahmoudinasab and Saadat (2016)	Human MCF-7 breast cancer cells exposed to a 50-Hz EMF showed decreased NQO1 and increased NQO2 gene expression. (NQO1 and NQO2 are detoxification enzymes).
Mahmoudinasab and Saadat (2018a)	Patterns of up-regulation of antioxidant genes are different between MCF-7 and SH-SY5Y cells exposed to an intermittent 50-Hz EMF.
Mahmoudinasab and Saadat (2018b)	SH-SY5Y cells exposed to a 50-Hz EMF. NQO1 mRNA level decreased in the "15 min field-on/15 min field-off" condition, the expression level of NQO2 was increased.
Mahmoudinasab et al. (2016)	Human MCF-7 breast cancer cells exposed to a 50-Hz EMF showed up and down regulations of 7 antioxidant genes.
Manzella et al. (2015)	50-Hz magnetic field affected in human dermal fibroblasts expression of clock genes: BMAL1, PER2, PER3, CRY1, and CRY2.
Mastrodonato et al. (2018)	50-Hz EMF exposure increased Wnt3 (neurogenesis gene) mRNA expression in subventricular zone of the lateral ventricle of mice.
Moraveji et al. (2016)	50-Hz EMF activated MAP2 gene in dermal papilla mesenchymal

	cells.
Mouhoub et al. (2017)	Static magnetic field enhanced expression of gene involved in the production of acidiolipin and phosphatidylethanolamine in <i>Salmonella hadar</i> .
Nasrabadi et al. (2018)	In neonatal human retinal pigment epithelial cells exposed to pulsed 50-Hz EMF, gene expressions of NES, RPE65, and PAX6 were decreased. (NES gene encodes nestin involved in radial growth of neurons. The RPE65 gene provides instructions for making a protein that is essential for normal vision. PAX6 acts as a "master control" gene for the development of eyes and other sensory organs.)
Nikolova et al. (2005)	Mouse embryonic stem cells exposed to a 50-Hz EMF changed transcript levels of the apoptosis-related bcl-2, bax, and cell cycle regulatory "growth arrest DNA damage inducible" GADD45 genes.
Pesqueira et al. (2017)	Short term exposure (8 h) upregulated the expression of tendon-associated genes SCX, COL1A1, TNC and DCN. Long-term exposure (8 h every 24 h up to 14 days) significantly upregulated COL1A1, COL3A1 and TNC.
Potenza et al. (2004a)	<i>Escherichia coli</i> exposed to static magnetic field showed three cDNAs to be expressed only in the exposed cells, whereas one cDNA was more expressed in the controls.
Reyes-Guerrero et al. (2010)	ELF EMF exerted a biphasic effect on female olfactory bulb estrogen receptor-beta mRNA gene expression, which increased during diestrous and decreased during estrous. No effect on estrogen receptor-alpha gene expression and in male rats.
Sadri et al. (2017)	Static magnetic field decreased expression of Sox-2, Nanog, and Oct-4 genes in human mesenchymal stem cells derived from newborn umbilical cords.
Sanie-Jahromi et al. (2016)	Human MCF-7 breast cancer cells and neuroblastoma SH-SY5Y cells exposed to a 50-Hz EMF had mostly down regulation of 7 DNA repair genes in MCF-7 cells. Co-treatment with cisplatin and EMF can enhance down-regulation of the genes involved in non-homologous end-joining pathway in both cell types.
Sanie-Jahromi et al. (2017)	ELF-EMF enhanced the effects of cisplatin + bleomycin on viability of MCF-7 cells, while SH-SY5Y cells were not affected. MCF-7 and SH-SY5Y cells showed non-random disagreement in DNA repair gene expression in these conditions.
Sanie-Jahromi and Saadat (2018)	MCF-7 and SH-SY5Y cells were treated with morphine and then exposed to a 50-Hz EMF. Non-homologous end joining (NHEJ) related genes were significantly decreased in co-treatment of cisplatin and "morphine + EMF".
Seong et al. (2014)	Human bone marrow-mesenchymal stem cells were exposed to a 50-Hz EMF. Analysis of neurons derived from these cells showed that early growth response protein 1 (Egr1) is one of the key transcription factors in ELF-EMF-induced neuronal

	differentiation.
Shokrollahi et al. (2018)	Soybean plants exposed to static magnetic field had decreased gene expression of Fe transporter at 20 mT. Opposite response observed at 30 mT. The results suggest that SMF triggered a signaling pathway that is mediated by iron.
Wang et al. (2009)	Human embryonic cells exposed to static magnetic field showed a short-term (<24 h) activation of IL-6 involved the coordinate up-regulation of toll-like receptor-4 (TLR4) with complementary changes to NEU3 and ST3GAL5 that reduced ganglioside GM3 and augmented the activation of TLR4 and IL-6. Loss of GM3 also provided a plausible mechanism for the attenuation of cellular responses to SMF that occurred over longer exposure periods.
Wang et al. (2020)	Caenorhabditis elegans exposed to 50-Hz, 3 mT EMF for 15 generations showed enhanced up-regulations of genes encoding ATPase and superoxide dismutase.
Yao et al. (2015)	Rat Schwann cells exposed to DC electric field showed expression of genes participate in multiple cellular signaling pathways involved in the regulation of cell migration, including pathways of regulation of actin cytoskeleton, focal adhesion, and PI3K-Akt.
Zhang H et al. (2016)	Mice exposed to a 50-Hz EMF showed a significant suppression in Bcl-2 expression and increase in Bax, Caspase-3 and Caspase-9 expression in splenic cells. G0/G1 cycle arrest observed.
Zhao et al. (2020)	Escherichia coli exposed to 3.1 THz RFR for 8 h showed increased plasmid copy number and protein expression.
Zheng et al. (2018)	Static magnetic field increased expression of several growth factors, migration genes, and upregulated the two YAP/TAZ-regulated genes in human dental pulp mesenchymal stem cells.

Supplement 4

Genetic effects at low intensity exposure to RFR and static/ELF EMF (literature up to January 2021)

	Power density/SAR (<0.1 W/Kg) or magnetic flux density	Effects observed
<u>RFR studies</u>		
Aitken et al. (2005)	Mice to 900-MHz RFR for 7 days at 12 h/day; SAR 0.09 W/kg	Mitochondrial genome damage in epididymal spermatozoa.
Akdag et al. (2016)	Male Wistar-Albino rats to 2400 MHz RFR from a Wi-Fi signal generator for a year; SAR 0.000141 (min)-0.007127 (max) W/kg	DNA damage in testes.
Alkis et al. (2019a)	Rats exposed to 900 MHz (brain SAR 0.0845 W/kg), 1800 MHz (0.04563 W/kg), and 2100 MHz (0.03957 W/kg) RFR 2 h/day for 6 months	Increased DNA strand breaks and oxidative DNA damage in brain.
Alkis et al. (2019b)	Rats exposed to 900 MHz, 1800 MHz, and 2100 MHz RFR 2 h/day for 6 months; maximum SAR over the rat 0.017 W/kg	
Atasoy et al. (2013)	Male Wister rats exposed to 2437 MHz (Wi-Fi) RFR; 24 h/day for 20 weeks; maximum SAR 0.091 W/kg	Oxidative DNA damage in blood and testes.
Beaubois et al. (2007)	Leaves of tomato plant exposed to 900-MHz RFR for 10 min at 0.0066 mW/cm ²	Increased expression of leucine-zipper transcription factor (bZIP) gene.
Belyaev et al. (2005)	Lymphocytes from human subjects exposed to GSM 915 MHz RFR for 2 h ; SAR 0.037 W/kg;	Increased condensation of chromatin.

Belyaev et al. (2009)	Human lymphocytes exposed to UMTS cell phone signal (1947.4 MHz, 5 MHz band width) for 1 h; SAR 0.04 W/kg	Chromatin affected and inhibition of DNA double-strand break.
Bourdineaud et al. (2017)	Eisenia fetida earthworms exposed to 900 MHz for 2 h; SAR 0.00013-0.00933 W/kg	DNA genotoxic effect and HSP70 gene expressions up regulated.
Campisi et al. (2010)	Rat neocortical astroglial to CW 900 MHz RFR for 5, 10, or 20 min; incident power density 0.0265 mW/cm ²	Significant increases in DNA fragmentation.
Chaturvedi et al. (2011)	Male mice exposed to 2450 MHz RFR, 2 h/day for 30 days; SAR 0.03561 W/kg	Increased DNA strand breaks in brain cells.
Deshmukh et al. (2013)	Male Fischer rats exposed to 900 MHz (0.0005953 W/kg), 1800 MHz (0.0005835 W/kg), and 2450 MHz (0.0006672 W/kg) RFR for 2 h/day, 5 days/week for 30 days.	Increased DNA strand breaks in brain tissues.
Deshmukh et al. (2015)	Male Fischer rats exposed to 900 MHz (0.0005953 W/kg), 1800 MHz (0.0005835 W/kg), and 2450 MHz (0.0006672 W/kg) RFR for 2 h/day, 5 days/week for 180 days.	Increased DNA strand breaks in brain tissues.
Deshmukh et al. (2016)	Male Fischer rats exposed to 900 MHz (0.0005953 W/kg), 1800 MHz (0.0005835 W/kg), and 2450 MHz (0.0006672 W/kg) RFR for 2 h/day, 5 days/week for 90 days.	Increased DNA strand breaks in brain tissues.

Eker et al. (2018)	Female Wistar albino rats exposed to 1800-MHz RFR for 2 h/day for 8 weeks; SAR 0.06 W/kg	Caspase-3 and p38MAPK gene expressions increased in eye tissues.
Furtado-Filho et al. (2014)	Rats of different ages (0-30 days) exposed to 950 MHz RFR for 0.5 h/day for 51 days (21 days of gestation and 6-30 days old): SAR pregnant rat 0.01-0.03 W/kg; neonate 0.88 W/kg, 6-day old 0.51 W/kg, 15-day old 0.18 W/kg, 30-day old 0.06 W/kg.	Decreased DNA strand breaks in liver of 15-day old and increased breaks in 30-day old rats.
Gulati et al. (2016)	Blood and buccal cells of people lived close (<400 meters) to a cell tower; 1800 MHz, Maximum power density (at 150 meters) 0.00122 mW/cm ² , some subjects lived in the area for more than 9 yrs	Increased DNA strand breaks in lymphocytes and micronucleus in buccal cells.
Gürler (2014)	Wistar rats exposed to 2450 MHz RFR 1 h/day for 30 consecutive days; power density 0.0036 mW/cm ²	Increased oxidative DNA damage in brain and blood.
Hanci et al. (2013)	Pregnant rats exposed 1 h/day on days 13-21 of pregnancy to 900-MHz RFR at power density 0.0265 mW/cm ² .	Testicular tissue of 21-day old offspring showed increased DNA oxidative damage.
He et al. (2016)	Mouse bone marrow stromal cells exposed to 900 MHz RFR 3 h/day for 5 days; SAR 4.1×10^{-4} W/kg (peak), 2.5×10^{-4} W/kg (average)	Increased expression of PARP-1 mRNA

Hekmat et al. (2013)	Calf thymus exposed to 940 MHz RFR for 45 min; SAR 0.04 W/kg	Altered DNA structure at 0 and 2 h after exposure.
Kesari and Behari (2009)	Male Wistar rats exposed to 50 GHz RFR for 2 h/day for 45 days; SAR 0.0008 W/kg	Increased in brain tissue DNA strand.
Kumar R. et al. (2021)	Male Wistar rats exposed to 900 MHz, 1800 MHz and 2450 MHz RFR at a specific absorption rate (SAR) of 5.84×10^{-4} W/kg, 5.94×10^{-4} W/kg and 6.4×10^{-4} W/kg, respectively for 2 h per day for 1-month, 3-month and 6-month periods.	Epigenetic modifications in the hippocampus, bigger effects with increasing frequency and duration of exposure.
Kumar S. et al. (2010)	Male Wistar rats exposed to 10-GHz RFR for 2 h a day for 45 days, SAR 0.014 W/kg	Increased micronucleus in blood cells.
Kumar S. et al. (2013)	Male Wistar rats exposed to 10 GHz RFR for 2 h a day for 45 days; SAR 0.014 W/kg	Increased micronucleus in blood cells and DNA strand breaks in spermatozoa.
Marinelli et al. (2004)	Acute T-lymphoblastoid leukemia cells exposed to 900 MHz RFR for 2-48 h, SAR 0.0035 W/kg	Increased DNA damage and activation of genes involved in pro-survival signaling.
Markova et al. (2005)	Human lymphocytes exposed to 905 and 915 MHz GSM signals for 1 h; SAR 0.037 W/kg	Affected chromatin conformation and 53BP1/gamma-H2AX foci
Markova et al. (2010)	Human diploid VH-10 fibroblasts and human adipose-tissue derived mesenchymal stem	Inhibited tumor suppressor TP53 binding protein 1 (53BP1) foci that are typically formed at the sites of DNA double strand break

	cells exposed to GSM (905 MHz or 915 MHz) or UMTS (1947.4 MHz, middle channel) RFR for 1, 2, or 3 hr; SAR 0.037-0.039 W/kg	location.
Megha et al. (2015a)	Fischer rats exposed to 900 and 1800 MHz RFR for 30 days (2 h/day, 5 days/week), SAR 0.00059 and 0.00058 W/kg	Reduced levels of neurotransmitters dopamine, norepinephrine, epinephrine, and serotonin, and downregulation of mRNA of tyrosine hydroxylase and tryptophan hydroxylase (synthesizing enzymes for the transmitters) in the hippocampus.
Megha et al. (2015b)	Fischer rats exposed to 900, 1800, and 2450 MHz RFR for 60 days (2 h/day, 5 days/week); SAR 0.00059, 0.00058, and 0.00066 W/kg	Increased DNA damage in the hippocampus
Nittby et al. (2008)	Fischer 344 rats exposed to 1800 MHz GSM RFR for 6 h; SAR whole body average 0.013 W/kg, head 0.03 W/kg	Expression in cortex and hippocampus of genes connected with membrane functions.
Odaci et al. (2016)	Pregnant Sprague - Dawley rats exposed to 900 MHz RFR 1 h each day during days 13 - 21 of pregnancy; whole body average SAR 0.024 W/kg	Testis and epididymis of offspring showed higher DNA oxidation.
Pandey et al. (2017)	Swiss albino mice exposed to 900-MHz RFR for 4 or 8 h per day for 35 days; SAR 0.0054-0.0516 W/kg	DNA strand breaks in germ cells.
Pesnya and Romanovsky (2013)	Onion (<i>Allium cepa</i>) exposed to GSM 900-MHz RFR from a cell phone for 1 h/day or 9 h/day for 3 days;	Increased the mitotic index, the frequency of mitotic and chromosome abnormalities, and the micronucleus frequency in an exposure-duration manner.

	incident power density 0.0005 mW/cm ²	
Phillips et al. (1998)	Human Molt-4 T-lymphoblastoid cells exposed to pulsed signals at cellular telephone frequencies of 813.5625 MHz (iDEN signal) and 836.55 MHz (TDMA signal) for 2 or 21 h. SAR 0.0024 and 0.024 W/Kg for iDEN and 0.0026 and 0.026 W/kg for TDMA)	Changes in DNA strand breaks
Qin et al. (2018)	Male mice exposed to 1800-MHz RFR 2 h/day for 32 days, SAR 0.0553 W/kg	Might be mediated through CaMKI/ROR α signaling pathway.
Rammal et al. (2014)	Tomato exposed to a 1250-MHz RFR for 10 days at 0.0095 mW/cm ²	Increased expression of two wound-plant genes.
Roux et al. (2006)	Tomato plants exposed to a 900-MHz RFR for 2-10 min at 0.0066 mW/cm ²	Induction of stress gene expression.
Roux et al. (2008)	Tomato plants exposed to a 900-MHz RFR for 10 min at 0.0066 mW/cm ²	Induction of stress gene expression.
Sarimov et al. (2004)	Human lymphocytes exposed to GSM 895-915 MHz signals for 30 min; SAR 0.0054 W/kg	Condensation of chromatin was observed.
Shahin et al. (2013)	Female mice (Mus musculus) exposed to continuous-wave 2.45 GHz RFR 2 h/day for 45 days; SAR 0.023 W/kg	Increased DNA strand breaks in the brain.
Sokolovic et al. (2015)	Wistar rats exposed to RFR (4 h/day, for 20, 40, and 60 days) from a Nokia 3110 cell	DNA fragmentation and oxidative changes in testicular tissues.

	phone; SAR 0.043-0.135 W/kg.	
Sun Y. et al. (2017)	Human HL-60 cells exposed to 900 Hz RFR 5 h/day for 5 days; peak and average SAR 4.1×10^{-4} and 2.5×10^{-4} W/kg	Increased oxidative DNA damage and decreased mitochondrial gene expression.
Tkalec et al. (2013)	Earthworm (<i>Eisenia fetida</i>) exposed to continuous-wave and AM-modulated 900-MHz RFR for 2 - 4 h; SAR 0.00013, 0.00035, 0.0011, and 0.00933 W/kg	Increased DNA strand breaks.
Tsybulin et al. (2013)	Japanese Quail embryos exposed in ovo to GSM 900 MHz signal from a cell phone intermittently (48 sec ON/12 sec OFF) during initial 38 h of brooding or for 158 h (120 h before brooding plus initial 38 h of brooding): SAR 0.000003 W/kg	The lower duration of exposure decreased DNA strand breaks, whereas higher duration resulted in a significant increase in DNA damage.
Vian et al. (2006)	Tomato plants exposed to a 900-MHz RFR for 10 min at 0.0066 mW/cm^2	Induction of mRNA encoding the stress-related bZIP transcription factor.
Yakymenko et al. (2018)	Quail embryos exposed to GSM 1800 GHz signal from a smart phone (48 s ON/12 s OFF) for 5 days before and 14 days during incubation, power density 0.00032 mW/cm^2	Increased DNA strand breaks and oxidative DNA damage.
Zong et al. (2015)	Mice exposed to 900 MHz RFR 4 h/day for 7 days; SAR 0.05 W/kg	Attenuated bleomycin-induced DNA breaks and repair.

<u>Static and ELF EMF Studies</u>		
Agliassa et al. (2018)	Arabidopsis thaliana (thale cress) exposed to 0.00004 mT static magnetic field for 38 days after sowing	Changes in gene expression in leaf and floral meristem.
Back et al. (2019)	Mouse embryonic stem cells exposed to hypomagnetic field (<0.005 mT) up to 12 days	Induced abnormal DNA methylation.
Bagheri Hosseinabadi et al. (2020)	Blood samples from thermal power plant workers; mean levels of exposure to ELF magnetic and electric fields were 0.0165 mT (± 6.46) and 22.5 V/m (± 5.38), respectively.	DNA strand breaks .in lymphocytes.
Baraúna et al. (2015)	Chromobacterium violaceum bacteria cultures exposed to ELF-EMF for 7 h at 0.00066 mT	Five differentially expressed proteins detected including the DNA-binding stress protein.
Belyaev et al. (2005)	Human lymphocytes exposed to 50 Hz magnetic field at 0.015 mT (peak) for 2 h (measurements made at 24 and 48 h after exposure).	Induced chromatin conformation changes.
Dominici et al. (2011)	Lymphocytes from welders (average magnetic field exposure from personal dosimeters 0.00781 mT (general environmental level 0.00003 mT)	Higher micronucleus frequency correlated with EMF exposure levels; decreased in sister chromatid exchange frequency.
Heredia-Rojas et al. (2010)	Human non-small cell lung cancer cells (INER-37) and mouse lymphoma cells (RMA E7) (transfected with a	An increased in luciferase gene expression was observed in INER-37 cells.

	plasmid with hsp70 expression when exposed to magnetic field and contains the reporter for the luciferases gene) exposed to a 60-Hz magnetic field at 0.008 and 0.00008 mT for 20 min.	
Sarimov et al. (2011)	Human lymphocytes exposed to 50-Hz magnetic field at 0.005-0.02 mT for 15-180 min	Magnetic field condensed relaxed chromatin and relaxed condensed chromatin.
Villarini et al. (2015)	Blood leukocytes from electric arc welders presumably exposed to 50-Hz EMF (mean 0.0078 mT; range: 0.00003-0.171 mT)	Decreased DNA strand breaks.
Wahab et al. (2007)	Human peripheral blood lymphocytes exposed to 50 Hz sinusoidal (continuous or pulsed) or square (continuous or pulsed) magnetic fields at 0.001 or 1 mT for 72 h.	Increase in the number of sister chromatid exchange/cell
Zendehdel et al. (2019)	Peripheral blood cells of male power line workers in a power plant. The median value of the magnetic field at the working sites was 0.00085 mT.	Increased in DNA strand breaks.

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Effects of EMF wave-form and cell types (*in italic*) studied (Literature up to January 2021)

RFR	
Belyaev et al. (2009)	UMTS different from GSM signal on DNA repair foci in human lymphocytes.
Campisi et al. (2010)	Increased DNA fragmentation in rat neocortical astroglial by 50-Hz modulated 900-MHz RFR, but no effect from continuous wave field.
D'Ambrosia et al. (1995)	Micronucleus frequency in human lymphocytes affected by pulsed but not CW 9 GHz RFR.
D'Ambrosia et al. (2002)	Micronucleus frequency in human lymphocytes affected by pulsed but not CW 1748-MHz RFR.
<i>Del Re et al. (2019)</i>	<i>Changes in repetitive-DNA in human cell exposed to GSM 900-MHz RFR depended on cell type studied (HeLa, BE(2)C, and SH SY5Y).</i>
Franzellitti et al. (2008)	HSP70C gene expression enhanced after 24 h exposure to GSM-217Hz signals and reduced after 4 and 16 h exposure to GSM-Talk signals In human trophoblasts.
Franzellitti et al. (2010)	DNA damage in human trophoblasts induced by GSM 1800 MHz RFR, but not by continuous-wave field.
Gapeyev et al. (2014)	Protective effect to x-ray induced DNA strand break in mouse lymphocytes with pulse-modulated and not continuous-wave RFR.
<i>Heredia-Rojas et al. (2010)</i>	<i>“Electromagnetic field” plasmid transfected into INER-37 and RMA E7 cell lines exposed to a 60-Hz MF. An increased luciferase gene expression was observed in INER-37 cells but had no effect on the RMA E7 cell line.</i>
Kumar et al. (2020)	1800-MHz more effective than 900-MHz RFR on inducing DNA damage in onion.
Lopaz-Martin et al. (2009)	Unmodulated RFR caused higher neuronal c-fos expression than pulsed modulated 900-MHz GSM field.
Luukkonen et al. (2009)	872-MHz continuous-wave RFR increased DNA strand breaks in SH-SY5Y human neuroblastoma cells, but no effect from GSM – modulated field.
Markova et al. (2005)	GSM-915 MHz RFR induced more consistent

	effect on human lymphocyte chromatin conformation than GSM-905 MHz RFR.
<i>Martin et al. (2020)</i>	<i>Four different types of human keratinocytes showed different patterns (Up- and down-regulation or no change) of expression of ADAMTS6, IL7R, and NOG genes exposed to a 60-GHz RFR.</i>
Ozgur et al. (2014)	1800-MHz RFR more potent than 900-MHz RFR on inducing DNA fragmentation (apoptosis) in hepatocarcinoma cells.
<i>Nylund and Leszczynski (2006)</i>	<i>Gene and protein expressions in response to GSM 900-MHz RFR depended on the type of human endothelial cell line (EA.hy926 and EA.hy926v1).</i>
<i>Remondini et al. (2006)</i>	<i>Gene expressions after exposure to 900 and 1800 –MHz RFR- NB69 neuroblastoma cells, T lymphocytes, and CHME5 microglial cells did not show significant changes, whereas EA.hy926 endothelial cells, U937 lymphoblastoma cells, and HL-60 leukemia cells showed up- or down-regulated genes.</i>
Romano-Spica et al. (2000)	Oncogene expression only occurred when exposed to 16-Hz modulated 50MHz RFR
Sarimov et al. (2004)	Different potencies between 915 MHz and 905-MHz RFR on chromatin conformation in human lymphocytes.
<i>Schwartz et al. (2008)</i>	<i>UMTS 1950-MHz RFR increased DNA breaks and micronucleus frequency in human fibroblasts, but not in lymphocytes.</i>
Semin et al. (1994)	4000-8000 MHz RFR, 1-6 Hz modulated RFR showed narrow “window” peak intensity and modulation frequency effects on DNA secondary structure.
Shckorbatov et al. (2009)	35-GHz RFR caused condensation of chromatin in human buccal epithelium cells- left circularly polarized radiation induced less effect than linearly polarized radiation.
Shckorbatov et al. (2010)	36.65-GHz RFR caused chromosome condensation in human fibroblasts –right-handed elliptically polarized radiation was more biological activity than the left-handed polarized one.
Tkalec et al. (2013)	AM-modulated 900- MHz RFR more potent than continuous-wave field in inducing DNA damage in earthworms coelomocytes.
Valbonesi et al. (2014)	GSM 1800-MHz signal, but not continuous-

	wave field, induced HSP-70 gene expression in rat PC-12 cells.
Vilic et al. (2017)	DNA damage in honey bee larvae- AM-modulated 900-MHz RFR more potent than continuous-wave field.
<i>Xu et al. (2013)</i>	<i>Gamma-H2AX foci after exposure to GSM 1800-MHz RFR induced in Chinese hamster lung cells and Human skin fibroblasts (HSFs), but not in rat astrocytes, human amniotic epithelial cells, human lens epithelial cells, and human umbilical vein endothelial cells.</i>
Zhang et al. (2008)	Intermittent 1800-MHz RFR more potent than continuous exposure on gene expression in rat neurons.
<i>Zhao et al. (2007)</i>	<i>Capase-2 and Capase-6 expressions up-regulated in neuron, but not in astrocytes.</i>
Static/ELF EMF	
Del Re et al. (2006)	50-Hz sinusoidal MF increased where as pulse square wave decreased heat-shock protein induction in E. coli.
Focke et al (2010)	Increased DNA fragmentation by intermittent 50-Hz MF, but no effect by continuous exposure.
Giorgi et al. (2011)	E. coli gene expression decreased by sinusoidal MF and increased by pulsed square-wave MF- not frequency dependent (25, 50, 75 Hz)
<i>Heredia-Rojas et al. (2010)</i>	<i>60-Hz MF induced luciferase gene expression in INER-37 cells, but not in RMA E7 cells.</i>
Ivancsits et al. (2002)	Intermittent more potent than continuous exposure of a 50-Hz MF on DNA damage in human fibroblasts.
<i>Lee et al. (2016)</i>	<i>60-Hz MF induced delay of cell cycle progression in MCF7 and MCF10A cells, but not in Jurkat and NIH3T3 cells.</i>
<i>Mahmoudinasab and Saadat (2018a)</i>	<i>Patterns of up-regulation of antioxidant genes are different between MCF-7 and SH-SY5Y cells exposed to an intermittent 50-Hz EMF.</i>
Mahmondinasab et al. (2016)	Different schedules of intermittent exposure to a 50-Hz MF had different effect on gene expression in human MCF-7 breast cancer cells
Mercado-Saenz et al. (2019)	Decreased spontaneous mitochondrial mutation in yeast by pulsed MF (25-Hz), no effect by sinusoidal field.

<i>Robison et al. (2002)</i>	<i>60-Hz MF exposure decreased DNA repair rate in HL-60 and HL-60R cells, but not in Raji cells.</i>
<i>Sanie-Jahromi and Saadat (2018)</i>	<i>co-treatment of “cisplatin +morphine + EMF” made bleomycin more cytotoxic in SH-SY5Y cells, but not in MCF-7cells.</i>
Sanie-Jahromi et al. (2016)	Significant differences in DNA-repair gene expression in MCF-7 cell exposed under 3 different patterns of 50-Hz EMF (5 min field-on/5 min field-off (30 min), 15 min field-on/15 min field-off (30 min), 30 min field-on continuously.)
<i>Sanie-Jahromi et al. (2017)</i>	<i>50-Hz MF exposure synergistic with cisplatin and bleomycin on DNA-repair gene expression and cell viability in MCF-7 cells, but not in SH-SY5Y cells.</i>
<i>Udroiu et al. (2015)</i>	<i>50-Hz MF exposure affected genotoxic effect of x-ray in mouse male germ cells, but not in peripheral blood erythrocytes.</i>
Wahab et al. (2007)	Sister chromatid exchange in human lymphocytes exposed to a 50-Hz MF (continuous or pulsed sinusoidal or continuous or pulsed square-wave). Square continuous-wave MF was the most potent.



SECTION 6

Genetic Effects of Non-Ionizing Electromagnetic Fields

2014 Supplement

Prof. Henry Lai, PhD (Ret.)
Department of Bioengineering
University of Washington
Seattle, WA USA

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I. INTRODUCTION

The following is an update of information and abstracts on research papers published since 2006/2007 on the genetic effects of nonionizing electromagnetic fields (EMF) in the radiofrequency (RF) and extremely-low frequency (ELF) ranges. Two static magnetic field papers (Jouni et al. 2012; Wang et al., 2009) are also included. Where additional information is relevant, some earlier papers, or papers not specifically related to genetic effects, are also included with citations contained within the discussion below. A list of abstracts, with summary sentences underlined for reader convenience, can be found at the end of this paper.

Analysis of these recent publications shows that there are more papers reporting effects than no effect.

In summary, the new radiofrequency studies report that 65% of genetic studies show effects and 35% do not show effects. **[Effects = 74 (65%) No Effects = 40 (35%)]**

In summary, the new ELF-EMF studies report that 82% of genetic studies show effects and 18% do not show effects **[Effects= 49 (83%) No Effects= 10 (17%)]**

Appendix A has references and abstracts for the RFR literature. Appendix B has references and abstracts for the ELF-EMF literature.

II. GENOTOXIC EFFECTS OF RADIOFREQUENCY RADIATION (RFR) AND OF EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS (ELF-EMF) (2007-2014)

The following is an update of information and abstracts on research papers published since 2006/2007 on the genetic effects of nonionizing electromagnetic fields (EMF) in the radiofrequency (RF) and extremely-low frequency (ELF) ranges. Two static magnetic field papers (Jouni et al. 2012; Wang et al., 2009) are also included. Where additional information is relevant, some earlier papers, or papers not specifically related to genetic effects, are also included with citations contained within the discussion below. A list of abstracts, with summary sentences underlined for reader convenience, can be found at the end of this paper.

Analysis of these recent publications shows that there are more papers reporting effects than no effect. With E representing a biological effect, and NE representing no biological effects, the recent literature finds RFR-genetic effects at: E=74 publications (65%); NE=40 publications (35%); and ELF-genetic effects at: E=49 (83%); NE=10 (17%).

Discussion

1. The effects of both RF and ELF fields are very similar. This is surprising because the energies carried by these EMFs are billions of folds different. An explanation for similar genetic effects has been provided by a recent paper by Blank and Goodman ([Blank M, Goodman R](#). DNA is a fractal antenna in electromagnetic fields. *Int. J. Radiat. Biol.* 87(4):409-415, 2011) in which they stated that ‘...the wide frequency range of interaction with EMF is the functional characteristic of a fractal antenna, and DNA appears to possess the two structural characteristics of fractal antennas, electronic conduction and self symmetry.’ However, similarities in effects between ELF and RF fields have also been reported in studies of other physiological processes, e.g., neurochemical and behavioral effects (Cf. Lai, H., Carino, M.A., Horita, A. and Guy, A.W. Opioid receptor subtypes that mediate a microwave-induced decrease in central cholinergic activity in the rat. *Bioelectromagnetics* 13:237-246, 1992; Lai, H. and Carino, M.A. Intracerebroventricular injections of mu and delta-opiate receptor antagonists block 60-Hz magnetic field-induced decreases in cholinergic activity in the frontal cortex and hippocampus of the rat. *Bioelectromagnetics* 19:433-437, 1998; Lai, H., Carino, M.A. and Ushijima, I. Acute exposure to a 60 Hz magnetic field affects rats' performance in the water maze. *Bioelectromagnetics* 19:117-122, 1998; Wang, B.M. and Lai, H. Acute exposure to pulsed 2450-MHz microwaves affects water maze learning in the rat. *Bioelectromagnetics* 21:52-56, 2000.) Thus, there is a basic interaction mechanism of biological tissues with electromagnetic fields that is independent of frequency. Many studies have implicated the involvement of free radical processes in the genetic effects of EMF: ELF-EMF (Butdak et al., 2012; Jouni et al., 2012; Luukkonen et al., 2014; Tiwari et al., 2014); RFR (Agarwal et al., 2009; Atasoy et al., 2012; Burlaka et al., 2013; Campisi et al., 2010; De Iuliis et al., 2009; Esmekaya et al., 2011; Ferreira et al., 2006; Gajski and Garaj-Vrhovac, 2009; Garaj-Vrhovac et al., 2011; Guler et al., 2010, 2012; Kesari and Behari, 2009; Kesari et al., 2010; Khalil et al., 2012; Kumar et al., 2010; Liu et al., 2013a,b; Luukkonen et al., 2009; Tomruk et al., 2010; Tkalec et al., 2013; Wu et al., 2008; Xu et al., 2010; Yao et al., 2003). Increase in free radical activity and changes in enzymes involved in cellular oxidative processes are the most consistent effects observed in cells and animals after EMF exposure. However, there are reports indicating that EMF could induce genetic effects without the involvement of free radicals (ELF- Alcaraz et al., 2013; RFR- Ferreira et al., 2006; Furtado-Filho et al., 2013) and increase in free radical after EMF exposure did not lead to genetic effects (Frahm et al., 2006). There are at least a couple of hundred published papers on the effects of EMF exposure on cellular oxidative processes. Many biological effects of EMF can be explained by intracellular changes in oxidative status, including the genetic effects reported in this review.
2. An important observation of the studies is that EMF can interact with other entities and synergistically cause genetic effects. These entities include: ELF-EMF- cisplatin (Buldak et al., 2012; El-Bialy et al., 2013), bleomycin (Cho et al., 2007), gadolinium (Cho et al., 2014); hydrogen peroxide and methyl methane sulfonate (Koyama et al., 2008), menadione (Luukkonen et al., 2011, 2014; Markkanen et al., 2008), ionizing radiation (Mairs et al., 2007; Jouni et al., 2012; Yoon et al., 2014); RFR- chemical

mutagens (Baohong et al., 2005), clastogens (Kim et al., 2008), x-rays (Manti et al., 2008), ultraviolet ray (Baohong et al., 2007), aphidicolin (Tiwari et al., 2008), picrotoxin (López-Martín et al., 2009), doxorubicin (Zhijian et al., 2010), and incoherent electromagnetic noise (Wu et al., 2008; Yao et al., 2008). Most of the compounds that interact with EMF are mutagens. This is important because in real life situations, a person is usually exposed to many different environmental factors simultaneously. Synergism of these factors with EMF should be considered more seriously.

3. Several long term/repeated exposure papers are included in this update: ELF-EMF (Borhani et al., 2011; Cuccurazzu et al., 2010; Erdal et al., 2007; Fedrowitz and Loscher, 2012; Mariucci et al., 2010; Panagopoulous et al., 2013; Udroui et al., 2006), and RFR (Asasoy et al., 2012; Atli Serkeroglu et al., 2013; Burlaka et al., 2013; Chavdoula et al., 2010; Deshmukh et al., 2013; Ferreira et al., 2006; Garaj-Vrhovac et al., 2011; Guler et al., 2010, 2012; Kesari and Behari, 2009; Kesari et al., 2010; Lakshmi et al., 2010; Paulraj and Behari, 2006; Tomruk et al., 2010; Yan et al., 2008). These data are important in the understanding of the biological effects of EMF exposure in real life situation, since human environmental EMF exposure is both chronic and intermittent. Within these long-term exposure studies, there are several that investigated the effect of EMF exposure on developing animals (ELF-EMF: Borhani et al., 2011; Cuccurazzu et al., 2010; Panagopoulous et al., 2013; Udroui et al., 2006, RFR: Burlaka et al., 2013; Ferreira et al., 2006; Guler et al., 2010, 2012; Serkeroglu et al., 2013; Tomruk et al., 2010; Zalata et al., In press). Data of effects of EMF exposure on growth and development of young animals are urgently needed. There are several studies indicating that RFR may affect reproduction, particularly with effects on sperm physiology and DNA (Agarwal et al., 2009; Atasoy et al., 2012; Avendano et al., 2012; Chavdoula et al., 2010; de Iuliis et al., 2009; Liu et al., 2013b; Panagopoulous et al., 2007). Similar effects of ELF-EMF on sperm have also been reported, e.g., Hong R, Zhang Y, Liu Y, Weng EQ. Effects of extremely low frequency electromagnetic fields on DNA of testicular cells and sperm chromatin structure in mice. *Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi*. 23(6):414-417, 2005; Iorio R, Scrimaglio R, Rantucci E, Delle Monache S, Di Gaetano A, Finetti N, Francavilla F, Santucci R, Tettamanti E, Colonna R. A preliminary study of oscillating electromagnetic field effects on human spermatozoon motility. *Bioelectromagnetics*. 28(1):72-75, 2007; Iorio R, Delle Monache S, Bennato F, Di Bartolomeo C, Scrimaglio R, Cinque B, Colonna RC. Involvement of mitochondrial activity in mediating ELF-EMF stimulatory effect on human sperm motility. *Bioelectromagnetics*. 32(1):15-27, 2011.
4. Another area that needs more research is the biological effects of low-intensity exposure. This is particularly true for ELF-EMF, since intensities of ELF-EMF in the environment are in microtesla (μ T) levels. There are many studies on biological effects of low-intensity RFR (see Table 1 in Levitt, B.B. and Lai, H. Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays. *Environ. Rev.* 18:369-395, 2010.) However, most cell and animal studies in ELF-EMF used fields in the millitesla (mT) level. Exceptions are the study of Sarimov et al. (2011) listed below in the reference section and the study of de Bruyn and de Jager (2010) ([de Bruyn L](#) and [de Jager L](#). Effect of long-term exposure to a randomly varied 50

Hz power frequency magnetic field on the fertility of the mouse. [Electromag. Biol. Med.](#) 29(1-2):52-61, 2010).

5. Two other important findings of these recent studies are that the effects of EMF are shown to be waveform specific and cell-type specific. Regarding waveform specificity, Campisi et al. (2010) reported increases in free radical activity and DNA fragmentation in brain cells after acute exposure to a 50-Hz amplitude-modulated 900-MHz RFR, whereas a continuous-wave 9000-MHz field produced no effect. Franzellitti et al. (2010) showed increased DNA strand breaks in trophoblasts after exposure to a 217-Hz modulated 1.8 GHz-RFR, but a continuous-wave field of the same carrier frequency was without effect. Tkalec et al (2013) reported that AM-modulated (1 KHz sinusoidal) 900-MHz RFR is more potent than non-modulated field in causing DNA damage in coelomocytes of exposed earthworms. Luukkonen et al. (2009) reported a continuous-wave 872-MHz RFR increased chemically-induced DNA strand breaks and free radicals in human neuroblastoma cells, whereas a GSM-modulated 872-MHz field had no significant effect. Zhang et al. (2008) found that gene expression in rat neurons is more sensitive to intermittent than continuous exposure to a 1.8 GHz-RFR. López-Martín et al. (2009) found that GSM and unmodulated RFR caused different effects on c-Fos gene expression in the rat brain. Regarding cell-type specificity, Nylund and Leszczynski (2006) and Remondini et al. (2006) reported different patterns of gene expression in different types of cells after exposure to RFR. Zhao et al. (2007) found that neurons are more sensitive to a 1.9 GHz cell phone radiation than astrocytes. Schwarz et al. (2008) reported DNA strand breaks and micronucleus formation in human fibroblasts, but not in lymphocytes, after exposure to a 1950-MHz UMTS field. Furthermore, Xu et al (2013) found DNA damages in some cell types and not in others after exposure to 1800-MHz RFR. Valbonesi et al. (2014) reported that HSP70 expression and MAPK signaling pathways in PC12 cells were affected by GSM-217 Hz signal and not by CW or GSM-talk signals. In ELF-EM research, Giorgi et al. (2011) found that DNA transposition in *E. coli* was *decreased* after exposure to a sinusoidal magnetic field and *increased* after exposure to a pulsed magnetic field. Kim et al. (2012) described DNA strand breaks in human fibroblasts after exposure to ELF magnetic field. They found that the pattern of changes depended on the eddy current and Lorentz force in the field. Nahab et al. (2007) reported that a square-continuous ELF magnetic field was more effective than sinusoidal-continuous or pulsed field in inducing sister chromatid exchange in human lymphocytes. These findings underscore the complicity of interaction of EMF with biological tissues and may partially explain why effects were observed in some studies and not others. It is essential to understand why and how certain wave-characteristics of an EMF are more effective than other characteristics in causing biological effects, and why certain types of cells are more susceptible to the effect of EMF? That there are different biological effects elicited by different EMF wave characteristics is critical proof for the existence of nonthermal effects.
6. Many biological/health effects have been reported in cells and animals after exposure to EMFs in both the ELF and RF ranges. (Sixty-five percent of the RFR papers and 82% of the ELF-EMF papers in the publication list below reported effects.) It is highly dishonest for a scientist to summarily deny the existence of biological effects of EMF. A

biological effect of EMF can be detrimental to health, but can also be turned into a beneficial means for the treatment of human diseases. Denying any effects hampers the development of electromagnetic treatments for diseases. Examples of possible clinical uses of EMF are: Alzheimer's disease ([Arendash GW](#), [Sanchez-Ramos J](#), [Mori T](#), [Mamcarz M](#), [Lin X](#), [Runfeldt M](#), [Wang L](#), [Zhang G](#), [Sava V](#), [Tan J](#), [Cao C](#)).

Electromagnetic field treatment protects against and reverses cognitive impairment in Alzheimer's disease mice. [J Alzheimers Dis](#). 19(1):191-210, 2010); Parkinson's disease (Wang Z, Che PL, Du J, Ha B, Yarema KJ. Static magnetic field exposure reproduces cellular effects of the Parkinson's disease drug candidate ZM241385. [PLoS One](#). 5(11):e13883, 2010); bone regeneration ([Lee HM](#), [Kwon UH](#), [Kim H](#), [Kim HJ](#), [Kim B](#), [Park JO](#), [Moon ES](#), [Moon SH](#). Pulsed electromagnetic field stimulates cellular proliferation in human intervertebral disc cells. [Yonsei Med. J](#). 51(6):954-959, 2010); cancer treatment (Costa FP, de Oliveira AC, Meirelles R, Machado MC, Zanesco T, Surjan R, Chammas MC, de Souza Rocha M, Morgan D, Cantor A, Zimmerman J, Brezovich I, Kuster N, Barbault A, Pasche B. Treatment of advanced hepatocellular carcinoma with very low levels of amplitude-modulated electromagnetic fields. [Br. J. Cancer](#). 105(5):640-648, 2011), and tissue regeneration ([Gaetani R](#), [Ledda M](#), [Barile L](#), [Chimenti I](#), [De Carlo F](#), [Forte E](#), [Ionta V](#), [Giuliani L](#), [D'Emilia E](#), [Frati G](#), [Miraldi F](#), [Pozzi D](#), [Messina E](#), [Grimaldi S](#), [Giacomello A](#), [Lisi A](#). Differentiation of human adult cardiac stem cells exposed to extremely low-frequency electromagnetic fields. [Cardiovasc. Res](#). 82(3):411-420, 2009).

7. It must be pointed out that, consistent with previous research, not very much of the cellular and animal genetic research data directly indicate that EMF (both RF and ELF EMF) is a carcinogen. However, the data show that EMF can possibly alter genetic functions and thus it is advisable that one should limit one's exposure to EMF.

APPENDIX A - ABSTRACTS ON GENETIC EFFECTS OF RADIOFREQUENCY AND CELL PHONE RADIATION (2007-2014)

Below is a key to abbreviations used throughout the following list of abstracts for recent papers published since 2006 and serve as my comments to help the reader quickly identify the significance of each work. The summary sentences by each author are underlined. The list is divided into RF effects papers, and ELF effects papers.

(E- effect observed; NE- no effect observed) (LE- long term exposure; GT- genotoxic effect, e.g., DNA damage, micronucleus formation, chromosome alterations; GE- gene expression; HU- human study; OX- oxidative effects, i.e., involvement of free radicals and oxidative enzymes; IA- interaction with other factors to cause genetic effects; DE- effects on developing animals; RP- reproduction, e.g., sperm damage; EH- compared with electro-hypersensitive subjects; WS- waveform specific effect, e.g., modulation and frequency; CS- cell type specific effect).

(E) Agarwal A, Desai NR, Makker K, Varghese A, Mouradi R, Sabanegh E, Sharma R. Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones on human ejaculated semen: an in vitro pilot study. Fertil Steril 92 1318-1325, 2009. (GT, RP, OX)

OBJECTIVE: To evaluate effects of cellular phone radiofrequency electromagnetic waves (RF-EMW) during talk mode on unprocessed (neat) ejaculated human semen. DESIGN: Prospective pilot study. SETTING: Center for reproductive medicine laboratory in tertiary hospital setting. SAMPLES: Neat semen samples from normal healthy donors (n = 23) and infertile patients (n = 9). INTERVENTION(S): After liquefaction, neat semen samples were divided into two aliquots. One aliquot (experimental) from each patient was exposed to cellular phone radiation (in talk mode) for 1 h, and the second aliquot (unexposed) served as the control sample under identical conditions. MAIN OUTCOME MEASURE(S): Evaluation of sperm parameters (motility, viability), reactive oxygen species (ROS), total antioxidant capacity (TAC) of semen, ROS-TAC score, and sperm DNA damage. RESULT(S): Samples exposed to RF-EMW showed a significant decrease in sperm motility and viability, increase in ROS level, and decrease in ROS-TAC score. Levels of TAC and DNA damage showed no significant differences from the unexposed group. CONCLUSION(S): Radiofrequency electromagnetic waves emitted from cell phones may lead to oxidative stress in human semen. We speculate that keeping the cell phone in a trouser pocket in talk mode may negatively affect spermatozoa and impair male fertility.

(E) Atasoy HI, Gunal MY, Atasoy P, Elgun S, Bugdayci G. Immunohistopathologic demonstration of deleterious effects on growing rat testes of radiofrequency waves emitted from conventional Wi-Fi devices. J Pediatr Urol. 2012 Mar 30. [Epub ahead of print] (GT, OX, LE, RP)

OBJECTIVE: To investigate effects on rat testes of radiofrequency radiation emitted from indoor Wi-Fi Internet access devices using 802.11.g wireless standards. **METHODS:** Ten Wistar albino male rats were divided into experimental and control groups, with five rats per group. Standard wireless gateways communicating at 2.437 GHz were used as radiofrequency wave sources. The experimental group was exposed to radiofrequency energy for 24 h a day for 20 weeks. The rats were sacrificed at the end of the study. Intracardiac blood was sampled for serum 8-hydroxy-2'-deoxyguanosine levels. Testes were removed and examined histologically and immunohistochemically. Testis tissues were analyzed for malondialdehyde levels and prooxidant-antioxidant enzyme activities. **RESULTS:** We observed significant increases in serum 8-hydroxy-2'-deoxyguanosine levels and 8-hydroxyguanosine staining in the testes of the experimental group indicating DNA damage due to exposure ($p < 0.05$). We also found decreased levels of catalase and glutathione peroxidase activity in the experimental group, which may have been due to radiofrequency effects on enzyme activity ($p < 0.05$). **CONCLUSIONS:** These findings raise questions about the safety of radiofrequency exposure from Wi-Fi Internet access devices for growing organisms of reproductive age, with a potential effect on both fertility and the integrity of germ cells.

(E) Atlı Şekeroğlu Z, Akar A, Sekeroğlu V. Evaluation of the cytogenotoxic damage in immature and mature rats exposed to 900 MHz radio frequency electromagnetic fields. Int J Radiat Biol. 89(11):985-992, 2013. [Epub ahead of print] (GT, DE, LE)

Abstract Purpose: One of the most important issues regarding radio frequency electromagnetic fields (RF-EMF) is their effect on genetic material. Therefore, we investigated the cytogenotoxic effects of 900 MHz radio frequency electromagnetic fields (RF-EMF) and the effect of a recovery period after exposure to RF-EMF on bone marrow cells of immature and mature rats. **Materials and methods:** The immature and mature rats in treatment groups were exposed to RF-EMF for 2 h/day for 45 days. Average electrical field values for immature and mature rats were 28.1 ± 4.8 V/m and 20.0 ± 3.2 V/m, respectively. Whole-body specific absorption rate (SAR) values for immature and mature rats were in the range of 0.38-0.78 W/kg, and 0.31-0.52 W/kg during the 45 days, respectively. Two recovery groups were kept for 15 days after RF-EMF exposure. **Results:** Significant differences were observed in chromosome aberrations (CA), micronucleus (MN) frequency, mitotic index (MI) and ratio of polychromatic erythrocytes (PCE) in all treatment and recovery groups. The cytogenotoxic damage in immature rats was statistically higher than the mature rats. The recovery period did not reduce the damage to the same extent as the corresponding control groups. **Conclusions:** The exposure of RF-EMF leads to cytotoxic and genotoxic damage in immature and mature rats. More sensitive studies are required to elucidate the possible carcinogenic risk of EMF exposure in humans, especially children.

(E) Avendaño C, Mata A, Sanchez Sarmiento CA, Doncel GF. Use of laptop computers connected to internet through Wi-Fi decreases human sperm motility and increases sperm DNA fragmentation. FertilSteril 97:39-45, 2012. (GT, RP)

OBJECTIVE: To evaluate the effects of laptop computers connected to local area networks wirelessly (Wi-Fi) on human spermatozoa. **DESIGN:** Prospective in vitro study. **SETTING:** Center for reproductive medicine. **PATIENT(S):** Semen samples from 29 healthy donors. **INTERVENTION(S):** Motile sperm were selected by swim up. Each sperm suspension was divided into two aliquots. One sperm aliquot (experimental) from each patient was exposed to an

internet-connected laptop by Wi-Fi for 4 hours, whereas the second aliquot (unexposed) was used as control, incubated under identical conditions without being exposed to the laptop. MAIN OUTCOME MEASURE(S): Evaluation of sperm motility, viability, and DNA fragmentation. RESULT(S): Donor sperm samples, mostly normozoospermic, exposed ex vivo during 4 hours to a wireless internet-connected laptop showed a significant decrease in progressive sperm motility and an increase in sperm DNA fragmentation. Levels of dead sperm showed no significant differences between the two groups. CONCLUSION(S): To our knowledge, this is the first study to evaluate the direct impact of laptop use on human spermatozoa. Ex vivo exposure of human spermatozoa to a wireless internet-connected laptop decreased motility and induced DNA fragmentation by a nonthermal effect. We speculate that keeping a laptop connected wirelessly to the internet on the lap near the testes may result in decreased male fertility. Further in vitro and in vivo studies are needed to prove this contention.

(E) Baohong Wang, Jiliang H, Lifen J, Deqiang L, Wei Z, Jianlin L, Hongping D. Studying the synergistic damage effects induced by 1.8 GHz radiofrequency field radiation (RFR) with four chemical mutagens on human lymphocyte DNA using comet assay in vitro. Mutat Res 578:149-57, 2005. (GT, IA)

The aim of this investigation was to study the synergistic DNA damage effects in human lymphocytes induced by 1.8GHz radiofrequency field radiation (RFR, SAR of 3W/kg) with four chemical mutagens, i.e. mitomycin C (MMC, DNA crosslinker), bleomycin (BLM, radiomimetic agent), methyl methanesulfonate (MMS, alkylating agent), and 4-nitroquinoline-1-oxide (4NQO, UV-mimetic agent). The DNA damage of lymphocytes exposed to RFR and/or with chemical mutagens was detected at two incubation time (0 or 21h) after treatment with comet assay in vitro. Three combinative exposure ways were used. Cells were exposed to RFR and chemical mutagens for 2 and 3h, respectively. Tail length (TL) and tail moment (TM) were utilized as DNA damage indexes. The results showed no difference of DNA damage indexes between RFR group and control group at 0 and 21h incubation after exposure ($P>0.05$). There were significant difference of DNA damage indexes between MMC group and RFR+MMC co-exposure group at 0 and 21h incubation after treatment ($P<0.01$). Also the significant difference of DNA damage indexes between 4NQO group and RFR+4NQO co-exposure group at 0 and 21h incubation after treatment was observed ($P<0.05$ or $P<0.01$). The DNA damage in RFR+BLM co-exposure groups and RFR+MMS co-exposure groups was not significantly increased, as compared with corresponding BLM and MMS groups ($P>0.05$). The experimental results indicated 1.8GHz RFR (SAR, 3W/kg) for 2h did not induce the human lymphocyte DNA damage effects in vitro, but could enhance the human lymphocyte DNA damage effects induced by MMC and 4NQO. The synergistic DNA damage effects of 1.8GHz RFR with BLM or MMS were not obvious.

(E) Baohong W, Lifen J, Lanjuan L, Jianlin L, Deqiang L, Wei Z, Jiliang H. Evaluating the combinative effects on human lymphocyte DNA damage induced by ultraviolet ray C plus 1.8GHz microwaves using comet assay in vitro. Toxicology. 232(3):311-316, 2007. (GT, IA)

The objective of this study was to observe whether 1.8GHz microwaves (MW) (SAR, 3 W/kg) exposure can influence human lymphocyte DNA damage induced by ultraviolet ray C (UVC). The lymphocytes, which were from three young healthy donors, were exposed to 254 nm UVC at the doses of 0.25, 0.5, 0.75, 1.0, 1.5 and 2.0 J m⁻², respectively. The lymphocytes were irradiated by 1.8GHz MW (SAR, 3 W/kg) for 0, 1.5 and 4 h. The combinative exposure of UVC

plus MW was conducted. The treated cells were incubated for 0, 1.5 and 4 h. Finally, comet assay was used to measure DNA damage of above treated lymphocytes. The results indicated that the difference of DNA damage induced between MW group and control group was not significant ($P>0.05$). The MTLs induced by UVC were 1.71 ± 0.09 , 2.02 ± 0.08 , 2.27 ± 0.17 , 2.27 ± 0.06 , 2.25 ± 0.12 , 2.24 ± 0.11 microm, respectively, which were significantly higher than that (0.96 ± 0.05 microm) of control ($P<0.01$). MTLs of some sub-groups in combinative exposure groups at 1.5-h incubation were significantly lower than those of corresponding UVC sub-groups ($P<0.01$ or $P<0.05$). However, MTLs of some sub-groups in combinative exposure groups at 4-h incubation were significantly higher than those of corresponding UVC sub-groups ($P<0.01$ or $P<0.05$). In this experiment it was found that 1.8GHz (SAR, 3 W/kg) MW exposure for 1.5 and 4 h did not enhance significantly human lymphocyte DNA damage, but could reduce and increase DNA damage of human lymphocytes induced by UVC at 1.5-h and 4-h incubation, respectively.

(E) Belyaev IY, Hillert L, Protopopova M, Tamm C, Malmgren LO, Persson BR, Selivanova G, Harms-Ringdahl M. 915 MHz microwaves and 50 Hz magnetic field affect chromatin conformation and 53BP1 foci in human lymphocytes from hypersensitive and healthy persons. Bioelectromagnetics 26:173-184, 2005. (GT, EH)

We used exposure to microwaves from a global system for mobile communication (GSM) mobile phone (915 MHz, specific absorption rate (SAR) 37 mW/kg) and power frequency magnetic field (50 Hz, 15 μ T peak value) to investigate the response of lymphocytes from healthy subjects and from persons reporting hypersensitivity to electromagnetic field (EMF). The hypersensitive and healthy donors were matched by gender and age and the data were analyzed blind to treatment condition. The changes in chromatin conformation were measured with the method of anomalous viscosity time dependencies (AVTD). 53BP1 protein, which has been shown to colocalize in foci with DNA double strand breaks (DSBs), was analyzed by immunostaining in situ. Exposure at room temperature to either 915 MHz or 50 Hz resulted in significant condensation of chromatin, shown as AVTD changes, which was similar to the effect of heat shock at 41 degrees C. No significant differences in responses between normal and hypersensitive subjects were detected. Neither 915 MHz nor 50 Hz exposure induced 53BP1 foci. On the contrary, a distinct decrease in background level of 53BP1 signaling was observed upon these exposures as well as after heat shock treatments. This decrease correlated with the AVTD data and may indicate decrease in accessibility of 53BP1 to antibodies because of stress-induced chromatin condensation. Apoptosis was determined by morphological changes and by apoptotic fragmentation of DNA as analyzed by pulsed-field gel electrophoresis (PFGE). No apoptosis was induced by exposure to 50 Hz and 915 MHz microwaves. In conclusion, 50 Hz magnetic field and 915 MHz microwaves under specified conditions of exposure induced comparable responses in lymphocytes from healthy and hypersensitive donors that were similar but not identical to stress response induced by heat shock.

(E) Belyaev IY, Koch CB, Terenius O, Roxstrom-Lindquist K, Malmgren LO, H Sommer W, Salford LG, Persson BR. Exposure of rat brain to 915 MHz GSM microwaves induces changes in gene expression but not double stranded DNA breaks or effects on chromatin conformation. Bioelectromagnetics 27:295-306, 2006. (GE)

We investigated whether exposure of rat brain to microwaves (MWs) of global system for mobile communication (GSM) induces DNA breaks, changes in chromatin conformation and in gene expression. An exposure installation was used based on a test mobile phone employing a GSM signal at 915 MHz, all standard modulations included, output power level in pulses 2 W, specific absorption rate (SAR) 0.4 mW/g. Rats were exposed or sham exposed to MWs during 2 h. After exposure, cell suspensions were prepared from brain samples, as well as from spleen and thymus. For analysis of gene expression patterns, total RNA was extracted from cerebellum. Changes in chromatin conformation, which are indicative of stress response and genotoxic effects, were measured by the method of anomalous viscosity time dependencies (AVTD). DNA double strand breaks (DSBs) were analyzed by pulsed-field gel electrophoresis (PFGE). Effects of MW exposure were observed on neither conformation of chromatin nor DNA DSBs. Gene expression profiles were obtained by Affymetrix U34 GeneChips representing 8800 rat genes and analyzed with the Affymetrix Microarray Suite (MAS) 5.0 software. In cerebellum from all exposed animals, 11 genes were upregulated in a range of 1.34-2.74 fold and one gene was downregulated 0.48-fold ($P < .0025$). The induced genes encode proteins with diverse functions including neurotransmitter regulation, blood-brain barrier (BBB), and melatonin production. The data shows that GSM MWs at 915 MHz did not induce PFGE-detectable DNA double stranded breaks or changes in chromatin conformation, but affected expression of genes in rat brain cells

(E) Belyaev IY, Markovà E, Hillert L, Malmgren LO, Persson BR. Microwaves from UMTS/GSM mobile phones induce long-lasting inhibition of 53BP1/gamma-H2AX DNA repair foci in human lymphocytes. Bioelectromagnetics 30:129-41, 2009. (GT, EH)

We have recently described frequency-dependent effects of mobile phone microwaves (MWs) of global system for mobile communication (GSM) on human lymphocytes from persons reporting hypersensitivity to electromagnetic fields and healthy persons. Contrary to GSM, universal global telecommunications system (UMTS) mobile phones emit wide-band MW signals. Hypothetically, UMTS MWs may result in higher biological effects compared to GSM signal because of eventual "effective" frequencies within the wideband. Here, we report for the first time that UMTS MWs affect chromatin and inhibit formation of DNA double-strand breaks co-localizing 53BP1/gamma-H2AX DNA repair foci in human lymphocytes from hypersensitive and healthy persons and confirm that effects of GSM MWs depend on carrier frequency. Remarkably, the effects of MWs on 53BP1/gamma-H2AX foci persisted up to 72 h following exposure of cells, even longer than the stress response following heat shock. The data are in line with the hypothesis that the type of signal, UMTS MWs, may have higher biological efficiency and possibly larger health risk effects compared to GSM radiation emissions. No significant differences in effects between groups of healthy and hypersensitive subjects were observed, except for the effects of UMTS MWs and GSM-915 MHz MWs on the formation of the DNA repair foci, which were different for hypersensitive ($P < 0.02[53BP1]/0.01[\text{gamma-H2AX}]$) but not for control subjects ($P > 0.05$). The non-parametric statistics used here did not indicate specificity of the differences revealed between the effects of GSM and UMTS MWs on cells from hypersensitive subjects and more data are needed to study the nature of these differences.

(NE) Bourthoumieu S, Joubert V, Marin B, Collin A, Leveque P, Terro F, Yardin C. Cytogenetic studies in human cells exposed in vitro to GSM-900 MHz radiofrequency radiation using R-banded karyotyping. Radiat Res 174:712-718, 2010. (GT)

It is important to determine the possible effects of exposure to radiofrequency (RF) radiation on the genetic material of cells since damage to the DNA of somatic cells may be linked to cancer development or cell death and damage to germ cells may lead to genetic damage in next and subsequent generations. The objective of this study was to investigate whether exposure to radiofrequency radiation similar to that emitted by mobile phones of second-generation standard Global System for Mobile Communication (GSM) induces genotoxic effects in cultured human cells. The cytogenetic effects of GSM-900 MHz (GSM-900) RF radiation were investigated using R-banded karyotyping after in vitro exposure of human cells (amniotic cells) for 24 h. The average specific absorption rate (SAR) was 0.25 W/kg. The exposures were carried out in wire-patch cells (WPCs) under strictly controlled conditions of temperature. The genotoxic effect was assessed immediately or 24 h after exposure using four different samples. One hundred metaphase cells were analyzed per assay. Positive controls were provided by using bleomycin. We found no direct cytogenetic effects of GSM-900 either 0 h or 24 h after exposure. To the best of our knowledge, our work is the first to study genotoxicity using complete R-banded karyotyping, which allows visualizing all the chromosomal rearrangements, either numerical or structural.

(NE) Bourthoumieu S, Terro F, Leveque P, Collin A, Joubert V, Yardin C. Aneuploidy studies in human cells exposed in vitro to GSM-900 MHz radiofrequency radiation using FISH. *Int J Radiat Biol* 87:400-408, 2011. (GT)

PURPOSE: Since previous research found an increase in the rate of aneuploidies in human lymphocytes exposed to radiofrequencies, it seems important to perform further studies. The objective of this study was then to investigate whether the exposure to RF (radiofrequency) radiation similar to that emitted by mobile phones of a second generation standard, i.e., Global System for Mobile communication (GSM) may induce aneuploidy in cultured human cells. **MATERIALS AND METHODS:** The potential induction of genomic instability by GSM-900 MHz radiofrequency (GSM-900) was investigated after in vitro exposure of human amniotic cells for 24 h to average-specific absorption rates (SAR) of 0.25, 1, 2 and 4 W/kg in the temperature range of 36.3-39.7°C. The exposures were carried out in a wire-patch cell (WPC). The rate of aneuploidy of chromosomes 11 and 17 was determined by interphase FISH (Fluorescence In Situ Hybridisation) immediately after independent exposure of three different donors for 24 h. At least 100 interphase cells were analysed per assay. **RESULTS:** No significant change in the rate of aneuploidy of chromosomes 11 and 17 was found following exposure to GSM-900 for 24 h at average SAR up to 4 W/kg. **CONCLUSION:** Our study did not show any in vitro aneuploidogenic effect of GSM using FISH and is not in agreement with the results of previous research.

(NE) Bourthoumieu S, Magnaudeix A, Terro F, Leveque P, Collin A, Yardin C. Study of p53 expression and post-transcriptional modifications after GSM-900 radiofrequency exposure of human amniotic cells. *Bioelectromagnetics*. 2012 Jul 5. doi: 10.1002/bem.21744. [Epub ahead of print] (GE)

The potential effects of radiofrequency (RF) exposure on the genetic material of cells are very important to determine since genome instability of somatic cells may be linked to cancer development. In response to genetic damage, the p53 protein is activated and can induce cell cycle arrest allowing more time for DNA repair or elimination of damaged cells through

apoptosis. The objective of this study was to investigate whether the exposure to RF electromagnetic fields, similar to those emitted by mobile phones of the second generation standard, Global System for Mobile Communications (GSM), may induce expression of the p53 protein and its activation by post-translational modifications in cultured human cells. The potential induction of p53 expression and activation by GSM-900 was investigated after in vitro exposure of human amniotic cells for 24 h to average specific absorption rates (SARs) of 0.25, 1, 2, and 4 W/kg in the temperature range of 36.3-39.7 °C. The exposures were carried out using a wire-patch cell (WPC) under strictly controlled conditions of temperature. Expression and activation of p53 by phosphorylation at serine 15 and 37 were studied using Western blot assay immediately after three independent exposures of cell cultures provided from three different donors. Bleomycin-exposed cells were used as a positive control. According to our results, no significant changes in the expression and activation of the p53 protein by phosphorylation at serine 15 and 37 were found following exposure to GSM-900 for 24 h at average SARs up to 4 W/kg in human embryonic cells.

(E) Burlaka A, Tsybulin O, Sidorik E, Lukin S, Polishuk V, Tshmistrenko S, Yakymenko I. Overproduction of free radical species in embryonal cells exposed to low intensity radiofrequency radiation. Exp Oncol. 35(3):219-225, 2013. (GT, LE, DE, OX)

Aim: Long-term exposure of humans to low intensity radiofrequency electromagnetic radiation (RF-EMR) leads to a statistically significant increase in tumor incidence. Mechanisms of such the effects are unclear, but features of oxidative stress in living cells under RF-EMR exposure were previously reported. Our study aims to assess a production of initial free radical species, which lead to oxidative stress in the cell. Materials and Methods: Embryos of Japanese quails were exposed in ovo to extremely low intensity RF-EMR of GSM 900 MHz (0.25 μ W/cm²) during 158-360 h discontinuously (48 c - ON, 12 c - OFF) before and in the initial stages of development. The levels of superoxide (O₂^{·-}), nitrogen oxide (NO[·]), thiobarbituric acid reactive substances (TBARS), 8-oxo-2'-deoxyguanosine (8-oxo-dG) and antioxidant enzymes' activities were assessed in cells/tissues of 38-h, 5- and 10-day RF-EMR exposed and unexposed embryos. Results: The exposure resulted in a significant persistent overproduction of superoxide and nitrogen oxide in embryo cells during all period of analyses. As a result, significantly increased levels of TBARS and 8-oxo-dG followed by significantly decreased levels of superoxide dismutase and catalase activities were developed in the exposed embryo cells. Conclusion: Exposure of developing quail embryos to extremely low intensity RF-EMR of GSM 900 MHz during at least one hundred and fifty-eight hours leads to a significant overproduction of free radicals/reactive oxygen species and oxidative damage of DNA in embryo cells. These oxidative changes may lead to pathologies up to oncogenic transformation of cells.

(E) Buttiglione M, Roca L, Montemurno E, Vitiello F, Capozzi V, Cibelli G. Radiofrequency radiation (900 MHz) induces Egr-1 gene expression and affects cell-cycle control in human neuroblastoma cells. J Cell Physiol. 213(3):759-767, 2007. (GE)

Many environmental signals, including ionizing radiation and UV rays, induce activation of Egr-1 gene, thus affecting cell growth and apoptosis. The paucity and the controversial knowledge about the effect of electromagnetic fields (EMF) exposure of nerve cells prompted us to investigate the bioeffects of radiofrequency (RF) radiation on SH-SY5Y neuroblastoma cells. The effect of a modulated RF field of 900 MHz, generated by a wire patch cell (WPC) antenna

exposure system on Egr-1 gene expression, was studied as a function of time. Short-term exposures induced a transient increase in Egr-1 mRNA level paralleled with activation of the MAPK subtypes ERK1/2 and SAPK/JNK. The effects of RF radiations on cell growth rate and apoptosis were also studied. Exposure to RF radiation had an anti-proliferative activity in SH-SY5Y cells with a significant effect observed at 24 h. RF radiation impaired cell cycle progression, reaching a significant G2-M arrest. In addition, the appearance of the sub-G1 peak, a hallmark of apoptosis, was highlighted after a 24-h exposure, together with a significant decrease in mRNA levels of Bcl-2 and survivin genes, both interfering with signaling between G2-M arrest and apoptosis. Our results provide evidence that exposure to a 900 MHz-modulated RF radiation affect both Egr-1 gene expression and cell regulatory functions, involving apoptosis inhibitors like Bcl-2 and survivin, thus providing important insights into a potentially broad mechanism for controlling in vitro cell viability.

(E) Cam ST, Seyhan N. Single-strand DNA breaks in human hair root cells exposed to mobile phone radiation. Int J Radiat Biol 88(5):420-424, 2012 (GT, HU)

Purpose: To analyze the short term effects of radiofrequency radiation (RFR) exposure on genomic deoxyribonucleic acid (DNA) of human hair root cells. Subjects and methods: Hair samples were collected from 8 healthy human subjects immediately before and after using a 900-MHz GSM (Global System for Mobile Communications) mobile phone for 15 and 30 minutes. Single-strand DNA breaks of hair root cells from the samples were determined using the 'comet assay'. Results: The data showed that talking on a mobile phone for 15 or 30 minutes significantly increased ($p < .05$) single-strand DNA breaks in cells of hair roots close to the phone. Comparing the 15-min and 30-min data using the paired t-test also showed that significantly more damages resulted after 30 minutes than after 15 minutes of phone use. Conclusions: A short-term exposure (15 and 30 minutes) to RFR (900-MHz) from a mobile phone caused a significant increase in DNA single-strand breaks in human hair root cells located around the ear which is used for the phone calls.

(E) Campisi A, Gulino M, Acquaviva R, Bellia P, Raciti G, Grasso R, Musumeci F, Vanella A, Triglia A. Reactive oxygen species levels and DNA fragmentation on astrocytes in primary culture after acute exposure to low intensity microwave electromagnetic field. Neurosci Lett 473:52-55. 2010. (GT, OX, WS)

The exposure of primary rat neocortical astroglial cell cultures to acute electromagnetic fields (EMF) in the microwave range was studied. Differentiated astroglial cell cultures at 14 days in vitro were exposed for 5, 10, or 20 min to either 900 MHz continuous waves or 900 MHz waves modulated in amplitude at 50 Hz using a sinusoidal waveform and 100% modulation index. The strength of the electric field (rms value) at the sample position was 10V/m. No change in cellular viability evaluated by MTT test and lactate dehydrogenase release was observed. A significant increase in ROS levels and DNA fragmentation was found only after exposure of the astrocytes to modulated EMF for 20 min. No evident effects were detected when shorter time intervals or continuous waves were used. The irradiation conditions allowed the exclusion of any possible thermal effect. Our data demonstrate, for the first time, that even acute exposure to low intensity EMF induces ROS production and DNA fragmentation in astrocytes in primary cultures, which also represent the principal target of modulated EMF. Our findings also suggest the hypothesis that the effects could be due to hyperstimulation of the glutamate receptors, which play a crucial

role in acute and chronic brain damage. Furthermore, the results show the importance of the amplitude modulation in the interaction between EMF and neocortical astrocytes.

(E) ¹ Cervellati F, Valacchi G, Lunghi L, Fabbri E, Valbonesi P, Marci R, Biondi C, Vesce F. **17- β -estradiol counteracts the effects of high frequency electromagnetic fields on trophoblastic connexins and integrins.** *Oxid Med Cell Longev.* 2013;2013:280850. doi: 10.1155/2013/280850. (GE)

We investigated the effect of high-frequency electromagnetic fields (HF-EMFs) and 17- β -estradiol on connexins (Cxs), integrins (Ints), and estrogen receptor (ER) expression, as well as on ultrastructure of trophoblast-derived HTR-8/SVneo cells. HF-EMF, 17- β -estradiol, and their combination induced an increase of Cx40 and Cx43 mRNA expression. HF-EMF decreased Int α 1 and β 1 mRNA levels but enhanced Int α 5 mRNA expression. All the Ints mRNA expressions were increased by 17- β -estradiol and exposure to both stimuli. ER- β mRNA was reduced by HF-EMF but augmented by 17- β -estradiol alone or with HF-EMF. ER- β immunofluorescence showed a cytoplasmic localization in sham and HF-EMF exposed cells which became nuclear after treatment with hormone or both stimuli. Electron microscopy evidenced a loss of cellular contact in exposed cells which appeared counteracted by 17- β -estradiol. We demonstrate that 17- β -estradiol modulates Cxs and Ints as well as ER- β expression induced by HF-EMF, suggesting an influence of both stimuli on trophoblast differentiation and migration.

(NE) Chang SK, Choi JS, Gil HW, Yang JO, Lee EY, Jeon YS, Lee ZW, Lee M, Hong MY, Ho Son T, Hong SY. **Genotoxicity evaluation of electromagnetic fields generated by 835-MHz mobile phone frequency band.** *Eur J Cancer Prev* 14:175-179, 2005. (GT, IA)
(Some interaction effects with chemicals are reported in this paper.)

It is still unclear whether the exposure to electromagnetic fields (EMFs) generated by mobile phone radiation is directly linked to cancer. We examined the biological effects of an EMF at 835 MHz, the most widely used communication frequency band in Korean CDMA mobile phone networks, on bacterial reverse mutation (Ames assay) and DNA stability (in vitro DNA degradation). In the Ames assay, tester strains alone or combined with positive mutagen were applied in an artificial mobile phone frequency EMF generator with continuous waveform at a specific absorption rate (SAR) of 4 W/kg for 48 h. In the presence of the 835-MHz EMF radiation, incubation with positive mutagen 4-nitroquinoline-1-oxide and cumene hydroxide further increased the mutation rate in Escherichia coli WP2 and TA102, respectively, while the contrary results in Salmonella typhimurium TA98 and TA1535 treated with 4-nitroquinoline-1-oxide and sodium azide, respectively, were shown as antimutagenic. However, these mutagenic or co-mutagenic effects of 835-MHz radiation were not significantly repeated in other relevant strains with same mutation type. In the DNA degradation test, the exposure to 835-MHz EMF did not change the rate of degradation observed using plasmid pBluescriptSK(+) as an indicator. Thus, we suggest that 835-MHz EMF under the conditions of our study neither affected the reverse mutation frequency nor accelerated DNA degradation in vitro.

(NE) Chauhan V, Mariampillai A, Bellier PV, Qutob SS, Gajda GB, Lemay E, Thansandote A, McNamee JP. **Gene expression analysis of a human lymphoblastoma cell**

line exposed in vitro to an intermittent 1.9 GHz pulse-modulated radiofrequency field. [Radiat Res.](#) 165(4):424-429, 2006. (GE)

This study was designed to determine whether radiofrequency (RF) fields of the type used for wireless communications could elicit a cellular stress response. As general indicators of a cellular stress response, we monitored changes in proto-oncogene and heat-shock protein expression. Exponentially growing human lymphoblastoma cells (TK6) were exposed to 1.9 GHz pulse-modulated RF fields at average specific absorption rates (SARs) of 1 and 10 W/kg. Perturbations in the expression levels of the proto-oncogenes FOS, JUN and MYC after exposure to sham and RF fields were assessed by real-time RT-PCR. In addition, the transcript levels of the cellular stress proteins HSP27 and inducible HSP70 were also monitored. We demonstrated that transcript levels of these genes in RF-field-exposed cells showed no significant difference in relation to the sham treatment group. However, concurrent positive (heat-shock) control samples displayed a significant elevation in the expression of HSP27, HSP70, FOS and JUN. Conversely, the levels of MYC mRNA were found to decline in the positive (heat-shock) control. In conclusion, our study found no evidence that the 1.9 GHz RF-field exposure caused a general stress response in TK6 cells under our experimental conditions.

(NE) [Chauhan V](#), [Mariampillai A](#), [Gajda GB](#), [Thansandote A](#), [McNamee JP](#). Analysis of proto-oncogene and heat-shock protein gene expression in human derived cell-lines exposed in vitro to an intermittent 1.9 GHz pulse-modulated radiofrequency field. [Int J Radiat Biol.](#) 82(5):347-354, 2006. (GE)

Purpose: Several studies have reported that radiofrequency (RF) fields, as emitted by mobile phones, may cause changes in gene expression in cultured human cell-lines. The current study was undertaken to evaluate this possibility in two human-derived immune cell-lines. Materials and methods: HL-60 and Mono-Mac-6 (MM6) cells were individually exposed to intermittent (5 min on, 10 min off) 1.9 GHz pulse-modulated RF fields at a average specific absorption rate (SAR) of 1 and 10 W/kg at 37 +/- 0.5 degrees C for 6 h. Concurrent negative and positive (heat-shock for 1 h at 43 degrees C) controls were conducted with each experiment. Immediately following RF field exposure (T = 6 h) and 18 h post-exposure (T = 24 h), cell pellets were collected from each of the culture dishes and analyzed for transcript levels of proto-oncogenes (c-jun, c-myc and c-fos) and the stress-related genes (heat shock proteins (HSP) HSP27 and HSP70B) by quantitative reverse transcriptase polymerase chain reaction (RT-PCR). Results: No significant effects were observed in mRNA expression of HSP27, HSP70, c-jun, c-myc or c-fos between the sham and RF-exposed groups, in either of the two cell-lines. However, the positive (heat-shock) control group displayed a significant elevation in the expression of HSP27, HSP70, c-fos and c-jun in both cell-lines at T = 6 and 24 h, relative to the sham and negative control groups. Conclusion: This study found no evidence that exposure of cells to non-thermalizing levels of 1.9 GHz pulse-modulated RF fields can cause any detectable change in stress-related gene expression.

(NE) [Chauhan V](#), [Qutob SS](#), [Lui S](#), [Mariampillai A](#), [Bellier PV](#), [Yauk CL](#), [Douglas GR](#), [Williams A](#), [McNamee JP](#). Analysis of gene expression in two human-derived cell lines exposed in vitro to a 1.9 GHz pulse-modulated radiofrequency field. [Proteomics.](#) 7(21):3896-3905, 2007. (GE)

There is considerable controversy surrounding the biological effects of radiofrequency (RF) fields, as emitted by mobile phones. Previous work from our laboratory has shown no effect related to the exposure of 1.9 GHz pulse-modulated RF fields on the expression of 22,000 genes in a human glioblastoma-derived cell-line (U87MG) at 6 h following a 4 h RF field exposure period. As a follow-up to this study, we have now examined the effect of RF field exposure on the possible expression of late onset genes in U87MG cells after a 24 h RF exposure period. In addition, a human monocyte-derived cell-line (Mono-Mac-6, MM6) was exposed to intermittent (5 min ON, 10 min OFF) RF fields for 6 h and then gene expression was assessed immediately after exposure and at 18 h postexposure. Both cell lines were exposed to 1.9 GHz pulse-modulated RF fields for 6 or 24 h at specific absorption rates (SARs) of 0.1-10.0 W/kg. In support of our previous results, we found no evidence that nonthermal RF field exposure could alter gene expression in either cultured U87MG or MM6 cells, relative to nonirradiated control groups. However, exposure of both cell-lines to heat-shock conditions (43 degrees C for 1 h) caused an alteration in the expression of a number of well-characterized heat-shock proteins.

(E) Chavdoula ED, Panagopoulos DJ, Margaritis LH. Comparison of biological effects between continuous and intermittent exposure to GSM-900-MHz mobile phone radiation: detection of apoptotic cell-death features. *Mutat Res* 700:51-61, 2010. (RP, LE, GT)

In the present study we used a 6-min daily exposure of dipteran flies, *Drosophila melanogaster*, to GSM-900 MHz (Global System for Mobile Telecommunications) mobile phone electromagnetic radiation (EMR), to compare the effects between the continuous and four different intermittent exposures of 6min total duration, and also to test whether intermittent exposure provides any cumulative effects on the insect's reproductive capacity as well as on the induction of apoptotic cell death. According to our previous experiments, a 6-min continuous exposure per day for five days to GSM-900 MHz and DCS-1800 MHz (Digital Cellular System) mobile phone radiation, brought about a large decrease in the insect's reproductive capacity, as defined by the number of F pupae. This decrease was found to be non thermal and correlated with an increased percentage of induced fragmented DNA in the egg chambers' cells at early- and mid-oogenesis. In the present experiments we show that intermittent exposure also decreases the reproductive capacity and alters the actin cytoskeleton network of the egg chambers, another known aspect of cell death that was not investigated in previous experiments, and that the effect is also due to DNA fragmentation. Intermittent exposures with 10-min intervals between exposure sessions proved to be almost equally effective as continuous exposure of the same total duration, whereas longer intervals between the exposures seemed to allow the organism the time required to recover and partly overcome the above-mentioned effects of the GSM exposure.

(E) [Chen G](#), [Lu D](#), [Chiang H](#), [Leszczynski D](#), [Xu Z](#). Using model organism *Saccharomyces cerevisiae* to evaluate the effects of ELF-MF and RF-EMF exposure on global gene expression. *Bioelectromagnetics*. 33(7):550-560, 2012 . (GE)

The potential health hazard of exposure to electromagnetic fields (EMF) continues to cause public concern. However, the possibility of biological and health effects of exposure to EMF remains controversial and their biophysical mechanisms are unknown. In the present study, we used *Saccharomyces cerevisiae* to identify genes responding to extremely low frequency magnetic fields (ELF-MF) and to radiofrequency EMF (RF-EMF) exposures. The yeast cells were exposed for 6 h to either 0.4 mT 50 Hz ELF-MF or 1800 MHz RF-EMF at a specific

absorption rate of 4.7 W/kg. Gene expression was analyzed by microarray screening and confirmed using real-time reverse transcription-polymerase chain reaction (RT-PCR). We were unable to confirm microarray-detected changes in three of the ELF-MF responsive candidate genes using RT-PCR ($P > 0.05$). On the other hand, out of the 40 potential RF-EMF responsive genes, only the expressions of structural maintenance of chromosomes 3 (SMC3) and aquaporin 2 (AQY2 (m)) were confirmed, while three other genes, that is, halotolerance protein 9 (HAL9), yet another kinase 1 (YAK1) and one function-unknown gene (open reading frame: YJL171C), showed opposite changes in expression compared to the microarray data ($P < 0.05$). In conclusion, the results of this study suggest that the yeast cells did not alter gene expression in response to 50 Hz ELF-MF and that the response to RF-EMF is limited to only a very small number of genes. The possible biological consequences of the gene expression changes induced by RF-EMF await further investigation.

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(E) De Iuliis GN, Newey RJ, King BV, Aitken RJ. Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro. PLoS One 4:e6446, 2009. (GT, OX, RP)

BACKGROUND: In recent times there has been some controversy over the impact of electromagnetic radiation on human health. The significance of mobile phone radiation on male reproduction is a key element of this debate since several studies have suggested a relationship between mobile phone use and semen quality. The potential mechanisms involved have not been established, however, human spermatozoa are known to be particularly vulnerable to oxidative stress by virtue of the abundant availability of substrates for free radical attack and the lack of cytoplasmic space to accommodate antioxidant enzymes. Moreover, the induction of oxidative stress in these cells not only perturbs their capacity for fertilization but also contributes to sperm DNA damage. The latter has, in turn, been linked with poor fertility, an increased incidence of miscarriage and morbidity in the offspring, including childhood cancer. In light of these associations, we have analyzed the influence of RF-EMR on the cell biology of human spermatozoa in vitro. **PRINCIPAL FINDINGS:** Purified human spermatozoa were exposed to radio-frequency electromagnetic radiation (RF-EMR) tuned to 1.8 GHz and covering a range of specific absorption rates (SAR) from 0.4 W/kg to 27.5 W/kg. In step with increasing SAR, motility and vitality were significantly reduced after RF-EMR exposure, while the mitochondrial generation of reactive oxygen species and DNA fragmentation were significantly elevated ($P < 0.001$). Furthermore, we also observed highly significant relationships between SAR, the oxidative DNA damage bio-marker, 8-OH-dG, and DNA fragmentation after RF-EMR exposure. **CONCLUSIONS:** RF-EMR in both the power density and frequency range of mobile phones enhances mitochondrial reactive oxygen species generation by human spermatozoa, decreasing the motility and vitality of these cells while stimulating DNA base adduct formation and, ultimately DNA fragmentation. These findings have clear implications for the safety of extensive mobile phone use by males of reproductive age, potentially affecting both their fertility and the health and wellbeing of their offspring.

(E) Del Vecchio G, Giuliani A, Fernandez M, Mesirca P, Bersani F, Pinto R, Ardoino L, Lovisolo GA, Giardino L, Calzà L. Continuous exposure to 900MHz GSM-modulated EMF alters morphological maturation of neural cells. Neurosci Lett. 455(3):173-177, 2009. (GE, DE)

The effects of radiofrequency electromagnetic field (RF-EMF) exposure on neuronal phenotype maturation have been studied in two different in vitro models: murine SN56 cholinergic cell line and rat primary cortical neurons. The samples were exposed at a dose of 1W/kg at 900 MHz GSM modulated. The phenotype analysis was carried out at 48 and 72 h (24 and 48 h of SN56 cell line differentiation) or at 24, 72, 120 h (2, 4 and 6 days in vitro for cortical neurons) of exposure, on live and immunolabeled neurons, and included the morphological study of neurite emission, outgrowth and branching. Moreover, cortical neurons were studied to detect alterations in the expression pattern of cytoskeleton regulating factors, e.g. beta-thymosin, and of early genes, e.g. c-Fos and c-Jun through real-time PCR on mRNA extracted after 24h exposure to EMF. We found that RF-EMF exposure reduced the number of neurites generated by both cell systems, and this alteration correlates to increased expression of beta-thymosin mRNA.

(E) Deshmukh PS, Megha K, Banerjee BD, Ahmed RS, Chandna S, Abegaonkar MP, Tripathi AK. Detection of Low Level Microwave Radiation Induced Deoxyribonucleic Acid Damage Vis-à-vis Genotoxicity in Brain of Fischer Rats. Toxicol Int. 20(1):19-24, 2013. (GT, LE)

BACKGROUND: Non-ionizing radiofrequency radiation has been increasingly used in industry, commerce, medicine and especially in mobile phone technology and has become a matter of serious concern in present time. **OBJECTIVE:** The present study was designed to investigate the possible deoxyribonucleic acid (DNA) damaging effects of low-level microwave radiation in brain of Fischer rats. **MATERIALS AND METHODS:** Experiments were performed on male Fischer rats exposed to microwave radiation for 30 days at three different frequencies: 900, 1800 and 2450 MHz. Animals were divided into 4 groups: Group I (Sham exposed): Animals not exposed to microwave radiation but kept under same conditions as that of other groups, Group II: Animals exposed to microwave radiation at frequency 900 MHz at specific absorption rate (SAR) $5.953 \times 10(-4)$ W/kg, Group III: Animals exposed to 1800 MHz at SAR $5.835 \times 10(-4)$ W/kg and Group IV: Animals exposed to 2450 MHz at SAR $6.672 \times 10(-4)$ W/kg. At the end of the exposure period animals were sacrificed immediately and DNA damage in brain tissue was assessed using alkaline comet assay. **RESULTS:** In the present study, we demonstrated DNA damaging effects of low level microwave radiation in brain. **CONCLUSION:** We concluded that low SAR microwave radiation exposure at these frequencies may induce DNA strand breaks in brain tissue.

(E) Engelmann JC, Deeken R, Müller T, Nimtz G, Roelfsema MR, Hedrich R. Is gene activity in plant cells affected by UMTS-irradiation? A whole genome approach. Adv Appl Bioinform Chem. 1:71-83, 2008. (GE)

Mobile phone technology makes use of radio frequency (RF) electromagnetic fields transmitted through a dense network of base stations in Europe. Possible harmful effects of RF fields on humans and animals are discussed, but their effect on plants has received little attention. In search for physiological processes of plant cells sensitive to RF fields, cell suspension cultures of *Arabidopsis thaliana* were exposed for 24 h to a RF field protocol representing typical microwave exposition in an urban environment. mRNA of exposed cultures and controls was used to hybridize Affymetrix-ATH1 whole genome microarrays. Differential expression analysis revealed significant changes in transcription of 10 genes, but they did not exceed a fold change

of 2.5. Besides that 3 of them are dark-inducible, their functions do not point to any known responses of plants to environmental stimuli. The changes in transcription of these genes were compared with published microarray datasets and revealed a weak similarity of the microwave to light treatment experiments. Considering the large changes described in published experiments, it is questionable if the small alterations caused by a 24 h continuous microwave exposure would have any impact on the growth and reproduction of whole plants.

(E) Esmekaya MA, Aytekin E, Ozgur E, Güler G, Ergun MA, Omeroğlu S, Seyhan N. Mutagenic and morphologic impacts of 1.8GHz radiofrequency radiation on human peripheral blood lymphocytes (hPBLs) and possible protective role of pre-treatment with Ginkgo biloba (EGb 761). Sci Total Environ. 410-411:59-64, 2011. (GT, OX)

The mutagenic and morphologic effects of 1.8GHz Global System for Mobile Communications (GSM) modulated RF (radiofrequency) radiation alone and in combination with Ginkgo biloba (EGb 761) pre-treatment in human peripheral blood lymphocytes (hPBLs) were investigated in this study using Sister Chromatid Exchange (SCE) and electron microscopy. Cell viability was assessed with 3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyltetrazolium bromide (MTT) reduction assay. The lymphocyte cultures were exposed to GSM modulated RF radiation at 1.8GHz for 6, 8, 24 and 48h with and without EGb 761. We observed morphological changes in pulse-modulated RF radiated lymphocytes. Longer exposure periods led to destruction of organelle and nucleus structures. Chromatin change and the loss of mitochondrial crista occurred in cells exposed to RF for 8h and 24h and were more pronounced in cells exposed for 48h. Cytoplasmic lysis and destruction of membrane integrity of cells and nuclei were also seen in 48h RF exposed cells. There was a significant increase ($p<0.05$) in SCE frequency in RF exposed lymphocytes compared to sham controls. EGb 761 pre-treatment significantly decreased SCE from RF radiation. RF radiation also inhibited cell viability in a time dependent manner. The inhibitory effects of RF radiation on the growth of lymphocytes were marked in longer exposure periods. EGb 761 pre-treatment significantly increased cell viability in RF+EGb 761 treated groups at 8 and 24h when compared to RF exposed groups alone. The results of our study showed that RF radiation affects cell morphology, increases SCE and inhibits cell proliferation. However, EGb 761 has a protective role against RF induced mutagenity. We concluded that RF radiation induces chromosomal damage in hPBLs but this damage may be reduced by EGb 761 pre-treatment.

(NE) Falzone N, Huyser C, Franken DR, Leszczynski D. Mobile phone radiation does not induce pro-apoptosis effects in human spermatozoa. Radiat Res 174:169-176, 2010. (GT, OX)

Abstract Recent reports suggest that mobile phone radiation may diminish male fertility. However, the effects of this radiation on human spermatozoa are largely unknown. The present study examined effects of the radiation on induction of apoptosis-related properties in human spermatozoa. Ejaculated, density-purified, highly motile human spermatozoa were exposed to mobile phone radiation at specific absorption rates (SARs) of 2.0 and 5.7 W/kg. At various times after exposure, flow cytometry was used to examine caspase 3 activity, externalization of phosphatidylserine (PS), induction of DNA strand breaks, and generation of reactive oxygen species. Mobile phone radiation had no statistically significant effect on any of the parameters

studied. This suggests that the impairment of fertility reported in some studies was not caused by the induction of apoptosis in spermatozoa.

(E) Ferreira AR, Knakievicz T, de Bittencourt Pasquali MA, Gelain DP, Dal-Pizzol F, Fernandez CE, de Almeida de Salles AA, Ferreira HB, Moreira JC. Ultra high frequency-electromagnetic field irradiation during pregnancy leads to an increase in erythrocytes micronuclei incidence in rat offspring. Life Sci 80: 43-50, 2006. (GT, OX, LE, DE)

Mobile telephones and their base stations are an important ultra high frequency-electromagnetic field (UHF-EMF) source and their utilization is increasing all over the world. Epidemiological studies suggested that low energy UHF-EMF emitted from a cellular telephone may cause biological effects, such as DNA damage and changes on oxidative metabolism. An in vivo mammalian cytogenetic test, the micronucleus (MN) assay, was used to investigate the occurrence of chromosomal damage in erythrocytes from rat offspring exposed to a non-thermal UHF-EMF from a cellular phone during their embryogenesis; the irradiated group showed a significant increase in MN occurrence. In order to investigate if UHF-EMF could also alter oxidative parameters in the peripheral blood and in the liver - an important hematopoietic tissue in rat embryos and newborns - we also measured the activity of antioxidant enzymes, quantified total sulfhydryl content, protein carbonyl groups, thiobarbituric acid-reactive species and total non-enzymatic antioxidant defense. No significant differences were found in any oxidative parameter of offspring blood and liver. The average number of pups in each litter has also not been significantly altered. Our results suggest that, under our experimental conditions, UHF-EMF is able to induce a genotoxic response in hematopoietic tissue during the embryogenesis through an unknown mechanism.

(NE) Finnie JW, Cai Z, Blumbergs PC, Manavis J, Kuchel TR. Expression of the immediate early gene, c-fos, in fetal brain after whole of gestation exposure of pregnant mice to global system for mobile communication microwaves. Pathology. 38(4):333-335, 2006. (GE, DE)

AIMS: To study immediate early gene, c-fos, expression as a marker of neural stress after whole of gestation exposure of the fetal mouse brain to mobile telephone-type radiofrequency fields. METHODS: Using a purpose-designed exposure system at 900 MHz, pregnant mice were given a single, far-field, whole body exposure at a specific absorption rate of 4 W/kg for 60 min/day from day 1 to day 19 of gestation. Pregnant control mice were sham-exposed or freely mobile in a cage without further restraint. Immediately prior to parturition on gestational day 19, fetal heads were collected, fixed in 4% paraformaldehyde and paraffin embedded. Any stress response in the brain was detected by c-fos immunohistochemistry in the cerebral cortex, basal ganglia, thalamus, hippocampus, midbrain, cerebellum and medulla. RESULTS: c-fos expression was of limited, but consistent, neuroanatomical distribution and there was no difference in immunoreactivity between exposed and control brains. CONCLUSION: In this animal model, no stress response was detected in the fetal brain using c-fos immunohistochemistry after whole of gestation exposure to mobile telephony.

(E) Franzellitti S, Valbonesi P, Ciancaglini N, Biondi C, Contin A, Bersani F, Fabbri E. Transient DNA damage induced by high-frequency electromagnetic fields (GSM 1.8 GHz)

in the human trophoblast HTR-8/SVneo cell line evaluated with the alkaline comet assay. *Mutat Res* 683(1-2):35-42, 2010. (GT, WS)

One of the most controversial issue regarding high-frequency electromagnetic fields (HF-EMF) is their putative capacity to affect DNA integrity. This is of particular concern due to the increasing use of HF-EMF in communication technologies, including mobile phones. Although epidemiological studies report no detrimental effects on human health, the possible disturbance generated by HF-EMF on cell physiology remains controversial. In addition, the question remains as to whether cells are able to compensate their potential effects. We have previously reported that a 1-h exposure to amplitude-modulated 1.8 GHz sinusoidal waves (GSM-217 Hz, SAR=2 W/kg) largely used in mobile telephony did not cause increased levels of primary DNA damage in human trophoblast HTR-8/SVneo cells. Nevertheless, further investigations on trophoblast cell responses after exposure to GSM signals of different types and durations were considered of interest. In the present work, HTR-8/SVneo cells were exposed for 4, 16 or 24h to 1.8 GHz continuous wave (CW) and different GSM signals, namely GSM-217 Hz and GSM-Talk (intermittent exposure: 5 min field on, 10 min field off). The alkaline comet assay was used to evaluate primary DNA damages and/or strand breaks due to uncompleted repair processes in HF-EMF exposed samples. The amplitude-modulated signals GSM-217 Hz and GSM-Talk induced a significant increase in comet parameters in trophoblast cells after 16 and 24h of exposure, while the un-modulated CW was ineffective. However, alterations were rapidly recovered and the DNA integrity of HF-EMF exposed cells was similar to that of sham-exposed cells within 2h of recovery in the absence irradiation. Our data suggest that HF-EMF with a carrier frequency and modulation scheme typical of the GSM signal may affect the DNA integrity.

(E) Furtado-Filho OV, Borba JB, Dallegrave A, Pizzolato TM, Henriques JA, Moreira JC, Saffi J. Effect of 950 MHz UHF electromagnetic radiation on biomarkers of oxidative damage, metabolism of UFA and antioxidants in the livers of young rats of different ages. *Int J Radiat Biol.* 2013 Jul 25. [Epub ahead of print] (LE, GT, OX)

Purpose: To assess the effect of 950 MHz ultra-high-frequency electromagnetic radiation (UHF EMR) on biomarkers of oxidative damage, as well as to verify the concentration of unsaturated fatty acids (UFA) and the expression of the catalase in the livers of rats of different ages. Materials and methods: Twelve rats were equally divided into two groups as controls (CR) and exposed (ER), for each age (0, 6, 15 and 30 days). Radiation exposure lasted half an hour per day for up to 51 days (21 days of gestation and 6, 15 or 30 days of life outside the womb). The specific absorption rate (SAR) ranged from 1.3-1.0 W/kg. The damage to lipids, proteins and DNA was verified by thiobarbituric acid reactive substances (TBARS), protein carbonyls and comets, respectively. UFA were determined by gas chromatography with a flame ionization detector. The expression of catalase was by Western blotting. Results: The neonates had low levels of TBARS and concentrations of UFA after exposure. There was no age difference in the accumulation of protein carbonyls for any age. The DNA damage of ER 15 or 30 days was different. The exposed neonates exhibited lower expression of catalase. Conclusions: 950 MHz UHF EMR does not cause oxidative stress (OS), and it is not genotoxic to the livers of neonates or those of 6 and 15 day old rats, but it changes the concentrations of polyunsaturated fatty acid (PUFA) in neonates. For rats of 30 days, no OS, but it is genotoxic to the livers of ER to total body irradiation.

(E) Gajski G, Garaj-Vrhovac V. Radioprotective effects of honeybee venom (*Apis mellifera*) against 915-MHz microwave radiation-induced DNA damage in wistar rat lymphocytes: in vitro study. Int J Toxicol 28:88-98, 2009. (GT, OX)

The aim of this study is to investigate the radioprotective effect of bee venom against DNA damage induced by 915-MHz microwave radiation (specific absorption rate of 0.6 W/kg) in Wistar rats. Whole blood lymphocytes of Wistar rats are treated with 1 microg/mL bee venom 4 hours prior to and immediately before irradiation. Standard and formamidopyrimidine-DNA glycosylase (Fpg)-modified comet assays are used to assess basal and oxidative DNA damage produced by reactive oxygen species. Bee venom shows a decrease in DNA damage compared with irradiated samples. Parameters of Fpg-modified comet assay are statistically different from controls, making this assay more sensitive and suggesting that oxidative stress is a possible mechanism of DNA damage induction. Bee venom is demonstrated to have a radioprotective effect against basal and oxidative DNA damage. Furthermore, bee venom is not genotoxic and does not produce oxidative damage in the low concentrations used in this study.

(E) Gandhi G, Anita, Genetic damage in mobile phone users: some preliminary findings. Ind J Hum Genet 11:99-104, 2005. (GT, HU)

BACKGROUND: The impact of microwave (MW)/radio frequency radiation (RFR) on important biological parameters is probably more than a simply thermal one. Exposure to radio frequency (RF) signals generated by the use of cellular telephones have increased dramatically and reported to affect physiological, neurological, cognitive and behavioural changes and to induce, initiate and promote carcinogenesis. Genotoxicity of RFR has also been reported in various test systems after in vitro and/or in vivo exposure but none in mobile phone users. **AIMS:** In the present study, DNA and chromosomal damage investigations were carried out on the peripheral blood lymphocytes of individuals using mobile phones, being exposed to MW frequency ranging from 800 to 2000 MHz. **METHODS:** DNA damage was assessed using the single cell gel electrophoresis assay and aneugenic and clastogenic damage by the in vivo capillary blood micronucleus test (MNT) in a total of 24 mobile phone users. **RESULTS:** Mean comet tail length (26.76 ± 0.054 mm; 39.75% of cells damaged) in mobile phone users was highly significant from that in the control group. The in vivo capillary blood MNT also revealed highly significant (0.25) frequency of micronucleated (MNd) cells. **CONCLUSIONS:** These results highlight a correlation between mobile phone use (exposure to RFR) and genetic damage and require interim public health actions in the wake of widespread use of mobile telephony.

(E) Gandhi G, Singh P. Cytogenetic damage in mobile phone users: preliminary data. Int J Hum Genet 5:259-265, 2005. (GT, HU)

Mobile telephones, sometimes called cellular (cell) phones or handies, are now an integral part of modern life. The mobile phone handsets are low-powered radiofrequency transmitters, emitting maximum powers in the range of 0.2 to 0.6 watts. Scientific concerns have increased sufficiently over the possible hazard to health from using cell phones. The reported adverse health effects include physiological, behavioural and cognitive changes as well as tumour formation and genetic damage. However findings are controversial and no consensus exists. Genotoxicity has been observed either in lower organisms or in vitro studies. The aim of the present study hence was to detect any cytogenetic damage in mobile phone users by analysing short term peripheral lymphocyte cultures for chromosomal aberrations and the buccal mucosal

cells for micronuclei (aneugenicity and clastogenicity). The results revealed increased number of micronucleated buccal cells and cytological abnormalities in cultured lymphocytes indicating the genotoxic response from mobile phone use.

(E) Garaj-Vrhovac V, Gajski G, Pažanin S, Sarolić A, Domijan AM, Flajs D, Peraica M. Assessment of cytogenetic damage and oxidative stress in personnel occupationally exposed to the pulsed microwave radiation of marine radar equipment. Int J Hyg Environ Health. 4(1):59-65, 2011. **(GT, HU, OX)**

Due to increased usage of microwave radiation, there are concerns of its adverse effect in today's society. Keeping this in view, study was aimed at workers occupationally exposed to pulsed microwave radiation, originating from marine radars. Electromagnetic field strength was measured at assigned marine radar frequencies (3 GHz, 5.5 GHz and 9.4 GHz) and corresponding specific absorption rate values were determined. Parameters of the comet assay and micronucleus test were studied both in the exposed workers and in corresponding unexposed subjects. Differences between mean tail intensity (0.67 vs. 1.22) and moment (0.08 vs. 0.16) as comet assay parameters and micronucleus test parameters (micronuclei, nucleoplasmic bridges and nuclear buds) were statistically significant between the two examined groups, suggesting that cytogenetic alterations occurred after microwave exposure. Concentrations of glutathione and malondialdehyde were measured spectrophotometrically and using high performance liquid chromatography. The glutathione concentration in exposed group was significantly lower than in controls (1.24 vs. 0.53) whereas the concentration of malondialdehyde was significantly higher (1.74 vs. 3.17), indicating oxidative stress. Results suggests that pulsed microwaves from working environment can be the cause of genetic and cell alterations and that oxidative stress can be one of the possible mechanisms of DNA and cell damage.

(E) Guler G, Tomruk A, Ozgur E, Seyhan N.The effect of radiofrequency radiation on DNA and lipid damage in non-pregnant and pregnant rabbits and their newborns. *Gen Physiol Biophys* 29:59-66, 2010. **(GT, OX, LE, DE)**

The concerns of people on possible adverse health effects of radiofrequency radiation (RFR) generated from mobile phones as well as their supporting transmitters (base stations) have increased markedly. RFR effect on oversensitive people, such as pregnant women and their developing fetuses, and older people is another source of concern that should be considered. In this study, oxidative DNA damage and lipid peroxidation levels in the brain tissue of pregnant and non-pregnant New Zealand White rabbits and their newborns exposed to RFR were investigated. Thirteen-month-old rabbits were studied in four groups as non-pregnant-control, non-pregnant-RFR exposed, pregnant-control and pregnant-RFR exposed. They were exposed to RFR (1800 MHz GSM; 14 V/m as reference level) for 15 min/day during 7 days. Malondialdehyde (MDA) and 8-hydroxy-2'-deoxyguanosine (8-OHdG) levels were analyzed. MDA and 8-OHdG levels of non-pregnant and pregnant-RFR exposed animals significantly increased with respect to controls ($p < 0.001$, Mann-Whitney test). No difference was found in the newborns ($p > 0.05$, Mann-Whitney). There exist very few experimental studies on the effects of RFR during pregnancy. It would be beneficial to increase the number of these studies in order to establish international standards for the protection of pregnant women from RFR.

(E) Güler G, Tomruk A, Ozgur E, Sahin D, Sepici A, Altan N, Seyhan N. The effect of radiofrequency radiation on DNA and lipid damage in female and male infant rabbits. Int J Radiat Biol. 88(4):367-373, 2012. (LE, GT, OX, DE)

PURPOSE: We aimed to design a prolonged radiofrequency (RF) radiation exposure and investigate in an animal model, possible bio-effects of RF radiation on the ongoing developmental stages of children from conception to childhood. **MATERIALS AND METHODS:** A total of 72 New Zealand female and male white rabbits aged one month were used. Females were exposed to RF radiation for 15 min/day during 7 days, whereas males were exposed to the same level of radiation for 15 min/day during 14 days. Thirty-six female and 36 male infant rabbits were randomly divided into four groups: Group I [Intrauterine (IU) exposure (-); Extrauterine (EU) exposure (-)]: Sham exposure which means rabbits were exposed to 1800 MHz Global System for Mobile Telecommunication (GSM)-like RF signals neither in the IU nor in the EU periods. Group II [IU exposure (-); EU exposure (+)]: Infant rabbits were exposed to 1800 MHz GSM-like RF signals when they reached one month of age. Group III [IU exposure (+); EU exposure (-)]: Infant rabbits were exposed to 1800 MHz GSM-like RF signals in the IU period (between 15th and 22nd days of the gestational period). Group IV [IU exposure (+); EU exposure (+)]: Infant rabbits were exposed to 1800 MHz GSM-like RF signals both in the IU period (between 15th and 22nd days of the gestational period) and in the EU period when they reached one month of age. Biochemical analysis for lipid peroxidation and DNA damage were carried out in the livers of all rabbits. **RESULTS:** Lipid peroxidation levels in the liver tissues of female and male infant rabbits increased under RF radiation exposure. Liver 8-hydroxy-2'-deoxyguanosine (8-OHdG) levels of female rabbits exposed to RF radiation were also found to increase when compared with the levels of non-exposed infants. However, there were no changes in liver 8-OHdG levels of male rabbits under RF exposure. **CONCLUSION:** Consequently, it can be concluded that GSM-like RF radiation may induce biochemical changes by increasing free radical attacks to structural biomolecules in the rabbit as an experimental animal model.

(NE) Gurbuz N, Sirav B, Yuvaci HU, Turhan N, Coskun ZK, Seyhan N. Is there any possible genotoxic effect in exfoliated bladder cells of rat under the exposure of 1800 MHz GSM-like modulated radio frequency radiation (RFR)? Electromagn Biol Med. 29(3):98-104, 2010. (LE, GT)

People are exposed to many carcinogenic and mutagenic chemicals in their everyday lives. These include antineoplastic drugs, Polycyclic aromatic hydrocarbons (PAH)s, aromatic amines, nitrosamines, metals, and electromagnetic radiation. Based on the state of knowledge acquired during the last 50 years of research on possible biological effects of electromagnetic fields (EMF), the majority of the scientific community is convinced that exposure to EMF below the existing security limits does not cause a risk to the health of the general public. However, this position is questioned by others, who are of the opinion that the available research data are contradictory or inconsistent and, therefore, unreliable. In this study, we aimed to investigate if there is any effect of 1800 MHz GSM modulated radio frequency radiation (RFR) on the number of micronucleus in exfoliated bladder cells of rat which will be informative about the genotoxic damage. Exposure period was 20 min/day, 5 days/week during a month. Six female Wistar rats were used for two groups: Group I (n=6): controls; Group II (n=6): 1.8 GHz exposed animals.

1800 MHz RFR did not showed a significant MN frequencies in rat bladder cells when compared with the control group ($p>0.05$). 1800 MHz RFR-exposed animals did not produce any genotoxic effect when compared with the control group ($p>0.05$). Kinetic studies are important for any biomarker, especially those in which tissue differentiation and maturation processes will heavily influence the time between induction of damage and collection of damaged cells for micronucleus analysis.

(NE) Gurbuz N, Sirav B, Colbay M, Yetkin I, Seyhan N. No genotoxic effect in exfoliated bladder cells of rat under the exposure of 1800 and 2100-MHz radio frequency radiation. Electromagn Biol Med. 2013 Nov 27. [Epub ahead of print] (GT, LE)

Abstract In this study, we aimed to investigate the effects of 1800 and 2100 MHz Radio Frequency (RF) radiation on the number of micronucleus (MN) in exfoliated bladder cells of rat which shows the genotoxic damage. Exposure period was 30 min/day, 6 days/week for a month and two months exposure periods. Thirty male wistar albino rats were used for five groups: Group I (n = 6): 1800 MHz RF exposed animals for one month, Group II (n = 6): 2100 MHz RF exposed animals for one month, Group III (n = 6): 2100 MHz RF exposed for two months, Group IV (n = 6): control group for one month, Group V (n = 6): control group for two months. Rats of the control groups were housed in their home cages during the entire experimental period without subjecting to any experimental manipulation. 1800 and 2100 MHz RF exposures did not result in any significant MN frequencies in rat bladder cells with respect to the control groups ($p>0.05$). There was no statistically significant difference between 2100 MHz RF exposed groups, either. Further studies are needed to demonstrate if there is any genotoxic effect, micronucleus formation in other tissues of rats.

(NE) Hansteen IL, Lågeide L, Clausen KO, Haugan V, Svendsen M, Eriksen JG, Skiaker R, Hauger E, Vistnes AI, Kure EH. Cytogenetic effects of 18.0 and 16.5 GHz microwave radiation on human lymphocytes in vitro. Anticancer Res 29:2885-2892, 2009. (GT, IA, WS)

BACKGROUND: There are few cell studies on the direct genotoxic effects of microwave radiation. In this study, cytogenetic effects of microwave radiation alone or in combination with mitomycin C (MMC) were investigated. **MATERIALS AND METHODS:** Lymphocytes from two smoking and four non-smoking donors were exposed for 53 hours in vitro to 1.0 W/m continuous-wave radiation at 18.0 GHz or 10 W/m pulsed-wave at 16.5 GHz, alone or in combination with MMC. DNA synthesis and repair were inhibited in vitro in some cultures. **RESULTS:** No synergistic effect was observed in cells exposed to combinations of microwave radiation and in vitro exposure to MMC, or to cells pre-exposed in vivo to tobacco smoke. For the 16.5 GHz pulsed exposure, a non-significant trend consisting of an increase in aberration frequencies with microwave radiation was shown for the DNA synthesis and repair inhibited cultures both with and without MMC. **CONCLUSION:** Neither 18.0 GHz continuous-wave nor 16.5 GHz pulsed-wave exposure to human lymphocytes in vitro induced statistically significant increases in chromosomal aberration frequencies. 16.5 GHz pulsed-wave exposure requires further documentation before a true negative conclusion can be drawn.

(NE) Hansteen IL, Clausen KO, Haugan V, Svendsen M, Svendsen MV, Eriksen JG, Skiaker R, Hauger E, Lågeide L, Vistnes AI, Kure EH. Cytogenetic effects of exposure to

2.3 GHz radiofrequency radiation on human lymphocytes in vitro. Anticancer Res 29:4323-4330, 2009. (GT, IA)

BACKGROUND: No previous in vitro studies have tested radio frequency radiation for at least one full cell cycle in culture. The aim was to test if exposure used in mobile phones and wireless network technologies would induce DNA damage in cultured human lymphocytes with and without a known clastogen. MATERIALS AND METHODS: Lymphocytes from six donors were exposed to 2.3 GHz, 10 W/m continuous waves, or 2.3 GHz, 10 W/m pulsed waves (200 Hz pulse frequency, 50% duty cycle). Mitomycin C was added to half of the cultures. DNA synthesis and repair were inhibited in one experiment. RESULTS: No statistically significant differences were observed between control and exposed cultures. A weak trend for more chromosomal damage with the interaction of pulsed fields with mitomycin C compared to a constant field was observed. CONCLUSION: Exposure during the whole cell cycle in inhibited cultures did not resulted in significant differences in chromosomal aberrations as compared to controls.

(E) Hekmat A, Saboury AA, Moosavi-Movahedi AA. The toxic effects of mobile phone radiofrequency (940MHz) on the structure of calf thymus DNA. Ecotoxicol Environ Saf. 2012 Nov 16. pii: S0147-6513(12)00368-5. doi: 10.1016/j.ecoenv.2012.10.016. [Epub ahead of print] (GT)

Currently, the biological effects of nonionizing electromagnetic fields (EMFs) including radiofrequency (RF) radiation have been the subject of numerous experimental and theoretical studies. The aim of this study is to evaluate the possible biological effects of mobile phone RF (940MHz, 15V/m and SAR=40mW/kg) on the structure of calf thymus DNA (ct DNA) immediately after exposure and 2h after 45min exposure via diverse range of spectroscopic instruments. The UV-vis and circular dichroism (CD) experiments depict that mobile phone EMFs can remarkably cause disturbance on ct DNA structure. In addition, the DNA samples, immediately after exposure and 2h after 45min exposure, are relatively thermally unstable compared to the DNA solution, which was placed in a small shielded box (unexposed ct DNA). Furthermore, the exposed DNA samples (the DNA samples that were exposed to 940MHz EMF) have more fluorescence emission when compared with the unexposed DNA, which may have occurred attributable to expansion of the exposed DNA structure. The results of dynamic light scattering (DLS) and zeta potential experiments demonstrate that RF-EMFs lead to increment in the surface charge and size of DNA. The structure of DNA immediately after exposure is not significantly different from the DNA sample 2h after 45min exposure. In other words, the EMF-induced conformational changes are irreversible. Collectively, our results reveal that 940MHz can alter the structure of DNA. The displacement of electrons in DNA by EMFs may lead to conformational changes of DNA and DNA disaggregation. Results from this study could have an important implication on the health effects of RF-EMFs exposure. In addition, this finding could proffer a novel strategy for the development of next generation of mobile phone.

(NE) Hintzsche H, Stopper H. Micronucleus frequency in buccal mucosa cells of mobile phone users. Toxicol Lett. 193(1):124-130, 2010. (GT, HU)

Mobile phones are being used extensively throughout the world, with more than four billion accounts existing in 2009. This technology applies electromagnetic radiation in the microwave

range. Health effects of this radiation have been subject of debate for a long time, both within the scientific community and within the general public. This study investigated the effect of mobile phone use on genomic instability of the human oral cavity's mucosa cells. 131 Individuals donated buccal mucosa cells extracted by slightly scraping the oral cavity with a cotton swab. Every participant filled out a questionnaire about mobile phone use including duration of weekly use, overall period of exposure and headset usage. 13 Individuals did not use mobile phones at all, 85 reported using the mobile phone for three hours per week or less, and 33 reported use of more than three hours per week. Additionally, information on age, gender, body weight, smoking status, medication and nutrition was retrieved. For staining of the cells a procedure using alpha-tubulin-antibody and chromomycin A(3) was applied. Micronuclei and other markers were evaluated in 1000 cells per individual at the microscope. A second scorer counted another 1000 cells, resulting in 2000 analyzed cells per individual. Mobile phone use did not lead to a significantly increased frequency of micronuclei.

(NE) Hintzsche H, Jastrow C, Kleine-Ostmann T, Schrader T, Stopper H. 900 MHz radiation does not induce micronucleus formation in different cell types. *Mutagenesis*. 27(4):477-483, 2012 . (GT)

The exposure of the population to non-ionising electromagnetic radiation is still increasing, mainly due to mobile communication. Whether low-intensity electromagnetic fields can cause other effects apart from heating has been a subject of debate. One of the effects, which were proposed to be caused by mobile phone radiation, is the occurrence of mitotic disturbances. The aim of this study was to investigate possible consequences of these mitotic disturbances as manifest genomic damage, i.e. micronucleus induction. Cells were irradiated at a frequency of 900 MHz, which is located in one of the main frequency bands applied for mobile communication. Two cell types were used, HaCaT cells as human cells and A(L) cells (human-hamster hybrid cells), in which mitotic disturbances had been reported to occur. After different post-exposure incubation periods, cells were fixed and micronucleus frequencies were evaluated. Both cell types did not show any genomic damage after exposure. To adapt the protocol for the micronucleus test into the direction of the protocol for mitotic disturbances, the post-exposure incubation period was reduced and exposure time was extended to one cell cycle length. This did not result in any increase of the genomic damage. In conclusion, micronucleus induction was not observed as a consequence of exposure to non-ionising radiation, even though this agent was reported to cause mitotic disturbances under similar experimental conditions.

(NE) Hirose H, Sakuma N, Kaji N, Suhara T, Sekijima M, Nojima T, Miyakoshi J. Phosphorylation and gene expression of p53 are not affected in human cells exposed to 2.1425 GHz band CW or W-CDMA modulated radiation allocated to mobile radio base stations. *Bioelectromagnetics* 27:494-504, 2006. (GT)

A large-scale in vitro study focusing on low-level radiofrequency (RF) fields from mobile radio base stations employing the International Mobile Telecommunication 2000 (IMT-2000) cellular system was conducted to test the hypothesis that modulated RF fields induce apoptosis or other cellular stress response that activate p53 or the p53-signaling pathway. First, we evaluated the response of human cells to microwave exposure at a specific absorption rate (SAR) of 80 mW/kg, which corresponds to the limit of the average whole-body SAR for general public exposure defined as a basic restriction by the International Commission on Non-Ionizing

Radiation Protection (ICNIRP) guidelines. Second, we investigated whether continuous wave (CW) and wideband code division multiple access (W-CDMA) modulated signal RF fields at 2.1425 GHz induced apoptosis or any signs of stress. Human glioblastoma A172 cells were exposed to W-CDMA radiation at SARs of 80, 250, and 800 mW/kg, and CW radiation at 80 mW/kg for 24 or 48 h. Human IMR-90 fibroblasts from fetal lungs were exposed to both W-CDMA and CW radiation at a SAR of 80 mW/kg for 28 h. Under the RF field exposure conditions described above, no significant differences in the percentage of apoptotic cells were observed between the test groups exposed to RF signals and the sham-exposed negative controls, as evaluated by the Annexin V affinity assay. No significant differences in expression levels of phosphorylated p53 at serine 15 or total p53 were observed between the test groups and the negative controls by the bead-based multiplex assay. Moreover, microarray hybridization and real-time RT-PCR analysis showed no noticeable differences in gene expression of the subsequent downstream targets of p53 signaling involved in apoptosis between the test groups and the negative controls. Our results confirm that exposure to low-level RF signals up to 800 mW/kg does not induce p53-dependent apoptosis, DNA damage, or other stress response in human cells.

(NE) Hirose H, Sakuma N, Kaji N, Nakayama K, Inoue K, Sekijima M, Nojima T, Miyakoshi J. Mobile phone base station-emitted radiation does not induce phosphorylation of Hsp27. Bioelectromagnetics 28:99-108, 2007. (GE)

An in vitro study focusing on the effects of low-level radiofrequency (RF) fields from mobile radio base stations employing the International Mobile Telecommunication 2000 (IMT-2000) cellular system was conducted to test the hypothesis that modulated RF fields act to induce phosphorylation and overexpression of heat shock protein hsp27. First, we evaluated the responses of human cells to microwave exposure at a specific absorption rate (SAR) of 80 mW/kg, which corresponds to the limit of the average whole-body SAR for general public exposure defined as a basic restriction in the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines. Second, we investigated whether continuous wave (CW) and Wideband Code Division Multiple Access (W-CDMA) modulated signal RF fields at 2.1425 GHz induced activation or gene expression of hsp27 and other heat shock proteins (hsps). Human glioblastoma A172 cells were exposed to W-CDMA radiation at SARs of 80 and 800 mW/kg for 2-48 h, and CW radiation at 80 mW/kg for 24 h. Human IMR-90 fibroblasts from fetal lungs were exposed to W-CDMA at 80 and 800 mW/kg for 2 or 28 h, and CW at 80 mW/kg for 28 h. Under the RF field exposure conditions described above, no significant differences in the expression levels of phosphorylated hsp27 at serine 82 (hsp27[pS82]) were observed between the test groups exposed to W-CDMA or CW signal and the sham-exposed negative controls, as evaluated immediately after the exposure periods by bead-based multiplex assays. Moreover, no noticeable differences in the gene expression of hsps were observed between the test groups and the negative controls by DNA Chip analysis. Our results confirm that exposure to low-level RF field up to 800 mW/kg does not induce phosphorylation of hsp27 or expression of hsp gene family.

(NE) Huang TQ, Lee MS, Oh E, Zhang BT, Seo JS, Park WY. Molecular responses of Jurkat T-cells to 1763 MHz radiofrequency radiation. Int J Radiat Biol 84:734-741, 2008. (GT, GE)

PURPOSE: The biological effects of exposure to mobile phone emitted radiofrequency (RF) radiation are the subject of intense study, yet the hypothesis that RF exposure is a potential health hazard remains controversial. In this paper, we monitored cellular and molecular changes in Jurkat human T lymphoma cells after irradiating with 1763 MHz RF radiation to understand the effect on RF radiation in immune cells. **MATERIALS AND METHODS:** Jurkat T-cells were exposed to RF radiation to assess the effects on cell proliferation, cell cycle progression, DNA damage and gene expression. Jurkat cells were exposed to 1763 MHz RF radiation at 10 W/kg specific absorption rate (SAR) and compared to sham exposed cells. **RESULTS:** RF exposure did not produce significant changes in cell numbers, cell cycle distributions, or levels of DNA damage. In genome-wide analysis of gene expressions, there were no genes changed more than two-fold upon RF-radiation while ten genes change to 1.3 approximately 1.8-fold. Among ten genes, two cytokine receptor genes such as chemokine (C-X-C motif) receptor 3 (CXCR3) and interleukin 1 receptor, type II (IL1R2) were down-regulated upon RF radiation, but they were not directly related to cell proliferation or DNA damage responses. **CONCLUSION:** These results indicate that the alterations in cell proliferation, cell cycle progression, DNA integrity or global gene expression was not detected upon 1763 MHz RF radiation under 10 W/kg SAR for 24 h to Jurkat T cells.

(NE) Huang TQ, Lee MS, Oh EH, Kalinec F, Zhang BT, Seo JS, Park WY. Characterization of biological effect of 1763 MHz radiofrequency exposure on auditory hair cells. Int J Radiat Biol 84:909-915, 2008. (GT, GE)

Purpose: Radiofrequency (RF) exposure at the frequency of mobile phones has been reported not to induce cellular damage in in vitro and in vivo models. We chose HEI-OC1 immortalized mouse auditory hair cells to characterize the cellular response to 1763 MHz RF exposure, because auditory cells could be exposed to mobile phone frequencies. **Materials and methods:** Cells were exposed to 1763 MHz RF at a 20 W/kg specific absorption rate (SAR) in a code division multiple access (CDMA) exposure chamber for 24 and 48 h to check for changes in cell cycle, DNA damage, stress response, and gene expression. **Results:** Neither of cell cycle changes nor DNA damage was detected in RF-exposed cells. The expression of heat shock proteins (HSP) and the phosphorylation of mitogen-activated protein kinases (MAPK) did not change, either. We tried to identify any alteration in gene expression using microarrays. Using the Applied Biosystems 1700 full genome expression mouse microarray, we found that only 29 genes (0.09% of total genes examined) were changed by more than 1.5-fold on RF exposure. **Conclusion:** From these results, we could not find any evidence of the induction of cellular responses, including cell cycle distribution, DNA damage, stress response and gene expression, after 1763 MHz RF exposure at an SAR of 20 W/kg in HEI-OC1 auditory hair cells.

(E) Jiang B, Nie J, Zhou Z, Zhang J, Tong J, Cao Y. Adaptive response in mice exposed to 900 MHz radiofrequency fields: primary DNA damage. PLoS One. 7(2):e32040, 2012. (LE, GT, IA)

The phenomenon of adaptive response (AR) in animal and human cells exposed to ionizing radiation is well documented in scientific literature. We have examined whether such AR could be induced in mice exposed to non-ionizing radiofrequency fields (RF) used for wireless communications. Mice were pre-exposed to 900 MHz RF at 120 $\mu\text{W}/\text{cm}^2$ power density for 4 hours/day for 1, 3, 5, 7 and 14 days and then subjected to an acute dose of 3 Gy γ -radiation. The

primary DNA damage in the form of alkali labile base damage and single strand breaks in the DNA of peripheral blood leukocytes was determined using the alkaline comet assay. The results indicated that the extent of damage in mice which were pre-exposed to RF for 1 day and then subjected to γ -radiation was similar and not significantly different from those exposed to γ -radiation alone. However, mice which were pre-exposed to RF for 3, 5, 7 and 14 days showed progressively decreased damage and was significantly different from those exposed to γ -radiation alone. Thus, the data indicated that RF pre-exposure is capable of inducing AR and suggested that the pre-exposure for more than 4 hours for 1 day is necessary to elicit such AR.

(NE) Juutilainen J, Heikkinen P, Soikkeli H, Mäki-Paakkanen J. Micronucleus frequency in erythrocytes of mice after long-term exposure to radiofrequency radiation. Int J Radiat Biol. 83(4):213-220, 2007. (LE, GT)

PURPOSE: The aim of the study was to investigate genotoxicity of long-term exposure to radiofrequency (RF) electromagnetic fields by measuring micronuclei in erythrocytes. The blood samples were collected in two animal studies evaluating possible cocarcinogenic effects of RF fields. **METHODS:** In study A, female CBA/S mice were exposed for 78 weeks (1.5 h/d, 5 d/week) to either a continuous 902.5 MHz signal similar to that emitted by analog NMT (Nordic Mobile Telephone) phones at a whole-body specific absorption rate (SAR) of 1.5 W/kg, or to a pulsed 902.4 MHz signal similar to that of digital GSM (Global System for Mobile Communications) phones at 0.35 W/kg. A third group was sham-exposed, and a fourth group served as cage controls. All but the cage control animals were exposed to 4 Gy of x-rays during three first weeks of the experiment. In study B, female transgenic mice (line K2) and their nontransgenic littermates were exposed for 52 weeks (1.5 h/d, 5 d/week). Two digital mobile phone signals, GSM and DAMPS (Digital Advanced Mobile Phone System), were used at 0.5 W/kg. All but the cage-control animals were exposed 3 times per week to an ultraviolet radiation dose of 1.2 MED (minimum erythema dose). **RESULTS AND CONCLUSIONS:** The results did not show any effects of RF fields on micronucleus frequency in polychromatic or normochromatic erythrocytes. The results were consistent in two mouse strains (and in a transgenic variant of the second strain), after 52 or 78 weeks of exposure, at three SAR levels relevant to human exposure from mobile phones, and for three different mobile signals.

(E) Karaca E, Durmaz B, Altug H, Yildiz T, Guducu C, Irgi M, Koksai MG, Ozkinay F, Gunduz C, Cogulu O. The genotoxic effect of radiofrequency waves on mouse brain. J Neurooncol 106:53-58, 2012. (GT, GE)

Erratum: J Neurooncol 2012 May;107:665.

Concerns about the health effects of radiofrequency (RF) waves have been raised because of the gradual increase in usage of cell phones, and there are scientific questions and debates about the safety of those instruments in daily life. The aim of this study is to evaluate the genotoxic effects of RF waves in an experimental brain cell culture model. Brain cell cultures of the mice were exposed to 10.715 GHz with specific absorption rate (SAR) 0.725 W/kg signals for 6 h in 3 days at 25°C to check for the changes in the micronucleus (MNi) assay and in the expression of 11 proapoptotic and antiapoptotic genes. It was found that MNi rate increased 11-fold and STAT3 expression decreased 7-fold in the cell cultures which were exposed to RF. Cell phones which spread RF may damage DNA and change gene expression in brain cells.

(E) Kesari KK, Behari J. Fifty-gigahertz Microwave exposure effect of radiations on rat brain. Appl Biochem Biotechnol 158:126-139, 2009. (GT, OX, LE)

The object of this study is to investigate the effects of 50-GHz microwave radiation on the brain of Wistar rats. Male rats of the Wistar strain were used in the study. Animals of 60-day age were divided into two groups-group 1, sham-exposed, and group 2, experimental (microwave-exposed). The rats were housed in a temperature-controlled room (25 degrees C) with constant humidity (40-50%) and received food and water ad libitum. During exposure, rats were placed in Plexiglas cages with drilled ventilation holes and kept in an anechoic chamber. The animals were exposed for 2 h a day for 45 days continuously at a power level of 0.86 $\mu\text{W}/\text{cm}^2$ with nominal specific absorption rate 8.0×10^{-4} w/kg. After the exposure period, the rats were killed and homogenized, and protein kinase C (PKC), DNA double-strand break, and antioxidant enzyme activity [superoxides dismutase (SOD), catalase, and glutathione peroxidase (GPx)] were estimated in the whole brain. Result shows that the chronic exposure to these radiations causes DNA double-strand break (head and tail length, intensity and tail migration) and a significant decrease in GPx and SOD activity ($p = <0.05$) in brain cells, whereas catalase activity shows significant increase in the exposed group of brain samples as compared with control ($p = <0.001$). In addition to these, PKC decreased significantly in whole brain and hippocampus ($p < 0.05$). All data are expressed as mean \pm standard deviation. We conclude that these radiations can have a significant effect on the whole brain.

(E) Kesari KK, Behari J, Kumar S. Mutagenic response of 2.45 GHz radiation exposure on rat brain. Int J Radiat Biol 86:334-343, 2010. (GT, OX, LE)

Purpose: To investigate the effect of 2.45 GHz microwave radiation on rat brain of male wistar strain. Material and methods: Male rats of wistar strain (35 days old with 130 ± 10 g body weight) were selected for this study. Animals were divided into two groups: Sham exposed and experimental. Animals were exposed for 2 h a day for 35 days to 2.45 GHz frequency at 0.34 mW/cm power density. The whole body specific absorption rate (SAR) was estimated to be 0.11 W/Kg. Exposure took place in a ventilated Plexiglas cage and kept in anechoic chamber in a far field configuration from the horn antenna. After the completion of exposure period, rats were sacrificed and the whole brain tissue was dissected and used for study of double strand DNA (Deoxyribonucleic acid) breaks by micro gel electrophoresis and the statistical analysis was carried out using comet assay (IV-2 version software). Thereafter, antioxidant enzymes and histone kinase estimation was also performed. Results: A significant increase was observed in comet head ($P < 0.002$), tail length ($P < 0.0002$) and in tail movement ($P < 0.0001$) in exposed brain cells. An analysis of antioxidant enzymes glutathione peroxidase ($P < 0.005$), and superoxide dismutase ($P < 0.006$) showed a decrease while an increase in catalase ($P < 0.006$) was observed. A significant decrease ($P < 0.023$) in histone kinase was also recorded in the exposed group as compared to the control (sham-exposed) ones. One-way analysis of variance (ANOVA) method was adopted for statistical analysis. Conclusion: The study concludes that the chronic exposure to these radiations may cause significant damage to brain, which may be an indication of possible tumour promotion (Behari and Paulraj 2007).

(E) Khalil AM, Gagaa M, Alshamali A. 8-Oxo-7, 8-dihydro-2'-deoxyguanosine as a biomarker of DNA damage by mobile phone radiation. Hum Exp Toxicol 31(7):734-740, 2012. (GT, OX)

We examined the effect of exposure to mobile phone 1800 MHz radio frequency radiation (RFR) upon the urinary excretion of 8-oxo-7, 8-dihydro-2'-deoxyguanosine (8-oxodG), one major form of oxidative DNA damage, in adult male Sprague-Dawley rats. Twenty-four rats were used in three independent experiments (RFR exposed and control, 12 rats, each). The animals were exposed to RFR for 2 h from Global System for Mobile Communications (GSM) signal generator with whole-body-specific absorption rate of 1.0 W/kg. Urine samples were collected from the rat while housed in a metabolic cage during the exposure period over a 4-h period at 0.5, 1.0, 2.0 and 4.0 h from the beginning of exposure. In the control group, the signal generator was left in the turn-off position. The creatinine-standardized concentrations of 8-oxodG were measured. With the exception of the urine collected in the last half an hour of exposure, significant elevations were noticed in the levels of 8-oxodG in urine samples from rats exposed to RFR when compared to control animals. Significant differences were seen overall across time points of urine collection with a maximum at 1 h after exposure, suggesting repair of the DNA lesions leading to 8-oxodG formation.

(E) Kim JY, Hong SY, Lee YM, Yu SA, Koh WS, Hong JR, Son T, Chang SK, Lee M. In vitro assessment of clastogenicity of mobile-phone radiation (835 MHz) using the alkaline comet assay and chromosomal aberration test. Environ Toxicol 23:319-327, 2008. (GT, IA)

Recently we demonstrated that 835-MHz radiofrequency radiation electromagnetic fields (RF-EMF) neither affected the reverse mutation frequency nor accelerated DNA degradation in vitro. Here, two kinds of cytogenetic endpoints were further investigated on mammalian cells exposed to 835-MHz RF-EMF (the most widely used communication frequency band in Korean CDMA mobile phone networks) alone and in combination with model clastogens: in vitro alkaline comet assay and in vitro chromosome aberration (CA) test. No direct cytogenetic effect of 835-MHz RF-EMF was found in the in vitro CA test. The combined exposure of the cells to RF-EMF in the presence of ethylmethanesulfonate (EMS) revealed a weak and insignificant cytogenetic effect when compared to cells exposed to EMS alone in CA test. Also, the comet assay results to evaluate the ability of RF-EMF alone to damage DNA were nearly negative, although showing a small increase in tail moment. However, the applied RF-EMF had potentiation effect in comet assay when administered in combination with model clastogens (cyclophosphamide or 4-nitroquinoline 1-oxide). Thus, our results imply that we cannot confidently exclude any possibility of an increased risk of genetic damage, with important implications for the possible health effects of exposure to 835-MHz electromagnetic fields.

(E) Kumar S, Kesari KK, Behari J. Evaluation of genotoxic effects in male Wistar rats following microwave exposure. Indian J Exp Biol 48:586-592, 2010. (GT, OX)

Wistar rats (70 days old) were exposed for 2 h a day for 45 days continuously at 10 GHz [power density 0.214 mW/cm², specific absorption rate (SAR) 0.014 W/kg] and 50 GHz (power density 0.86 microW/cm², SAR 8.0 x10⁻⁴ W/kg). Micronuclei (MN), reactive oxygen species (ROS), and antioxidant enzymes activity were estimated in the blood cells and serum. These radiations induce micronuclei formation and significant increase in ROS production. Significant changes in the level of serum glutathione peroxidase, superoxide dismutase and catalase were observed in exposed group as compared with control group. It is concluded that microwave exposure can be affective at genetic level. This may be an indication of tumor promotion, which comes through the overproduction of reactive oxygen species.

(E) Lakshmi NK, Tiwari R, Bhargava SC, Ahuja YR. Investigations on DNA damage and frequency of micronuclei in occupational exposure to electromagnetic fields (EMFs) emitted from video display terminals (VDTs). Gen Mol Biol 33, 154-158, 2010. (GT, HU, LE)

The potential effect of electromagnetic fields (EMFs) emitted from video display terminals (VDTs) to elicit biological response is a major concern for the public. The software professionals are subjected to cumulative EMFs in their occupational environments. This study was undertaken to evaluate DNA damage and incidences of micronuclei in such professionals. To the best of our knowledge, the present study is the first attempt to carry out cytogenetic investigations on assessing bioeffects in personal computer users. The study subjects (n = 138) included software professionals using VDTs for more than 2 years with age, gender, socioeconomic status matched controls (n = 151). DNA damage and frequency of micronuclei were evaluated using alkaline comet assay and cytochalasin blocked micronucleus assay respectively. Overall DNA damage and incidence of micronuclei showed no significant differences between the exposed and control subjects. With exposure characteristics, such as total duration (years) and frequency of use (minutes/day) sub-groups were assessed for such parameters. Although cumulative frequency of use showed no significant changes in the DNA integrity of the classified sub-groups, the long-term users (> 10 years) showed higher induction of DNA damage and increased frequency of micronuclei and micro nucleated cells.

(E) Liu C, Duan W, Xu S, Chen C, He M, Zhang L, Yu Z, Zhou Z. Exposure to 1800 MHz radiofrequency electromagnetic radiation induces oxidative DNA base damage in a mouse spermatocyte-derived cell line. Toxicol Lett 218(1): 2-9, 2013a. (GT, OX, RP)

Whether exposure to radiofrequency electromagnetic radiation (RF-EMR) emitted from mobile phones can induce DNA damage in male germ cells remains unclear. In this study, we conducted a 24 h intermittent exposure (5 min on and 10 min off) of a mouse spermatocyte-derived GC-2 cell line to 1800 MHz Global System for Mobile Communication (GSM) signals in GSM-Talk mode at specific absorption rates (SAR) of 1 W/kg, 2 W/kg or 4 W/kg. Subsequently, through the use of formamidopyrimidine DNA glycosylase (FPG) in a modified comet assay, we determined that the extent of DNA migration was significantly increased at a SAR of 4 W/kg. Flow cytometry analysis demonstrated that levels of the DNA adduct 8-oxoguanine (8-oxoG) were also increased at a SAR of 4 W/kg. These increases were concomitant with similar increases in the generation of reactive oxygen species (ROS); these phenomena were mitigated by co-treatment with the antioxidant α -tocopherol. However, no detectable DNA strand breakage was observed by the alkaline comet assay. Taking together, these findings may imply the novel possibility that RF-EMR with insufficient energy for the direct induction of DNA strand breaks may produce genotoxicity through oxidative DNA base damage in male germ cells.

(E) Liu C, Gao P, Xu SC, Wang Y, Chen CH, He MD, Yu ZP, Zhang L, Zhou Z. Mobile phone radiation induces mode-dependent DNA damage in a mouse spermatocyte-derived cell line: a protective role of melatonin. Int J Radiat Biol. 2013b Aug 19. [Epub ahead of print] (GT, OX, RP)

Purpose: To evaluate whether exposure to mobile phone radiation (MPR) can induce DNA damage in male germ cells. Materials and methods: A mouse spermatocyte-derived GC-2 cell line was exposed to a commercial mobile phone handset once every 20 minutes in standby,

listen, dialed or dialing modes for 24 h. DNA damage was determined using an alkaline comet assay. Results: The levels of DNA damage were significantly increased following exposure to MPR in the listen, dialed and dialing modes. Moreover, there were significantly higher increases in the dialed and dialing modes than in the listen mode. Interestingly, these results were consistent with the radiation intensities of these modes. However, the DNA damage effects of MPR in the dialing mode were efficiently attenuated by melatonin pretreatment. Conclusions: These results regarding mode-dependent DNA damage have important implications for the safety of inappropriate mobile phone use by males of reproductive age and also suggest a simple preventive measure, keeping our body from mobile phones as far away as possible, not only during conversations but during "dialed" and "dialing" operation modes as well. Since the "dialed" mode is actually part of the standby mode, mobile phones should be kept at a safe distance from our body even during standby operation. Furthermore, the protective role of melatonin suggests that it may be a promising pharmacological candidate for preventing mobile phone use-related reproductive impairments.

(E) Lixia S, Yao K, Kaijun W, Deqiang L, Huajun H, Xiangwei G, Baohong W, Wei Z, Jianling L, Wei W. Effects of 1.8GHz radiofrequency field on DNA damage and expression of heat shock protein 70 in human lens epithelial cells. Mutat Res 602(1-2):135-42, 2006. (GT, GE)

To investigate the DNA damage, expression of heat shock protein 70 (Hsp70) and cell proliferation of human lens epithelial cells (hLEC) after exposure to the 1.8GHz radiofrequency field (RF) of a global system for mobile communications (GSM). An Xc-1800 RF exposure system was used to employ a GSM signal at 1.8GHz (217Hz amplitude-modulated) with the output power in the specific absorption rate (SAR) of 1, 2 and 3W/kg. After 2h exposure to RF, the DNA damage of hLEC was accessed by comet assay at five different incubation times: 0, 30, 60, 120 and 240min, respectively. Western blot and RT-PCR were used to determine the expression of Hsp70 in hLECs after RF exposure. The proliferation rate of cells was evaluated by bromodeoxyuridine incorporation on days 0, 1 and 4 after exposure. The results show that the difference of DNA-breaks between the exposed and sham-exposed (control) groups induced by 1 and 2W/kg irradiation were not significant at any incubation time point ($P>0.05$). The DNA damage caused by 3W/kg irradiation was significantly increased at the times of 0 and 30min after exposure ($P<0.05$), a phenomenon that could not be seen at the time points of 60, 120 or 240min ($P>0.05$). Detectable mRNA as well as protein expression of Hsp70 was found in all groups. Exposure at SARs of 2 and 3W/kg for 2h exhibited significantly increased Hsp70 protein expression ($P<0.05$), while no change in Hsp70 mRNA expression could be found in any of the groups ($P>0.05$). No difference of the cell proliferation rate between the sham-exposed and exposed cells was found at any exposure dose tested ($P>0.05$). The results indicate that exposure to non-thermal dosages of RF for wireless communications can induce no or repairable DNA damage and the increased Hsp70 protein expression in hLECs occurred without change in the cell proliferation rate. The non-thermal stress response of Hsp70 protein increase to RF exposure might be involved in protecting hLEC from DNA damage and maintaining the cellular capacity for proliferation.

(E) López-Martín E, Bregains J, Relova-Quinteiro JL, Cadarso-Suárez C, Jorge-Barreiro FJ, Ares-Pena FJ. The action of pulse-modulated GSM radiation increases regional changes in brain activity and c-Fos expression in cortical and subcortical areas in a rat

model of picrotoxin-induced seizure proneness. J Neurosci Res. 87(6):1484-1499, 2009. (AS, GE, WS, IA)

The action of the pulse-modulated GSM radiofrequency of mobile phones has been suggested as a physical phenomenon that might have biological effects on the mammalian central nervous system. In the present study, GSM-exposed picrotoxin-pretreated rats showed differences in clinical and EEG signs, and in c-Fos expression in the brain, with respect to picrotoxin-treated rats exposed to an equivalent dose of unmodulated radiation. Neither radiation treatment caused tissue heating, so thermal effects can be ruled out. The most marked effects of GSM radiation on c-Fos expression in picrotoxin-treated rats were observed in limbic structures, olfactory cortex areas and subcortical areas, the dentate gyrus, and the central lateral nucleus of the thalamic intralaminar nucleus group. Nonpicrotoxin-treated animals exposed to unmodulated radiation showed the highest levels of neuronal c-Fos expression in cortical areas. These results suggest a specific effect of the pulse modulation of GSM radiation on brain activity of a picrotoxin-induced seizure-proneness rat model and indicate that this mobile-phone-type radiation might induce regional changes in previous preexcitability conditions of neuronal activation.

(E) Luukkonen J, Hakulinen P, Mäki-Paakkanen J, Juutilainen J, Naarala J. Enhancement of chemically induced reactive oxygen species production and DNA damage in human SH-SY5Y neuroblastoma cells by 872MHz radiofrequency radiation. Mutat Res 662:54-58, 2009. (GT, OX, WS)

The objective of the study was to investigate effects of 872 MHz radiofrequency (RF) radiation on intracellular reactive oxygen species (ROS) production and DNA damage at a relatively high SAR value (5W/kg). The experiments also involved combined exposure to RF radiation and menadione, a chemical inducing intracellular ROS production and DNA damage. The production of ROS was measured using the fluorescent probe dichlorofluorescein and DNA damage was evaluated by the Comet assay. Human SH-SY5Y neuroblastoma cells were exposed to RF radiation for 1h with or without menadione. Control cultures were sham exposed. Both continuous waves (CW) and a pulsed signal similar to that used in global system for mobile communications (GSM) mobile phones were used. Exposure to the CW RF radiation increased DNA breakage ($p<0.01$) in comparison to the cells exposed only to menadione. Comparison of the same groups also showed that ROS level was higher in cells exposed to CW RF radiation at 30 and 60 min after the end of exposure ($p<0.05$ and $p<0.01$, respectively). No effects of the GSM signal were seen on either ROS production or DNA damage. The results of the present study suggest that 872MHz CW RF radiation at 5W/kg might enhance chemically induced ROS production and thus cause secondary DNA damage. However, there is no known mechanism that would explain such effects from CW RF radiation but not from GSM modulated RF radiation at identical SAR.

(NE) Luukkonen J, Juutilainen J, Naarala J. Combined effects of 872 MHz radiofrequency radiation and ferrous chloride on reactive oxygen species production and DNA damage in human SH-SY5Y neuroblastoma cells. Bioelectromagnetics 31:417-424, 2010. (GT, OX)

The aim of the present study was to investigate possible cooperative effects of radiofrequency (RF) radiation and ferrous chloride (FeCl) on reactive oxygen species (ROS) production and

DNA damage. In order to test intracellular ROS production as a possible underlying mechanism of DNA damage, we applied the fluorescent probe DCFH-DA. Integrity of DNA was quantified by alkaline comet assay. The exposures to 872 MHz RF radiation were conducted at a specific absorption rate (SAR) of 5 W/kg using continuous waves (CW) or a modulated signal similar to that used in Global System for Mobile Communications (GSM) phones. Four groups were included: Sham exposure (control), RF radiation, Chemical treatment, Chemical treatment, and RF radiation. In the ROS production experiments, human neuroblastoma (SH-SY5Y) cells were exposed to RF radiation and 10 microg/ml FeCl for 1 h. In the comet assay experiments, the exposure time was 3 h and an additional chemical (0.015% diethyl maleate) was used to make DNA damage level observable. The chemical treatments resulted in statistically significant responses, but no effects from either CW or modulated RF radiation were observed on ROS production, DNA damage or cell viability.

(NE) Maes A, Van Gorp U, Verschaeve L. Cytogenetic investigation of subjects professionally exposed to radiofrequency radiation. *Mutagenesis* 21:139-42, 2006. (GT, IA)

Nowadays, virtually everybody is exposed to radiofrequency radiation (RFR) from mobile phone base station antennas or other sources. At least according to some scientists, this exposure can have detrimental health effects. We investigated cytogenetic effects in peripheral blood lymphocytes from subjects who were professionally exposed to mobile phone electromagnetic fields in an attempt to demonstrate possible RFR-induced genetic effects. These subjects can be considered well suited for this purpose as their RFR exposure is 'normal' though rather high, and definitely higher than that of the 'general population'. The alkaline comet assay, sister chromatid exchange (SCE) and chromosome aberration tests revealed no evidence of RFR-induced genetic effects. Blood cells were also exposed to the well known chemical mutagen mitomycin C in order to investigate possible combined effects of RFR and the chemical. No cooperative action was found between the electromagnetic field exposure and the mutagen using either the comet assay or SCE test.

(E) Manti L, Braselmann H, Calabrese ML, Massa R, Pugliese M, Scampoli P, Sicignano G, Grossi G. Effects of modulated microwave radiation at cellular telephone frequency (1.95 GHz) on X-ray-induced chromosome aberrations in human lymphocytes in vitro. *Radiat Res* 169:575-583, 2008. (GT, IA)

The case for a DNA-damaging action produced by radiofrequency (RF) signals remains controversial despite extensive research. With the advent of the Universal Mobile Telecommunication System (UMTS) the number of RF-radiation-exposed individuals is likely to escalate. Since the epigenetic effects of RF radiation are poorly understood and since the potential modifications of repair efficiency after exposure to known cytotoxic agents such as ionizing radiation have been investigated infrequently thus far, we studied the influence of UMTS exposure on the yield of chromosome aberrations induced by X rays. Human peripheral blood lymphocytes were exposed in vitro to a UMTS signal (frequency carrier of 1.95 GHz) for 24 h at 0.5 and 2.0 W/kg specific absorption rate (SAR) using a previously characterized waveguide system. The frequency of chromosome aberrations was measured on metaphase spreads from cells given 4 Gy of X rays immediately before RF radiation or sham exposures by fluorescence in situ hybridization. Unirradiated controls were RF-radiation- or sham-exposed. No significant variations due to the UMTS exposure were found in the fraction of aberrant cells. However, the frequency of exchanges per cell was affected by the SAR, showing a small but

statistically significant increase of 0.11 exchange per cell compared to 0 W/kg SAR. We conclude that, although the 1.95 GHz signal (UMTS modulated) does not exacerbate the yield of aberrant cells caused by ionizing radiation, the overall burden of X-ray-induced chromosomal damage per cell in first-mitosis lymphocytes may be enhanced at 2.0 W/kg SAR. Hence the SAR may either influence the repair of X-ray-induced DNA breaks or alter the cell death pathways of the damage response.

(E) Mazor R, Korenstein-Ilan A, Barbul A, Eshet Y, Shahadi A, Jerby E, Korenstein R. Increased levels of numerical chromosome aberrations after in vitro exposure of human peripheral blood lymphocytes to radiofrequency electromagnetic fields for 72 hours. Radiat Res. 169(1):28-37, 2008. (GT)

We investigated the effects of 72 h in vitro exposure of 10 human lymphocyte samples to radiofrequency electromagnetic fields (800 MHz, continuous wave) on genomic instability. The lymphocytes were exposed in a specially designed waveguide resonator at specific absorption rates (SARs) of 2.9 and 4.1 W/kg in a temperature range of 36-37 degrees C. The induced aneuploidy of chromosomes 1, 10, 11 and 17 was determined by interphase FISH using semi-automated image analysis. We observed increased levels of aneuploidy depending on the chromosome studied as well as on the level of exposure. In chromosomes 1 and 10, there was increased aneuploidy at the higher SAR, while for chromosomes 11 and 17, the increases were observed only for the lower SAR. Multisomy (chromosomal gains) appeared to be the primary contributor to the increased aneuploidy. The effect of temperature on the level of aneuploidy was examined over the range of 33.5-40 degrees C for 72 h with no statistically significant difference in the level of aneuploidy compared to 37 degrees C. These findings suggest the possible existence of an athermal effect of RF radiation that causes increased levels of aneuploidy. These results contribute to the assessment of potential health risks after continuous chronic exposure to RF radiation at SARs close to the current levels set by ICNIRP guidelines.

(E) Nikolova T, Czyz J, Rolletschek A, Blyszczuk P, Fuchs J, Jovtchev G, Schuderer J, Kuster N, Wobus AM. Electromagnetic fields affect transcript levels of apoptosis-related genes in embryonic stem cell-derived neural progenitor cells. ASEB J 19(12):1686-1688, 2005. (GT, GE)

Mouse embryonic stem (ES) cells were used as an experimental model to study the effects of electromagnetic fields (EMF). ES-derived nestin-positive neural progenitor cells were exposed to extremely low frequency EMF simulating power line magnetic fields at 50 Hz (ELF-EMF) and to radiofrequency EMF simulating the Global System for Mobile Communication (GSM) signals at 1.71 GHz (RF-EMF). Following EMF exposure, cells were analyzed for transcript levels of cell cycle regulatory, apoptosis-related, and neural-specific genes and proteins; changes in proliferation; apoptosis; and cytogenetic effects. Quantitative RT-PCR analysis revealed that ELF-EMF exposure to ES-derived neural cells significantly affected transcript levels of the apoptosis-related bcl-2, bax, and cell cycle regulatory "growth arrest DNA damage inducible" GADD45 genes, whereas mRNA levels of neural-specific genes were not affected. RF-EMF exposure of neural progenitor cells resulted in down-regulation of neural-specific Nurr1 and in up-regulation of bax and GADD45 mRNA levels. Short-term RF-EMF exposure for 6 h, but not for 48 h, resulted in a low and transient increase of DNA double-strand breaks. No effects of ELF- and RF-EMF on mitochondrial function, nuclear apoptosis, cell proliferation, and

chromosomal alterations were observed. We may conclude that EMF exposure of ES-derived neural progenitor cells transiently affects the transcript level of genes related to apoptosis and cell cycle control. However, these responses are not associated with detectable changes of cell physiology, suggesting compensatory mechanisms at the translational and posttranslational level.

(E) Nittby H, Widegren B, Krogh M, Grafström G, Berlin H, Rehn G, Eberhardt JL, Malmgren L, Persson BRR, Salford L. Exposure to radiation from global system for mobile communications at 1,800 MHz significantly changes gene expression in rat hippocampus and cortex. Environmentalist 28(4), 458-465, 2008. (GE)

We have earlier shown that radio frequency electromagnetic fields can cause significant leakage of albumin through the blood–brain barrier of exposed rats as compared to non-exposed rats, and also significant neuronal damage in rat brains several weeks after a 2 h exposure to a mobile phone, at 915 MHz with a global system for mobile communications (GSM) frequency modulation, at whole-body specific absorption rate values (SAR) of 200, 20, 2, and 0.2 mW/kg. We have now studied whether 6 h of exposure to the radiation from a GSM mobile test phone at 1,800 MHz (at a whole-body SAR-value of 13 mW/kg, corresponding to a brain SAR-value of 30 mW/kg) has an effect upon the gene expression pattern in rat brain cortex and hippocampus—areas where we have observed albumin leakage from capillaries into neurons and neuronal damage. Microarray analysis of 31,099 rat genes, including splicing variants, was performed in cortex and hippocampus of 8 Fischer 344 rats, 4 animals exposed to global system for mobile communications electromagnetic fields for 6 h in an anechoic chamber, one rat at a time, and 4 controls kept as long in the same anechoic chamber without exposure, also in this case one rat at a time. Gene ontology analysis (using the gene ontology categories biological processes, molecular functions, and cell components) of the differentially expressed genes of the exposed animals versus the control group revealed the following highly significant altered gene categories in both cortex and hippocampus: extracellular region, signal transducer activity, intrinsic to membrane, and integral to membrane. The fact that most of these categories are connected with membrane functions may have a relation to our earlier observation of albumin transport through brain capillaries.

(E) Nylund R, Leszczynski D. Mobile phone radiation causes changes in gene and protein expression in human endothelial cell lines and the response seems to be genome- and proteome-dependent. Proteomics 6:4769-4780, 2006. (GE, CS)

We have examined in vitro cell response to mobile phone radiation (900 MHz GSM signal) using two variants of human endothelial cell line: EA.hy926 and EA.hy926v1. Gene expression changes were examined in three experiments using cDNA Expression Arrays and protein expression changes were examined in ten experiments using 2-DE and PDQuest software. Obtained results show that gene and protein expression were altered, in both examined cell lines, in response to one hour mobile phone radiation exposure at an average specific absorption rate of 2.8 W/kg. However, the same genes and proteins were differently affected by the exposure in each of the cell lines. This suggests that the cell response to mobile phone radiation might be genome- and proteome-dependent. Therefore, it is likely that different types of cells and from different species might respond differently to mobile phone radiation or might have different sensitivity to this weak stimulus. Our findings might also explain, at least in part, the origin of discrepancies in replication studies between different laboratories.

(E) Panagopoulos DJ, Chavdoula ED, Nezis IP, Margaritis LH. Cell death induced by GSM 900-MHz and DCS 1800-MHz mobile telephony radiation. Mutat Res 626:69-78, 2007. (GT, RP)

In the present study, the TUNEL (Terminal deoxynucleotidyltransferase-UTP Nick End Labeling) assay - a well known technique widely used for detecting fragmented DNA in various types of cells - was used to detect cell death (DNA fragmentation) in a biological model, the early and mid stages of oogenesis of the insect *Drosophila melanogaster*. The flies were exposed *in vivo* to either GSM 900-MHz (Global System for Mobile telecommunications) or DCS 1800-MHz (Digital Cellular System) radiation from a common digital mobile phone, for few minutes per day during the first 6 days of their adult life. The exposure conditions were similar to those to which a mobile phone user is exposed, and were determined according to previous studies of ours [D.J Panagopoulos, A. Karabarbounis, L.H. Margaritis, Effect of GSM 900-MHz mobile phone radiation on the reproductive capacity of *D. melanogaster*, *Electromagn. Biol Med* 23 (2004) 29-43; D.J Panagopoulos, N. Messini, A. Karabarbounis, A.L. Philippetis, L.H. Margaritis, Radio frequency electromagnetic radiation within "safety levels" alters the physiological function of insects, in: P. Kostarakis, P. Stavroulakis (Eds.), *Proceedings of the Millennium International Workshop on Biological Effects of Electromagnetic Fields*, Heraklion, Crete, Greece, October 17-20, 2000, pp. 169-175, ISBN: 960-86733-0-5; D.J Panagopoulos, L.H. Margaritis, Effects of electromagnetic fields on the reproductive capacity of *D. melanogaster*, in: P. Stavroulakis (Ed.), *Biological Effects of Electromagnetic Fields*, Springer, 2003, pp. 545-578], which had shown a large decrease in the oviposition of the same insect caused by GSM radiation. Our present results suggest that the decrease in oviposition previously reported, is due to degeneration of large numbers of egg chambers after DNA fragmentation of their constituent cells, induced by both types of mobile telephony radiation. Induced cell death is recorded for the first time, in all types of cells constituting an egg chamber (follicle cells, nurse cells and the oocyte) and in all stages of the early and mid-oogenesis, from germarium to stage 10, during which programmed cell death does not physiologically occur. Germarium and stages 7-8 were found to be the most sensitive developmental stages also in response to electromagnetic stress induced by the GSM and DCS fields and, moreover, germarium was found to be even more sensitive than stages 7-8.

(NE) Paparini A, Rossi P, Gianfranceschi G, Brugaletta V, Falsaperla R, De Luca P, Romano Spica V. No evidence of major transcriptional changes in the brain of mice exposed to 1800 MHz GSM signal. Bioelectromagnetics. 29(4):312-323, 2008. (GE)

To analyze possible effects of microwaves on gene expression, mice were exposed to global system for mobile communication (GSM) 1800 MHz signal for 1 h at a whole body SAR of 1.1 W/kg. Gene expression was studied in the whole brain, where the average SAR was 0.2 W/kg, by expression microarrays containing over 22,600 probe sets. Comparison of data from sham and exposed animals showed no significant difference in gene expression modulation. However, when less stringent constraints were adopted to analyze microarray results, 75 genes were found to be modulated following exposure. Forty-two probes showed fold changes ranging from 1.5 to 2.8, whereas 33 were down-regulated from 0.67- to 0.29-fold changes, but these differences in gene expression were not confirmed by real-time PCR. Under these specific limited conditions, no consistent indication of gene expression modulation in whole mouse brain was found associated to GSM 1800 MHz exposure.

(E) Paulraj R, Behari J. Single strand DNA breaks in rat brain cells exposed to microwave radiation. Mutat Res 596:76-80, 2006. (GT, LE)

This investigation concerns with the effect of low intensity microwave (2.45 and 16.5GHz, SAR 1.0 and 2.01W/kg, respectively) radiation on developing rat brain. Wistar rats (35 days old, male, six rats in each group) were selected for this study. These animals were exposed for 35 days at the above mentioned frequencies separately in two different exposure systems. After the exposure period, the rats were sacrificed and the whole brain tissue was dissected and used for study of single strand DNA breaks by micro gel electrophoresis (comet assay). Single strand DNA breaks were measured as tail length of comet. Fifty cells from each slide and two slides per animal were observed. One-way ANOVA method was adopted for statistical analysis. This study shows that the chronic exposure to these radiations cause statistically significant ($p<0.001$) increase in DNA single strand breaks in brain cells of rat.

(E) Pesnya DS, Romanovsky AV. Comparison of cytotoxic and genotoxic effects of plutonium-239 alpha particles and mobile phone GSM 900 radiation in the Allium cepa test. Mutat Res. 2012 Oct 8. pii: S1383-5718(12)00291-4. doi: 10.1016/j.mrgentox.2012.08.010. [Epub ahead of print] (GT)

The goal of this study was to compare the cytotoxic and genotoxic effects of plutonium-239 alpha particles and GSM 900 modulated mobile phone radiation in the Allium cepa test. Three groups of bulbs were exposed to mobile phone radiation during 0 (sham), 3 and 9hours. A positive control group was treated during 20 min with plutonium-239 alpha-radiation. Mitotic abnormalities, chromosome aberrations, micronuclei and mitotic index were analyzed. Exposure to alpha-radiation from plutonium-239 and exposure to modulated radiation from mobile phone during 3 and 9h significantly increased the mitotic index. GSM 900 mobile phone radiation as well as alpha-radiation from plutonium-239 induced both clastogenic and aneugenic effects. However, the aneugenic activity of mobile phone radiation was more pronounced. After 9 hours of exposure to mobile phone radiation, polyploid cells, three-groups metaphases, amitoses and some unspecified abnormalities were detected, which were not registered in the other experimental groups. Importantly, GSM 900 mobile phone radiation increased the mitotic index, the frequency of mitotic and chromosome abnormalities, and the micronucleus frequency in a time-dependent manner. Due to its sensitivity, the Allium cepa test can be recommended as a useful cytogenetic assay to assess cytotoxic and genotoxic effects of radiofrequency electromagnetic fields.

(NE) Qutob SS, Chauhan V, Bellier PV, Yauk CL, Douglas GR, Berndt L, Williams A, Gajda GB, Lemay E, Thansandote A, McNamee JP. Microarray gene expression profiling of a human glioblastoma cell line exposed in vitro to a 1.9 GHz pulse-modulated radiofrequency field. Radiat Res 165:636-644, 2006. (GE)

The widespread use of mobile phones has led to public concerns about the health effects associated with exposure to radiofrequency (RF) fields. The paramount concern of most persons relates to the potential of these fields to cause cancer. Unlike ionizing radiation, RF fields used for mobile telecommunications (800-1900 MHz) do not possess sufficient energy to directly damage DNA. Most rodent bioassay and in vitro genotoxicity/mutation studies have reported that RF fields at non-thermal levels have no direct mutagenic, genotoxic or carcinogenic effects.

However, some evidence has suggested that RF fields may cause detectable postexposure changes in gene expression. Therefore, the purpose of this study was to assess the ability of exposure to a 1.9 GHz pulse-modulated RF field for 4 h at specific absorption rates (SARs) of 0.1, 1.0 and 10.0 W/kg to affect global gene expression in U87MG glioblastoma cells. We found no evidence that non-thermal RF fields can affect gene expression in cultured U87MG cells relative to the nonirradiated control groups, whereas exposure to heat shock at 43 degrees C for 1 h up-regulated a number of typical stress-responsive genes in the positive control group. Future studies will assess the effect of RF fields on other cell lines and on gene expression in the mouse brain after in vivo exposure.

(E) Remondini D, Nylund R, Reivinen J, Poullietier de Gannes F, Veyret B, Lagroye I, Haro E, Trillo MA, Capri M, Franceschi C, Schlatterer K, Gminski R, Fitzner R, Tauber R, Schuderer J, Kuster N, Leszczynski D, Bersani F, Maercker C. Gene expression changes in human cells after exposure to mobile phone microwaves. *Proteomics* 6:4745-4754, 2006. (GE, CS)

Possible biological effects of mobile phone microwaves were investigated in vitro. In this study, which was part of the 5FP EU project REFLEX (Risk Evaluation of Potential Environmental Hazards From Low-Energy Electromagnetic Field Exposure Using Sensitive in vitro Methods), six human cell types, immortalized cell lines and primary cells, were exposed to 900 and 1800 MHz. RNA was isolated from exposed and sham-exposed cells and labeled for transcriptome analysis on whole-genome cDNA arrays. The results were evaluated statistically using bioinformatics techniques and examined for biological relevance with the help of different databases. NB69 neuroblastoma cells, T lymphocytes, and CHME5 microglial cells did not show significant changes in gene expression. In EA.hy926 endothelial cells, U937 lymphoblastoma cells, and HL-60 leukemia cells we found between 12 and 34 up- or down-regulated genes. Analysis of the affected gene families does not point towards a stress response. However, following microwave exposure, some but not all human cells might react with an increase in expression of genes encoding ribosomal proteins and therefore up-regulating the cellular metabolism.

(NE) Ros-Llor I, Sanchez-Siles M, Camacho-Alonso F, Lopez-Jornet P. Effect of mobile phones on micronucleus frequency in human exfoliated oral mucosal cells. *Oral Dis.* 18:786-792, 2012. (GT)

Objective: In the last two decades, the use of mobile phones has increased enormously all over the world. The controversy regarding whether radiofrequency (RF) fields exert effects upon biological systems is a concern for the general population. An evaluation is made of DNA damage and cytokinetic defects, proliferative potential, and cell death because of RF radiation emitted by mobile phones in healthy young users. Study design: This cohort study was carried out in 50 Caucasian mobile phone users. We collected two cell samples from each subject (a total of 100 cell samples), corresponding to the right and left cheek mucosa, respectively. Case histories and personal information were assessed, including age, gender, body height and weight, history of cancer, smoking and alcohol consumption, exposure to chemical carcinogens or radiation, and dietary habits. Sampling comprised cell collection from both cheeks with a cytobrush, centrifugation, slide preparation, fixation, and staining, followed by fluorescent microscopic analysis. A total of 2000 exfoliated cells were screened for nuclear abnormalities,

especially micronucleus. Results: No statistically significant changes were recorded in relation to age, gender, body mass index, or smoking status. A comparison of the results vs the control area according to the side of the face on which the mobile phone was placed, and in relation to the duration of exposure (years) to mobile phone radiation in the total 100 samples, yielded no significant differences. Conclusions: No genotoxic effects because of RF exposure were observed in relation to any of the study parameters.

(NE) Sakuma N, Komatsubara Y, Takeda H, Hirose H, Sekijima M, Nojima T, Miyakoshi J. DNA strand breaks are not induced in human cells exposed to 2.1425 GHz band CW and W-CDMA modulated radiofrequency fields allocated to mobile radio base stations. Bioelectromagnetics 27:51-57, 2006. (CT)

We conducted a large-scale in vitro study focused on the effects of low level radiofrequency (RF) fields from mobile radio base stations employing the International Mobile Telecommunication 2000 (IMT-2000) cellular system in order to test the hypothesis that modulated RF fields may act as a DNA damaging agent. First, we evaluated the responses of human cells to microwave exposure at a specific absorption rate (SAR) of 80 mW/kg, which corresponds to the limit of the average whole body SAR for general public exposure defined as a basic restriction in the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines. Second, we investigated whether continuous wave (CW) and Wideband Code Division Multiple Access (W-CDMA) modulated signal RF fields at 2.1425 GHz induced different levels of DNA damage. Human glioblastoma A172 cells and normal human IMR-90 fibroblasts from fetal lungs were exposed to mobile communication frequency radiation to investigate whether such exposure produced DNA strand breaks in cell culture. A172 cells were exposed to W-CDMA radiation at SARs of 80, 250, and 800 mW/kg and CW radiation at 80 mW/kg for 2 and 24 h, while IMR-90 cells were exposed to both W-CDMA and CW radiations at a SAR of 80 mW/kg for the same time periods. Under the same RF field exposure conditions, no significant differences in the DNA strand breaks were observed between the test groups exposed to W-CDMA or CW radiation and the sham exposed negative controls, as evaluated immediately after the exposure periods by alkaline comet assays. Our results confirm that low level exposures do not act as a genotoxicant up to a SAR of 800 mW/kg.

(NE) Sakurai T, Kiyokawa T, Narita E, Suzuki Y, Taki M, Miyakoshi J. Analysis of gene expression in a human-derived glial cell line exposed to 2.45 GHz continuous radiofrequency electromagnetic fields. J Radiat Res. 52(2):185-192, 2011. (GE)

The increasing use of mobile phones has aroused public concern regarding the potential health risks of radiofrequency (RF) fields. We investigated the effects of exposure to RF fields (2.45 GHz, continuous wave) at specific absorption rate (SAR) of 1, 5, and 10 W/kg for 1, 4, and 24 h on gene expression in a normal human glial cell line, SVGp12, using DNA microarray. Microarray analysis revealed 23 assigned gene spots and 5 non-assigned gene spots as prospective altered gene spots. Twenty-two genes out of the 23 assigned gene spots were further analyzed by reverse transcription-polymerase chain reaction to validate the results of microarray, and no significant alterations in gene expression were observed. Under the experimental conditions used in this study, we found no evidence that exposure to RF fields affected gene expression in SVGp12 cells.

(NE) Sannino A, Di Costanzo G, Brescia F, Sarti M, Zeni O, Juutilainen J, Scarfi MR. Human fibroblasts and 900 MHz radiofrequency radiation: evaluation of DNA damage after exposure and co-exposure to 3-Chloro-4-(dichloromethyl)-5-Hydroxy-2(5h)-furanone (MX). Radiat Res 171:743-751, 2009. (NT, IA)

Abstract Sannino, A., Di Costanzo, G., Brescia, F., Sarti, M., Zeni, O., Juutilainen, J and Scarfi, M. R. Human Fibroblasts and 900 MHz Radiofrequency Radiation: Evaluation of DNA Damage after Exposure and Co-exposure to 3-Chloro-4-(dichloromethyl)-5-Hydroxy-2(5h)-furanone (MX). Radiat Res 171, 743-751 (2009). The aim of this study was to investigate DNA damage in human dermal fibroblasts from a healthy subject and from a subject affected by Turner's syndrome that were exposed for 24 h to radiofrequency (RF) radiation at 900 MHz. The RF-radiation exposure was carried out alone or in combination with 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone (MX), a well-known environmental mutagen and carcinogen produced during the chlorination of drinking water. Turner's syndrome fibroblasts were also exposed for a shorter time (1 h). A signal similar to that emitted by Global System for Mobile Communications (GSM) mobile phones was used at a specific absorption rate of 1 W/kg under strictly controlled conditions of temperature and dosimetry. To evaluate DNA damage after RF-radiation exposure alone, the alkaline comet assay and the cytokinesis-block micronucleus assay were used. In the combined-exposure experiments, MX was given at a concentration of 25 microM for 1 h immediately after the RF-radiation exposure, and the effects were evaluated by the alkaline comet assay. The results revealed no genotoxic and cytotoxic effects from RF radiation alone in either cell line. As expected, MX treatment induced an increase in DNA migration in the comet assay, but no enhancement of the MX-induced DNA damage was observed in the cells exposed to RF radiation.

(E) Schwarz C, Kratochvil E, Pilger A, Kuster N, Adlkofer F, Rüdiger HW. Radiofrequency electromagnetic fields (UMTS, 1,950 MHz) induce genotoxic effects in vitro in human fibroblasts but not in lymphocytes. Int Arch Occup Environ Health 81:755-767, 2008. (GT, CS)

OBJECTIVE: Universal Mobile Telecommunication System (UMTS) was recently introduced as the third generation mobile communication standard in Europe. This was done without any information on biological effects and genotoxic properties of these particular high-frequency electromagnetic fields. This is disconcerting, because genotoxic effects of the second generation standard Global System for Mobile Communication have been reported after exposure of human cells in vitro. METHODS: Human cultured fibroblasts of three different donors and three different short-term human lymphocyte cultures were exposed to 1,950 MHz UMTS below the specific absorption rate (SAR) safety limit of 2 W/kg. The alkaline comet assay and the micronucleus assay were used to ascertain dose and time-dependent genotoxic effects. Five hundred cells per slide were visually evaluated in the comet assay and comet tail factor (CTF) was calculated. In the micronucleus assay 1,000 binucleated cells were evaluated per assay. The origin of the micronuclei was determined by fluorescence labeled anticentromere antibodies. All evaluations were performed under blinded conditions. RESULTS: UMTS exposure increased the CTF and induced centromere-negative micronuclei (MN) in human cultured fibroblasts in a dose and time-dependent way. Incubation for 24 h at a SAR of 0.05 W/kg generated a statistically significant rise in both CTF and MN ($P = 0.02$). At a SAR of 0.1 W/kg the CTF was significantly

increased after 8 h of incubation ($P = 0.02$), the number of MN after 12 h ($P = 0.02$). No UMTS effect was obtained with lymphocytes, either unstimulated or stimulated with Phytohemagglutinin. CONCLUSION: UMTS exposure may cause genetic alterations in some but not in all human cells in vitro.

(E) Sekeroğlu V, Akar A, Sekeroğlu ZA. Cytotoxic and genotoxic effects of high-frequency electromagnetic fields (GSM 1800 MHz) on immature and mature rats. Ecotoxicol Environ Saf. 80:140-144, 2012. (LE, GT, DE)

We investigated the cytogenotoxic effects of high frequency electromagnetic fields (HF-EMF) for 45 day and the effect of a recovery period of 15 day after exposure to EMF on bone marrow cells of immature and mature rats. The animals in treatment groups were exposed to 1800 MHz EMF at SAR of 0.37 W/kg and 0.49 W/kg for 2h/day for 45 day. Two recovery groups were kept for a recovery period of 15 day without EMF after exposure to HF-EMF. Two control groups for both immature and mature rats were also included. Significant differences were also observed in chromosome aberrations (CA), micronucleus (MN) frequency, mitotic index (MI) and ratio of polychromatic erythrocytes (PCEs) in all treatment groups. The cytogenotoxic damage was more remarkable in immature rats and, the recovery period did not improve this damage in immature rats. Because much higher and irreversible cytogenotoxic damage was observed in immature rats than in mature rats, further studies are needed to understand effects of EMF on DNA damage and DNA repair, and to determine safe limits for environment and human, especially for children.

(NE) Sekijima M, Takeda H, Yasunaga K, Sakuma N, Hirose H, Nojima T, Miyakoshi J. 2-GHz band CW and W-CDMA modulated radiofrequency fields have no significant effect on cell proliferation and gene expression profile in human cells. J Radiat Res. 51(3):277-284, 2010. (GE)

We investigated the mechanisms by which radiofrequency (RF) fields exert their activity, and the changes in both cell proliferation and the gene expression profile in the human cell lines, A172 (glioblastoma), H4 (neuroglioma), and IMR-90 (fibroblasts from normal fetal lung) following exposure to 2.1425 GHz continuous wave (CW) and Wideband Code Division Multiple Access (W-CDMA) RF fields at three field levels. During the incubation phase, cells were exposed at the specific absorption rates (SARs) of 80, 250, or 800 mW/kg with both CW and W-CDMA RF fields for up to 96 h. Heat shock treatment was used as the positive control. No significant differences in cell growth or viability were observed between any test group exposed to W-CDMA or CW radiation and the sham-exposed negative controls. Using the Affymetrix Human Genome Array, only a very small ($< 1\%$) number of available genes (ca. 16,000 to 19,000) exhibited altered expression in each experiment. The results confirm that low-level exposure to 2.1425 GHz CW and W-CDMA RF fields for up to 96 h did not act as an acute cytotoxicant in either cell proliferation or the gene expression profile. These results suggest that RF exposure up to the limit of whole-body average SAR levels as specified in the ICNIRP guidelines is unlikely to elicit a general stress response in the tested cell lines under these conditions.

(E) Souza LD, Cerqueira ED, Meireles JR. Assessment of nuclear abnormalities in exfoliated cells from the oral epithelium of mobile phone users. Electromagn Biol Med. 2013 May 28. [Epub ahead of print] (GE, HU)

Abstract Transmission and reception of mobile telephony signals take place through electromagnetic wave radiation, or electromagnetic radiofrequency fields, between the mobile terminal and the radio base station. Based on reports in the literature on adverse effects from exposure to this type of radiation, the objective of this study was to evaluate the genotoxic and cytotoxic potential of such exposure, by means of the micronucleus test on exfoliated cells from the oral epithelium. The sample included 45 individuals distributed in 3 groups according to the amount of time in hours per week (t) spent using mobile phones: group I, $t > 5$ h; group II, $t > 1$ h and ≤ 5 h; and group III, $t \leq 1$ h. Cells from the oral mucosa were analyzed to assess the numbers of micronuclei, broken egg structures and degenerative nuclear abnormalities indicative of apoptosis (condensed chromatin, karyorrhexis and pyknosis) or necrosis (karyolysis in addition to these changes). The occurrences of micronuclei and degenerative nuclear abnormalities did not differ between the groups, but the number of broken egg (structures that may be associated with gene amplification) was significantly greater in the individuals in group I ($p < 0.05$).

(NE) Speit G, Schütz P, Hoffmann H. Genotoxic effects of exposure to radiofrequency electromagnetic fields (RF-EMF) in cultured mammalian cells are not independently reproducible. Mutat Res. 626(1-2):42-47, 2007. (GT)

Conflicting results have been published regarding the induction of genotoxic effects by exposure to radiofrequency electromagnetic fields (RF-EMF). Using the comet assay, the micronucleus test and the chromosome aberration test with human fibroblasts (ES1 cells), the EU-funded "REFLEX" project (Risk Evaluation of Potential Environmental Hazards From Low Energy Electromagnetic Field Exposure Using Sensitive in vitro Methods) reported clearly positive effects for various exposure conditions. Because of the ongoing discussion on the biological significance of the effects observed, it was the aim of the present study to independently repeat the results using the same cells, the same equipment and the same exposure conditions. We therefore exposed ES1 cells to RF-EMF (1800 MHz; SAR 2 W/kg, continuous wave with intermittent exposure) for different time periods and then performed the alkaline (pH>13) comet assay and the micronucleus test (MNT). For both tests, clearly negative results were obtained in independently repeated experiments. We also performed these experiments with V79 cells, a sensitive Chinese hamster cell line that is frequently used in genotoxicity testing, and also did not measure any genotoxic effect in the comet assay and the MNT. Appropriate measures of quality control were considered to exclude variations in the test performance, failure of the RF-EMF exposure or an evaluation bias. The reasons for the difference between the results reported by the REFLEX project and our experiments remain unclear.

(NE) Stronati L, Testa A, Moquet J, Edwards A, Cordelli E, Villani P, Marino C, Fresegna AM, Appolloni M, Lloyd D. 935 MHz cellular phone radiation. An in vitro study of genotoxicity in human lymphocytes. Int J Radiat Biol 82:339-346, 2006. (GT, IA)

Purpose: The possibility of genotoxicity of radiofrequency radiation (RFR) applied alone or in combination with x-rays was investigated in vitro using several assays on human lymphocytes. The chosen specific absorption rate (SAR) values are near the upper limit of actual energy absorption in localized tissue when persons use some cellular telephones. The purpose of the combined exposures was to examine whether RFR might act epigenetically by reducing the fidelity of repair of DNA damage caused by a well-characterized and established mutagen. Methods: Blood specimens from 14 donors were exposed continuously for 24 h to a

Global System for Mobile Communications (GSM) basic 935 MHz signal. The signal was applied at two SAR; 1 and 2 W/Kg, alone or combined with a 1-min exposure to 1.0 Gy of 250 kVp x-rays given immediately before or after the RFR. The assays employed were the alkaline comet technique to detect DNA strand breakage, metaphase analyses to detect unstable chromosomal aberrations and sister chromatid exchanges, micronuclei in cytokinesis-blocked binucleate lymphocytes and the nuclear division index to detect alterations in the speed of in vitro cell cycling. Results: By comparison with appropriate sham-exposed and control samples, no effect of RFR alone could be found for any of the assay endpoints. In addition RFR did not modify any measured effects of the x-radiation. Conclusions: This study has used several standard in vitro tests for chromosomal and DNA damage in Go human lymphocytes exposed in vitro to a combination of x-rays and RFR. It has comprehensively examined whether a 24-h continuous exposure to a 935 MHz GSM basic signal delivering SAR of 1 or 2 W/Kg is genotoxic per se or whether, it can influence the genotoxicity of the well-established clastogenic agent; x-radiation. Within the experimental parameters of the study in all instances no effect from the RFR signal was observed.

(E) Sun LX, Yao K, He JL, Lu DQ, Wang KJ, Li HW.[Effect of acute exposure to microwave from mobile phone on DNA damage and repair of cultured human lens epithelial cells in vitro.] Zhonghua Lao Dong Wei Sheng Zhi Ye Bing ZaZhi. 24:465-467, 2006. [Article in Chinese] (GT)

OBJECTIVE: To investigate the DNA damage of human lens epithelial cells (LECs) caused by acute exposure to low-power 217 Hz modulated 1.8 GHz microwave radiation and DNA repair. METHODS: Cultured LECs were exposed to 217 Hz modulated 1.8 GHz microwave radiation at SAR (specific absorption rate) of 0, 1, 2, 3 and 4 W/kg for 2 hours in an sXc-1800 incubator and irradiate system. The DNA single strand breaks were detected with comet assay in sham-irradiated cells and irradiated cells incubated for varying periods: 0, 30, 60, 120 and 240 min after irradiation. Images of comets were digitized and analyzed using an Imagine-pro plus software, and the indexes used in this study were tail length (TL) and tail moment (TM). RESULTS: The difference in DNA-breaks between the exposure and sham exposure groups induced by 1 and 2 W/kg irradiation was not significant at every detect time ($P > 0.05$). As for the dosage of 3 and 4 W/kg there was difference in both groups immediately after irradiation ($P < 0.01$). At the time of 30 min after irradiation the difference went on at both group ($P < 0.01$). However, the difference disappeared after one hour's incubation in 3 W/kg group ($P > 0.05$), and existed in 4 W/kg group. CONCLUSION: No or repairable DNA damage was observed after 2 hour irradiation of 1.8 GHz microwave on LECs when SAR \leq 3 W/kg. The DNA damages caused by 4 W/kg irradiation were irreversible.

(E) Tiwari R, Lakshmi NK, Surender V, Rajesh AD, Bhargava SC, Ahuja YR. Combinative exposure effect of radio frequency signals from CDMA mobile phones and aphidicolin on DNA integrity. Electromagn Biol Med 27:418-425, 2008. (GT, IA)

The aim of present study is to assess DNA integrity on the effect of exposure to a radio frequency (RF) signal from Code Division Multiple Access (CDMA) mobile phones. Whole blood samples from six healthy male individuals were exposed for RF signals from a CDMA mobile phone for 1 h. Alkaline comet assay was performed to assess the DNA damage. The combinative exposure effect of the RF signals and APC at two concentrations on DNA integrity was studied. DNA repair efficiency of the samples was also studied after 2 h of exposure. The

RF signals and APC (0.2 microg/ml) alone or in synergism did not have any significant DNA damage as compared to sham exposed. However, univariate analysis showed that DNA damage was significantly different among combinative exposure of RF signals and APC at 0.2 microg/ml ($p < 0.05$) and at 2 microg/ml ($p < 0.02$). APC at 2 microg/ml concentration also showed significant damage levels ($p < 0.05$) when compared to sham exposed. DNA repair efficiency also varied in a significant way in combinative exposure sets ($p < 0.05$). From these results, it appears that the repair inhibitor APC enhances DNA breaks at 2 microg/ml concentration and that the damage is possibly repairable. Thus, it can be inferred that the in vitro exposure to RF signals induces reversible DNA damage in synergism with APC.

(E) Tkalec M, Stambuk A, Srut M, Malarić K, Klobučar GI. Oxidative and genotoxic effects of 900MHz electromagnetic fields in the earthworm *Eisenia fetida*. Ecotoxicol Environ Saf. 90:7-12, 2013. (GT, OX, WS)

Accumulating evidence suggests that exposure to radiofrequency electromagnetic field (RF-EMF) can have various biological effects. In this study the oxidative and genotoxic effects were investigated in earthworms *Eisenia fetida* exposed in vivo to RF-EMF at the mobile phone frequency (900MHz). Earthworms were exposed to the homogeneous RF-EMF at field levels of 10, 23, 41 and 120Vm(-1) for a period of 2h using a Gigahertz Transversal Electromagnetic (GTEM) cell. At the field level of 23Vm(-1) the effect of longer exposure (4h) and field modulation (80% AM 1kHz sinusoidal) was investigated as well. All exposure treatments induced significant genotoxic effect in earthworms coelomocytes detected by the Comet assay, demonstrating DNA damaging capacity of 900MHz electromagnetic radiation. Field modulation additionally increased the genotoxic effect. Moreover, our results indicated the induction of antioxidant stress response in terms of enhanced catalase and glutathione reductase activity as a result of the RF-EMF exposure, and demonstrated the generation of lipid and protein oxidative damage. Antioxidant responses and the potential of RF-EMF to induce damage to lipids, proteins and DNA differed depending on the field level applied, modulation of the field and duration of *E. fetida* exposure to 900MHz electromagnetic radiation. Nature of detected DNA lesions and oxidative stress as the mechanism of action for the induction of DNA damage are discussed.

(E) Tomruk A, Guler G, Dincel AS. The influence of 1800 MHz GSM-like signals on hepatic oxidative DNA and lipid damage in nonpregnant, pregnant, and newly born rabbits. Cell Biochem Biophys 56:39-47, 2010. (GT, OX, DE, LE)

The aim of our study is to evaluate the possible biological effects of whole-body 1800 MHz GSM-like radiofrequency (RF) radiation exposure on liver oxidative DNA damage and lipid peroxidation levels in nonpregnant, pregnant New Zealand White rabbits, and in their newly borns. Eighteen nonpregnant and pregnant rabbits were used and randomly divided into four groups which were composed of nine rabbits: (i) Group I (nonpregnant control), (ii) Group II (nonpregnant-RF exposed), (iii) Group III (pregnant control), (iv) Group IV (pregnant-RF exposed). Newborns of the pregnant rabbits were also divided into two groups: (v) Group V (newborns of Group III) and (vi) Group VI (newborns of Group IV). 1800 MHz GSM-like RF radiation whole-body exposure (15 min/day for a week) was applied to Group II and Group IV. No significant differences were found in liver 8 OHdG/10 dG levels of exposure groups (Group II and Group IV) compared to controls (Group I and Group III). However, in Group II and Group IV malondialdehyde (MDA) and ferrous oxidation in xylenol orange (FOX) levels were

increased compared to Group I ($P < 0.05$, Mann-Whitney). No significant differences were found in liver tissue of 8 OHdG/10 dG and MDA levels between Group VI and Group V ($P > 0.05$, Mann-Whitney) while liver FOX levels were found significantly increased in Group VI with respect to Group V ($P < 0.05$, Mann-Whitney). Consequently, the whole-body 1800 MHz GSM-like RF radiation exposure may lead to oxidative destruction as being indicators of subsequent reactions that occur to form oxygen toxicity in tissues.

(E) Trivino Pardo JC, Grimaldi S, Taranta M, Naldi I, Cinti C. Microwave electromagnetic field regulates gene expression in T-lymphoblastoid leukemia CCRF-CEM cell line exposed to 900 MHz. Electromagn Biol Med. 31(1):1-18, 2012. (GE)

Electric, magnetic, and electromagnetic fields are ubiquitous in our society, and concerns have been expressed regarding possible adverse effects of these exposures. Research on Extremely Low-Frequency (ELF) magnetic fields has been performed for more than two decades, and the methodology and quality of studies have improved over time. Studies have consistently shown increased risk for childhood leukemia associated with ELF magnetic fields. There are still inadequate data for other outcomes. More recently, focus has shifted toward Radio Frequencies (RF) exposures from mobile telephony. There are no persuasive data suggesting a health risk, but this research field is still immature with regard to the quantity and quality of available data. This technology is constantly changing and there is a need for continued research on this issue. To investigate whether exposure to high-frequency electromagnetic fields (EMF) could induce adverse health effects, we cultured acute T-lymphoblastoid leukemia cells (CCRF-CEM) in the presence of 900 MHz MW-EMF generated by a transverse electromagnetic (TEM) cell at short and long exposure times. We evaluated the effect of high-frequency EMF on gene expression and we identified functional pathways influenced by 900 MHz MW-EMF exposure.

(E) Trosić I, Pavčić I, Milković-Kraus S, Mladinić M, Zeljezić D. Effect of electromagnetic radiofrequency radiation on the rats' brain, liver and kidney cells measured by comet assay. Coll Antropol 35:1259-1264, 2011. (GT)

The goal of study was to evaluate DNA damage in rat's renal, liver and brain cells after in vivo exposure to radiofrequency/microwave (Rf/Mw) radiation of cellular phone frequencies range. To determine DNA damage, a single cell gel electrophoresis/comet assay was used. Wistar rats (male, 12 week old, approximate body weight 350 g) ($N = 9$) were exposed to the carrier frequency of 915 MHz with Global System Mobile signal modulation (GSM), power density of 2.4 W/m², whole body average specific absorption rate SAR of 0.6 W/kg. The animals were irradiated for one hour/day, seven days/week during two weeks period. The exposure set-up was Gigahertz Transversal Electromagnetic Mode Cell (GTEM--cell). Sham irradiated controls ($N = 9$) were apart of the study. The body temperature was measured before and after exposure. There were no differences in temperature in between control and treated animals. Comet assay parameters such as the tail length and tail intensity were evaluated. In comparison with tail length in controls (13.5 +/- 0.7 microm), the tail was slightly elongated in brain cells of irradiated animals (14.0 +/- 0.3 microm). The tail length obtained for liver (14.5 +/- 0.3 microm) and kidney (13.9 +/- 0.5 microm) homogenates notably differs in comparison with matched sham controls (13.6 +/- 0.3 microm) and (12.9 +/- 0.9 microm). Differences in tail intensity between control and exposed animals were not significant. The results of this study suggest that, under the experimental conditions applied, repeated 915 MHz irradiation could be a cause of DNA breaks

in renal and liver cells, but not affect the cell genome at the higher extent compared to the basal damage.

(NE) Valbonesi P, Franzellitti S, Piano A, Contin A, Biondi C, Fabbri E. Evaluation of HSP70 Expression and DNA damage in cells of a human trophoblast cell line exposed to 1.8 GHz amplitude-modulated radiofrequency fields. Radiat Res 169:270-279, 2008. (GT, GE)

The aim of this study was to determine whether high-frequency electromagnetic fields (EMFs) could induce cellular effects. The human trophoblast cell line HTR-8/SVneo was used as a model to evaluate the expression of proteins (HSP70 and HSC70) and genes (HSP70A, B, C and HSC70) of the HSP70 family and the primary DNA damage response after nonthermal exposure to pulse-modulated 1817 MHz sinusoidal waves (GSM-217 Hz; 1 h; SAR of 2 W/kg). HSP70 expression was significantly enhanced by heat, which was applied as the prototypical stimulus. The HSP70A, B and C transcripts were differentially expressed under basal conditions, and they were all significantly induced above basal levels by thermal stress. Conversely, HSC70 protein and gene expression was not influenced by heat. Exposing HTR-8/SVneo cells to high-frequency EMFs did not change either HSP70 or HSC70 protein or gene expression. A significant increase in DNA strand breaks was caused by exposure to HO, which was used as a positive stimulus; however, no effect was observed after exposure of cells to high-frequency EMFs. Overall, no evidence was found that a 1-h exposure to GSM-217 Hz induced a HSP70-mediated stress response or primary DNA damage in HTR-8/SVneo cells. Nevertheless, further investigations on trophoblast cell responses after exposure to GSM signals of different types and durations are needed.

(E) Valbonesi P, Franzellitti S, Bersani F, Contin A, Fabbri E. Effects of the exposure to intermittent 1.8 GHz radio frequency electromagnetic fields on HSP70 expression and MAPK signaling pathways in PC12 cells. Int J Radiat Biol. 2014 Feb 11. [Epub ahead of print] (GE, WS)

Purpose: We previously reported effects on heat shock protein 70 (HSP70) mRNA expression, a cytoprotective protein induced under stressful condition, in human trophoblast cells exposed to amplitude-modulated Global System for Mobile Communication (GSM) signals. In the present work the same experimental conditions were applied to the rat PC12 cells, in order to assess the stress responses mediated by HSP70 and by the Mitogen Activated Protein Kinases (MAPK) in neuronal-like cells, an interesting model to study possible effects of mobile phone frequencies exposure. Materials and methods: HSP70 gene expression level was evaluated by reverse transcriptase polymerase chain reaction, HSP70 protein expression and MAPK phosphorylation were assessed by Western blotting. PC12 cells were exposed for 4, 16 or 24 h to 1.8 GHz continuous wave signal (CW, carrier frequency without modulation) or to two different GSM modulation schemes, GSM-217Hz and GSM-Talk (which generates temporal changes between two different GSM signals, active during talking or listening phases respectively, thus simulating a typical conversation). Specific adsorption rate (SAR) was 2 W/kg. Results: After PC12 cells exposure to the GSM-217Hz signal for 16 or 24 h, HSP70 transcription significantly increased, whereas no effect was observed in cells exposed to the CW or GSM-Talk signals. HSP70 protein expression and three different MAPK signaling pathways were not affected by the exposure to any of the three different 1.8 GHz signals. Conclusion: The positive effect on HSP70 mRNA expression, observed only in cells exposed to the GSM-217Hz signal, is a repeatable response

previously reported in human trophoblast cells and now confirmed in PC12 cells. Further investigations towards a possible role of 1.8 GHz signal modulation are therefore advisable.

(NE) Verschaeve L, Heikkinen P, Verheyen G, Van Gorp U, Boonen F, Vander Plaetse F, Maes A, Kumlin T, Maki-Paakkanen J, Puranen L, Juutilainen J. Investigation of co-genotoxic effects of radiofrequency electromagnetic fields in vivo. Radiat Res 165:598-607, 2006. (GT, LE, IA)

We investigated the possible combined genotoxic effects of radiofrequency (RF) electromagnetic fields (900 MHz, amplitude modulated at 217 Hz, mobile phone signal) with the drinking water mutagen and carcinogen 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone (MX). Female rats were exposed to RF fields for a period of 2 years for 2 h per day, 5 days per week at average whole-body specific absorption rates of 0.3 or 0.9 W/kg. MX was given in the drinking water at a concentration of 19 µg/ml. Blood samples were taken at 3, 6 and 24 months of exposure and brain and liver samples were taken at the end of the study (24 months). DNA damage was assessed in all samples using the alkaline comet assay, and micronuclei were determined in erythrocytes. We did not find significant genotoxic activity of MX in blood and liver cells. However, MX induced DNA damage in rat brain. Co-exposures to MX and RF radiation did not significantly increase the response of blood, liver and brain cells compared to MX exposure only. In conclusion, this 2-year animal study involving long-term exposures to RF radiation and MX did not provide any evidence for enhanced genotoxicity in rats exposed to RF radiation.

(NE) Vijayalaxmi. Cytogenetic studies in human blood lymphocytes exposed in vitro to 2.45 GHz or 8.2 GHz radiofrequency radiation. Radiat Res 166, 532–538, 2006. (GT)

Peripheral blood samples collected from healthy human volunteers were exposed in vitro to 2.45 GHz or 8.2 GHz pulsed-wave radiofrequency (RF) radiation. The net forward power, average power density, mean specific absorption rate, and the temperature maintained during the 2-h exposure of the cells to 2.45 GHz or 8.2 GHz were, respectively, 21 W or 60 W, 5 mW/cm² or 10 mW/cm², 2.13 W/kg or 20.71 W/kg, and 36.9 ± 0.1°C or 37.5 ± 0.2°C. Aliquots of the same blood samples that were either sham-exposed or exposed in vitro to an acute dose of 1.5 Gy γ radiation were used as unexposed and positive controls, respectively. Cultured lymphocytes were examined to determine the extent of cytogenetic damage assessed from the incidence of chromosomal aberrations and micronuclei. Under the conditions used to perform the experiments, the levels of damage in RF-radiation-exposed and sham-exposed lymphocytes were not significantly different. Also, there were no significant differences in the response of unstimulated lymphocytes and lymphocytes stimulated with phytohemagglutinin when exposed to 8.2 GHz RF radiation. In contrast, the positive control cells that had been subjected to γ irradiation exhibited significantly more damage than RF-radiation- and sham-exposed lymphocytes.

(NE) Waldmann P, Bohnenberger S, Greinert R, Hermann-Then B, Heselich A, Klug SJ, Koenig J, Kuhr K, Kuster N, Merker M, Murbach M, Pollet D, Schadenboeck W, Scheidemann-Wesp U, Schwab B, Volkmer B, Weyer V, Blettner M. Influence of GSM Signals on Human Peripheral Lymphocytes: Study of Genotoxicity. Radiat Res. 2013 Jan 14. [Epub ahead of print] (GT)

Exposure to radiofrequency (RF) electromagnetic fields (EMF) is continuously increasing worldwide. Yet, conflicting results of a possible genotoxic effect of RF EMF continue to be discussed. In the present study, a possible genotoxic effect of RF EMF (GSM, 1,800 MHz) in human lymphocytes was investigated by a collaboration of six independent institutes (institutes a, b, c, d, e, h). Peripheral blood of 20 healthy, nonsmoking volunteers of two age groups (10 volunteers 16-20 years old and 10 volunteers 50-65 years old) was taken, stimulated and intermittently exposed to three specific absorption rates (SARs) of RF EMF (0.2 W/kg, 2 W/kg, 10 W/kg) and sham for 28 h (institute a). The exposures were performed in a setup with strictly controlled conditions of temperature and dose, and randomly and automatically determined waveguide SARs, which were designed and periodically maintained by ITIS (institute h). Four genotoxicity tests with different end points were conducted (institute a): chromosome aberration test (five types of structural aberrations), micronucleus test, sister chromatid exchange test and the alkaline comet assay (Olive tail moment and % DNA). To demonstrate the validity of the study, positive controls were implemented. The genotoxicity end points were evaluated independently by three laboratories blind to SAR information (institute c = laboratory 1; institute d = laboratory 2; institute e = laboratory 3). Statistical analysis was carried out by institute b. Methods of primary statistical analysis and rules to adjust for multiple testing were specified in a statistical analysis plan based on a data review before unblinding. A linear trend test based on a linear mixed model was used for outcomes of comet assay and exact permutation test for linear trend for all other outcomes. It was ascertained that only outcomes with a significant SAR trend found by at least two of three analyzing laboratories indicated a substantiated suspicion of an exposure effect. On the basis of these specifications, none of the nine end points tested for SAR trend showed a significant and reproducible exposure effect. Highly significant differences between sham exposures and positive controls were detected by each analyzing laboratory, thus validating the study. In conclusion, the results show no evidence of a genotoxic effect induced by RF EMF (GSM, 1,800 MHz).

(E) Wu W, Yao K, Wang KJ, Lu DQ, He JL, Xu LH, Sun WJ. [Blocking 1800 MHz mobile phone radiation-induced reactive oxygen species production and DNA damage in lens epithelial cells by noise magnetic fields.]Zhejiang Da XueXueBao Yi Xue Ban 37:34-38, 2008. [Article in Chinese] (GT, IA, OX)

OBJECTIVE: To investigate whether the exposure to the electromagnetic noise can block reactive oxygen species (ROS) production and DNA damage of lens epithelial cells induced by 1800 MHz mobile phone radiation. METHODS: The DCFH-DA method and comet assay were used respectively to detect the intracellular ROS and DNA damage of cultured human lens epithelial cells induced by 4 W/kg 1800 MHz mobile phone radiation or/and 2microT electromagnetic noise for 24 h intermittently. RESULT: 1800 MHz mobile phone radiation at 4 W/kg for 24 h increased intracellular ROS and DNA damage significantly ($P<0.05$). However, the ROS level and DNA damage of mobile phone radiation plus noise group were not significant enhanced ($P>0.05$) as compared to sham exposure group. Conclusion: Electromagnetic noise can block intracellular ROS production and DNA damage of human lens epithelial cells induced by 1800 MHz mobile phone radiation.

(E) Xu S, Zhong M, Zhang L, Zhou Z, Zhang W, Wang Y, Wang X, Li M, Chen Y, Chen C, He M, Zhang G, Yu Z. Exposure to 1800 MHz radiofrequency radiation induces

oxidative damage to mitochondrial DNA in primary cultured neurons. Brain Res 1311:189-196. 2010. (GT, OX)

Increasing evidence indicates that oxidative stress may be involved in the adverse effects of radiofrequency (RF) radiation on the brain. Because mitochondrial DNA (mtDNA) defects are closely associated with various nervous system diseases and mtDNA is highly susceptible to oxidative stress, the purpose of this study was to determine whether radiofrequency radiation can cause oxidative damage to mtDNA. In this study, we exposed primary cultured cortical neurons to pulsed RF electromagnetic fields at a frequency of 1800 MHz modulated by 217 Hz at an average special absorption rate (SAR) of 2 W/kg. At 24h after exposure, we found that RF radiation induced a significant increase in the levels of 8-hydroxyguanine (8-OHdG), a common biomarker of DNA oxidative damage, in the mitochondria of neurons. Consistent with this finding, the copy number of mtDNA and the levels of mitochondrial RNA (mtRNA) transcripts showed an obvious reduction after RF exposure. Each of these mtDNA disturbances could be reversed by pretreatment with melatonin, which is known to be an efficient in the brain. Together, these results suggested that 1800 MHz RF radiation could cause oxidative damage to mtDNA in primary cultured neurons. Oxidative damage to mtDNA may account for the neurotoxicity of RF radiation in the brain.

(E) Xu S, Chen G, Chen C, Sun C, Zhang D, Murbach M, Kuster N, Zeng Q, Xu Z. Cell Type-Dependent Induction of DNA Damage by 1800 MHz Radiofrequency Electromagnetic Fields Does Not Result in Significant Cellular Dysfunctions. PLoS One. 8(1):e54906, 2013. (GT, CS)

BACKGROUND: Although IARC clarifies radiofrequency electromagnetic fields (RF-EMF) as possible human carcinogen, the debate on its health impact continues due to the inconsistent results. Genotoxic effect has been considered as a golden standard to determine if an environmental factor is a carcinogen, but the currently available data for RF-EMF remain controversial. As an environmental stimulus, the effect of RF-EMF on cellular DNA may be subtle. Therefore, more sensitive method and systematic research strategy are warranted to evaluate its genotoxicity. **OBJECTIVES:** To determine whether RF-EMF does induce DNA damage and if the effect is cell-type dependent by adopting a more sensitive method γ H2AX foci formation; and to investigate the biological consequences if RF-EMF does increase γ H2AX foci formation. **METHODS:** Six different types of cells were intermittently exposed to GSM 1800 MHz RF-EMF at a specific absorption rate of 3.0 W/kg for 1 h or 24 h, then subjected to immunostaining with anti- γ H2AX antibody. The biological consequences in γ H2AX-elevated cell type were further explored with comet and TUNEL assays, flow cytometry, and cell growth assay. **RESULTS:** Exposure to RF-EMF for 24 h significantly induced γ H2AX foci formation in Chinese hamster lung cells and Human skin fibroblasts (HSFs), but not the other cells. However, RF-EMF-elevated γ H2AX foci formation in HSF cells did not result in detectable DNA fragmentation, sustainable cell cycle arrest, cell proliferation or viability change. RF-EMF exposure slightly but not significantly increased the cellular ROS level. **CONCLUSIONS:** RF-EMF induces DNA damage in a cell type-dependent manner, but the elevated γ H2AX foci formation in HSF cells does not result in significant cellular dysfunctions.

(NE) Yadav AS, Sharma MK. Increased frequency of micronucleated exfoliated cells among humans exposed in vivo to mobile telephone radiations. Mutat Res.650(2):175-180, 2008. (LE, GT, HU)

The health concerns have been raised following the enormous increase in the use of wireless mobile telephones throughout the world. This investigation had been taken, with the motive to find out whether mobile phone radiations cause any in vivo effects on the frequency of micronucleated exfoliated cells in the exposed subjects. A total of 109 subjects including 85 regular mobile phone users (exposed) and 24 non-users (controls) had participated in this study. Exfoliated cells were obtained by swabbing the buccal-mucosa from exposed as well as sex-age-matched controls. One thousand exfoliated cells were screened from each individual for nuclear anomalies including micronuclei (MN), karyolysis (KL), karyorrhexis (KH), broken egg (BE) and binucleated (BN) cells. The average daily duration of exposure to mobile phone radiations is 61.26 min with an overall average duration of exposure in term of years is 2.35 years in exposed subjects along with the 9.84 ± 0.745 micronucleated cells (MNCs) and 10.72 ± 0.889 total micronuclei (TMN) as compared to zero duration of exposure along with average 3.75 ± 0.774 MNC and 4.00 ± 0.808 TMN in controls. The means are significantly different in case of MNC and TMN at 0.01% level of significance. The mean of KL in controls is 13.17 ± 2.750 and in exposed subjects is 13.06 ± 1.793 . The value of means of KH in exposed subjects (1.84 ± 0.432) is slightly higher than in controls (1.42 ± 0.737). Mean frequency of broken egg is found to be more in exposed subjects (0.65 ± 0.276) as compared to controls (0.50 ± 0.217). Frequency of presence of more than one nucleus in a cell (binucleated) is also higher in exposed (2.72 ± 0.374) in comparison to controls (0.67 ± 0.231). Although there is a slight increase in mean frequency of KH, BE and BN in exposed subjects but the difference is not found statistically significant. Correlation between 0-1, 1-2, 2-3 and 3-4 years of exposure and the frequency of MNC and TMN has been calculated and found to be positively correlated.

(E) Yan JG, Agresti M, Zhang LL, Yan Y, Matloub HS. Upregulation of specific mRNA levels in rat brain after cell phone exposure. Electromagn Biol Med. 27(2):147-154, 2008. (LE, GE)

Adult Sprague-Dawley rats were exposed to regular cell phones for 6 h per day for 126 days (18 weeks). RT-PCR was used to investigate the changes in levels of mRNA synthesis of several injury-associated proteins. Calcium ATPase, Neural Cell Adhesion Molecule, Neural Growth Factor, and Vascular Endothelial Growth Factor were evaluated. The results showed statistically significant mRNA up-regulation of these proteins in the brains of rats exposed to cell phone radiation. These results indicate that relative chronic exposure to cell phone microwave radiation may result in cumulative injuries that could eventually lead to clinically significant neurological damage.

(E) Yao K, Wu W, Wang K, Ni S, Ye P, Yu Y, Ye J, Sun L. Electromagnetic noise inhibits radiofrequency radiation-induced DNA damage and reactive oxygen species increase in human lens epithelial cells. Mol Vis 14:964-969, 2008. (GT, IA, OX)

PURPOSE: The goal of this study was to investigate whether superposing of electromagnetic noise could block or attenuate DNA damage and intracellular reactive oxygen species (ROS) increase of cultured human lens epithelial cells (HLECs) induced by acute exposure to 1.8 GHz

radiofrequency field (RF) of the Global System for Mobile Communications (GSM). METHODS: An sXc-1800 RF exposure system was used to produce a GSM signal at 1.8 GHz (217 Hz amplitude-modulated) with the specific absorption rate (SAR) of 1, 2, 3, and 4 W/kg. After 2 h of intermittent exposure, the ROS level was assessed by the fluorescent probe, 2',7'-dichlorodihydrofluorescein diacetate (DCFH-DA). DNA damage to HLECs was examined by alkaline comet assay and the phosphorylated form of histone variant H2AX (gammaH2AX) foci formation assay. RESULTS: After exposure to 1.8 GHz RF for 2 h, HLECs exhibited significant intracellular ROS increase in the 2, 3, and 4 W/kg groups. RF radiation at the SAR of 3 W/kg and 4 W/kg could induce significant DNA damage, examined by alkaline comet assay, which was used to detect mainly single strand breaks (SSBs), while no statistical difference in double strand breaks (DSBs), evaluated by gammaH2AX foci, was found between RF exposure (SAR: 3 and 4 W/kg) and sham exposure groups. When RF was superposed with 2 muT electromagnetic noise could block RF-induced ROS increase and DNA damage. CONCLUSIONS: DNA damage induced by 1.8 GHz radiofrequency field for 2 h, which was mainly SSBs, may be associated with the increased ROS production. Electromagnetic noise could block RF-induced ROS formation and DNA damage.

(NE) Yildirim MS, Yildirim A, Zamani AG, Okudan N. Effect of mobile phone station on micronucleus frequency and chromosomal aberrations in human blood cells. Genet Couns. 21(2):243-251, 2010. (HU, LE, GT)

The use of mobile telephones has rapidly increased worldwide as well as the number of mobile phone base stations that lead to rise low level radiofrequency emissions which may in turn have possible harm for human health. The national radiation protection board has published the known effects of radio waves exposure on humans living close to mobile phone base stations. However, several studies have claimed that the base station has detrimental effects on different tissues. In this study, we aimed to evaluate the effects of mobile phone base stations on the micronucleus (MN) frequency and chromosomal aberrations on blood in people who were living around mobile phone base stations and healthy controls. Frequency of MN and chromosomal aberrations in study and control groups was 8.96 +/- 3.51 and 6.97 +/- 1.52 (p: 0.16); 0.36 +/- 0.31 and 0.75 +/- 0.61 (p: 0.07), respectively. Our results show that there was not a significant difference of MN frequency and chromosomal aberrations between the two study groups. The results claim that cellular phones and their base stations do not produce important carcinogenic changes.

(E) Zalata, A., A. Z. El-Samanoudy, D. Shaalan, Y. El-Baiomy, and T. Mostafa. In vitro effect of cell phone radiation on motility, DNA fragmentation and clusterin gene expression of sperm. Int J Fertil Steril, In Press. Published online ahead of print. (GT, GE, RP)

Background: Use of cellular phones that emits radiofrequency electromagnetic field (RF-EMF) has been increased exponentially and became a part of everyday life. This study aimed to investigate the effects of RF-EMF radiation emitted from cellular phones on sperm motility variables, sperm DNA fragmentation and clusterin (CLU) gene expression. Materials and Methods: 124 semen samples were grouped into; normozoospermia (N, n=26), asthenozoospermia (A, n=32), asthenoteratozoospermia (AT, n=31) and oligoasthenoteratozoospermia (OAT, n=35). Semen samples were divided into two aliquots; samples not exposed to cell phone and samples exposed to cell phone radiation (850 MHz, maximum power < 1 watt; SAR 1.46 W/kg at 10 cm distance) for 1 hr. Before and immediately

after exposure both aliquots were subjected to assessment of sperm motility, acrosin activity, sperm DNA fragmentation and CLU gene expression. Statistical differences were analyzed using paired t-student test for comparisons where $P < 0.05$ was set as significant. Results: There was significant decrease in sperm motility, sperm linear velocity, sperm linearity index, sperm acrosin activity and significant increase in sperm DNA fragmentation percent, CLU gene expression and CLU protein levels in the exposed semen samples to RF-EMF compared with non- exposed samples in $OAT > AT > A > N$ groups ($P < 0.05$).

Conclusions: Cell phone emissions have a negative impact on exposed sperm motility indices, sperm acrosin activity, sperm DNA fragmentation and CLU gene expression especially in OAT cases.

(NE) Zeni O, Schiavoni A, Perrotta A, Forigo D, Deplano M, Scarfi MR. Evaluation of genotoxic effects in human leukocytes after in vitro exposure to 1950 MHz UMTS radiofrequency field. Bioelectromagnetics 29:177-184, 2008. (GT)

In the present study the third generation wireless technology of the Universal Mobile Telecommunication System (UMTS) signal was investigated for the induction of genotoxic effects in human leukocytes. Peripheral blood from six healthy donors was used and, for each donor, intermittent exposures (6 min RF on, 2 h RF off) at the frequency of 1950 MHz were conducted at a specific absorption rate of 2.2 W/kg. The exposures were performed in a transverse electro magnetic (TEM) cell hosted in an incubator under strictly controlled conditions of temperature and dosimetry. Following long duration intermittent RF exposures (from 24 to 68 h) in different stages of the cell cycle, micronucleus formation was evaluated by applying the cytokinesis block micronucleus assay, which also provides information on cell division kinetics. Primary DNA damage (strand breaks/alkali labile sites) was also investigated following 24 h of intermittent RF exposures, by applying the alkaline single cell gel electrophoresis (SCG)/comet assay. Positive controls were included by treating cell cultures with Mitomycin-C and methylmethanesulfonate for micronucleus and comet assays, respectively. The results obtained indicate that intermittent exposures of human lymphocytes in different stages of cell cycle do not induce either an increase in micronucleated cells, or change in cell cycle kinetics; moreover, 24 h intermittent exposures also fail to affect DNA structure of human leukocytes soon after the exposures, likely indicating that repairable DNA damage was not induced.

(E) Zhang DY, Xu ZP, Chiang H, Lu DQ, Zeng QL. [Effects of GSM 1800 MHz radiofrequency electromagnetic fields on DNA damage in Chinese hamster lung cells.] Zhonghua Yu Fang Yi Xue Za Zhi 40:149-152, 2006. [Article in Chinese] (GT)

OBJECTIVE: To study the effects of GSM 1800 MHz radiofrequency electromagnetic fields (RF EMF) on DNA damage in Chinese hamster lung (CHL) cells. METHODS: The cells were intermittently exposed or sham-exposed to GSM 1800 MHz RF EMF (5 minutes on/10 minutes off) at a special absorption rate (SAR) of 3.0 W/kg for 1 hour or 24 hours. Meanwhile, cells exposed to 2-acetaminofluorene, a DNA damage agent, at a final concentration of 20 mg/L for 2 hours were used as positive control. After exposure, cells were fixed by using 4% paraformaldehyde and processed for phosphorylated form of H2AX (gammaH2AX) immunofluorescence measurement. The primary antibody used for immunofluorescence was mouse monoclonal antibody against gammaH2AX and the secondary antibody was fluorescein

isothiocyanate (FITC)-conjugated goat anti-mouse IgG. Nuclei were counterstained with 4, 6-diamidino-2-phenylindole (DAPI). The gammaH2AX foci and nuclei were visualized with an Olympus AX70 fluorescent microscope. Image Pro-Plus software was used to count the gammaH2AX foci in each cell. For each exposure condition, at least 50 cells were selected to detect gammaH2AX foci. Cells were classified as positive when more than five foci were detected. The percentage of gammaH2AX foci positive cells was adopted as the index of DNA damage. RESULTS: The percentage of gammaH2AX foci positive cell of 1800 MHz RF EMF exposure for 24 hours (37.9 +/- 8.6)% or 2-acetylaminofluorene exposure (50.9 +/- 9.4)% was significantly higher compared with the sham-exposure (28.0 +/- 8.4)%. However, there was no significant difference between the sham-exposure and RF EMF exposure for 1 hour (31.8 +/- 8.7)%. CONCLUSION: 1800 MHz RF EMF (SAR, 3.0 W/kg) for 24 hours might induce DNA damage in CHL cells.

(E) Zhang SZ, Yao GD, Lu DQ, Chiang H, Xu ZP. [Effect of 1.8 GHz radiofrequency electromagnetic fields on gene expression of rat neurons]. Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 26(8):449-452, 2008. [Article in Chinese] **(GE, WS)**

OBJECTIVE: To investigate the changes of gene expression in rat neuron induced by 1.8 GHz radiofrequency electromagnetic fields (RF EMF) to screen for RF EMF-responsive genes and the effect of different exposure times and modes on the gene expression in neuron. METHODS: Total RNA was extracted immediately and purified from the primary culture of neurons after intermittent exposed or sham-exposed to a frequency of 1.8 GHz RF EMF for 24 hours at an average special absorption rate (SAR) of 2 W/kg. Affymetrix Rat Neurobiology U34 array was applied to investigate the changes of gene expression in rat neuron. Differentially expressed genes (Egr-1, Mbp and Plp) were further confirmed by semi-quantitative reverse transcription polymerase chain reaction (RT PCR). The expression levels of Egr-1, Mbp and Plp were observed at different exposure times (6, 24 h) and modes (intermittent and continuous exposure). RESULTS: Among 1200 candidate genes, 24 up-regulated and 10 down-regulated genes were found by using Affymetrix microarray suite software 5.0 which are associated with multiple cellular functions (cytoskeleton, signal transduction pathway, metabolism, etc.) after functional classification. Under 24 h and 6 h intermittent exposure, Egr-1 and Plp in experiment groups showed statistic significance ($P < 0.05$) compared with the control groups, while expression of Mbp did not change significantly ($P > 0.05$). After 24 h continuous exposure, Egr-1 and Mbp in experiment groups showed statistic significance ($P < 0.05$) compared with the control group, while expression of Plp did not change significantly ($P > 0.05$). Under the same exposure mode 6 h, expression of all the 3 genes did not change significantly. Different times (6, 24 h) and modes (intermittent and continuous exposure) of exposure exerted remarkable different influences on the expression of Egr-1, Mbp, Plp genes ($P < 0.01$). CONCLUSION: The changes of many genes transcription were involved in the effect of 1.8 GHz RF EMF on rat neurons; Down-regulation of Egr-1 and up-regulation of Mbp, Plp indicated the negative effects of RF EMF on neurons; The effect of RF intermittent exposure on gene expression was more obvious than that of continuous exposure; The effect of 24 h RF exposure (both intermittent and continuous) on gene expression was more obvious than that of 6 h (both intermittent and continuous).

(E) Zhao R, Zhang S, Xu Z, Ju L, Lu D, Yao G. Studying gene expression profile of rat neuron exposed to 1800MHz radiofrequency electromagnetic fields with cDNA microassay. *Toxicology* 235:167-175, 2007. **(GE)**

A widespread use of mobile phone (MP) evokes a growing concern for their possible adverse effects on human, especially the brain. Gene expression is a unique way of characterizing how cells and organism adapt to changes in the external environment, so the aim of this investigation was to determine whether 1800 MHz radiofrequency electromagnetic fields (RF EMF) can influence the gene expression of neuron. Affymetrix Rat Neurobiology U34 array was applied to investigate the changes of gene expression in rat neuron after exposed to the pulsed RF EMF at a frequency of 1800 MHz modulated by 217 Hz which is commonly used in MP. Among 1200 candidate genes, 24 up-regulated genes and 10 down-regulated genes were identified after 24-h intermittent exposure at an average special absorption rate (SAR) of 2 W/kg, which are associated with multiple cellular functions (cytoskeleton, signal transduction pathway, metabolism, etc.) after functional classification. The results were further confirmed by quantitative real-time polymerase chain reaction (RT PCR). The present results indicated that the gene expression of rat neuron could be altered by exposure to RF EMF under our experimental conditions.

(E) Zhao TY, Zou SP, Knapp PE. Exposure to cell phone radiation up-regulates apoptosis genes in primary cultures of neurons and astrocytes. Neurosci Lett. 412(1):34-38, 2007. (GE, CS)

The health effects of cell phone radiation exposure are a growing public concern. This study investigated whether expression of genes related to cell death pathways are dysregulated in primary cultured neurons and astrocytes by exposure to a working Global System for Mobile Communication (GSM) cell phone rated at a frequency of 1900MHz. Primary cultures were exposed to cell phone emissions for 2h. We used array analysis and real-time RT-PCR to show up-regulation of caspase-2, caspase-6 and Asc (apoptosis associated speck-like protein containing a card) gene expression in neurons and astrocytes. Up-regulation occurred in both "on" and "stand-by" modes in neurons, but only in "on" mode in astrocytes. Additionally, astrocytes showed up-regulation of the Bax gene. The effects are specific since up-regulation was not seen for other genes associated with apoptosis, such as caspase-9 in either neurons or astrocytes, or Bax in neurons. The results show that even relatively short-term exposure to cell phone radiofrequency emissions can up-regulate elements of apoptotic pathways in cells derived from the brain, and that neurons appear to be more sensitive to this effect than astrocytes.

(E) Zhijian C, Xiaoxue L, Yezhen L, Shijie C, Lifan J, Jianlin L, Deqiang L, Jiliang H. Impact of 1.8-GHz radiofrequency radiation (RFR) on DNA damage and repair induced by doxorubicin in human B-cell lymphoblastoid cells. Mutat Res. 695(1-2):16-21, 2010. (GT, IA)

In the present in vitro study, a comet assay was used to determine whether 1.8-GHz radiofrequency radiation (RFR, SAR of 2W/kg) can influence DNA repair in human B-cell lymphoblastoid cells exposed to doxorubicin (DOX) at the doses of 0microg/ml, 0.05microg/ml, 0.075microg/ml, 0.10microg/ml, 0.15microg/ml and 0.20microg/ml. The combinative exposures to RFR with DOX were divided into five categories. DNA damage was detected at 0h, 6h, 12h, 18h and 24h after exposure to DOX via the comet assay, and the percent of DNA in the tail (% tail DNA) served as the indicator of DNA damage. The results demonstrated that (1) RFR could not directly induce DNA damage of human B-cell lymphoblastoid cells; (2) DOX could significantly induce DNA damage of human B-cell lymphoblastoid cells with the dose-effect

relationship, and there were special repair characteristics of DNA damage induced by DOX; (3) E-E-E type (exposure to RFR for 2h, then simultaneous exposure to RFR and DOX, and exposure to RFR for 6h, 12h, 18h and 24h after exposure to DOX) combinative exposure could obviously influence DNA repair at 6h and 12h after exposure to DOX for four DOX doses (0.075microg/ml, 0.10microg/ml, 0.15microg/ml and 0.20microg/ml) in human B-cell lymphoblastoid cells.

(NE) Zhijian C, Xiaoxue L, Yezhen L, Deqiang L, Shijie C, Lifan J, Jianlin L, Jiliang H. Influence of 1.8-GHz (GSM) radiofrequency radiation (RFR) on DNA damage and repair induced by X-rays in human leukocytes in vitro. *Mutat Res.* 677(1-2):100-104, 2009. (GT, IA)

In the present study, the in vitro comet assay was used to determine whether 1.8-GHz radiofrequency radiation (RFR) can influence DNA repair in human leukocytes exposed to X-rays. The specific energy absorption rate (SAR) of 2 W/kg (the current European safety limit) was applied. The leukocytes from four young healthy donors were intermittently exposed to RFR for 24 h (fields on for 5 min, fields off for 10 min), and then irradiated with X-rays at doses of 0.25, 0.5, 1.0 and 2.0 Gy. DNA damage to human leukocytes was detected using the comet assay at 0, 15, 45, 90, 150 and 240 min after exposure to X-rays. Using the comet assay, the percent of DNA in the tail (% tail DNA) served as the indicator of DNA damage; the DNA repair percentage (DRP) served as the indicator of the DNA repair speed. The results demonstrated that (1) the DNA repair speeds of human leukocytes after X-ray exposure exhibited individual differences among the four donors; (2) the intermittent exposures of 1.8-GHz RFR at the SAR of 2 W/kg for 24 h did not directly induce DNA damage or exhibit synergistic effects with X-rays on human leukocytes.

(NE) Ziemann C, Brockmeyer H, Reddy SB, Vijayalaxmi, Prihoda TJ, Kuster N, Tillmann T, Dasenbrock C. Absence of genotoxic potential of 902 MHz (GSM) and 1747 MHz (DCS) wireless communication signals: In vivo two-year bioassay in B6C3F1 mice. *Int J Radiat Biol.* 85(5):454-464, 2009. (GT, LE)

PURPOSE: The aim of the present investigation was to determine the incidence of micronuclei in peripheral blood erythrocytes of B6C3F1 mice that had been chronically exposed to radiofrequencies (RF) used for mobile communication. MATERIALS AND METHODS: 'Ferris wheels' were used to expose tube-restrained male and female mice to simulated environmental RF signals of the Global System for Mobile Communications (GSM, 902 MHz) or Digital Cellular System (DCS, 1747 MHz). RF signals were applied to the mice for 2 hours/day on 5 days/week for two years, at maximal whole-body-averaged specific absorption rates of 0.4, 1.3, and 4.0 W/kg body weight. Concurrent sham-exposed mice, cage controls, and positive controls injected with mitomycin C were included in this investigation. At necropsy, peripheral blood smears were prepared, and coded slides were stained using May-Grunwald-Giemsa or acridine orange. The incidence of micronuclei was recorded for each mouse in 2000 polychromatic and 2000 normochromatic erythrocytes. RESULTS: There were no significant differences in the frequency of micronuclei between RF-exposed, sham-exposed, and cage control mice, irrespective of the staining/counting method used. Micronuclei were, however, significantly increased in polychromatic erythrocytes of the positive control mice.

CONCLUSIONS: In conclusion, the data did not indicate RF-induced genotoxicity in mice after two years of exposure.

APPENDIX B - ABSTRACTS ON GENETIC EFFECTS OF EXTREMELY-LOW FREQUENCY ELECTROMAGNETIC FIELDS (2007-2014)

Below is a key to abbreviations used throughout the following list of abstracts for recent papers published since 2006 and serve as my comments to help the reader quickly identify the significance of each work. The summary sentences by each author are underlined. The list is divided into RF effects papers, and ELF effects papers.

(**E**- effect observed; **NE**- no effect observed) (**LE**- long term exposure; **GT**- genotoxic effect, e.g., DNA damage, micronucleus formation, chromosome alterations; **GE**- gene expression; **HU**- human study; **OX**- oxidative effects, i.e., involvement of free radicals and oxidative enzymes; **IA**- interaction with other factors to cause genetic effects; **DE**- effects on developing animals; **RP**- reproduction, e.g., sperm damage; **EH**- compared with electro-hypersensitive subjects; **WS**- waveform specific effect, e.g., modulation and frequency; **CS**- cell type specific effect).

(**NE**) Albert GC, McNamee JP, Marro L, Bellier PV, Prato FS, Thomas AW. Assessment of genetic damage in peripheral blood of human volunteers exposed (whole-body) to a 200 μ T, 60 Hz magnetic field. Int J Radiat Biol. 85(2):144-152, 2009. (**GT, IA**)

AIM: To investigate the extent of damage in nucleated cells in peripheral blood of healthy human volunteers exposed to a whole-body 60 Hz, 200 microT magnetic field. **MATERIALS AND METHODS:** In this study, 10 male and 10 female healthy human volunteers received a 4 h whole-body exposure to a 200 microT, 60 Hz magnetic field. In addition, five males and five females were treated in a similar fashion, but were exposed to sham conditions. For each subject, a blood sample was obtained prior to the exposure period and aliquots were used as negative- (pre-exposure) and positive- [1.5 Gray (Gy) (60)Cobalt ((60)Co) gamma-irradiation] controls. At the end of the 4 h exposure period, a second blood sample was obtained. The extent of DNA damage was assessed in peripheral human blood leukocytes from all samples using the alkaline comet assay. To detect possible clastogenic effects, the incidence of micronuclei was assessed in phytohemagglutinin (PHA)-stimulated lymphocytes using the cytokinesis-block micronucleus assay. **RESULTS:** There was no evidence of either increased DNA damage, as indicated by the alkaline comet assay, or increased incidence of micronuclei (MN) in the magnetic field exposed group. However, an in vitro exposure of 1.5 Gy gamma-irradiation caused a significant increase in both DNA damage and MN induction. **CONCLUSIONS:** This study found no evidence that an acute, whole-body exposure to a 200 microT, 60 Hz magnetic field for 4 hours could cause DNA damage in human blood.

(E) Alcaraz M, Olmos E, Alcaraz-Saura M, Achel DG, Castillo J. Effect of long-term 50 Hz magnetic field exposure on the micronucleated polychromatic erythrocytes of mice. Electromagn Biol Med. 2013 Jun 19. [Epub ahead of print] (GT)

Abstract In recent years extremely low-frequency magnetic fields (ELF-EMF) have become widely used in human activities, leading to an increased chance of exposure to ELF-EMF. There are few reports on in vivo mammalian genotoxic effects using micronucleus (MN) assays, which generally have been used as a short-term screening system. We analyzed the possible genotoxic effect induced by long-term exposure (7, 14, 21, 28 d) of a 50 Hz ELM-MF to mice by measuring the increase in frequency of micronucleated polychromatic erythrocyte in their bone marrow (MNPCEs) and we compared it with that induced by 50 cGy of X-rays. Subsequently, we tried to reduce this chromosomal damage by administering four antioxidant substances with radioprotective capacities: dimethyl sulfoxide (DMSO), 6-n-propyl-2-thiouracil (PTU), grape-procyanidins (P) and citrus flavonoids extract (CE). The increase in micronucleated cells was higher in both physical treatments (Control < ELF-EMF ($p < 0.01$) < X-rays ($p > 0.001$)); however, the antioxidant substances only showed a genoprotective capacity against the damage induced by ionizing radiation (Ci > PTU = DMSO ($p < 0.001$) > P = CE ($p < 0.001$). The 50 Hz ELM-MF increased MNPCEs in mouse bone marrow, expressing a genotoxic capacity. Administration of antioxidant substances with radioprotective capacities known to act through the elimination of free radicals did not diminish the genotoxic effect induced by ELM-MF.

(E) Balamuralikrishnan B, Balachandar V, Kumar SS, Stalin N, Varsha P, Devi SM, Arun M, Manikantan P, Venkatesan C, Sasikala K, Dharwadkar SN. Evaluation of Chromosomal Alteration in Electrical Workers Occupationally Exposed to Low Frequency of Electro Magnetic Field (EMFs) in Coimbatore Population, India. Asian Pac J Cancer Prev. 13(6):2961-2966, 2012. (HU, LE, GT)

Extremely low frequency electromagnetic fields (EMFs) have been classified as possibly carcinogenic to humans by the International Agency for Research on Cancer. An increased number of chromosomal alterations in peripheral lymphocytes are correlated with elevated incidence of cancer. The aim of the present study was to assess occupationally induced chromosomal damage in EMF workers exposed to low levels of radiation. We used conventional metaphase chromosome aberration (CA) analysis and the micronucleus (MN) assay as biological indicators of nonionizing radiation exposure. In the present study totally 70 subjects were selected including 50 exposed and 20 controls. Informed written consent was obtained from all participants and the study was performed in accordance with the Declaration of Helsinki and the approval of the local ethical committee. A higher degree of CA and MN was observed in exposed subjects compared to controls, the frequency of CA being significantly enhanced with long years of exposure ($P < 0.05$). Moreover increase in CA and MN with age was noted in both exposed subjects and controls, but was significantly greater in the former. The results of this study demonstrated that a significant induction of cytogenetic damage in peripheral lymphocytes of workers occupationally exposed to EMFs in electric transformer and distribution stations. In conclusion, our findings suggest that EMFs possess genotoxic capability, as measured by CA and MN assays; CA analysis appeared more sensitive than other cytogenetic end-points. It can be concluded that chronic occupational exposure to EMFs may lead to an increased risk of genetic damage among electrical workers.

(E) Belyaev IY, Hillert L, Protopopova M, Tamm C, Malmgren LO, Persson BR, Selivanova G, Harms-Ringdahl M. 915 MHz microwaves and 50 Hz magnetic field affect chromatin conformation and 53BP1 foci in human lymphocytes from hypersensitive and healthy persons. *Bioelectromagnetics* 26:173-184, 2005. (GT, EH)

We used exposure to microwaves from a global system for mobile communication (GSM) mobile phone (915 MHz, specific absorption rate (SAR) 37 mW/kg) and power frequency magnetic field (50 Hz, 15 μ T peak value) to investigate the response of lymphocytes from healthy subjects and from persons reporting hypersensitivity to electromagnetic field (EMF). The hypersensitive and healthy donors were matched by gender and age and the data were analyzed blind to treatment condition. The changes in chromatin conformation were measured with the method of anomalous viscosity time dependencies (AVTD). 53BP1 protein, which has been shown to colocalize in foci with DNA double strand breaks (DSBs), was analyzed by immunostaining in situ. Exposure at room temperature to either 915 MHz or 50 Hz resulted in significant condensation of chromatin, shown as AVTD changes, which was similar to the effect of heat shock at 41 degrees C. No significant differences in responses between normal and hypersensitive subjects were detected. Neither 915 MHz nor 50 Hz exposure induced 53BP1 foci. On the contrary, a distinct decrease in background level of 53BP1 signaling was observed upon these exposures as well as after heat shock treatments. This decrease correlated with the AVTD data and may indicate decrease in accessibility of 53BP1 to antibodies because of stress-induced chromatin condensation. Apoptosis was determined by morphological changes and by apoptotic fragmentation of DNA as analyzed by pulsed-field gel electrophoresis (PFGE). No apoptosis was induced by exposure to 50 Hz and 915 MHz microwaves. In conclusion, 50 Hz magnetic field and 915 MHz microwaves under specified conditions of exposure induced comparable responses in lymphocytes from healthy and hypersensitive donors that were similar but not identical to stress response induced by heat shock.

(E) [Borhani N](#), [Rajaei F](#), [Salehi Z](#), [Javadi A](#). Analysis of DNA fragmentation in mouse embryos exposed to an extremely low-frequency electromagnetic field. [Electromagn Biol Med](#). 30(4):246-252, 2011. (GT, DE, LE)

Effects of extremely low-frequency electromagnetic fields (ELF-EMFs) on DNA damage in biological systems are still a matter of dispute. The aim of the present study was to investigate the possible effect of electromagnetic field exposure on DNA fragmentation in cells (blastomers) of mouse blastocysts. Eighty female NMRI mice were randomly divided into 2 groups of 40 animals each. The control group was left unexposed whereas the animals in the EMF-group were exposed to a 50-Hz EMF at 0.5 mT 4 h per day, 6 days a week for a duration of 2 weeks. After the 8(th) day of exposure, the female mice in both groups were superovulated (with injections of pregnant mare serum gonadotropin and human chorionic gonadotropin) and then mated overnight. At approximately 4 days after mating (102 h after the human chorionic gonadotropin treatment), blastocysts were obtained by flushing the uterus horns. The mean numbers of pregnant mice, blastocysts after flushing, blastomers within the blastocysts, and the DNA fragmentation index following staining in both groups were compared using statistical methods (SPSS, the Chi-square test, the Student's t-test and the Mann-Whitney U-test, $P < 0.05$). The results showed that the mean number of blastocysts after flushing was significantly decreased in the EMF-group compared to that of the control group ($P < 0.03$). The DNA fragmentation index was significantly increased in the EMF-group compared to control (10.53% vs. 7.14%; $P <$

0.001). However, there was no significant difference in the mean numbers of blastomers and numbers of pregnant mice between the EMF-exposed and control group. Our findings indicate that the EMF exposure in preimplantation stage could have detrimental effects on female mouse fertility and embryo development by decreasing the number of blastocysts and increasing the blastocysts DNA fragmentation.

(E) Buldak RJ, Polaniak R, Buldak L, Zwirska-Korczala K, Skonieczna M, Monsiol A, Kukla M, Dulawa-Buldak A, Birkner E. Short-term exposure to 50 Hz ELF-EMF alters the cisplatin-induced oxidative response in AT478 murine squamous cell carcinoma cells. *Bioelectromagnetics*. 2012 Apr 25. doi: 10.1002/bem.21732. [Epub ahead of print] (GT, IA, OX)

The aim of this study was to assess the influence of cisplatin and an extremely low frequency electromagnetic field (ELF-EMF) on antioxidant enzyme activity and the lipid peroxidation ratio, as well as the level of DNA damage and reactive oxygen species (ROS) production in AT478 carcinoma cells. Cells were cultured for 24 and 72 h in culture medium with cisplatin. Additionally, the cells were irradiated with 50 Hz/1 mT ELF-EMF for 16 min using a solenoid as a source of the ELF-EMF. The amount of ROS, superoxide dismutase (SOD) isoenzyme activity, glutathione peroxidase (GSH-Px) activity, DNA damage, and malondialdehyde (MDA) levels were assessed. Cells that were exposed to cisplatin exhibited a significant increase in ROS and antioxidant enzyme activity. The addition of ELF-EMF exposure to cisplatin treatment resulted in decreased ROS levels and antioxidant enzyme activity. A significant reduction in MDA concentrations was observed in all of the study groups, with the greatest decrease associated with treatment by both cisplatin and ELF-EMF. Cisplatin induced the most severe DNA damage; however, when cells were also irradiated with ELF-EMF, less DNA damage occurred. Exposure to ELF-EMF alone resulted in an increase in DNA damage compared to control cells. ELF-EMF lessened the effects of oxidative stress and DNA damage that were induced by cisplatin; however, ELF-EMF alone was a mild oxidative stressor and DNA damage inducer. We speculate that ELF-EMF exerts differential effects depending on the exogenous conditions. This information may be of value for appraising the pathophysiologic consequences of exposure to ELF-EMF.

(E) Calabrò E, Condello S, Magazù S, Ientile, R. Static and 50 Hz electromagnetic fields effects on human neuronal-like cells vibration bands in the mid-infrared region. *J Electromagnetic Analysis and Applications* 3(2) 69-78, 2011. (GT)

Human neuronal-like cells were exposed to static and 50 Hz electromagnetic fields at the intensities of 2 mT and 1 mT, respectively. The effects of exposure were investigated in the mid-infrared region by means of Fourier self deconvolution spectroscopic analysis. After exposure of 3 hours to static and 50 Hz electromagnetic fields, the vibration bands of CH₂ methylene group increased significantly after both exposures, suggesting a relative increase of lipid related to conformational changes in the cell membrane due to electromagnetic fields. In addition, PO₂- stretching phosphate bands decreased after both exposures, suggesting that alteration in DNA/RNA can be occurred. In particular, exposure of 3 hours to 50 Hz electromagnetic fields produced significant increases in β -sheet contents in amide I, and around the 1740 cm⁻¹ band assigned to non-hydrogen-bonded ester carbonyl stretching mode, that can be

related to unfolding processes of proteins structure and cells death. Further exposure up to 18 hours to static magnetic field produced an increase in β -sheet contents as to α -helix components of amide I region, as well.

(E) [Celikler S](#), [Aydemir N](#), [Vatan O](#), [Kurtuldu S](#), [Bilaloglu R](#). A biomonitoring study of genotoxic risk to workers of transformers and distribution line stations. [Int J Environ Health Res](#). 19(6):421-430, 2009. **(GT, HU)**

A cytogenetic monitoring study was carried out on a group of workers from transformer and distribution line stations in the Bursa province of Turkey, to investigate the genotoxic risk of occupational exposure to extremely low frequency electric (ELF) and magnetic fields (EMF). Cytogenetic analysis, namely chromosomal aberrations (CAs) and micronucleus (MN) tests were performed on a strictly selected group of 55 workers and compared to 17 controls. CA and MN frequencies in electrical workers appeared significantly higher than in controls ($p < 0.001$, 0.05 , respectively). The frequency of CA in exposed groups were significantly enhanced with the years of exposure ($p < 0.01$). The effect of smoking on the level of CA and MN was not significant in the control and exposure groups. The results of this study demonstrated that a significant induction of cytogenetic damage in peripheral lymphocytes of workers engaged to occupational exposure to ELMF in electric transformer and distribution stations.

(E) [Chen GD](#), [Lu DQ](#), [Jiang H](#), [Xu ZP](#). [Effects of 50 Hz magnetic fields on gene expression in MCF-7 cells]. [Zhejiang Da Xue Xue Bao Yi Xue Ban](#). 37(1):15-22, 2008. [Article in Chinese] **(GT, GE)**

OBJECTIVE: To investigate whether 50 Hz magnetic fields (MF) can change the gene expression profile in MCF-7 cells and to screen MF responsive genes. **METHODS:** In vitro cultured MCF-7 cells were continuously exposed or sham-exposed to 0.4 mT of 50 Hz MF for 24 hours. Affymetrix Human Genome Genechips (U133A) were applied to analyze gene expression profiles in MF exposed and sham-exposed MCF-7 cells and the data were processed with Genechip data analysis software MAS 5.0 and DMT 3.0. Real-time RT-PCR assay was employed to examine the differentially expressed genes. **RESULT:** Thirty differentially expressed genes were screened with 100 % consistency change calls in the MF exposed MCF-7 cells. Six independent real-time RT-PCR analyses showed that SCNN1A, METTL3 and GPR137B were slightly but statistically significantly changed in MCF-7 cells after exposure to 50 Hz MF ($P < 0.05$), while other analyzed genes exhibited slight up-and down-fluctuations in expressions and no increase or decrease in each gene expression reached statistical significance ($P > 0.05$). **CONCLUSION:** The present study identified three 50 Hz MF responsive genes in MCF-7 cells and the biological consequences of expression changes in these MF responsive genes need to be further investigated. 0.4 mT 50 Hz MF exposure for longer duration might induce DNA double-strand breaks in human lens epithelial cells in vitro.

(NE) [Chen G](#), [Lu D](#), [Chiang H](#), [Leszczynski D](#), [Xu Z](#). Using model organism *Saccharomyces cerevisiae* to evaluate the effects of ELF-MF and RF-EMF exposure on global gene expression. [Bioelectromagnetics](#). 33(7):550-560, 2012. **(GE)**

The potential health hazard of exposure to electromagnetic fields (EMF) continues to cause public concern. However, the possibility of biological and health effects of exposure to EMF remains controversial and their biophysical mechanisms are unknown. In the present study, we used *Saccharomyces cerevisiae* to identify genes responding to extremely low frequency magnetic fields (ELF-MF) and to radiofrequency EMF (RF-EMF) exposures. The yeast cells were exposed for 6 h to either 0.4 mT 50 Hz ELF-MF or 1800 MHz RF-EMF at a specific absorption rate of 4.7 W/kg. Gene expression was analyzed by microarray screening and confirmed using real-time reverse transcription-polymerase chain reaction (RT-PCR). We were unable to confirm microarray-detected changes in three of the ELF-MF responsive candidate genes using RT-PCR ($P > 0.05$). On the other hand, out of the 40 potential RF-EMF responsive genes, only the expressions of structural maintenance of chromosomes 3 (SMC3) and aquaporin 2 (AQY2 (m)) were confirmed, while three other genes, that is, halotolerance protein 9 (HAL9), yet another kinase 1 (YAK1) and one function-unknown gene (open reading frame: YJL171C), showed opposite changes in expression compared to the microarray data ($P < 0.05$). In conclusion, the results of this study suggest that the yeast cells did not alter gene expression in response to 50 Hz ELF-MF and that the response to RF-EMF is limited to only a very small number of genes. The possible biological consequences of the gene expression changes induced by RF-EMF await further investigation.

(E) Cho S, Lee Y, Lee S, Choi YJ, Chung HW. Enhanced cytotoxic and genotoxic effects of gadolinium following ELF-EMF irradiation in human lymphocytes. Drug Chem Toxicol. 2014 Jan 30. [Epub ahead of print] (GT, IA)

Gadolinium (Gd) and its chelated derivatives are widely utilized for various industrial and medical purposes, particularly as a contrast agent for magnetic resonance imaging (MRI). There are many studies of Gd nephrotoxicity and neurotoxicity, whereas research on cyto- and genotoxicity in normal human lymphocytes is scarce. It is important to investigate the effect of extremely low-frequency electromagnetic fields (ELF-EMF) on Gd toxicity, as patients are co-exposed to Gd and ELF-EMF generated by MRI scanners. We investigated the cytotoxicity and genotoxicity of Gd and the possible enhancing effect of ELF-EMF on Gd toxicity in cultured human lymphocytes by performing a micronuclei (MN) assay, trypan blue dye exclusion, single cell gel electrophoresis, and apoptosis analyses using flow cytometry. Isolated lymphocytes were exposed to 0.2-1.2 mM of Gd only or in combination with a 60-Hz ELF-EMF of 0.8-mT field strength. Exposing human lymphocytes to Gd resulted in a concentration- and time-dependent decrease in cell viability and an increase in MN frequency, single strand DNA breakage, apoptotic cell death, and ROS production. ELF-EMF (0.8 mT) exposure also increased cell death, MN frequency, olive tail moment, and apoptosis induced by Gd treatment alone. These results suggest that Gd induces DNA damage and apoptotic cell death in human lymphocytes and that ELF-EMF enhances the cytotoxicity and genotoxicity of Gd.

(E) Cho YH, Jeon HK, Chung HW. Effects of extremely low-frequency electromagnetic fields on delayed chromosomal instability induced by bleomycin in normal human fibroblast cells. J Toxicol Environ Health A. 70(15-16):1252-1258, 2007. (GT, IA)

This study was carried out to examine the interaction of extremely low-frequency electromagnetic fields (ELF-EMF) on delayed chromosomal instability by bleomycin (BLM) in

human fibroblast cells. A micronucleus-centromere assay using DNA probes for chromosomes 1 and 4 was performed and a 60-Hz ELF-EMF of 0.8 mT field strength was applied either alone or with BLM throughout the culture period. The frequencies of micronuclei (MN) and aneuploidy were analyzed at 28, 88, and 240 h after treatment with BLM. The coexposure of cells to BLM and ELF-EMF led to a significant increase in the frequencies of MN and aneuploidy compared to the cells treated with BLM alone. No difference was observed between field-exposed and sham-exposed control cells. The frequency of MN induced by BLM was increased at 28 h, and further analysis showed a persistent increase up to 240 h, but the new levels were not significantly different from the level at 28 h. BLM increased the frequencies of aneuploidy at 28, 88, and 240 h, and significantly higher frequency of aneuploidy was observed in the cells analyzed at 240 h compared to the cells examined at 28 h. No interaction of ELF-EMF on delayed chromosomal instability by BLM was observed. Our results suggest that ELF-EMF enhances the cytotoxicity of BLM. BLM might induce delayed chromosomal instability, but no effect of ELF-EMF was observed on the BLM-induced delayed chromosomal instability in fibroblast cells.

(E) Collard JF, Lazar C, Nowé A, Hinsenkamp M. Statistical validation of the acceleration of the differentiation at the expense of the proliferation in human epidermal cells exposed to extremely low frequency electric fields. Prog Biophys Mol Biol. 111(1):37-45, 2013. (GE)

An acceleration of differentiation at the expense of proliferation is observed in our previous publications and in the literature after exposure of various biological models to low frequency and low-amplitude electric and electromagnetic fields. This observation is related with a significant modification of genes expression. We observed and compared over time this modification. This study use microarray data obtained on epidermis cultures harvested from human abdominoplasty exposed to ELF electric fields. This protocol is repeated with samples collected on three different healthy patients. The sampling over time allows comparison of the effect of the stimulus at a given time with the evolution of control group. After 4 days, we observed a significant difference of the genes expression between control (D4C) and stimulated (D4S) ($p < 0.05$). On the control between day 4 and 7, we observed another group of genes with significant difference ($p < 0.05$) in their expression. We identify the common genes between these two groups and we select from them those expressing no difference between stimulate at 4 days (D4S) and control after 7 days (D7C). The same analysis was performed with D4S-D4C-D12C and D7S-D7C-D12C. The lists of genes which follow this pattern show acceleration in their expressions under stimulation appearing on control at a later time. In this list, genes such as DKK1, SPRR3, NDRG4, and CHEK1 are involved in cell proliferation or differentiation. Numerous other genes are also playing a function in mitosis, cell cycle or in the DNA replication transcription and translation.

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(E) Cuccurazzu B, Leone L, Podda MV, Piacentini R, Riccardi E, Ripoli C, Azzena GB, Grassi C.

Exposure to extremely low-frequency (50 Hz) electromagnetic fields enhances adult hippocampal neurogenesis in C57BL/6 mice. Exp Neurol. 226(1):173-182, 2010. (LE, GE, DE)

Throughout life, new neurons are continuously generated in the hippocampus, which is therefore a major site of structural plasticity in the adult brain. We recently demonstrated that extremely low-frequency electromagnetic fields (ELFEFs) promote the neuronal differentiation of neural stem cells in vitro by up-regulating Ca(v)1-channel activity. The aim of the present study was to determine whether 50-Hz/1 mT ELFEF stimulation also affects adult hippocampal neurogenesis in vivo, and if so, to identify the molecular mechanisms underlying this action and its functional impact on synaptic plasticity. ELFEF exposure (1 to 7 h/day for 7 days) significantly enhanced neurogenesis in the dentate gyrus (DG) of adult mice, as documented by increased numbers of cells double-labeled for 5-bromo-deoxyuridine (BrdU) and double cortin. Quantitative RT-PCR analysis of hippocampal extracts revealed significant ELFEF exposure-induced increases in the transcription of pro-neuronal genes (Mash1, NeuroD2, Hes1) and genes encoding Ca(v)1.2 channel α (1C) subunits. Increased expression of NeuroD1, NeuroD2 and Ca(v)1 channels was also documented by Western blot analysis. Immunofluorescence experiments showed that, 30 days after ELFEF stimulation, roughly half of the newly generated immature neurons had survived and become mature dentate granule cells (as shown by their immunoreactivity for both BrdU and NeuN) and were integrated into the granule cell layer of the DG. Electrophysiological experiments demonstrated that the new mature neurons influenced hippocampal synaptic plasticity, as reflected by increased long-term potentiation. Our findings show that ELFEF exposure can be an effective tool for increasing in vivo neurogenesis, and they could lead to the development of novel therapeutic approaches in regenerative medicine.

(E) [Di Campli E](#), [Di Bartolomeo S](#), [Grande R](#), [Di Giulio M](#), [Cellini L](#). Effects of extremely low-frequency electromagnetic fields on *Helicobacter pylori* biofilm. [Curr Microbiol.](#) 60(6):412-418, 2010. (GE)

The aim of this work was to investigate the effects of exposure to extremely low-frequency electromagnetic fields (ELF-EMF) both on biofilm formation and on mature biofilm of *Helicobacter pylori*. Bacterial cultures and 2-day-old biofilm of *H. pylori* ATCC 43629 were exposed to ELF-EMF (50 Hz frequency-1 mT intensity) for 2 days to assess their effect on the cell adhesion and on the mature biofilm detachment, respectively. All the exposed cultures and the respective sham exposed controls were studied for: the cell viability status, the cell morphological analysis, the biofilm mass measurement, the genotypic profile, and the luxS and amiA gene expression. The ELF-EMF acted on the bacterial population during the biofilm formation displaying significant differences in cell viability, as well as, in morphotypes measured by the prevalence of spiral forms (58.41%) in respect to the controls (33.14%), whereas, on mature biofilm, no significant differences were found when compared to the controls. The measurement of biofilm cell mass was significantly reduced in exposed cultures in both examined experimental conditions. No changes in DNA patterns were recorded, whereas a modulation in amiA gene expression was detected. An exposure to ELF-EMF of *H. pylori* biofilm induces phenotypic changes on adhering bacteria and decreases the cell adhesion unbalancing the bacterial population therefore reducing the *H. pylori* capability to protect itself.

(E) [Dominici L](#), [Villarini M](#), [Fatigoni C](#), [Monarca S](#), [Moretti M](#). Genotoxic hazard evaluation in welders occupationally exposed to extremely low-frequency magnetic fields (ELF-MF). [Int J Hyg Environ Health.](#) 215(1):68-75, 2011. (GT, HU)

Electric arc welding is known to involve considerable exposure to extremely low-frequency magnetic fields (ELF-MF). A cytogenetic monitoring study was carried out in a group of welders to investigate the genotoxic risk of occupational exposure to ELF-MF. This study assessed individual occupational exposure to ELF-MF using a personal magnetic-field dosimeter, and the cytogenetic effects were examined by comparing micronuclei (MN) and sister chromatid exchange (SCE) frequencies in the lymphocytes of the exposed workers with those of non-exposed control subjects (blood donors) matched for age and smoking habit. Cytogenetic analyses were carried out on 21 workers enrolled from two different welding companies in Central Italy and compared to 21 controls. Some differences between the groups were observed on analysis of SCE and MN, whereas replication indices in the exposed were found not to differ from the controls. In particular, the exposed group showed a significantly higher frequency of MN (group mean \pm SEM: 6.10 \pm 0.39) compared to the control group (4.45 \pm 0.30). Moreover, the increase in MN is associated with a proportional increase in ELF-MF exposure levels with a dose-response relationship. A significant decrease in SCE frequency was observed in exposed subjects (3.73 \pm 0.21) compared to controls (4.89 \pm 0.12). The hypothesis of a correlation between genotoxic assays and ELF-MF exposure value was partially supported, especially as regards MN assay. Since these results are derived from a small-scale pilot study, a larger scale study should be undertaken.

(E) [Du XG](#), [Xu SS](#), [Chen Q](#), [Lu DQ](#), [Xu ZP](#), [Zeng QL](#). [Effects of 50 Hz magnetic fields on DNA double-strand breaks in human lens epithelial cells]. [Zhejiang Da Xue Xue Bao Yi Xue Ban](#). 37(1):9-14, 2008. [Article in Chinese] **(GT)**

OBJECTIVE: To investigate the effects of 50 Hz magnetic fields (MF) on DNA double-strand breaks in human lens epithelial cells (hLECs). **METHODS:** The cultured human lens epithelial cells were exposed to 0.4 mT 50 Hz MF for 2 h, 6 h, 12 h, 24 h and 48 h. Cells exposed to 4-nitroquinoline-1-oxide, a DNA damage agent, at a final concentration of 0.1 micromol/L for 1 h were used as positive controls. After exposure, cells were fixed with 4 % paraformaldehyde and for H2AX (gamma H2AX) immunofluorescence measurement. gamma H2AX foci were detected at least 200 cells for each sample. Cells were classified as positive when more than three foci per cell were observed. Mean values of foci per cell and percentage of foci positive cells were adopted as indexes of DNA double-strand breaks. **RESULT:** The mean value of foci per cell and the percentage of gamma H2AX foci positive cells in 50 Hz MF exposure group for 24 h were (2.93 \pm 0.43) and (27.88 \pm 2.59)%, respectively, which were significantly higher than those of sham-exposure group [(1.77 \pm 0.37) and (19.38 \pm 2.70)%, $P < 0.05$], and the mean value of foci per cell and the percentage of gamma H2AX foci positive cells in 50 Hz MF exposure group for 48 h were (3.14 \pm 0.35) and (31.00 \pm 3.44)%, which were significantly higher than those of sham-exposure group ($P < 0.01$). However there was no significant difference between 50 Hz MF exposure groups for 2 h, 6 h, 12 h and sham-exposure group for above two indexes ($P > 0.05$). **CONCLUSION:** 0.4 mT 50 Hz MF exposure for longer duration might induce DNA double-strand breaks in human lens epithelial cells in vitro.

(E) [El-Bialy NS](#), [Rageh MM](#). Extremely low-frequency magnetic field enhances the therapeutic efficacy of low-dose cisplatin in the treatment of Ehrlich carcinoma. [Biomed Res Int](#). 2013;2013:189352. doi: 10.1155/2013/189352. Epub 2013 Jan 14. **(GT, IA)**

The present study examines the therapeutic efficacy of the administration of low-dose cisplatin (cis) followed by exposure to extremely low-frequency magnetic field (ELF-MF), with an average intensity of 10 mT, on Ehrlich carcinoma in vivo. The cytotoxic and genotoxic actions of this combination were studied using comet assay, mitotic index (MI), and the induction of micronucleus (MN). Moreover, the inhibition of tumor growth was also measured. Treatment with cisplatin and ELF-MF (group A) increased the number of damaged cells by 54% compared with 41% for mice treated with cisplatin alone (group B), 20% for mice treated by exposure to ELF-MF (group C), and 9% for the control group (group D). Also the mitotic index decreased significantly for all treated groups ($P < 0.001$). The decrement percent for the treated groups (A, B, and C) were 70%, 65%, and 22%, respectively, compared with the control group (D). Additionally, the rate of tumor growth at day 12 was suppressed significantly ($P < 0.001$) for groups A, B, and C with respect to group (D). These results suggest that ELF-MF enhanced the cytotoxic activity of cisplatin and potentiate the benefit of using a combination of low-dose cisplatin and ELF-MF in the treatment of Ehrlich carcinoma.

(E) Erdal N, Gürgül S, Celik A. Cytogenetic effects of extremely low frequency magnetic field on Wistar rat bone marrow. Mutat Res. 630(1-2):69-77, 2007. (GT, LE)

In this study, the genotoxic and cytotoxic potential of extremely low frequency magnetic fields (ELF-MF) was investigated in Wistar rat tibial bone marrow cells, using the chromosomal aberration (CA) and micronucleus (MN) test systems. In addition to these test systems, we also investigated the mitotic index (MI), and the ratio of polychromatic erythrocytes (PCEs) to normochromatic erythrocytes (NCEs). Wistar rats were exposed to acute (1 day for 4h) and long-term (4h/day for 45 days) to a horizontal 50Hz, 1mT uniform magnetic field generated by a Helmholtz coil system. Mitomycin C (MMC, 2mg/kg BW) was used as positive control. Results obtained by chromosome analysis do not show any statistically significant differences between the negative control and both acute and long-term ELF-MF exposed samples. When comparing the group mean CA of long-term exposure with the negative control and acute exposure, the group mean of the long-term exposed group was higher, but this was not statistically significant. However, the mean micronucleus frequency of the longer-term exposed group was considerably higher than the negative control and acutely exposed groups. This difference was statistically significant ($p < 0.01$). The results of the MI in bone marrow showed that the averages of both A-MF and L-MF groups significantly decreased when compared to those in the negative control ($p < 0.001$ and $p < 0.01$, respectively). No significant differences were found between the group mean MI of A-MF exposure with L-MF. We found that the average of PCEs/NCEs ratios of A-MF exposed group was significantly lower than the negative control and L-MF exposed groups ($p < 0.001$ and $p < 0.01$, respectively). In addition, the group mean of the PCEs/NCEs ratios of L-MF was significantly lower than negative control ($p < 0.01$). We also found that the MMC treated group showed higher the number of CA and the frequency of MN formation when compared to those in all other each groups (p -values of all each groups < 0.01) and also MMC treated group showed lower MI and the PCEs/NCEs ratios when compared to those in all other each groups (p -values of all groups < 0.01). These observations indicate the in vivo susceptibility of mammals to the genotoxicity potential of ELF-MF.

(E) Fedrowitz M, Löscher W. Gene expression in the mammary gland tissue of female Fischer 344 and Lewis rats after magnetic field exposure (50 Hz, 100 μ T) for 2 weeks. Int J

[Radiat Biol.](#) 88(5):425-429, 2012. (GE, LE) See also: Fedrowitz [M](#), [Hass R](#), [Löscher W](#). Effects of 50 Hz magnetic field exposure on the stress marker α -amylase in the rat mammary gland. [Int J Radiat Biol.](#) 88(7):556-564, 2012.

PURPOSE: The issue of whether exposure to environmental power-frequency magnetic fields (MF) has impact on breast cancer development still remains equivocal. Previously, we observed rat strain differences in the MF response of breast tissue, so that the genetic background plays a role in MF effects. The present experiment aimed to elucidate candidate genes involved in MF effects by comparison of MF-susceptible Fischer 344 (F344) rats and MF-insensitive Lewis rats. **MATERIALS AND METHODS:** Female F344 and Lewis rats were exposed to MF (50 Hz, 100 μ T) for two weeks, and a whole genome microarray analysis in the mammary gland tissue was performed. **RESULTS:** A remarkably decreased α -amylase gene expression, decreases in carbonic anhydrase 6 and lactoperoxidase, both relevant for pH regulation, and an increased gene expression of cystatin E/M, a tumor suppressor, were observed in MF-exposed F344, but not in Lewis rats. **CONCLUSION:** The MF-exposed F344 breast tissue showed alterations in gene expression, which were absent in Lewis and may therefore be involved in the MF-susceptibility of F344. Notably α -amylase might serve as a promising target to study MF effects, because first experiments indicate that MF exposure alters the functionality of this enzyme in breast tissue.

(E) [Focke F](#), [Schuermann D](#), [Kuster N](#), [Schär P](#). DNA fragmentation in human fibroblasts under extremely low frequency electromagnetic field exposure. [Mutat Res.](#) 683(1-2):74-83, 2010. (GT)

Extremely low frequency electromagnetic fields (ELF-EMFs) were reported to affect DNA integrity in human cells with evidence based on the Comet assay. These findings were heavily debated for two main reasons; the lack of reproducibility, and the absence of a plausible scientific rationale for how EMFs could damage DNA. Starting out from a replication of the relevant experiments, we performed this study to clarify the existence and explore origin and nature of ELF-EMF induced DNA effects. Our data confirm that intermittent (but not continuous) exposure of human primary fibroblasts to a 50 Hz EMF at a flux density of 1 mT induces a slight but significant increase of DNA fragmentation in the Comet assay, and we provide first evidence for this to be caused by the magnetic rather than the electric field. Moreover, we show that EMF-induced responses in the Comet assay are dependent on cell proliferation, suggesting that processes of DNA replication rather than the DNA itself may be affected. Consistently, the Comet effects correlated with a reduction of actively replicating cells and a concomitant increase of apoptotic cells in exposed cultures, whereas a combined Fpg-Comet test failed to produce evidence for a notable contribution of oxidative DNA base damage. Hence, ELF-EMF induced effects in the Comet assay are reproducible under specific conditions and can be explained by minor disturbances in S-phase processes and occasional triggering of apoptosis rather than by the generation of DNA damage.

(E) [Frisch P](#), [Li GC](#), [McLeod K](#), [Laramée CB](#). Induction of heat shock gene expression in RAT1 primary fibroblast cells by ELF electric fields. *Bioelectromagnetics*. 34(5):405-413, 2013. (GE)

Recent studies have demonstrated that the Ku70 gene fragment can be placed in the anti-sense orientation under the control of a heat-inducible heat shock protein 70 (HSP70) promoter and activated through heat shock exposure. This results in attenuation of the Ku70 protein expression, inhibiting cellular repair processes, and sensitizing the transfected cells to exposures such as the ionizing radiation exposures used clinically. However, achieving the tissue temperatures necessary to thermally induce the HSP70 response presents significant limitations to the clinical application of this strategy. Previous findings suggest an alternative approach to inducing a heat shock response, specifically through the use of extremely low frequency (ELF) electrical field stimulation. To further pursue this approach, we investigated HSP70 responses in transfected rat primary fibroblast (RAT1) cells exposed to 10 Hz electric fields at intensities of 20-500 V/m. We confirmed that low frequency electric fields can induce HSP70 heat shock expression, with peak responses obtained at 8 h following a 2 h field exposure. However, the approximate threefold increase in expression is substantially lower than that obtained using thermal stimulation, raising questions of the clinical utility of the response.

(E) [Giorgi G](#), [Marcantonio P](#), [Bersani F](#), [Gavocci E](#), [Del Re B](#). Effect of extremely low frequency magnetic field exposure on DNA transposition in relation to frequency, wave shape and exposure time. [Int J Radiat Biol](#). 87(6):601-608, 2011. **(GT, WS)**

PURPOSE: To examine the effect of extremely low frequency magnetic field (ELF-MF) exposure on transposon (Tn) mobility in relation to the exposure time, the frequency and the wave shape of the field applied. **MATERIALS AND METHODS:** Two Escherichia coli model systems were used: (1) Cells unable to express β -galactosidase (LacZ(-)), containing a mini-transposon Tn10 element able to give ability to express β -galactosidase (LacZ(+)) upon its transposition; therefore in these cells transposition activity can be evaluated by analysing LacZ(+) clones; (2) cells carrying Fertility plasmid (F(+)), and a Tn5 element located on the chromosome; therefore in these cells transposition activity can be estimated by a bacterial conjugation assay. Cells were exposed to sinusoidal (SiMF) or pulsed-square wave (PMF) magnetic fields of various frequencies (20, 50, 75 Hz) and for different exposure times (15 and 90 min). **RESULTS:** Both mini-Tn10 and Tn5 transposition decreased under SiMF and increased under PMF, as compared to sham exposure control. No significant difference was found between frequencies and between exposure times. **CONCLUSIONS:** ELF-MF exposure affects transposition activity and the effects critically depend on the wave shape of the field, but not on the frequency and the exposure time, at least in the range observed.

(E) [Heredia-Rojas JA](#), [Rodríguez de la Fuente AO](#), [Alcocer González JM](#), [Rodríguez-Flores LE](#), [Rodríguez-Padilla C](#), [Santovo-Stephano MA](#), [Castañeda-Garza E](#), [Taméz-Guerra RS](#). Effect of 60 Hz magnetic fields on the activation of hsp70 promoter in cultured INER-37 and RMA E7 cells. [In Vitro Cell Dev Biol Anim](#). 46(9):758-63, 2010. **(GE)**

It has been reported that 50-60 Hz magnetic fields (MF) with flux densities ranging from microtesla to millitesla are able to induce heat shock factor or heat shock proteins in various cells. In this study, we investigated the effect of 60 Hz sinusoidal MF at 8 and 80 μ T on the expression of the luciferase gene contained in a plasmid labeled as electromagnetic field-plasmid (pEMF). This gene construct contains the specific sequences previously described for the

induction of hsp70 expression by MF, as well as the reporter for the luciferase gene. The pEMF vector was transfected into INER-37 and RMA E7 cell lines that were later exposed to either MF or thermal shock (TS). Cells that received the MF or TS treatments and their controls were processed according to the luciferase assay system for evaluate luciferase activity. An increased luciferase gene expression was observed in INER-37 cells exposed to MF and TS compared with controls ($p < 0.05$), but MF exposure had no effect on the RMA E7 cell line.

(NE) [Huwiler SG](#), [Beyer C](#), [Fröhlich J](#), [Hennecke H](#), [Egli T](#), [Schürmann D](#), [Rehrauer H](#), [Fischer HM](#). Genome-wide transcription analysis of *Escherichia coli* in response to extremely low-frequency magnetic fields. [Bioelectromagnetics](#). 2012 Feb 13. doi: 10.1002/bem.21709. [Epub ahead of print] **(GE)**

The widespread use of electricity raises the question of whether or not 50 Hz (power line frequency in Europe) magnetic fields (MFs) affect organisms. We investigated the transcription of *Escherichia coli* K-12 MG1655 in response to extremely low-frequency (ELF) MFs. Fields generated by three signal types (sinusoidal continuous, sinusoidal intermittent, and power line intermittent; all at 50 Hz, 1 mT) were applied and gene expression was monitored at the transcript level using an Affymetrix whole-genome microarray. Bacterial cells were grown continuously in a chemostat (dilution rate $D = 0.4 \text{ h}^{-1}$) fed with glucose-limited minimal medium and exposed to 50 Hz MFs with a homogenous flux density of 1 mT. For all three types of MFs investigated, neither bacterial growth (determined using optical density) nor culturable counts were affected. Likewise, no statistically significant change (fold-change > 2 , $P \leq 0.01$) in the expression of 4,358 genes and 714 intergenic regions represented on the gene chip was detected after MF exposure for 2.5 h (1.4 generations) or 15 h (8.7 generations). Moreover, short-term exposure (8 min) to the sinusoidal continuous and power line intermittent signal neither affected bacterial growth nor showed evidence for reliable changes in transcription. In conclusion, our experiments did not indicate that the different tested MFs (50 Hz, 1 mT) affected the transcription of *E. coli*.

(NE) [Jin YB](#), [Kang GY](#), [Lee JS](#), [Choi JI](#), [Lee JW](#), [Hong SC](#), [Myung SH](#), [Lee YS](#). Effects on micronuclei formation of 60-Hz electromagnetic field exposure with ionizing radiation, hydrogen peroxide, or c-Myc overexpression. [Int J Radiat Biol](#). 88(4):374-380, 2012. **(GT, IA)**

PURPOSE: Epidemiological studies have demonstrated a possible correlation between exposure to extremely low-frequency magnetic fields (ELF-MF) and cancer. However, this correlation has yet to be definitively confirmed by epidemiological studies. The principal objective of this study was to assess the effects of 60 Hz magnetic fields in a normal cell line system, and particularly in combination with various external factors, via micronucleus (MN) assays. **MATERIALS AND METHODS:** Mouse embryonic fibroblast NIH3T3 cells and human lung fibroblast WI-38 cells were exposed for 4 h to a 60 Hz, 1 mT uniform magnetic field with or without ionizing radiation (IR, 2 Gy), H_2O_2 (100 μM) and cellular myelocytomatosis oncogene (c-Myc) activation. **RESULTS:** The results obtained showed no significant differences between the cells exposed to ELF-MF alone and the unexposed cells. Moreover, no synergistic effects were observed when ELF-MF was combined with IR, H_2O_2 , and c-Myc

activation. **CONCLUSIONS:** Our results demonstrate that ELF-MF did not enhance MN frequency by IR, H₂O₂ and c-Myc activation.

(NE) Jin YB, Choi SH, Lee JS, Kim JK, Lee JW, Hong SC, Myung SH, Lee YS. Absence of DNA damage after 60-Hz electromagnetic field exposure combined with ionizing radiation, hydrogen peroxide, or c-Myc overexpression. Radiat Environ Biophys. 2013 Dec 5. [Epub ahead of print] (GT, IA)

The principal objective of this study was to assess the DNA damage in a normal cell line system after exposure to 60 Hz of extremely low frequency magnetic field (ELF-MF) and particularly in combination with various external factors, via comet assays. NIH3T3 mouse fibroblast cells, WI-38 human lung fibroblast cells, L132 human lung epithelial cells, and MCF10A human mammary gland epithelial cells were exposed for 4 or 16 h to a 60-Hz, 1 mT uniform magnetic field in the presence or absence of ionizing radiation (IR, 1 Gy), H₂O₂ (50 µM), or c-Myc oncogenic activation. The results obtained showed no significant differences between the cells exposed to ELF-MF alone and the unexposed cells. Moreover, no synergistic or additive effects were observed after 4 or 16 h of pre-exposure to 1 mT ELF-MF or simultaneous exposure to ELF-MF combined with IR, H₂O₂, or c-Myc activation.

(E) Jouni FJ, Abdolmaleki P, Ghanati F. Oxidative stress in broad bean (Vicia faba L.) induced by static magnetic field under natural radioactivity. Mutat Res. 741(1-2):116-121, 2012. (LE, GT, OX, IA)

The investigation was performed to evaluate the influence of the static magnetic field on oxidative stress in Vicia faba cultivated in soil from high background natural radioactivity in Iran. Soil samples were collected from Ramsar, Iran where the annual radiation absorbed dose from background radiation is substantially higher than 20 mSv/year. The soil samples were then divided into 2 separate groups including high and low natural radioactivity. The plants were continuously exposed to static magnetic field of 15 mT for 8 days, each 8h/day. The results showed that in the plants cultivated in soils with high background natural radioactivity and low background natural radioactivity the activity of antioxidant enzymes as well as flavonoid content were lower than those of the control. Treatment of plants with static magnetic field showed similar results in terms of lowering of antioxidant defense system and increase of peroxidation of membrane lipids. Accumulation of ROS also resulted in chromosomal aberration and DNA damage. This phenomenon was more pronounced when a combination of natural radiation and treatment with static magnetic field was applied. The results suggest that exposure to static magnetic field causes accumulation of reactive oxygen species in V. faba and natural radioactivity of soil exaggerates oxidative stress.

(E) Kim J, Ha CS, Lee HJ, Song K. Repetitive exposure to a 60-Hz time-varying magnetic field induces DNA double-strand breaks and apoptosis in human cells. Biochem Biophys Res Commun. 400(4):739-744, 2010. (GT)

We investigated the effects of extremely low frequency time-varying magnetic fields (MFs) on human normal and cancer cells. Whereas a single exposure to a 60-Hz time-varying MF of 6 mT for 30min showed no effect, repetitive exposure decreased cell viability. This decrease was

accompanied by phosphorylation of γ -H2AX, a common DNA double-strand break (DSB) marker, and checkpoint kinase 2 (Chk2), which is critical to the DNA damage checkpoint pathway. In addition, repetitive exposure to a time-varying MF of 6 mT for 30 min every 24 h for 3 days led to p38 activation and induction of apoptosis in cancer and normal cells. Therefore, these results demonstrate that repetitive exposure to MF with extremely low frequency can induce DNA DSBs and apoptosis through p38 activation. These results also suggest the need for further evaluation of the effects of repetitive exposure to environmental time-varying MFs on human health.

(E) Kim J, Yoon Y, Yun S, Park GS, Lee HJ, Song K. Time-varying magnetic fields of 60 Hz at 7 mT induce DNA double-strand breaks and activate DNA damage checkpoints without apoptosis. Bioelectromagnetics. 33(5):383-393, 2012. (GT, WS)

The potential genotoxic effect of a time-varying magnetic field (MF) on human cells was investigated. Upon continuous exposure of human primary fibroblast and cervical cancer cells to a 60 Hz MF at 7 mT for 10-60 min, no significant change in cell viability was observed. However, deoxyribonucleic acid (DNA) double-strand breaks (DSBs) were detected, and the DNA damage checkpoint pathway was activated in these cells without programmed cell death (called apoptosis). The exposure of human cells to a 60 Hz MF did not induce intracellular reactive oxygen species (ROS) production, suggesting that the observed DNA DSBs are not directly caused by ROS. We also compared the position and time dependency of DNA DSBs with numerical simulation of MFs. The Lorentz force and eddy currents in these experiments were numerically calculated to investigate the influence of each factor on DNA DSBs. The DNA DSBs mainly occurred at the central region, where the MF was strongest, after a 30-min exposure. After 90 min, however, the amount of DNA DSBs increased rapidly in the outer regions, where the eddy current and Lorentz force were strong.

(NE) Kirschenlohr H, Ellis P, Hesketh R, Metcalfe J. Gene Expression Profiles in White Blood Cells of Volunteers Exposed to a 50 Hz Electromagnetic Field. Radiat Res. 178(3): 138-149, 2012. (GE, HU)

Consistent and independently replicated laboratory evidence to support a causative relationship between environmental exposure to extremely low-frequency electromagnetic fields (EMFs) at power line frequencies and the associated increase in risk of childhood leukemia has not been obtained. In particular, although gene expression responses have been reported in a wide variety of cells, none has emerged as robust, widely replicated effects. DNA microarrays facilitate comprehensive searches for changes in gene expression without a requirement to select candidate responsive genes. To determine if gene expression changes occur in white blood cells of volunteers exposed to an ELF-EMF, each of 17 pairs of male volunteers age 20-30 was subjected either to a 50 Hz EMF exposure of $62.0 \pm 7.1 \mu\text{T}$ for 2 h or to a sham exposure ($0.21 \pm 0.05 \mu\text{T}$) at the same time (11:00 a.m. to 13:00 p.m.). The alternative regime for each volunteer was repeated on the following day and the two-day sequence was repeated 6 days later, with the exception that a null exposure ($0.085 \pm 0.01 \mu\text{T}$) replaced the sham exposure. Five blood samples (10 ml) were collected at 2 h intervals from 9:00 to 17:00 with five additional samples during the exposure and sham or null exposure periods on each study day. RNA samples were pooled for the same time on each study day for the group of 17 volunteers that were subjected to the

ELF-EMF exposure/sham or null exposure sequence and were analyzed on Illumina microarrays. Time courses for 16 mammalian genes previously reported to be responsive to ELF-EMF exposure, including immediate early genes, stress response, cell proliferation and apoptotic genes were examined in detail. No genes or gene sets showed consistent response profiles to repeated ELF-EMF exposures. A stress response was detected as a transient increase in plasma cortisol at the onset of either exposure or sham exposure on the first study day. The cortisol response diminished progressively on subsequent exposures or sham exposures, and was attributable to mild stress associated with the experimental protocol.

(E) [Kovama S](#), [Sakurai T](#), [Nakahara T](#), [Miyakoshi J](#). Extremely low frequency (ELF) magnetic fields enhance chemically induced formation of apurinic/aprimidinic (AP) sites in A172 cells. [Int J Radiat Biol](#). 84(1):53-59, 2008. (GT, IA)

PURPOSE: To detect the effects of extremely low frequency (ELF) magnetic fields, the number of apurinic/aprimidinic (AP) sites in human glioma A172 cells was measured following exposure to ELF magnetic fields. **MATERIALS AND METHODS:** The cells were exposed to an ELF magnetic field alone, to genotoxic agents (methyl methane sulfonate (MMS) and hydrogen peroxide (H₂O₂)) alone, or to an ELF magnetic field with the genotoxic agents. After exposure, DNA was extracted, and the number of AP sites was measured. **RESULTS:** There was no difference in the number of AP sites between cells exposed to an ELF magnetic field and sham controls. With MMS or H₂O₂ alone, the number of AP sites increased with longer treatment times. Exposure to an ELF magnetic field in combination with the genotoxic agents increased AP-site levels compared with the genotoxic agents alone. **CONCLUSIONS:** Our results suggest that the number of AP sites induced by MMS or H₂O₂ is enhanced by exposure to ELF magnetic fields at 5 millitesla (mT). This may occur because such exposure can enhance the activity or lengthen the lifetime of radical pairs.

(E) [Lee JW](#), [Kim MS](#), [Kim YJ](#), [Choi YJ](#), [Lee Y](#), [Chung HW](#). Genotoxic effects of 3 T magnetic resonance imaging in cultured human lymphocytes. [Bioelectromagnetics](#). 32(7):535-542, 2011. (GT)

The clinical and preclinical use of high-field intensity (HF, 3 T and above) magnetic resonance imaging (MRI) scanners have significantly increased in the past few years. However, potential health risks are implied in the MRI and especially HF MRI environment due to high-static magnetic fields, fast gradient magnetic fields, and strong radiofrequency electromagnetic fields. In this study, the genotoxic potential of 3 T clinical MRI scans in cultured human lymphocytes in vitro was investigated by analyzing chromosome aberrations (CA), micronuclei (MN), and single-cell gel electrophoresis. Human lymphocytes were exposed to electromagnetic fields generated during MRI scanning (clinical routine brain examination protocols: three-channel head coil) for 22, 45, 67, and 89 min. We observed a significant increase in the frequency of single-strand DNA breaks following exposure to a 3 T MRI. In addition, the frequency of both CAs and MN in exposed cells increased in a time-dependent manner. The frequencies of MN in lymphocytes exposed to complex electromagnetic fields for 0, 22, 45, 67, and 89 min were 9.67, 11.67, 14.67, 18.00, and 20.33 per 1000 cells, respectively. Similarly, the frequencies of CAs in lymphocytes exposed for 0, 45, 67, and 89 min were 1.33, 2.33, 3.67, and 4.67 per 200 cells,

respectively. These results suggest that exposure to 3 T MRI induces genotoxic effects in human lymphocytes.

(E) Leone L, Fusco S, Mastrodonato A, Piacentini R, Barbati SA, Zaffina S, Pani G, Podda MV, Grassi C. Epigenetic Modulation of Adult Hippocampal Neurogenesis by Extremely Low-Frequency Electromagnetic Fields. Mol Neurobiol. 2014 Feb 16. [Epub ahead of print] (GE)

Throughout life, adult neurogenesis generates new neurons in the dentate gyrus of hippocampus that have a critical role in memory formation. Strategies able to stimulate this endogenous process have raised considerable interest because of their potential use to treat neurological disorders entailing cognitive impairment. We previously reported that mice exposed to extremely low-frequency electromagnetic fields (ELFEFs) showed increased hippocampal neurogenesis. Here, we demonstrate that the ELFEF-dependent enhancement of hippocampal neurogenesis improves spatial learning and memory. To gain insights on the molecular mechanisms underlying ELFEFs' effects, we extended our studies to an in vitro model of neural stem cells (NSCs) isolated from the hippocampi of newborn mice. We found that ELFEFs enhanced proliferation and neuronal differentiation of hippocampal NSCs by regulation of epigenetic mechanisms leading to pro-neuronal gene expression. Upon ELFEF stimulation of NSCs, we observed a significant enhancement of expression of the pro-proliferative gene hairy enhancer of split 1 and the neuronal determination genes NeuroD1 and Neurogenin1. These events were preceded by increased acetylation of H3K9 and binding of the phosphorylated transcription factor cAMP response element-binding protein (CREB) on the regulatory sequence of these genes. Such ELFEF-dependent epigenetic modifications were prevented by the Ca_v1-channel blocker nifedipine, and were associated with increased occupancy of CREB-binding protein (CBP) to the same loci within the analyzed promoters. Our results unravel the molecular mechanisms underlying the ELFEFs' ability to improve endogenous neurogenesis, pointing to histone acetylation-related chromatin remodeling as a critical determinant. These findings could pave the way to the development of novel therapeutic approaches in regenerative medicine.

(E) Li SS, Zhang ZY, Yang CJ, Lian HY, Cai P. Gene expression and reproductive abilities of male *Drosophila melanogaster* subjected to ELF-EMF exposure. Mutat Res. 758(1-2):95-103, 2013. (GE, LE, RP)

Extremely low frequency electromagnetic field (ELF-EMF) exposure is attracting increased attention as a possible disease-inducing factor. The in vivo effects of short-term and long-term ELF-EMF exposure on male *Drosophila melanogaster* were studied using transcriptomic analysis for preliminary screening and QRT-PCR for further verification. Transcriptomic analysis indicated that 439 genes were up-regulated and 874 genes were down-regulated following short-term exposures and that 514 genes were up-regulated and 1206 genes were down-regulated following long-term exposures (expression >2- or <0.5-fold, respectively). In addition, there are 238 up-regulated genes and 598 down-regulated genes in the intersection of short-term and long-term exposure (expression >2- or <0.5-fold). The DEGs (differentially expressed genes) in *D. melanogaster* following short-term exposures were involved in metabolic processes, cytoskeletal organization, mitotic spindle organization, cell death, protein modification and proteolysis. Long-term exposure led to changes in expression of genes involved in metabolic

processes, response to stress, mitotic spindle organization, aging, cell death and cellular respiration. In the intersection of short-term and long-term exposure, a series of DEGs were related to apoptosis, aging, immunological stress and reproduction. To check the ELF-EMF effects on reproduction, some experiments on male reproduction ability were performed. Their results indicated that short-term ELF-EMF exposure may decrease the reproductive ability of males, but long-term exposures had no effect on reproductive ability. Down-regulation of ark gene in the exposed males suggests that the decrease in reproductive capacity may be induced by the effects of ELF-EMF exposure on spermatogenesis through the caspase pathway. QRT-PCR analysis confirmed that jra, ark and decay genes were down regulated in males exposed for 1 Generation (1G) and 72 h, which suggests that apoptosis may be inhibited in vivo. ELF-EMF exposure may have accelerated cell senescence, as suggested by the down-regulation of both cat and jra genes and the up-regulation of hsp22 gene. Up-regulation of totA and hsp22 genes during exposure suggests that exposed flies might induce an in vivo immune response to counter the adverse effects encountered during ELF-EMF exposure. Down-regulation of cat genes suggests that the partial oxidative protection system might be restrained, especially during short-term exposures. This study demonstrates the bioeffects of ELF-EMF exposure and provides evidence for understanding the in vivo mechanisms of ELF-EMF exposure on male *D. melanogaster*.

(E) [Lupke M](#), [Frahm J](#), [Lantow M](#), [Maercker C](#), [Remondini D](#), [Bersani F](#), [Simkó M](#). Gene expression analysis of ELF-MF exposed human monocytes indicating the involvement of the alternative activation pathway. [Biochim Biophys Acta](#). 1763(4):402-12, 2006. (GE)

This study focused on the cell activating capacity of extremely low frequency magnetic fields (ELF-MF) on human umbilical cord blood-derived monocytes. Our results confirm the previous findings of cell activating capacity of ELF-MF (1.0 mT) in human monocytes, which was detected as an increased ROS release. Furthermore, gene expression profiling (whole-genome cDNA array Human Unigene RZPD-2) was performed to achieve a comprehensive view of involved genes during the cell activation process after 45 min ELF-MF exposure. Our results indicate the alteration of 986 genes involved in metabolism, cellular physiological processes, signal transduction and immune response. Significant regulations could be analyzed for 5 genes (expression >2- or <0.5-fold): IL15RA (Interleukin 15 receptor, alpha chain), EPS15R (Epidermal growth factor receptor pathway substrate 15 - like 1), DNMT3A (Hypothetical protein MGC16121), DNMT3A (DNA (cytosine-5) methyltransferase 3 alpha), and one gene with no match to known genes, DKFZP586J1624. Real-time RT-PCR analysis of the kinetic of the expression of IL15RA, and IL10RA during 45 min ELF-MF exposure indicates the regulation of cell activation via the alternative pathway, whereas the delayed gene expression of FOS, IL2RA and the melatonin synthesizing enzyme HIOMT suggests the suppression of inflammatory processes. Accordingly, we suggest that ELF-MF activates human monocytes via the alternative pathway.

(E) [Luukkonen J](#), [Liimatainen A](#), [Höytö A](#), [Juutilainen J](#), [Naarala J](#). Pre-exposure to 50 Hz magnetic fields modifies menadione-induced genotoxic effects in human SH-SY5Y neuroblastoma cells. [PLoS One](#). 2011 Mar 23;6(3):e18021. (GT, IA)

BACKGROUND: Extremely low frequency (ELF) magnetic fields (MF) are generated by power lines and various electric appliances. They have been classified as possibly carcinogenic

by the International Agency for Research on Cancer, but a mechanistic explanation for carcinogenic effects is lacking. A previous study in our laboratory showed that pre-exposure to ELF MF altered cancer-relevant cellular responses (cell cycle arrest, apoptosis) to menadione-induced DNA damage, but it did not include endpoints measuring actual genetic damage. In the present study, we examined whether pre-exposure to ELF MF affects chemically induced DNA damage level, DNA repair rate, or micronucleus frequency in human SH-SY5Y neuroblastoma cells. **METHODOLOGY/PRINCIPAL FINDINGS:** Exposure to 50 Hz MF was conducted at 100 μ T for 24 hours, followed by chemical exposure for 3 hours. The chemicals used for inducing DNA damage and subsequent micronucleus formation were menadione and methyl methanesulphonate (MMS). Pre-treatment with MF enhanced menadione-induced DNA damage, DNA repair rate, and micronucleus formation in human SH-SY5Y neuroblastoma cells. Although the results with MMS indicated similar effects, the differences were not statistically significant. No effects were observed after MF exposure alone. **CONCLUSIONS:** The results confirm our previous findings showing that pre-exposure to MFs as low as 100 μ T alters cellular responses to menadione, and show that increased genotoxicity results from such interaction. The present findings also indicate that complementary data at several chronological points may be critical for understanding the MF effects on DNA damage, repair, and post-repair integrity of the genome.

(E) Luukkonen J, Liimatainen A, Juutilainen J, Naarala J. Induction of genomic instability, oxidative processes, and mitochondrial activity by 50Hz magnetic fields in human SH-SY5Y neuroblastoma cells. Mutat Res. 760:33-41, 2014. (GT, OX, IA)

Epidemiological studies have suggested that exposure to 50Hz magnetic fields (MF) increases the risk of childhood leukemia, but there is no mechanistic explanation for carcinogenic effects. In two previous studies we have observed that a 24-h pre-exposure to MF alters cellular responses to menadione-induced DNA damage. The aim of this study was to investigate the cellular changes that must occur already during the first 24h of exposure to MF, and to explore whether the MF-induced changes in DNA damage response can lead to genomic instability in the progeny of the exposed cells. In order to answer these questions, human SH-SY5Y neuroblastoma cells were exposed to a 50-Hz, 100- μ T MF for 24h, followed by 3-h exposure to menadione. The main finding was that MF exposure was associated with increased level of micronuclei, used as an indicator of induced genomic instability, at 8 and 15d after the exposures. Other delayed effects in MF-exposed cells included increased mitochondrial activity at 8d, and increased reactive oxygen species (ROS) production and lipid peroxidation at 15d after the exposures. Oxidative processes (ROS production, reduced glutathione level, and mitochondrial superoxide level) were affected by MF immediately after the exposure. In conclusion, the present results suggest that MF exposure disturbs oxidative balance immediately after the exposure, which might explain our previous findings on MF altered cellular responses to menadione-induced DNA damage. Persistently elevated levels of micronuclei were found in the progeny of MF-exposed cells, indicating induction of genomic instability.

(E) Ma Q, Deng P, Zhu G, Liu C, Zhang L, Zhou Z, Luo X, Li M, Zhong M, Yu Z, Chen C, Zhang Y. Extremely low-frequency electromagnetic fields affect transcript levels of

neuronal differentiation-related genes in embryonic neural stem cells. PLoS One. 2014 Mar 3;9(3):e90041. doi: 10.1371/journal.pone.0090041. eCollection 2014. (GE)

Previous studies have reported that extremely low-frequency electromagnetic fields (ELF-EMF) can affect the processes of brain development, but the underlying mechanism is largely unknown. The proliferation and differentiation of embryonic neural stem cells (eNSCs) is essential for brain development during the gestation period. To date, there is no report about the effects of ELF-EMF on eNSCs. In this paper, we studied the effects of ELF-EMF on the proliferation and differentiation of eNSCs. Primary cultured eNSCs were treated with 50 Hz ELF-EMF; various magnetic intensities and exposure times were applied. Our data showed that there was no significant change in cell proliferation, which was evaluated by cell viability (CCK-8 assay), DNA synthesis (Edu incorporation), average diameter of neurospheres, cell cycle distribution (flow cytometry) and transcript levels of cell cycle related genes (P53, P21 and GADD45 detected by real-time PCR). When eNSCs were induced to differentiation, real-time PCR results showed a down-regulation of Sox2 and up-regulation of Math1, Math3, Ngn1 and Tuj1 mRNA levels after 50 Hz ELF-EMF exposure (2 mT for 3 days), but the percentages of neurons (Tuj1 positive cells) and astrocytes (GFAP positive cells) were not altered when detected by immunofluorescence assay. Although cell proliferation and the percentages of neurons and astrocytes differentiated from eNSCs were not affected by 50 Hz ELF-EMF, the expression of genes regulating neuronal differentiation was altered. In conclusion, our results support that 50 Hz ELF-EMF induce molecular changes during eNSCs differentiation, which might be compensated by post-transcriptional mechanisms to support cellular homeostasis.

(E) [Mairs RJ](#), [Hughes K](#), [Fitzsimmons S](#), [Prise KM](#), [Livingstone A](#), [Wilson L](#), [Baig N](#), [Clark AM](#), [Timpson A](#), [Patel G](#), [Folkard M](#), [Angerson WJ](#), [Boyd M](#). Microsatellite analysis for determination of the mutagenicity of extremely low-frequency electromagnetic fields and ionising radiation in vitro. [Mutat Res.](#) 626(1-2):34-41, 2007. (GT, IA)

Extremely low-frequency electromagnetic fields (ELF-EMF) have been reported to induce lesions in DNA and to enhance the mutagenicity of ionising radiation. However, the significance of these findings is uncertain because the determination of the carcinogenic potential of EMFs has largely been based on investigations of large chromosomal aberrations. Using a more sensitive method of detecting DNA damage involving microsatellite sequences, we observed that exposure of UVW human glioma cells to ELF-EMF alone at a field strength of 1 mT (50 Hz) for 12 h gave rise to 0.011 mutations/locus/cell. This was equivalent to a 3.75-fold increase in mutation induction compared with unexposed controls. Furthermore, ELF-EMF increased the mutagenic capacity of 0.3 and 3 Gy gamma-irradiation by factors of 2.6 and 2.75, respectively. These results suggest not only that ELF-EMF is mutagenic as a single agent but also that it can potentiate the mutagenicity of ionising radiation. Treatment with 0.3 Gy induced more than 10 times more mutations per unit dose than irradiation with 3 Gy, indicating hypermutability at low dose.

(E) [Mariucci G](#), [Villarini M](#), [Moretti M](#), [Taha E](#), [Conte C](#), [Minelli A](#), [Aristei C](#), [Ambrosini MV](#).

Brain DNA damage and 70-kDa heat shock protein expression in CD1 mice exposed to extremely low frequency magnetic fields. [Int J Radiat Biol.](#) 86(8):701-710, 2010. (GT, LE)

PURPOSE: The question of whether exposure to extremely low frequency magnetic fields (ELF-MF), may contribute to cerebral cancer and neurodegeneration is of current interest. In this study we investigated whether exposure to ELF-MF (50 Hz-1 mT) harms cerebral DNA and induces expression of 70-kDa heat shock protein (hsp70). **MATERIALS AND METHODS:** CD1 mice were exposed to a MF (50 Hz-1 mT) for 1 or 7 days (15 h/day) and sacrificed either at the end of exposure or after 24 h. Unexposed and sham-exposed mice were used as controls. Mouse brains were dissected into cerebral cortex-striatum, hippocampus and cerebellum to evaluate primary DNA damage and hsp70 gene expression. Food intake, weight gain, and motor activity were also evaluated. **RESULTS:** An increase in primary DNA damage was detected in all cerebral areas of the exposed mice sacrificed at the end of exposure, as compared to controls. DNA damage, as can be evaluated by the comet assay, appeared to be repaired in mice sacrificed 24 h after a 7-day exposure. Neither a short (15 h) nor long (7 days) MF-exposure induced hsp70 expression, metabolic and behavioural changes. **CONCLUSIONS:** These results indicate that in vivo ELF-MF induce reversible brain DNA damage while they do not elicit the stress response.

(E) Markkanen A, Juutilainen J, Naarala J. Pre-exposure to 50 Hz magnetic fields modifies menadione-induced DNA damage response in murine L929 cells. *Int J Radiat Biol.* 84(9):742-751, 2008. (IA)

PURPOSE: Effects on DNA damage response were investigated in murine L929 cells exposed to 50 Hz magnetic fields (MF) with or without ultraviolet B (UVB, wavelength 280-320 nm) radiation or menadione (MQ). **MATERIALS AND METHODS:** Cells were exposed to MF at 100 or 300 microT combined with MQ (150 microM, 1 hour) or UVB radiation (160 J/m(2)) using various exposure schedules. The samples were stained with propidium iodide (PI) and analysed by flow cytometer for cell cycle stages. Apoptotic cells were defined as sub G(1) events. **RESULTS:** In cells first exposed to 100 microT MF for 24 h, the response to subsequent MQ treatment was significantly altered so that the proportion of sub G(1) cells was decreased and the proportion of cells in the G(2)/M phase was increased. When a 300 microT MF was used, also the proportion of cells in the G(1) phase was decreased. MF exposures after MQ treatment did not alter responses to MQ. No effects were found from MF exposure alone or from MF combined with UVB radiation. **CONCLUSIONS:** The results strengthen previous findings suggesting that pre-exposure to MF can alter cellular responses to other agents, and indicate that MF as low as 100 microT has measurable impacts on cancer-relevant cellular processes such as DNA-damage.

(NE) Mizuno K, Narita E, Yamada M, Shinohara N, Miyakoshi J. ELF magnetic fields do not affect cell survival and DNA damage induced by ultraviolet B. *Bioelectromagnetics.* 35(2):108-115, 2014. (GT, IA)

We investigated whether extremely low frequency (ELF) magnetic field exposure has modification effects on cell survival after ultraviolet B (UV-B) irradiation and on repair process of DNA damage induced by UV-B irradiation in WI38VA13 subcloned 2RA and XP2OS(SV) cells. The ELF magnetic field exposure was conducted using a Helmholtz coil-based system that was designed to generate a sinusoidal magnetic field at 5 mT and 60 Hz. Cell survival was assessed by WST assay after UV-B irradiation at 20-80 J/m(2) , ELF magnetic field exposure for

24 h, followed by incubation for 48 h. DNA damage was assessed by quantification of cyclobutane pyrimidine dimer formation and 6-4 photoproduct formation using ELISA after UV-B irradiation at 20-80 J/m² followed by ELF magnetic field exposure for 24 h. No significant changes were observed in cell survival between ELF magnetic field and sham exposures. Similarly, DNA damage induced by UV-B irradiation did not change significantly following ELF magnetic field exposure. Our results suggest that ELF magnetic field exposure at 5 mT does not have modification effect on cell survival after UV-B irradiation and on repair process of DNA damage induced by UV-B irradiation.

(E) Nikolova T, Czyz J, Rolletschek A, Blyszczuk P, Fuchs J, Jovtchev G, Schuderer J, Kuster N, Wobus AM. Electromagnetic fields affect transcript levels of apoptosis-related genes in embryonic stem cell-derived neural progenitor cells. ASEB J 19(12):1686-1688, 2005. (GT, GE)

Mouse embryonic stem (ES) cells were used as an experimental model to study the effects of electromagnetic fields (EMF). ES-derived nestin-positive neural progenitor cells were exposed to extremely low frequency EMF simulating power line magnetic fields at 50 Hz (ELF-EMF) and to radiofrequency EMF simulating the Global System for Mobile Communication (GSM) signals at 1.71 GHz (RF-EMF). Following EMF exposure, cells were analyzed for transcript levels of cell cycle regulatory, apoptosis-related, and neural-specific genes and proteins; changes in proliferation; apoptosis; and cytogenetic effects. Quantitative RT-PCR analysis revealed that ELF-EMF exposure to ES-derived neural cells significantly affected transcript levels of the apoptosis-related bcl-2, bax, and cell cycle regulatory "growth arrest DNA damage inducible" GADD45 genes, whereas mRNA levels of neural-specific genes were not affected. RF-EMF exposure of neural progenitor cells resulted in down-regulation of neural-specific Nurr1 and in up-regulation of bax and GADD45 mRNA levels. Short-term RF-EMF exposure for 6 h, but not for 48 h, resulted in a low and transient increase of DNA double-strand breaks. No effects of ELF- and RF-EMF on mitochondrial function, nuclear apoptosis, cell proliferation, and chromosomal alterations were observed. We may conclude that EMF exposure of ES-derived neural progenitor cells transiently affects the transcript level of genes related to apoptosis and cell cycle control. However, these responses are not associated with detectable changes of cell physiology, suggesting compensatory mechanisms at the translational and posttranslational level.

(NE) Okudan N, Celik I, Salbacak A, Cicekcibasi AE, Buyukmumcu M, Gökbel H. Effects of long-term 50 Hz magnetic field exposure on the micro nucleated polychromatic erythrocyte and blood lymphocyte frequency and argyrophilic nucleolar organizer regions in lymphocytes of mice. Neuro Endocrinol Lett. 31(2):208-214, 2010. (GT)

OBJECTIVES: We aimed to investigate the effects of weak extremely low frequency electromagnetic fields (ELF-EMFs) on the nucleus size, the silver staining nucleolar organizer regions (AgNORs), the frequency of micro nucleated peripheral blood lymphocytes (MPBLs) and the micro nucleated polychromatic erythrocytes (MPCs). **METHODS:** One hundred and twenty Swiss albino mice were equally divided into 6 groups. The study groups were exposed to 1, 2, 3, 4 and 5 microT 50 Hz-EMFs for 40 days. Micronucleus number (MN) per PBL was determined. **RESULTS:** ELF-EMF exposure caused a nonlinear decline of nucleus area. A sharp drop occurred in AgNOR area of 1 microT group, and following it gained an insignificantly higher level than that of the control group. The field did not change mean AgNOR

numbers per nucleus of the groups. Relative AgNOR area had the highest level in 1 microT-exposure group, and the level was quite similar to that of the 5 microT-exposure group. The remaining groups had significantly lower values quite similar to that of the control level. The field exposure at any intensity did not affect significantly the frequency of either MPBLs or MPCEs. The number of MN per PBL in the 4 and 5 microT-exposure groups were significantly higher than those of the lower intensity exposure groups. The males in 4 microT-exposure group displayed the highest MN number per PBL, whereas values changed in a nonlinear manner.

CONCLUSIONS: The results of the present study suggest that ≤ 5 microT intensities of 50 Hz EMFs did not cause genotoxic effect on the mouse.

(E) Panagopoulos DJ, Karabarounis A, Lioliousis C. ELF alternating magnetic field decreases reproduction by DNA damage induction. Cell Biochem Biophys. 67(2):703-16, 2013. (LE, GT, RP)

In the present experiments, the effect of 50-Hz alternating magnetic field on *Drosophila melanogaster* reproduction was studied. Newly eclosed insects were separated into identical groups of ten males and ten females and exposed to three different intensities of the ELF magnetic field (1, 11, and 21 G) continuously during the first 5 days of their adult lives. The reproductive capacity was assessed by the number of F1 pupae according to a well-defined protocol of ours. The magnetic field was found to decrease reproduction by up to 4.3%. The effect increased with increasing field intensities. The decline in reproductive capacity was found to be due to severe DNA damage (DNA fragmentation) and consequent cell death induction in the reproductive cells as determined by the TUNEL assay applied during early and mid-oogenesis (from germarium to stage 10) where physiological apoptosis does not occur. The increase in DNA damage was more significant than the corresponding decrease in reproductive capacity (up to ~7.5%). The TUNEL-positive signal denoting DNA fragmentation was observed exclusively at the two most sensitive developmental stages of oogenesis: the early and mid-oogenesis checkpoints (i.e. region 2a/2b of the germarium and stages 7-8 just before the onset of vitellogenesis)-in contrast to exposure to microwave radiation of earlier work of ours in which the DNA fragmentation was induced at all developmental stages of early and mid-oogenesis. Moreover, the TUNEL-positive signal was observed in all three types of egg chamber cells, mainly in the nurse and follicle cells and also in the oocyte, in agreement with the microwave exposure of our earlier works. According to previous reports, cell death induction in the oocyte was observed only in the case of microwave exposure and not after exposure to other stress factors as toxic chemicals or food deprivation. Now it is also observed for the first time after ELF magnetic field exposure. Finally, in contrast to microwave exposure of previous experiments of ours in which the germarium checkpoint was found to be more sensitive than stage 7-8, in the magnetic field exposure of the present experiments the mid-oogenesis checkpoint was found to be more sensitive than the germarium.

(E) Rageh MM, El-Gebaly RH, El-Bialy NS. Assessment of genotoxic and cytotoxic hazards in brain and bone marrow cells of newborn rats exposed to extremely low-frequency magnetic field. J Biomed Biotechnol. 2012;2012:716023. (LE, GT, DE, OX)

The present study aimed to evaluate the association between whole body exposure to extremely low frequency magnetic field (ELF-MF) and genotoxic , cytotoxic hazards in brain and bone

marrow cells of newborn rats. Newborn rats (10 days after delivery) were exposed continuously to 50 Hz, 0.5 mT for 30 days. The control group was treated as the exposed one with the sole difference that the rats were not exposed to magnetic field. Comet assay was used to quantify the level of DNA damage in isolated brain cells. Also bone marrow cells were flushed out to assess micronucleus induction and mitotic index. Spectrophotometric methods were used to measure the level of malondialdehyde (MDA) and the activity of glutathione (GSH) and superoxide dismutase (SOD). The results showed a significant increase in the mean tail moment indicating DNA damage in exposed group ($P < 0.01$, 0.001, 0.0001). Moreover ELF-MF exposure induced a significant ($P < 0.01$, 0.001) four folds increase in the induction of micronucleus and about three folds increase in mitotic index ($P < 0.0001$). Additionally newborn rats exposed to ELF-MF showed significant higher levels of MDA and SOD ($P < 0.05$). Meanwhile ELF-MF failed to alter the activity of GSH. In conclusion, the present study suggests an association between DNA damage and ELF-MF exposure in newborn rats.

(E) Reyes-Guerrero G, Guzmán C, García DE, Camacho-Arroyo I, Vázquez-García M. Extremely low-frequency electromagnetic fields differentially regulate estrogen receptor-alpha and -beta expression in the rat olfactory bulb. *Neurosci Lett.* 471(2):109-13, 2010. (GE)

Recently, the effects of extremely low-frequency electromagnetic fields (ELF EMF) on biological systems have been extensively investigated. In this report, the influence of ELF EMF on olfactory bulb (OB) estrogen receptor-alpha (ER alpha) mRNA and -beta (ER beta) mRNA expression was studied by RT-PCR in adult female and male rats. Results reveal for the first time that ELF EMF exerted a biphasic effect on female OB ER beta mRNA gene expression, which increased during diestrous and decreased during estrous. We did not observe any influence of ELF EMF on female OB ER alpha mRNA expression. Our data demonstrate a fluctuating pattern of ER-alpha and -beta mRNA expression in the female OB throughout the phases of the estrous cycle in non-ELF EMF-exposed animals. Thus the highest ER alpha expression was observed in diestrous and the lowest in proestrous. The pattern of ER beta mRNA was less variable, the lowest expression was observed in diestrous. ER-alpha mRNA and -beta mRNA expression level in the male OB did not exhibit any variation either in ELF EMF-exposed or non-ELF EMF-exposed animals. In summary, ELF EMF modulate ER beta gene expression in the OB of female adult rats but not in males.

(E) Ruiz-Gómez MJ, Sendra-Portero F, Martínez-Morillo M. Effect of 2.45 mT sinusoidal 50 Hz magnetic field on *Saccharomyces cerevisiae* strains deficient in DNA strand breaks repair. *Int J Radiat Biol.* 86(7):602-611, 2010. (GT)

PURPOSE: To investigate whether extremely-low frequency magnetic field (MF) exposure produce alterations in the growth, cell cycle, survival and DNA damage of wild type (wt) and mutant yeast strains. **MATERIALS AND METHODS:** wt and high affinity DNA binding factor 1 (hdf1), radiation sensitive 52 (rad52), rad52 hdf1 mutant *Saccharomyces cerevisiae* strains were exposed to 2.45 mT, sinusoidal 50 Hz MF for 96 h. MF was generated by a pair of Helmholtz coils. During this time the growth was monitored by measuring the optical density at 600 nm and cell cycle evolution were analysed by microscopic morphological analysis. Then, yeast survival was assayed by the drop test and DNA was extracted and electrophoresed.

RESULTS: A significant increase in the growth was observed for rad52 strain ($P = 0.005$, Analysis of Variance [ANOVA]) and close to significance for rad52 hdf1 strain ($P = 0.069$, ANOVA). In addition, the surviving fraction values obtained for MF-exposed samples were in all cases less than for the controls, being the P value obtained for the whole set of MF-treated strains close to significance ($P = 0.066$, Student's t -test). In contrast, the cell cycle evolution and the DNA pattern obtained for wt and the mutant strains were not altered after exposure to MF.

CONCLUSIONS: The data presented in the current report show that the applied MF (2.45 mT, sinusoidal 50 Hz, 96 h) induces alterations in the growth and survival of *S. cerevisiae* strains deficient in DNA strand breaks repair. In contrast, the MF treatment does not induce alterations in the cell cycle and does not cause DNA damage.

(E) Sarimov R, Alipov ED, Belyaev IY. Fifty hertz magnetic fields individually affect chromatin conformation in human lymphocytes: dependence on amplitude, temperature, and initial chromatin state. *Bioelectromagnetics*. 32(7):570-579, 2011. (GT)

Effects of magnetic field (MF) at 50 Hz on chromatin conformation were studied by the method of anomalous viscosity time dependence (AVTD) in human lymphocytes from two healthy donors. MF within the peak amplitude range of 5-20 μ T affected chromatin conformation. These MF effects differed significantly between studied donors, and depended on magnetic flux density and initial condensation of chromatin. While the initial state of chromatin was rather stable in one donor during one calendar year of measurements, the initial condensation varied significantly in cells from another donor. Both this variation and the MF effect depended on temperature during exposure. Despite these variations, the general rule was that MF condensed the relaxed chromatin and relaxed the condensed chromatin. Thus, in this study we show that individual effects of 50 Hz MF exposure at peak amplitudes within the range of 5-20 μ T may be observed in human lymphocytes in dependence on the initial state of chromatin and temperature.

(E) Tiwari R, Lakshmi NK, Bhargava SC, Ahuja YR. Epinephrine, DNA integrity and oxidative stress in workers exposed to extremely low-frequency electromagnetic fields (ELF-EMFs) at 132 kV substations. *Electromagn Biol Med*. 2014 Jan 24. [Epub ahead of print] (LE, GT, HU, OX)

There is apprehension about widespread use of electrical and electromagnetic gadgets which are supposed to emit electromagnetic radiations. Reports are controversy. These electromagnetic fields (EMFs) have considerable effect on endocrine system of exposed subjects. This study was focused to assess the possible bioeffects of extremely low-frequency (ELF)-EMFs on epinephrine level, DNA damage and oxidative stress in subjects occupationally exposed to 132 kV high-voltage substations. The blood sample of 142 exposed subjects and 151 non-exposed individuals was analyzed. Plasma epinephrine was measured by enzyme-linked immunosorbent assay, DNA damage was studied by alkaline comet assay along with oxidative stress. Epinephrine levels of sub-groups showed mean concentration of 75.22 ± 1.46 , 64.43 ± 8.26 and 48.47 ± 4.97 for high, medium and low exposed groups, respectively. DNA damage ranged between 1.69 μ m and 9.91 μ m. The oxidative stress levels showed significant increase. The individuals employed in the live-line procedures were found to be vulnerable for EM stress with altered epinephrine concentrations, DNA damage and increased oxidative stress.

(E) [Udroiu I](#), [Cristaldi M](#), [Ieradi LA](#), [Bedini A](#), [Giuliani L](#), [Tanzarella C](#). Clastogenicity and aneuploidy in newborn and adult mice exposed to 50 Hz magnetic fields. [Int J Radiat Biol.](#) 82(8):561-567, 2006. **(GT, DE, LE)**

PURPOSE: To detect possible clastogenic and aneugenic properties of a 50 Hz, 650 μ T magnetic field. **MATERIALS AND METHODS:** The micronucleus test with CREST (Calcinosis, Raynaud's phenomenon, Esophageal dysmotility, Sclerodactility, Telangiectasia) antibody staining was performed on liver and peripheral blood sampled from newborn mice exposed to an ELF (Extremely Low Frequency) magnetic field during the whole intra-uterine life (21 days), and on bone marrow and peripheral blood sampled from adult mice exposed to the same magnetic field for the same period. **RESULTS:** Data obtained in newborn mice show a significant increase in micronuclei frequencies. In absolute terms, most of the induced micronuclei were CREST-negative (i.e., formed by a chromosome fragment). However, in relative terms, ELF exposure caused a two-fold increase in CREST-negative micronuclei and a four-fold increase in CREST-positive micronuclei (i.e., formed by a whole chromosome). No significant effect was recorded on exposed adults. **CONCLUSIONS:** These findings suggest the need for investigation of aneugenic properties of ELF magnetic fields in order to establish a possible relationship to carcinogenesis.

(NE) [Verschaeve L](#), [Anthonissen R](#), [Grudniewska M](#), [Wudarski J](#), [Gevaert L](#), [Maes A](#). Genotoxicity investigation of ELF-magnetic fields in *Salmonella typhimurium* with the sensitive SOS-based VITOTOX test. [Bioelectromagnetics.](#) 32(7):580-584, 2011. **(GT, IA)**

We performed a genotoxicity investigation of extremely low-frequency (ELF) magnetic fields (MFs, 50 Hz, 100 and 500 μ T, 1 and 2 h exposure) alone and in combination with known chemical mutagens using the VITOTOX test. This test is a very sensitive reporter assay of *Salmonella typhimurium* bacteria based on the SOS response. Our study showed that ELF-MFs do not induce SOS-based mutagenicity in *S. typhimurium* bacteria and do not show any synergetic effect when combined with chemical mutagens.

(E) [Villarini M](#), [Ambrosini MV](#), [Moretti M](#), [Dominici L](#), [Taha E](#), [Piobbico D](#), [Gambelungho C](#), [Mariucci G](#). Brain hsp70 expression and DNA damage in mice exposed to extremely low frequency magnetic fields: a dose-response study. [Int J Radiat Biol.](#) 89(7):562-570, 2013. **(LE, GT)**

Purpose: To determine whether a dose-response relationship exists among exposure to extremely low frequency magnetic fields (ELF-MF) at different densities and 70-kDa heat shock protein (hsp70) expression and DNA damage in mouse brain. **Materials and Methods:** Male CD1 mice were exposed to ELF-MF (50 Hz; 0.1, 0.2, 1 or 2 mT) for 7 days (15 hours/day) and sacrificed either at the end of exposure or after 24 h. Hsp70 expression was determined in cerebral cortex-striatum, hippocampus and cerebellum by real-time reverse-transcriptase polymerase chain reaction (RT-PCR) and western blot analysis. Primary DNA damage was evaluated in the same tissues by comet assay. Sham-exposed mice were used as controls. **Results:** No changes in both hsp70 mRNA and corresponding protein occurred following exposure to ELF-MF, except for a weak increase in the mRNA in hippocampus of exposed mice to 0.1 mT ELF-MF. Only mice exposed to 1 or 2 mT and sacrificed immediately after exposure presented DNA strand

breaks higher than controls in all the cerebral areas; such DNA breakage reverted to baseline in the mice sacrificed 24 h after exposure. Conclusions: These data show that high density ELF-MF only induce reversible brain DNA damage while they do not affect hsp70 expression.

(E) [Wahab MA](#), [Podd JV](#), [Rapley BI](#), [Rowland RE](#). Elevated sister chromatid exchange frequencies in dividing human peripheral blood lymphocytes exposed to 50 Hz magnetic fields. [Bioelectromagnetics](#). 28(4):281-288, 2007. (GT, WS)

The in vitro cytomolecular technique, sister chromatid exchange (SCE), was applied to test the clastogenic potentiality of extremely low frequency (ELF) electromagnetic fields (EMFs) on human peripheral blood lymphocytes (HPBLs). SCE frequencies were scored in dividing peripheral blood lymphocytes (PBLs) from six healthy male blood donors in two rounds of experiments, R1 and R2, to determine reproducibility. Lymphocyte cultures in the eight experiments conducted in each round were exposed to 50 Hz sinusoidal (continuous or pulsed) or square (continuous or pulsed) MFs at field strengths of 1 microT or 1 mT for 72 h. A significant increase in the number of SCEs/cell in the grouped experimental conditions compared to the controls was observed in both rounds. The highest SCE frequency in R1 was 10.03 for a square continuous field, and 10.39 for a square continuous field was the second highest frequency in R2. DNA crosslinking at the replication fork is proposed as a model which could explain the mechanistic link between ELF EMF exposure and increased SCE frequency.

(E) Wang Z, Sarje A, Che PL, Yarema KJ. Moderate strength (0.23-0.28 T) static magnetic fields (SMF) modulate signaling and differentiation in human embryonic cells. BMC Genomics. 10:356, 2009. (GE)

BACKGROUND: Compelling evidence exists that magnetic fields modulate living systems. To date, however rigorous studies have focused on identifying the molecular-level biosensor (e.g., radical ion pairs or membranes) or on the behavior of whole animals leaving a gap in understanding how molecular effects are translated into tissue-wide and organism-level responses. This study begins to bridge this gulf by investigating static magnetic fields (SMF) through global mRNA profiling in human embryonic cells coupled with software analysis to identify the affected signaling pathways. **RESULTS:** Software analysis of gene expression in cells exposed to 0.23-0.28 T SMF showed that nine signaling networks responded to SMF; of these, detailed biochemical validation was performed for the network linked to the inflammatory cytokine IL-6. We found the short-term (<24 h) activation of IL-6 involved the coordinate up-regulation of toll-like receptor-4 (TLR4) with complementary changes to NEU3 and ST3GAL5 that reduced ganglioside GM3 in a manner that augmented the activation of TLR4 and IL-6. Loss of GM3 also provided a plausible mechanism for the attenuation of cellular responses to SMF that occurred over longer exposure periods. Finally, SMF-mediated responses were manifest at the cellular level as morphological changes and biochemical markers indicative of pre-oligodendrocyte differentiation. **CONCLUSION:** This study provides a framework describing how magnetic exposure is transduced from a plausible molecular biosensor (lipid membranes) to cell-level responses that include differentiation toward neural lineages. In addition, SMF provided a stimulus that uncovered new relationships - that exist even in the absence of magnetic fields - between gangliosides, the time-dependent regulation of IL-6 signaling by these glycosphingolipids, and the fate of embryonic cells.

(NE) Williams PA, Ingebretsen RJ, Dawson RJ. 14.6 mT ELF magnetic field exposure yields no DNA breaks in model system Salmonella, but provides evidence of heat stress protection. Bioelectromagnetics. 27(6):445-450, 2006. (GT)

In this study, we demonstrate that common extremely low frequency magnetic field (MF) exposure does not cause DNA breaks in this Salmonella test system. The data does, however, provide evidence that MF exposure induces protection from heat stress. Bacterial cultures were exposed to MF (14.6 mT 60 Hz field, cycled 5 min on, 10 min off for 4 h) and a temperature-matched control. Double- and single-stranded DNA breaks were assayed using a recombination event counter. After MF or control exposure they were grown on indicator plates from which recombination events can be quantified and the frequency of DNA strand breaks deduced. The effect of MF was also monitored using a recombination-deficient mutant (recA). The results showed no significant increase in recombination events and strand breaks due to MF. Evidence of heat stress protection was determined using a cell viability assay that compared the survival rates of MF exposed and control cells after the administration of a 10 min 53 degrees C heat stress. The control cells exhibited nine times more cell mortality than the MF exposed cells. This Salmonella system provides many mutants and genetic tools for further investigation of this phenomenon.

(E) Yokus B, Akdag MZ, Dasdag S, Cakir DU, Kizil M. Extremely low frequency magnetic fields cause oxidative DNA damage in rats. Int J Radiat Biol. 84(10):789-795, 2008. (GT)

PURPOSE: To detect the genotoxic effects of extremely low frequency (ELF) -magnetic fields (MF) on oxidative DNA base modifications [8-hydroxyguanine (8-OH-Gua), 2,6-diamino-4-hydroxy-5-formamidopyrimidine (FapyGua) and 4,6-diamino-5-formamidopyrimidine (FapyAde)] in rat leucocytes, measured following exposure to ELF-MF. **MATERIALS AND METHODS:** After exposure to ELF-MF (50 Hz, 100 and 500 microT, for 2 hours/day during 10 months), DNA was extracted, and measurement of DNA lesions was achieved by gas chromatography/mass spectrometry (GC/MS) and liquid chromatography/mass spectrometry (LC/MS). **RESULTS:** Levels of FapyAde, FapyGua and 8OHdG in DNA were increased by both 100 microT and 500 microT ELF-MF as compared to a cage-control and a sham group; however, statistical significance was observed only in the group exposed to 100 microT. **CONCLUSION:** This is the first study to report that ELF-MF exposure generates oxidatively induced DNA base modifications which are mutagenic in mammalian cells, such as FapyGua, FapyAde and 8-OH-Gua, in vivo. This may explain previous studies showing DNA damage and genomic instability. These findings support the hypothesis that chronic exposure to 50-Hz MF may be potentially genotoxic. However, the intensity of ELF-MF has an important influence on the extent of DNA damage.

(E) Yoon HE, Lee JS, Myung SH, Lee YS. Increased γ -H2AX by exposure to a 60-Hz magnetic fields combined with ionizing radiation, but not hydrogen peroxide, in non-tumorigenic human cell lines. Int J Radiat Biol. 2014 Jan 28. [Epub ahead of print] (GT, IA)

Purpose: Genotoxic effects have been considered the gold standard to determine if an environmental factor is a carcinogen, but the currently available data for extremely low

frequency time-varying magnetic fields (ELF-MFs) remain controversial. As an environmental stimulus, the effect of ELF-MF on cellular DNA may be subtle. Therefore, a more sensitive method and systematic research strategy are warranted to evaluate genotoxicity. Materials and methods: We investigated the effect of ELF-MFs in combination with ionizing radiation (IR) or H_2O_2 on the DNA damage response of expression of phosphorylated H2AX (γ -H2AX) and production of γ -H2AX foci in non-tumorigenic human cell systems consisting of human lung fibroblast WI38 cells and human lung epithelial L132 cells. Results: Exposure to a 60-Hz, 2 mT ELF-MFs for 6 h produced increased γ -H2AX expression, as well as γ -H2AX foci production, a common DNA double-strand break (DSB) marker. However, exposure to a 1 mT ELF-MFs did not have the same effect. Moreover, 2 mT ELF-MFs exposure potentiated the expression of γ -H2AX and γ -H2AX foci production when combined with IR, but not when combined with H_2O_2 . Conclusions: ELF-MFs could affect the DNA damage response and, in combination with different stimuli, provide different effects on γ -H2AX.



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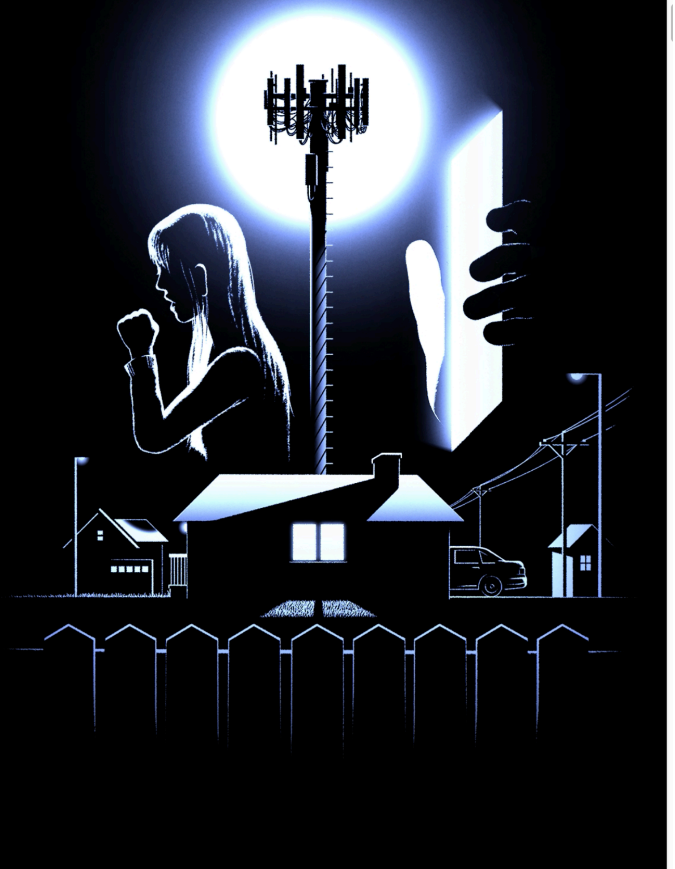
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Technology

How the FCC Shields Cellphone Companies From Safety Concerns

by Peter Elkind
Nov. 10, 5 a.m. EST



Anson Chan, special to ProPublica

The wireless industry is rolling out thousands of new transmitters amid a growing body of research that calls cellphone safety into question. Federal regulators say there's nothing to worry about — even as they rely on standards established in 1996.

By Peter Elkind

The health complaints started rolling in within weeks of the activation of a new cellphone tower in August 2020 in Pittsfield, an old factory town in Massachusetts' Berkshire Mountains. Seventeen residents reported headaches, dizziness, insomnia or confusion. A few children had to sleep with “vomit buckets” by their beds.

Like many people, Bobbie Orsi had never paid close attention to questions about the health effects of cellphone technology. She mostly viewed it as an issue that had long ago been put to rest. But after becoming the chair of Pittsfield's Board of Health as the complaints emerged, Orsi, a 66-year-old registered

nurse who had spent much of her career in public health, decided to educate herself. She combed through a stack of research studies. She watched webinars. She grilled a dozen scientists and doctors. Over several months, Orsi went from curious, to concerned, to convinced, first, that radio-frequency emissions from Verizon's 115-foot 4G tower were to blame for the problems in Pittsfield, and second, that growing evidence of harm from cellphones — everything from effects on fertility and fetal development to associations with cancer — has been downplayed in the U.S.

Orsi and the Pittsfield board decided to try to do something about Verizon's tower. They quickly discovered that they would get no help from federal regulators. The Federal Communications Commission (FCC), which has responsibility for protecting Americans from potential radiation hazards generated by wireless transmitters and cellphones, has repeatedly sided with the telecom industry in denying the possibility of virtually any human harm. Worse, from Orsi's perspective, federal law and FCC rules are so aligned with the industry that state and local governments are barred from taking action to block cell towers to protect the health of their citizens, even as companies are explicitly empowered to sue any government that tries to take such an action.

It turned out that Verizon, in such matters, has more legal rights than the people of Pittsfield. Still, the lawyers for Orsi and her colleagues thought they saw a long-shot legal opening: They would argue that the FCC's exclusive oversight role applied only to approving cell tower sites, not to health problems triggered after one was built and its transmitters switched on.

In April, the Pittsfield Health Board issued an emergency cease-and-desist order directing Verizon to shut down the tower as a "public nuisance" and "cause of sickness" that "renders dwellings unfit for human habitation." (Several families had abandoned their homes.) The order was the first of its kind in the country. It was, Orsi said, "a gutsy move — maybe naively gutsy." Almost as quickly as the battle began, it ended.

On May 10, Verizon sued the city in federal court. The company contended that the Pittsfield residents' medical complaints were bogus. And, in any case, Verizon argued, the cease-and-desist order was barred because federal law gave the FCC the sole power to regulate wireless-radiation risks. Fearing a hopeless and costly David-and-Goliath battle, Pittsfield's City Council refused to fund the fight. A month later, the Board of Health withdrew its cease-and-desist order. But it was a signal of a growing fear — other cities have fought cell sites only to be forced to back down — and evidence of a striking shoulder-to-shoulder partnership between a federal agency and the industry it is supposed to regulate.

The build-out of a new generation of wireless networks, known as 5G, is amping up the stakes of this conflict for localities across America. It will require an estimated 800,000 new base stations, including both towers and densely spaced "small cell" transmitters mounted on rooftops and street poles. That means nearly tripling the current number of transmitters, and many of them will be placed close to houses and apartments. The FCC has held firm to its position that there's no reason for concern. In a statement for this article, a spokesperson said the agency "takes safety issues very seriously" but declined to make officials available for on-the-record interviews.

The FCC is an improbable organization to serve the role of protecting humans. It specializes in technical issues that make the communications system function, not in health and safety. "At the FCC, they feel like this is really not their problem," said Edwin Mantiply, who dealt with cellphone-radiation issues before

retiring from the agency four years ago. “It’s not their job to do this kind of thing. They might have a token biologist or two, but that’s not their job.”

The result, Mantiply said, was that in situations where the science isn’t black and white — and it isn’t when it comes to cellphones — the agency tended to listen to the telecom industry, which vehemently insists that cellphones are safe. “They don’t really want to deal with uncertainty,” Mantiply said of the FCC. In the view of Mantiply and a rising number of scientists, there’s more than enough evidence about cellphone risks to be concerned — and some of the strongest evidence comes from the federal government itself.

In 2018, a massive, nearly-two-decade study by the National Toxicology Program (NTP), part of the National Institutes of Health, found “clear evidence” that cellphone radiation caused cancer in lab animals. “We’re really in the middle of a paradigm shift,” said Linda Birnbaum, who was director of the NTP until 2019. It’s no longer right to assume cellphones are safe, she said. “Protective policy is needed today. We really don’t need more science to know that we should be reducing exposures.”

The FCC rejected the need for any such action when it reviewed its standards on cellphone radiation in 2019. The agency decided it would continue to rely on exposure limits it established in 1996, when Motorola’s StarTAC flip phone was considered cutting edge. The way the FCC went about reexamining its standards so dismayed a federal appeals court that, in 2021, it excoriated the agency for what it called a “ cursory analysis.” The court accused it of “brushing off” evidence of potential harm and failing to explain its reasoning. The agency’s “silence,” the court said, left unclear whether the government even “considered any of the evidence in the record.” The appeals court ordered the agency to revisit the adequacy of its safeguards.

All this has left Orsi frustrated. Petite and intense, she has been through these sorts of fights before. Years ago, with the eventual support of the Environmental Protection Agency (EPA), she helped push General Electric to clean up the toxic chemicals it had dumped in Pittsfield. Now she feels powerless.

“The Board of Health has a mandate to protect the citizens of Pittsfield,” she said. “But the bottom line is the FCC has made it impossible for us to do anything. If a company can come in and do something to make people sick, and the Board of Health has no authority to act, that’s ludicrous.”

To see how completely the U.S. telecom industry has prevailed in the rhetorical war over cellphone safety so far, consider this example. In February 2019, near the end of a hearing largely devoted to extolling the wonders of 5G technology, Sen. Richard Blumenthal, D-Conn., asked representatives of two wireless industry trade groups what sort of research the industry was funding on the biological effects of 5G, which remains largely untested. “There are no industry-backed studies, to my knowledge, right now,” replied Brad Gillen of the CTIA (originally called the Cellular Telecommunications Industry Association). “I’m not aware of any,” replied Steve Berry of the Competitive Carriers Association.

Wireless companies maintain that cellphones and base stations operating within the FCC’s exposure limits pose no proven risk. A CTIA spokesperson wrote in a statement, “The consensus of the international scientific community is that radiofrequency energy from wireless devices and networks, including 5G, has not been shown to cause health problems.”

Included in that list was the National Cancer Institute. The spokesperson also said the industry is in favor of additional science. (Verizon itself declined to comment on the record for this article.) In a September 2021

meeting with Pittsfield's Board of Health, for example, Verizon's chief expert was a University of Pittsburgh theoretical physics professor named Eric Swanson. He testified that wireless radiation is far too weak to cause cancer or any of the problems the Pittsfield residents were reporting. He suggested they have psychological problems.

Fears of radio-frequency radiation, Swanson declared in the videotaped meeting, are based entirely on "fringe opinion," backed only by cherry-picked evidence. Swanson said he'd spotted one such study on "an Alex Jones website" and voiced exasperation: "This is the kind of stuff I have to deal with." Concerns about wireless radiation, he said, are at odds with the overwhelming scientific consensus. "All international bodies," he said, "declare cellphones to be safe."

The FCC has been similarly scornful. In a June 2020 Washington Post op-ed, Thomas Johnson, general counsel for the agency during the administration of President Donald Trump, wrote: "Conjectures about 5G's effect on human health are long on panic and short on science." Johnson has since decamped to a law firm that represents telecom companies. (Johnson declined requests for comment.)

"It's a slog at the moment to convince people this isn't just crazy stuff," said Louis Slesin, an MIT-trained environmental policy Ph.D. and the editor of Microwave News, an industry newsletter that has chronicled the wireless-radiation debate for four decades. "This is part of the organized campaign to devalue the science, with the government as a co-conspirator. The other really important factor is nobody wants to hear this because everybody loves the technology. If you shut down people's phones, the country would come to a stop."

But a growing body of international research asserts that there is reason to worry about harms — many of them unrelated to cancer — from wireless radiation. Henry Lai, an emeritus professor of bioengineering at the University of Washington, has compiled a database of 1,123 peer-reviewed studies published since 1990 investigating biological effects from wireless-radiation exposure. Some 77% have found "significant" effects, according to Lai. By contrast, an earlier review by Lai found that 72% of industry-sponsored studies reported no biological effects.

One branch of research has studied radiation impacts on test animals, mostly rats and mice, but also guinea pigs, rabbits and cows. Another has examined epidemiological patterns, looking for health effects on human groups, such as heavy long-term cellphone users or people living near cellphone towers. Studies have found impacts on fertility, fetal development, DNA, memory function and the nervous system, as well as an association with an array of cancers. Several investigations reported a significantly increased risk of brain tumors, called gliomas, among the heaviest cellphone users. And the International Agency for Research on Cancer, an arm of the World Health Organization, in 2011 classified wireless radiation as "possibly carcinogenic to humans."

Individual studies underline the value of simple precautions, which include using a headset or speaker and keeping the phone away from direct contact with your body. In 2009, Ashok Agarwal, director of research at the Cleveland Clinic's American Center for Reproductive Medicine, found that exposing human semen to cellphone radiation for an hour caused a "significant decrease" in sperm motility and viability, impairing male fertility. He advises patients to avoid carrying phones in their pants pockets.

Epidemiological studies show a rise in behavioral disorders among children whose mothers were heavy cellphone users while pregnant, while lab research found hyperactivity and reduced memory in mice exposed in the womb to cellphone radiation.

"The evidence is really, really strong now that there is a causal relationship between cellphone radiation exposure and behavior issues in children," said Dr. Hugh Taylor, a professor of obstetrics and gynecology at the Yale School of Medicine and past president of the American Society for Reproductive Medicine. The period of fetal brain development is a "very vulnerable time," he said.

The American Academy of Pediatrics has written that the FCC's safeguards "do not account for the unique vulnerability and use patterns specific to pregnant women and children." It urged the agency to adopt measures "protective of children," warning that their thinner skulls leave them "disproportionately impacted" by cellphone radiation, and called for better consumer disclosure about exposure risks.

Both the FCC and U.S. Food and Drug Administration (FDA) websites dismiss the existence of any special health risk to children. And the agencies don't counsel people to limit their exposure. Instead, they list safety steps, while insisting they're really not necessary. The FCC's "Wireless Devices and Health Concerns" page, for example, notes that "some parties" recommend safety measures, "even though no scientific evidence currently establishes a definitive link between wireless device use and cancer or other illnesses." It then states, in bold: "The FCC does not endorse the need for these practices." Only then does it list "some simple steps that you can take to reduce your exposure" to radio-frequency energy from cellphones.

Efforts in the U.S. to promote awareness of wireless-radiation risks have sparked fierce industry resistance. In 2014, the CDC added this modest language to its website: "Along with many organizations worldwide, we recommend caution in cellphone use." An influential industry consultant emailed the CDC within days, as a public-records request later revealed, complaining that "changes are truly needed" in the CDC's language. The agency quickly softened its warning, which now says: "Some organizations recommend caution in cellphone use."

The industry's main trade group, CTIA, has beaten back local consumer-disclosure measures. For example, in 2015, CTIA sued Berkeley, California, after its City Council passed an ordinance requiring retailers to post a safety notice warning customers that carrying a cellphone tucked in a pocket or bra might expose them to excessive radiation. (This was based on FCC guidelines, typically buried in small-print information included with new phones, that phones shouldn't be kept in direct contact with the head or body.)

A five-year legal battle, including a trip to the U.S. Supreme Court, ensued. It ended after the FCC weighed in, saying the ordinance interfered with its exclusive authority by "over-warning" consumers and frightening them "into believing that RF emissions from FCC-certified cellphones are unsafe." With that, the judge ruled against the city.

"The industry doesn't want you to pay any attention to that stuff because that just creates anxiety among users," said Joel Moskowitz, director of the Center for Family and Community Health at the University of California-Berkeley, who advised the city in its fight. "They want you to think these devices are perfectly safe."

By contrast, more than 20 foreign governments have adopted protective measures or recommended precautions. France requires new phones to be sold with headsets and written guidance on limiting radiation exposures; it also bans phones marketed to small children and ads aimed at anyone younger than

14. Greece and Switzerland routinely monitor radio-frequency radiation levels throughout the country. Britain, Canada, Finland, Germany, Italy, India and South Korea urge citizens to limit both their own exposure and cellphone use by children. The European Environment Agency does too, noting: "There is sufficient evidence of risk to advise people, especially children, not to place the handset against their heads."

When the FCC's rules on radio-frequency emissions from phones and transmitters were adopted 26 years ago, just 1 in 6 Americans owned cellphones, which they typically used for short periods. Today, 97% of adults own a cellphone, and they use the device for an average of five hours a day. More than half of children under 12 own a smartphone.

Then and now, the FCC's rules targeted just one health hazard: the possibility that wireless radiation can cause immediate "thermal" damage, by overheating skin the way a microwave oven heats food. Most experts agree that risk is nonexistent under any but the most unusual circumstances. Meanwhile, the FCC doesn't even consider "biological" impacts: the possibility that wireless exposure, even at levels well below the FCC limits, can cause an array of human health problems, as well as harm to animals and the environment. The FCC's approach matches the industry's long-standing position: that wireless radiation is simply too weak to cause any non-heating damage.

Of course, the wireless industry has every incentive to take this position. Going back to the 1990s, the industry has recognized the financial peril posed by health concerns over radiation, and it has pressed the public and government to reject them altogether. In 1994, for example, Motorola swung into action when it learned of troubling research by Lai and a University of Washington colleague, Narendra Singh, who found that two hours of exposure to modest levels of wireless radiation damaged DNA in the brains of lab rats. Such changes can lead to cancerous tumors.

Motorola's then-PR chief described a strategy to discredit the findings in a pair of memos that were later leaked to Microwave News. Motorola's approach would serve as a template for the industry's response to troublesome research over the three decades that followed. The researchers' methodology would be challenged for raising "too many uncertainties" to justify any conclusions. The scientists' credibility would be questioned and their findings dismissed as irrelevant. Finally, friendly academics, "willing and able to reassure the public on these matters," would be recruited to rebut the findings. (At the time, Motorola defended its conduct as the "essence of sound science and corporate responsibility" and affirmed that there was "a sound scientific basis for public confidence in the safety of cellular telephones.")

Doubters in the government would be neutralized too. As the FCC moved toward adopting wireless-radiation limits in 1996, EPA officials, whose experts had conducted the most extensive government research on wireless-radiation risk, affirmed their concern about possible biological harm in a presentation to the FCC. They urged the FCC to follow a two-stage strategy: to meet a looming congressional deadline by first setting interim limits covering known thermal effects; then to commission a group of experts to study biological risks and develop permanent exposure guidelines. But the FCC never pursued "Phase 2." Instead, just months later, Congress completed a multiyear defunding of the EPA's wireless-radiation group, sidelining the agency from researching the issue. This left most independent study of the issue to scientists in other countries. At the EPA, a lone radio-frequency radiation expert named Norbert Hankin remained, periodically rankling the wireless industry by publicly rebutting "the generalization by many that the [FCC] guidelines protect human beings from harm by any or all mechanisms."

Going forward, the FCC, which has no in-house health or medical expertise of its own, would increasingly rely on the FDA and industry-influenced technical organizations. (The FDA itself has collaborated with the CTIA, the wireless industry trade group, to study cellphone safety. That research found “no association” between exposure to “cell phones and adverse health effects.”) Still, there was enough concern among government scientists from multiple agencies that, in 1999, the FDA asked the NTP to “assess the risk to human health.”

The NTP conducts detailed lab studies, typically on rodents, to evaluate environmental hazards. Its findings, widely regarded as the gold standard for toxicology work, routinely prompt federal public-health actions. The FDA requested that the NTP conduct its own animal experiments, which were “crucial” to assess cancer risk because of the long delay between human exposure to a carcinogen and a tumor diagnosis. As an FDA memo put it, “There is currently insufficient scientific basis for concluding either that wireless communication technologies are safe or that they pose a risk to millions of users.”

The NTP study was the biggest the agency had ever conducted and lasted over a decade. It used an unusually large number of rats and mice — some 3,000 — and involved both setting up a lab in Chicago and designing and constructing special radiation-exposure chambers for the rodents in Switzerland. The final report was released in November 2018. The results were dramatic. The study found “clear evidence” of rare cancerous heart tumors, called schwannomas, in male rats; “some evidence” of tumors in their brains and adrenal glands; and signs of DNA damage. The percentage that developed tumors was small, but, as the study’s authors noted earlier, “Given the extremely large number of people who use wireless communication devices, even a very small increase in the incidence of disease resulting from exposure” could have “broad implications for public health.”

The federal government’s scientists had spoken. But the parts of the government charged with following the science and protecting people responded (in the case of the FCC) by publicly ignoring the results or (in the case of the FDA) pooh-poohing them. The study changed nothing, said Dr. Jeffrey Shuren, director of the FDA’s Center for Devices and Radiological Health, and the chief official advising the FCC on wireless issues, in a statement at the time of the study’s release. Shuren disputed several key findings and asserted that the study “was not designed to test the safety of cellphone use in humans,” even though his own agency had commissioned it specifically for that reason. He added: “We believe the existing safety limits for cellphones remain acceptable for protecting the public health.” (An FDA spokesperson said Shuren declined to comment.)

The NTP findings, combined with similar results that year from the Ramazzini research institute in Italy and other studies, demanded a strong response, according to three long-time former government experts who spoke to ProPublica. “It should have been the game-changer,” added Moskowitz, the Berkeley public-health researcher. The former government officials believe the NTP findings should have led to a detailed statistical risk assessment by federal health agencies, spelling out the possible incidence of cancer in the general population; development of stricter FCC limits to address biological risks; prominent user warnings detailing simple steps people should take to minimize their exposure; and dramatically increased research funding.

None of that happened. “Their conclusion was, ‘Oh, there was nothing going on,’” said Birnbaum, the NTP’s then-director and a toxicologist. “Many of us found that very hard to believe.” Today Birnbaum, who

retired in 2019 after 40 years with government health agencies, is tempered in her assessment of the evidence.

“Do I see a smoking gun? Not per se. But do I see smoke? Absolutely. There’s enough data now to say that things can happen.” Birnbaum said the NTP results should have triggered a consumer advisory akin to “the black-box warning on a drug, to say this has been associated to possibly cause cancer.”

Even as the NTP study was happening, the FCC in 2013 had been prodded by a Government Accountability Office report to review its radio-frequency exposure limit, unchanged since 1996. “We recognize that a great deal of scientific research has been completed in recent years and new research is currently underway, warranting a comprehensive examination,” the FCC wrote, in opening its inquiry.

Over the six years that followed, 1,200 comments poured into the FCC’s docket, including scores of studies (and a briefing on the NTP findings); appeals for stronger protections signed by hundreds of international scientists; and 170 personal accounts of “electro-sensitivity” radiation sickness, similar to the complaints in Pittsfield, resulting from neighborhood cell towers. An Interior Department letter voiced concern about the impact of radiation from towers on migrating birds, noting that the FCC’s limits “continue to be based on thermal heating, a criterion now nearly 30 years out of date and inapplicable today.”

The FCC was overwhelmed by the flood of comments, according to Mantiply, the agency official most involved in radio-frequency issues during this period. “We didn’t have the resources to even read all the comments,” he told ProPublica. Mantiply thought higher-ups were ignoring the issue. “There was really nothing being done on it,” he said. “The inquiry was just on a back burner, and the back burner was turned off.”

So Mantiply, a soft-spoken physical scientist, decided to take action. In 2017, as the FCC’s review of its wireless standards entered its fourth year, he said, he and three colleagues proposed hiring an outside consulting firm to conduct an environmental assessment, a detailed formal examination, of the submissions on the radiation safety limits. But their boss, Julius Knapp, the head of the FCC’s Office of Engineering and Technology, summarily rejected the proposal, according to Mantiply. “He said, ‘No, we’re not going to do that.’ He let us know in no uncertain terms. He just rejected it in a single meeting.” (Knapp, who is now retired, declined to comment on the record. FCC officials, through a spokesperson, declined requests to discuss the matter. Former FCC engineer Walter Johnston, one of the colleagues Mantiply identified as backing his proposal, said he didn’t remember it ever being presented as a “formal recommendation.”)

Mantiply’s proposal came at a time when the Trump White House and FCC commissioners were aggressively promoting 5G. FCC leadership was “not really thrilled with us pushing these inquiries,” Mantiply said. “They just felt like it’d get a lot of attention, that it would be in The Washington Post.” On his final day at the FCC in August 2018, as he was retiring after 42 years in government, Mantiply raised the issue with FCC Commissioner Jessica Rosenworcel during a brief courtesy visit. “Don’t dismiss all this stuff because you’re hearing from industry, and they’re dismissing it,” Mantiply told her. “There’s uncertainty, and we don’t know what’s going on. It’s a very, very difficult problem.” Rosenworcel, he said, listened politely.

Fifteen months later, the FCC voted unanimously to shut down its review after six years. There was no need to change anything, the commissioners concluded. After examining the record, the FCC declared in a written order, it had seen no evidence that the science underlying its standards was “outdated or insufficient to protect human safety.”

The U.S. Court of Appeals in Washington, D.C., disagreed. Responding to a pair of lawsuits filed by the Environmental Health Trust and other activist groups, the court ruled in August 2021 that the FCC had failed to meet “even the low threshold of reasoned analysis” in finding that its limits “adequately protect against the harmful effects of exposure to radiofrequency radiation unrelated to cancer.” (The FCC had responded sufficiently to fears that wireless radiation causes cancer, the judges wrote.)

It was a striking rebuke, given the judiciary’s practice of offering agency decisions a high degree of deference, especially on technical matters. The court wrote that it was taking “no position in the scientific debate” on wireless radiation’s effects, but it was scornful of the FCC’s heavy reliance on three “conclusory” statements from the FDA about safety. In oral argument, one judge also challenged the FCC’s claim that an interagency working group was closely monitoring concerns about wireless exposure on the FCC’s behalf; in fact, the group hadn’t met since 2018.

The FCC’s actions, the court wrote, waved off any concern about protections for children and ignored “substantive evidence of potential environmental harms.” And the FCC had said nothing about the potential impacts of the many technological changes, including 5G, that had taken place since 1996. “Ultimately,” the court wrote, “the Commission’s order remains bereft of any explanation as to why, in light of the studies in the record, its guidelines remain adequate.”

With that, the court sent the issue back to the FCC, for either a fresh review of its 26-year-old standard or better explanations to justify it. In the 15 months since, the FCC, now led by Rosenworcel, who was elevated by President Joe Biden, has taken no formal action.

In its statement to ProPublica, the FCC said it is exploring “next steps” with its “federal partners.” However, the FDA, the FCC’s chief partner on health concerns, said in its own statement that it is not currently working with the FCC on any response to the court ruling. There’s been no visible sign of any preliminary FCC steps, according to four lawyers and representatives of the environmental groups that brought the court challenge.

In the past few years, with the appearance of more neighborhood cell towers and transmitters, pressure has begun to rise on this issue beyond environmental groups, longtime activists and officials in liberal jurisdictions. In November 2020, a bipartisan state commission in New Hampshire charged with investigating 5G issued a detailed report concluding that wireless radiation “poses a significant threat to human health and the environment.” Among its recommendations: that all new cell towers be at least 1,640 feet (500 meters) from any residence, school or business. And in April, Mark Gordon, the Republican governor of Wyoming, wrote to Rosenworcel, urging the agency to reexamine its radiation limits based on “current scientific research” to make sure “the health and safety of our citizens is prioritized.”

In Pittsfield, Orsi and her colleagues on the board have grown resigned to their inability to take action against Verizon. Reactions have varied around town. One group of affected neighbors is waging its own separate long-shot legal battle with the company. Others are coping with dark humor. Before Halloween, the local daily suggested dressing up as a cellphone tower to “strike fear in the heart of your neighbors.” Nobody in Pittsfield is holding out hope that the federal government will intervene.

“It’s very natural for the FCC to listen to the industry,” said Mantiply, the former agency staffer. “That’s their audience and who they deal with most of the time.” But, he added, “They’re answering to industry more than anything.”

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Peter Elkind is a reporter covering government and business. Doris Burke contributed research.

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the views of Children's Health Defense.

COMMENT

Open Access



Scientific evidence invalidates health assumptions underlying the FCC and ICNIRP exposure limit determinations for radiofrequency radiation: implications for 5G

International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF)*

Abstract

In the late-1990s, the FCC and ICNIRP adopted radiofrequency radiation (RFR) exposure limits to protect the public and workers from adverse effects of RFR. These limits were based on results from behavioral studies conducted in the 1980s involving 40–60-minute exposures in 5 monkeys and 8 rats, and then applying arbitrary safety factors to an apparent threshold specific absorption rate (SAR) of 4W/kg. The limits were also based on two major assumptions: any biological effects were due to excessive tissue heating and no effects would occur below the putative threshold SAR, as well as twelve assumptions that were not specified by either the FCC or ICNIRP. In this paper, we show how the past 25 years of extensive research on RFR demonstrates that the assumptions underlying the FCC's and ICNIRP's exposure limits are invalid and continue to present a public health harm. Adverse effects observed at exposures below the assumed threshold SAR include non-thermal induction of reactive oxygen species, DNA damage, cardiomyopathy, carcinogenicity, sperm damage, and neurological effects, including electromagnetic hypersensitivity. Also, multiple human studies have found statistically significant associations between RFR exposure and increased brain and thyroid cancer risk. Yet, in 2020, and in light of the body of evidence reviewed in this article, the FCC and ICNIRP reaffirmed the same limits that were established in the 1990s. Consequently, these exposure limits, which are based on false suppositions, do not adequately protect workers, children, hypersensitive individuals, and the general population from short-term or long-term RFR exposures. Thus, urgently needed are health protective exposure limits for humans and the environment. These limits must be based on scientific evidence rather than on erroneous assumptions, especially given the increasing worldwide exposures of people and the environment to RFR, including novel forms of radiation from 5G telecommunications for which there are no adequate health effects studies.

Keywords: Federal Communications Commission (FCC), International commission on non-ionizing radiation protection (ICNIRP), Radiofrequency radiation (RFR), Exposure limits, Exposure assessment, Radiation health effects, Reactive oxygen species (ROS), DNA damage, 5G, Scientific integrity, Cell phone*, Mobile phone*

Introduction

In establishing exposure limits for toxic or carcinogenic agents, regulatory agencies generally set standards that take into account uncertainties of health risks for the general population [1] and for susceptible subgroups such as children [2]. That approach has not been applied in the same way to the setting of exposure limits for

*The terms cell phone and mobile phone are used interchangeably in this commentary; cell phone is the term used in the United States, while mobile phone is the term used in most of Europe.

*Correspondence: ron.melnick@gmail.comTucson, USA

¹Tucson, USA



radiofrequency radiation (RFR) (frequency range: 3 kHz to 300 GHz). Moreover, assumptions underlying the current RFR exposure limits are flawed; hence, the limits that are currently applied do not adequately protect human and environmental health. This issue is discussed in greater detail under Assumption #9.

The Federal Communications Commission's (FCC) limits for maximum permissible exposure to RF electromagnetic fields (EMF) [3] were established in 1996 [4], and currently include many recommendations from the International Commission on Non-Ionizing Radiation Protection [5]. These exposure limits were expected to protect against adverse health effects in humans that might occur from short-term (i.e., acute) exposures to RFR and have been maintained by the FCC for the past 26 years. The exposure limits that were established by the FCC in 1996 relied on criteria recommended by the National Council on Radiation Protection & Measurements (NCRP) [6] and the Institute of Electrical and Electronics Engineers (ANSI/IEEE) [7, 8]. The limits were "based on a determination that potentially harmful biological effects can occur at a SAR (specific absorption rate) level of 4.0 W/kg as averaged over the whole-body." The SAR is a measure of the rate of RF energy absorbed per unit mass.

The threshold for a behavioral response and for acute thermal damage in sensitive tissues was considered to be an exposure that produced a whole-body SAR greater than 4 W/kg. In parallel with the development of the FCC's RFR exposure limits, ICNIRP's guidelines for limiting exposure to RF-EMF were also based on behavioral studies conducted in rats and monkeys in the 1980s [9].

The harmful effects that served as the basis for the exposure criteria were changes in behavior observed in small numbers of rats and monkeys when exposed to RFR for up to 60 minutes to power densities at which the whole-body SAR was approximately 4 W/kg or higher [10, 11]. Those studies were conducted in the early 1980s (1980 and 1984, respectively) by investigators of the US Navy Department. Consequently, 4 W/kg was identified as the threshold SAR for adverse health effects induced by RFR. In food-deprived monkeys that were exposed to three different frequencies (225 MHz, 1.3 GHz, and 5.8 GHz) during 60-min sessions, lever-pressing response rates for the delivery of food pellets were reduced compared to sham exposure sessions. The threshold SAR for this decreased response was reported to range from 3.2 to 8.4 W/kg [11]. Similarly, in food-deprived rats exposed to 40-min sessions at 1.28 or 5.62 GHz radiation, the threshold SAR for a decrease in response rate was reported to range from approximately 3.8 to 4.9 W/kg [10]. In experimental studies in which monkeys were exposed in an anechoic chamber for 4 hours to 1.29 GHz

radiation at various power densities, an increase in mean body temperature of 0.7°C was associated with a whole-body SAR of 4 W/kg [12]. Behavior disruption associated with an increase in body temperature of approximately 1.0°C was assumed to be the most sensitive measure of harmful effects from RF-EMF exposure.

After establishing 4 W/kg as the threshold dose for acute harmful effects, both the FCC [3, 4] and ICNIRP [5, 9] set exposure limits for controlled occupational exposures to 0.4 W/kg SAR averaged over the whole body (based on applying a 10-fold safety/uncertainty factor). For the general population, the FCC's and ICNIRP's exposure limits were set at 0.08 W/kg SAR averaged over the whole body (by applying an additional 5-fold safety/uncertainty factor) for frequencies between 3 MHz and 3 GHz. The exposure limits established by the FCC and ICNIRP do not account for any impact of differing signal characteristics, such as carrier wave modulations or pulsing of the signal. Whole-body exposures for the general population are based simply on power levels averaged over 30-minute periods [3, 5].

Based on SAR distributions from whole-body exposures in which local (i.e., partial body) SARs were estimated to be 10 to 20 times the average value, local exposure limits were set 20 times higher than the average whole-body exposure limit [4–7]. For occupational exposures, local peak exposure limits were permitted up to 8 W/kg averaged over any 1-g cube of tissue [4] or 10 W/kg averaged over any 10 g of contiguous tissue [9] by the FCC and ICNIRP, respectively. For the general population, local peak SARs for partial-body exposures were not to exceed 1.6 W/kg averaged over any 1 g of cube-shaped tissue [3], or not to exceed 2.0 W/kg averaged over any 10 g of cube-shaped tissue [5]. Higher limit values are permissible for extremities. Extremities include the hands, wrists, feet, ankles, and pinnae (the external part of the ear), despite the close proximity of the ear to the brain. These adjustments were made long before the widespread use of wireless communication devices in which the emitting antenna is typically held close to local body organs such as the brain. The NCRP document [6] acknowledges that exposures could be greater than the recommended safety limit values when people are in close proximity to emitters of RFR.

The setting of exposure limits for the prevention of excessive tissue heating was based on the following assumptions: 1) electromagnetic waves at frequencies used in wireless communications do not have sufficient energy to break chemical bonds or ionize molecules [13]; 2) RFR could not damage DNA; and 3) tissue heating was the only possible biological effect of nonionizing radiation [5, 9, 14–16]. For potential environmental and human health issues that are not addressed in the

A) Effects of RF radiation at exposures below the putative threshold SAR of 4 W/kg

Assumption 1) There is a threshold exposure for any adverse health effect caused by RF radiation; in the frequency range of 100 kHz to 6 GHz it is a whole-body exposure that exceeds an SAR of 4 W/kg. Any biological effect of RF radiation above the threshold exposure is due to tissue heating.

Assumption 2) RF radiation is incapable of causing DNA damage other than by heating; there is no mechanism for non-thermal DNA damage.

Assumption 3) Two to seven exposures to RF radiation for up to one hour duration are sufficient to exclude adverse effects for any duration of exposure including chronic exposures.

Assumption 4) No additional effects would occur from RF radiation with co-exposure to other environmental agents.

B) Factors affecting dosimetry

Assumption 5) Health effects are dependent only on the SAR value; carrier wave modulations, frequency, or pulsing do not matter except as they influence the SAR.

C) Human brain cancer risk

Assumption 6) The multiple human studies that find associations between exposure to cell phone RF radiation and increases in brain cancer risk are flawed because of biases in the published case-control studies, and because brain cancer rates have remained steady since the time that use of wireless communication devices became widespread.

D) Individual variations in exposure and sensitivity to RF-EMF

Assumption 7) There are no differences among individuals, including children, in the absorption of RF-EMF and susceptibility to this radiation.

Assumption 8) There are no differences among individuals in their sensitivity to RF radiation-induced health effects.

E) Applied safety factors for EMF-RF workers and the general population

Assumption 9) A 50-fold safety factor for whole body exposure to RF radiation is adequate for protecting the general population to any health risks from RF radiation.

Assumption 10) A 10-fold safety factor for whole body exposure to RF radiation is adequate for protecting workers to any health risks from RF radiation.

Assumption 11) Exposure of any gram of cube-shaped tissue up to 1.6 W/kg, or 10 grams of cube-shaped tissue up to 2 W/kg, (duration not specified) will not increase the risk of that tissue to any toxic or carcinogenic effects in the general population.

Assumption 12) Exposure of any gram of cube-shaped tissue up to 8 W/kg, or 10 grams of cube-shaped tissue up to 10 W/kg, (duration not specified) will not increase the risk of that tissue to any toxic or carcinogenic effects in workers.

F) Environmental exposure to RF radiation

Assumption 13) There is no concern for environmental effects of RF radiation or for effects on wildlife or household pets.

G) 5G (5th generation wireless)

Assumption 14) No health effects data are needed for exposures to 5G; safety is assumed because penetration is limited to the skin ("minimal body penetration").

Fig. 1 Assumptions Underlying the FCC/ICNIRP Exposure Limits for RF Radiation

setting of exposure limits (for example effects of chronic exposures, or effects of co-exposure of skin to RFR and other environmental agents, such as would occur with 5G exposure in combination with sunlight), the implicit assumption is that such effects do not matter, or that the arbitrarily selected safety/uncertainty factor is sufficient to deal with those concerns. In any case, it is expected that underlying assumptions applied to health risk assessments would be clearly described [1].

Exposure limits for RF radiation are based on numerous assumptions; however, research studies published over the past 25 years show that most of those assumptions are not supported by scientific evidence. In the NCRP report [6], the authors noted that when further understanding of biological effects of RF radiation becomes available, exposure guidelines will need to be evaluated and possibly revised. The ANSI/IEEE document [7] also notes that effects of chronic exposure or evidence of non-thermal interactions could result in revising exposure standards. Unfortunately, these recommendations were never implemented. Assumptions of

safety from exposures that could adversely affect human or environmental health should be tested and validated *before* widespread exposures occur, not afterwards, by agencies responsible for protecting public health.

In this paper, we highlight studies that demonstrate the fallacy of inherent assumptions in the FCC/ICNIRP guidelines for RF radiation exposure limits, and we find that the limits fail to protect human and environmental health. Fourteen assumptions that underlie the RFR exposure limits established in the 1990s and reaffirmed in 2020 by the FCC [4, 5] and ICNIRP [5, 9] are addressed in this paper and are shown in Fig. 1.

Assumptions underlying exposure limits for RF radiation and the scientific evidence demonstrating that these assumptions are not valid

A. Effects of RF radiation at exposures below the putative threshold SAR of 4W/kg

Assumption 1) *There is a threshold exposure for any adverse health effect caused by RF radiation; in the*

frequency range of 100 kHz to 6 GHz it is a whole-body exposure that exceeds an SAR of 4 W/kg. Any biological effect of RF radiation above the threshold exposure is due to tissue heating.

Cardiomyopathy and carcinogenicity

In response to a request from the Food and Drug Administration's (FDA) Center for Devices and Radiological Health [17], the National Toxicology Program (NTP) conducted toxicity and carcinogenicity studies of cell phone (CDMA- or GSM-modulated) radiation in rats and mice exposed to RFR at frequencies of 900 MHz and 1800 MHz, respectively [18, 19]. Exposures to RFR for up to 2 years occurred in reverberation chambers over 18 hours/day on a continuous cycle of 10 minutes on and 10 minutes off. In rats, the whole-body SAR levels during the 10-minute on cycles were 0, 1.5, 3, or 6 W/kg.

The major histopathological findings from the NTP study in male rats [18] included dose-related increases in cardiomyopathy, increased incidence of cancers and preneoplastic lesions in the heart (schwannoma and Schwann cell hyperplasia) and brain (glioma and glial cell hyperplasia), increases in prostate gland tumors and hyperplasias, significant increases in adrenal gland tumors, and significant increases in the overall incidence of benign or malignant neoplasms in all organs in the 3 W/kg groups. The incidence of cardiomyopathy was also increased in GSM-exposed female rats, and significant increases in DNA damage were found in rats and mice [18, 19]. Similarly, an earlier study by Chou et al. [20] found a significant (3.6-fold) increase in the incidence of primary malignant neoplasms in male rats exposed to 2450 MHz pulsed RFR for 25 months (21.5 hr./day) at an SAR that ranged from 0.15 to 0.4 W/kg.

A 3-day external peer-review of the NTP studies confirmed there was "clear evidence of carcinogenic activity" in male rats for heart schwannomas, and "some evidence of carcinogenic activity" for brain gliomas and adrenal gland tumors with exposure to either GSM- or CDMA-modulated RF radiation [21]. In addition, a lifetime study by the Ramazzini Institute reported a significant increase in heart schwannomas in male rats exposed 19 hour/day to 1800 MHz GSM-modulated RFR at a field strength of 50 V/m, equivalent to a whole-body SAR of 0.1 W/kg [22]. The incidence of heart Schwann cell hyperplasia was also increased in that exposure group. These findings are consistent with results from the NTP study and demonstrate that the proliferative effect of modulated RFR in heart Schwann cells is a reproducible finding that can occur at doses far below the assumed whole-body threshold SAR of 4 W/kg.

ICNIRP [23] dismissed the evidence of carcinogenicity for RFR that was provided in the studies by the NTP [18] and the Ramazzini Institute [22] based on their earlier critique of those studies [24]. However, that critique demonstrated an unfortunate lack of understanding together with a misrepresentation of the design, conduct, and interpretation of experimental carcinogenicity studies in animal models [25], as well as a lack of appreciation for the remarkable concordance between the tumor responses observed in experimental animals with those identified in cancer epidemiology studies of mobile phone users described under Assumption #6.

Neither heating effects nor thermal stress was likely causal of the adverse health effects observed in the NTP [18] study, since there was no tissue damage observed in a 28-day study at the same SARs, there was no significant effect on body weight during the 2-year study, and there were no exposure-related clinical observations that would indicate thermal or metabolic stress. Furthermore, a preliminary thermal pilot study demonstrated that body temperatures did not increase by more than 1°C at the exposure levels used in the chronic studies [26], and there is no evidence that a small change in body temperature associated with the RFR exposures in the NTP study can cause the types of carcinogenic effects that were observed. The similar findings of GSM-modulated RFR on Schwann cells by the Ramazzini Institute [22] at much lower whole-body SARs confirm these effects to be independent of tissue heating.

Neurological effects

Though the FCC and ICNIRP exposure limits are based on a putative threshold dose of 4 W/kg due to behavioral disruption observed at higher doses in rats and monkeys [10, 11] numerous studies have shown consistent and reproducible deficits in spatial learning and memory in laboratory animals exposed to RF radiation at SARs below 4 W/kg. Examples of study exposures that demonstrated these neurological effects included 900 MHz GSM at 0.41–0.98 W/kg, 2 hr./day for 4 days in mice [27]; 900 MHz GSM at 0.52–1.08 W/kg, 2 hr./day for 1 month in rats [28]; 900 MHz GSM at 1.15 W/kg, 1 hr./day for 28 days in rats [29]; 900 MHz pulsed RFR at 0.3–0.9 W/kg for 6 hr./day in rats from conception to birth and tested at 30 days of age [30]; 900 MHz GSM and 1966 MHz UMTS at 0.4 W/kg for 6 months in rats [31]; and 900 MHz continuous wave EMF at 0.016 W/kg 3 hr./day for 28 days in rats [32]. The studies cited above are not the only studies showing these effects, but they clearly demonstrate that exposure to RFR at an SAR of 4 W/kg is not a threshold dose for neurological effects in rodents. The effects of RF radiation on spatial learning and memory indicate

the hippocampus as a target site of these exposures. For a more complete listing of neurological effects of RFR reported between 2007 and 2017 see Lai [33].

In addition, many studies have reported changes in brain electrical activities in human subjects, measured by electroencephalography (EEG), including sleep disturbance from single exposures to cell phone RF radiation. This is not surprising since the nervous system transmits messages based on electrical signals generated by nerve cells. Decreased β -trace protein, which is a key enzyme in the synthesis of a sleep-promoting neurohormone, has been seen in young adults with high-cumulative amounts of hours of mobile phone use [34]. Another frequently reported effect of RF radiation is increased blood-brain barrier permeability in rats at SARs much lower than 4 W/kg, e.g. [32, 35–41]. Oxidative stress induced in the brain of animals exposed to RF-EMF has been associated with observed neurological effects [42]. Although many studies did not observe significant changes in neurological effects in humans and several studies did not observe increased permeability in the blood-brain barrier in animal models [33], differences in EMF frequency, modulation, duration of exposure, and direction of incident waves to the exposed subject, as well as difference in dielectric properties and the size and shape of the exposed subject likely account for differences in observed effects [43, 44].

Sperm damage

The effect of non-ionizing microwave radiation on the testis (testicular degeneration in mice) was first reported 60 years ago [45]. Since then, and with the rapid increase in use of RF-EMF emitting devices, numerous studies have investigated testicular effects of RFR and potential associations with male infertility [46–50]. Human and animal studies have shown that the testis is one of the most sensitive organs to RF-EMF exposures, and that keeping a mobile phone in trouser pockets in talk mode can affect fertility parameters e.g., sperm motility, sperm count, sperm morphology, and apoptosis [48, 51]. Meta-analyses of published epidemiologic studies on the impact of mobile phone radiation on sperm quality in adult men have found significant decreases in sperm motility, sperm viability and/or sperm concentrations that were associated with mobile phone usage [52–55]. Several physical factors associated with exposure conditions can affect the outcome of human studies, including depth of energy penetration, duration of call, type of transmission technology, distance of the device to the body or testis, and power density with defined SAR. For example, Zilberlicht et al. [56] observed higher rates of

abnormal sperm concentrations among men who held their phones less than 50 cm from their groin.

The effects of RFR on reproductive parameters in humans are consistent with results from experimental studies in animals and in vitro studies. For example, exposure of human semen to 850 MHz radiation from mobile phones for 1 hour at an SAR of 1.46 W/kg caused a significant decrease in sperm viability that was associated with an increase in reactive oxygen species (ROS) [50] or an increase in sperm DNA fragmentation [57]. Exposure of isolated human spermatozoa to 1.8 GHz RF-EMF significantly reduced sperm motility and induced ROS generation at an SAR of 1.0 W/kg, and significantly increased oxidative DNA damage and DNA fragmentation at an SAR of 2.8 W/kg [58].

Some examples of effects of RFR on male fertility factors in studies with experimental animals at SARs below 4 W/kg include: a decrease in sperm count and an increase in ROS in rats exposed to mobile phone frequencies 2 hr./day, for 35 days (SAR=0.9 W/kg) [59]; increases in oxidative stress, 8-hydroxy-deoxyguanosine (8-OHdG), and DNA strand breaks in the testes of rats exposed to 900 MHz (SAR=0.166 W/kg), 1800 MHz (0.166 W/kg), or 2100 MHz (0.174 W/kg) 2 hr./day for 6 months [60]; an increase in ROS, a decrease in sperm count, and altered sperm morphology in rats exposed to 900 MHz 3G mobile phone radiation (SAR=0.26 W/kg) 2 hr./day for 45 days [61]; decreased sperm quality in rats in which local exposure of the scrotum to 2575–2635 MHz 4G smartphone time division LTE radiation occurred for 1 min over 10 min intervals 6 hr./day for 150 days [62]; impaired testicular development at 35 days of age in male offspring of pregnant rats that were exposed to 2.45 GHz RFR (SAR=1.75 W/kg) 2 hr./day throughout pregnancy [63]; decreased sperm motility in mice exposed to 905 MHz RFR (SAR=2.2 W/kg) 12 hr./day for 5 weeks, and increased ROS formation and DNA fragmentation after 1 week of exposure [64]. Although negative studies have also been reported, it is important to remember that the outcome of experimental studies can be affected by differences in exposure conditions, including the frequency, modulation, polarization, stray electromagnetic fields, local SAR, duration of exposure, and analytical methods [43, 44].

Although the mechanism of testicular effects from exposure to non-thermal levels of RFR is not fully known, numerous studies in rats and mice, and in human sperm have found associations between negative effects on fertility parameters and increases in ROS and/or DNA damage [48, 51, 57, 58, 60, 61, 64–68]. Thus, the adverse effects of RFR on sperm quality are likely due in large part to induced generation of ROS.

Assumption 2) *RF radiation is incapable of causing DNA damage other than by heating; there is no mechanism for non-thermal DNA damage.*

In 2009, ICNIRP [16] claimed that “low energy photons of RF radiation are too weak to affect ionization or cause significant damage to biological molecules such as DNA, under ordinary circumstances.” However, DNA damage and other genotoxic effects have been observed in numerous studies of low intensity RFR in animal models and in humans. For example, the NTP study found statistically significant increases in DNA damage in brain cells of exposed rats and mice compared to sham controls [18, 19, 69], and Akdag et al. [70] found statistically significant increases in DNA damage in hair cells in the ear canal among 30 to 60 year-old men who used mobile phones for 10 years for 0–30 min/day, 30–60 min/day, or greater than 60 min/day compared to people who did not use mobile phones. In the latter study, the extent of DNA damage increased with increasing daily exposure duration. In a review of published studies on genetic effects of ELF- and RF-EMF, Lai [71] listed more than 150 studies in which non-thermal exposures to RFR produced increases in DNA damage, chromosome aberrations, or micronuclei formation.

In addition, it is well established that DNA damage can also be caused by indirect processes, such as by the generation of reactive oxygen species (ROS), and numerous studies have demonstrated DNA damage at exposures below the putative threshold SAR of 4 W/kg. More than 120 published studies have demonstrated oxidative effects associated with exposure to low intensity RFR (Additional file 1: Appendix 1). An analysis of experimental studies on molecular effects of low intensity RF radiation (RFR) in biological systems found that the majority (93 of 100 studies) demonstrated the induction of oxidative effects [72]. More recent studies (from 2017) revealed that all 30 relevant publications (100%) detected significant oxidative effects under low intensity RFR exposures, and most of these studies used modulated RFR from wireless communication devices.

Increased production of ROS in living cells may be caused by weak magnetic fields altering recombination rates of short-lived radical pairs generated by normal metabolic processes leading to changes in free radical concentrations [73], or by low intensity extremely low frequency (ELF) EMFs resulting in alterations in voltage-gated ion channels in cell membranes causing changes in cation flow across membranes [74]. These mechanisms apply to both ELF-EMFs and to RFR modulated by pulsed fields at extremely low frequencies. Other biophysical mechanisms by which non-thermal RF-EMF can

cause biological effects through interactions with normal cellular processes have been described [75].

Increasing NADH oxidase activity is another mechanism by which RFR can increase ROS production. NADH oxidases, which are membrane-associated enzymes that catalyze one-electron reduction of oxygen to superoxide radical using NADH as the electron donor, have been identified as primary mediators of RFR interactions in cellular systems [76]. A significant (3-fold) increase in the activity of NADH oxidase was measured in purified plasma membranes from HeLa cells exposed to 875 MHz for 5 or 10 min at a power density of 200 $\mu\text{W}/\text{cm}^2$. This exposure intensity is significantly lower than the ICNIRP [5] safety limit.

The major source of ROS in living cells is the mitochondrial electron transport chain, where leakage of electrons generates superoxide radicals due to the partial reduction of oxygen [77]. A dose-dependent effect of 1.8 GHz modulated RFR exposure (SAR = 0.15 and 1.5 W/kg) on mitochondrial ROS production was detected in mouse spermatogonial germ cells [65]. Exposure of quail embryos to extremely low intensity modulated RFR (GSM 900 or 1800 MHz, 0.25 or 0.32 $\mu\text{W}/\text{cm}^2$) during the initial days of embryogenesis resulted in a robust overproduction of superoxide radical and nitrogen oxide in mitochondria of embryonic cells [78, 79]. Thus, multiple mechanisms for the increased production of ROS by low intensity RF radiation have been demonstrated.

Numerous studies have been published on mutagenic effects of low intensity RF-EMFs, especially studies that identified increases in levels of a specific marker of oxidative DNA damage and a risk factor for cancer, 8-hydroxy-2'-deoxyguanosine (8-OHdG) [58, 60, 78–84]. For example, the level of 8-OHdG in human spermatozoa was increased significantly after in vitro exposure for 16 hr. to 1.8 GHz at a power level of 2.8 W/kg and correlated with levels of ROS generation [58]. Likewise, exposure of quail embryos *in ovo* to GSM-modulated 900 MHz of 0.25 $\mu\text{W}/\text{cm}^2$ for 1.5, 5, or 10 days was sufficient to produce a significant, two-threefold, increase in 8-OHdG levels in embryonic cells [79]. Umbilical cord blood and placenta tissue samples obtained after delivery from women who used mobile phones during pregnancy had significantly higher levels of oxidative stress parameters, including 8-OHdG and malondialdehyde, compared to cord blood and placental tissue from women who did not use mobile phones during pregnancy [85]. In addition, DNA damage, analyzed by the comet assay, was increased significantly in cord blood lymphocytes obtained from women who used mobile phones during pregnancy compared to cord blood lymphocytes obtained from women who did not use mobile phones.

As low intensity RF radiation does not have sufficient energy to ionize DNA molecules, and as increased production of ROS in living cells due to RF-EMF exposures has been reliably documented, an indirect effect of this type of radiation is the formation of oxidative damage to DNA. The most aggressive form of ROS that can cause oxidative DNA damage is the hydroxyl radical; this reactive oxygen species can be generated from superoxide radical and hydrogen peroxide [86], which may be produced in living cells exposed to low intensity RF radiation. Ultraviolet radiation (UVR, encompassing UVA, UVB, and UVC), which is classified by IARC as “carcinogenic to humans”, can also cause indirect DNA damage by generating ROS [87]. Thus, both RFR and UVR, which can similarly induce oxidative DNA damage, can increase cancer risk by a similar mechanism.

Increased production of ROS and depletion of antioxidant capacity in living cells exposed to low intensity RF radiation can result in oxidative DNA damage. Induction of oxidative stress, which is a key characteristic of many human carcinogens [88], including UVR and asbestos, can also lead to genotoxicity and carcinogenicity of non-ionizing RF radiation without causing direct DNA damage.

Assumption 3) *Two to seven exposures to RF radiation for up to 1 hour duration are sufficient to exclude adverse effects for any duration of exposure including chronic exposures.*

The behavioral studies in 8 male rats and 5 male monkeys that served as the basis for the exposure limits to RF radiation adopted by the FCC and ICNIRP involved 2 to 7 exposure sessions of 40-minute duration for rats [10] and 3 exposure sessions of 60-minute duration for monkeys at each power density [11]. Additional support for the threshold SAR of 4 W/kg in the frequency range of 100 kHz to 6 GHz came from behavioral studies conducted in rats and monkeys by D’Andrea et al. [89, 90]. However, D’Andrea et al. [91, 92] also reported that exposure of rats to continuous wave 2450 MHz RFR for 14 or 16 weeks caused significant differences in behavioral activity between sham-exposed rats and RFR-exposed rats at mean SARs of 0.7 W/kg and at 1.23 W/kg, indicating that 4 W/kg is not a threshold SAR with extended exposure durations. Since that time many studies have shown that responses to non-thermal RFR depend on both exposure intensity and exposure duration [93]. Importantly, the same response was observed with lower exposure intensity but prolonged exposure duration as at higher exposure intensity and shorter duration [94].

Recognizing that the exposure limits do not address potential health effects after long-term exposures to

RF radiation emitted from wireless devices that people are experiencing, the FDA [17] nominated RF radiation to the NTP for chronic toxicology and carcinogenicity studies out of concern that “existing exposure guidelines are based on protection from acute injury from thermal effects of RFR exposure, and may not be protective against any non-thermal effects of chronic exposures.” Adverse health effects noted in Assumption #1, including cardiomyopathy, carcinogenicity, sperm damage, and neurological effects, as well as the human epidemiology studies to be described in Assumption #6, occurred with much longer exposures to RF radiation than the exposure durations used in the acute studies in rats [10] and monkeys [11]. Consequently, the acute behavioral exposure studies that served as the basis for exposure limits to RF radiation established by the FCC and ICNIRP are inadequate to identify and characterize adverse effects of RF radiation after longer exposure durations. Neither the exposure limits established in the 1990s by the FCC [4] or by ICNIRP [9], nor those reaffirmed more recently by these groups [3, 5] address health risks associated with long-term exposure to RF radiation.

Assumption 4) *No additional effects would occur from RF radiation with co-exposure to other environmental agents.*

The current FCC/ICNIRP exposure limits do not take into consideration interactive effects of RF radiation with other environmental agents even though such effects have been documented. Interactions of RF radiation with other agents may result in antagonistic or synergistic effects, i.e., effects that are greater than the sum of each agent alone.

In the International Agency for Research on Cancer (IARC) evaluation of the carcinogenicity of RF-EMF [44], the expert working group noted that 4 of 6 co-carcinogenesis studies available at that time showed increased responses with exposure to RF-EMF. One of those studies reported co-carcinogenic effects of UMTS-modulated RF radiation at 4.8 W/m² in the liver and lung of mice that had been treated with the carcinogen ethylnitrosourea (ENU) in utero [95]; the incidence of liver and lung cancers were increased in mice exposed to ENU plus RF radiation compared to cage controls, sham controls and ENU alone. After the IARC evaluation, Lerchl et al. [96] replicated the experimental design of Tillmann et al. [95] by exposing mice to RF-EMF at whole-body SAR levels of 0 (sham), 0.04, 0.4, and 2 W/kg. Significant increases in lung adenomas and/or liver carcinomas were observed at all exposure levels. Lerchl et al. [96] concluded that their “findings are a very clear indication that tumor-promoting effects

of life-long RF-EMF exposure may occur at levels supposedly too low to cause thermal effects.” Thus, the reproducibility of the tumor-promoting effects of RFR at non-thermal exposure levels has been demonstrated.

Other examples of reported synergistic effects include the following study results. Synergistic effects on damage to human lymphocytes were observed with co-exposure to RFR (1.8 GHz RFR, SAR 3 W/kg) and 2 different mutagens, namely, mitomycin C or 4-nitroquinoline-1-oxide [97], or with co-exposure to ultraviolet (UVC) light [98]. A synergistic effect was found on DNA damage in human blood cells exposed to 2450 MHz radiation (5 mW/cm²) and then exposed to mitomycin C [99]. A potentiation effect on DNA damage was observed in cultured mammalian cells exposed to CDMA-modulated 835 MHz RF-EMF (SAR = 4 W/kg) and the clastogens cyclophosphamide or 4-nitroquinoline-1-oxide [100]. Gene expression was altered in neuronal and glial cells of rats pre-treated with lipopolysaccharide, a neuroinflammatory agent, and then exposed to 1800 MHz GSM modulated radiation (SAR = 3.22 W/kg) for 2 hr. [101]. In rats pre-treated with picrotoxin, a chemical that induces seizures, exposure to pulse-modulated 900 MHz GSM-modulated RF radiation of mobile phones increased regional changes in brain activity and c-Fos expression [102, 103].

Exposure limits based on exposure to only RF radiation will result in an underestimation of the true risk and inadequate protection of human health under conditions in which co-exposures to other toxic agents lead to synergistic adverse effects [104].

B. Factors affecting dosimetry

Assumption 5) *Health effects are dependent only on the time-averaged SAR value; carrier wave modulations, frequency, or pulsing do not matter except as they influence the SAR.*

The FCC's and ICNIRP's exposure limits to RFR are based on SARs for frequencies up to 6 GHz and on power densities for frequencies between 6 GHz and 300 GHz averaged over 6-minute or 30-minute intervals for local areas and whole-body exposures [3, 5]. However, time-averaged dosimetry does not capture the unique characteristics of modulated or pulsed RFR. For example, GSM modulation may involve as many as 8 voice channels with a duration of 0.577 msec for each channel. Thus, the exposure from GSM modulation can be 8-times higher during each time slot pulse compared to exposure to a continuous wave at equivalent time-averaged SARs. Also, as noted under assumption #14, repetitive pulses of data in bursts with short exposures to 5G can cause localized

temperature spikes in the skin [105]. The impact of pulsed radiation on biological activities at the molecular or cellular levels is not taken into consideration with time-averaged dosimetry.

Another issue not addressed by time-averaged dosimetry is the importance of low frequency modulations on biological systems. As discussed under assumption #2, increased production of ROS in living cells and DNA damage have been demonstrated with exposure to low frequency modulations of radiofrequency carrier waves [106]. Exposure limits based on time-averaged SAR dosimetry or power density, without consideration of the impact of amplitude or frequency modulations, do not adequately address potential health effects of real-world exposures to RFR. There is ample evidence that various effects of RFR exposure depend on carrier wave modulations, frequency, or pulsing [43, 107, 108]. In contrast to ICNIRP/FCC, the IARC monograph on RFR carcinogenicity noted that RFR effects may be influenced by such exposure characteristics as duration of exposure, carrier frequency, type of modulation, polarization, exposure intermittence, and background electromagnetic fields [44].

C. Human brain tumor risk

Assumption 6) *The multiple human studies that find associations between exposure to cell phone RF radiation and increases in brain tumor risk are flawed because of biases in the published case-control studies, and because brain cancer rates have remained steady since the time that use of wireless communication devices became widespread.*

Although claims have been made that “current limits for cell phones are acceptable for protecting the public health” because “even with frequent daily use by the vast majority of adults, we have not seen an increase in events like brain tumors” [109], the SEER (Surveillance, Epidemiology, and End Results Program) database shows an annual decrease of 0.3% for all brain tumors, but an increase of 0.3% per year for glioblastoma in the US between 2000 and 2018 (<https://seer.cancer.gov/explorer/>). Most concerning was that the annual increase for glioblastoma was 2.7% per year for people under 20 years of age. In addition, Zada et al. [110] reported that the incidence of glioblastoma multiforme (GBM) in the frontal lobe, temporal lobe, and cerebellum increased in the US between 1992 and 2006, and Philips et al. [111] likewise reported a statistically significant increasing incidence of GBM in the frontal and temporal lobes of the brain in the UK during 1995–2015. In Sweden, rates of brain tumors in the Swedish National Inpatient Register and the Swedish Cancer Register increased from 1998 to

2015 [112]. In addition, it should be realized that cumulative exposure, side-of-head use, and latency for tumor formation from RFR are not fully captured in national cancer registries. Thus, the claim that trends in brain cancer incidence rates have not increased since mobile phones were introduced is both wrong and misleading. The specificity of effect needs to be factored into such trend analyses.

Case-control studies, using sound scientific methods, have consistently found increased risks with long-term, heavy mobile phone use for brain tumors of the glioma type and acoustic neuroma. This association was evaluated at IARC in 2011 by 30 expert participants who concluded that radiofrequency (RF) radiation is a “possible” human carcinogen [44]. In contrast, the much-cited Danish cohort study on ‘mobile phone users’ [113] was disregarded by IARC due to serious methodological shortcomings in the study design, including exposure misclassifications [44, 114].

Results of meta-analyses of glioma risk and acoustic neuroma from Swedish case-control studies conducted by Hardell and coworkers [115, 116], the 13-nation Interphone study [117], and the French study by Coureau et al. [118] are shown in Table 1 as odds ratios (OR) with 95% confidence intervals. For glioma on any location in the head, a statistically significant increase of nearly two-fold was found, while for ipsilateral mobile phone use (tumor and phone use on the same side of the head) the risk was increased by 2.5-fold. These ORs are based on the groups in each study with the highest category of cumulative call time, which were ≥ 1640 hr. in the Interphone study [117, 119] and the Swedish studies [115, 116], and ≥ 896 hr. in the study by Coureau et al. [118]. Decreased survival among glioma cases, especially astrocytoma grade IV, was associated with long-term and high cumulative use of wireless phones [120]. Increased risk for the mutant

type of *p53* gene expression in the peripheral zone of astrocytoma grade IV was associated with use of mobile phones for ≥ 3 hours a day. Increase in this mutation was significantly correlated with shorter overall survival time [121].

For acoustic neuroma, risk was significantly increased with cumulative exposure and ipsilateral use by 2.7-fold. A random effects model, which was based on a test for heterogeneity, was used for the meta-analyses of these published studies. Tumor volume of acoustic neuroma increased per 100 hr. of cumulative use of wireless phones in the Swedish study and years of latency, indicating tumor promotion [115].

Other case-control studies of mobile phone use also reported increased risk of acoustic neuroma [122–124]. Those studies were not included in the meta-analysis because data on cumulative mobile phone use with numbers of cases and controls were not given or there were other shortcomings. It is also noteworthy that tumor risks were increased in subsets of the Interphone study; for example, there was nearly a 2-fold increase in the risk of acoustic neuroma for ≥ 10 y and ipsilateral use among the North European countries that participated in the Interphone study [125].

Claims have been made that associations between increases in brain cancer risk and exposure to cell phone RF radiation in the published case-control studies may be attributable to recall and/or selection biases [5, 109]. However, a re-analysis of the Canadian data that was included in the Interphone study showed that there was no effect on the risk of glioma after adjustments were made for selection and recall biases [126]. Odds ratios (OR) for glioma were increased significantly and to a similar extent when comparing the highest quartile of use to those who were not regular users whether or not adjustments for biases were made. In addition, Hardell

Table 1 Odds ratios (OR) with 95% confidence interval (CI) for glioma and acoustic neuroma in case-control studies in the highest category for cumulative mobile phone use in hours^a

	Glioma				Acoustic neuroma			
	All		Ipsilateral		All		Ipsilateral	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Interphone [117, 119] Cumulative use ≥ 1640 hr	1.40	1.03–1.89	1.96	1.22–3.16	1.32	0.88–1.97	2.33	1.23–4.40
Coureau et al. [118] Cum use ≥ 896 hr	2.89	1.41–5.93	2.11	0.73–6.08				
Hardell et al. [115, 116] Cumulative use ≥ 1640 hr	2.13	1.61–2.82	3.11	2.18–4.44	2.40	1.39–4.16	3.18	1.65–6.12
Meta-analysis longest cumulative use	1.90	1.31–2.76	2.54	1.83–3.52	1.73	0.96–3.09	2.71	1.72–4.28

^a Note Hardell et al. [115, 116] also assessed use of cordless phones

and Carlberg [116] showed that the risk for glioma with mobile phone use was increased significantly even when compared to the risk for meningioma. Because risk of meningioma was not increased significantly, this tumor response could not be attributed to recall bias. Clearly, selection and recall biases do not explain the elevated brain tumor risk associated with the use of mobile phones. Thus, epidemiological evidence contradicts the opinions of the FCC and ICNIRP on brain tumor risk from RF radiation.

It should also be noted that the thyroid gland is a target organ for RFR from smartphones. A case-control study on mobile phone use suggested an increased risk for thyroid microcarcinoma associated with long-term cell phone use [127]. Peripheral lymphocyte DNA obtained from cases and controls was used to study genotype-environment interactions. The study showed that several genetic variants based on single nucleotide polymorphisms (SNPs) increased the risk of thyroid cancer with mobile phone use [128]. Increasing incidence of thyroid cancer in the Nordic countries, especially over the last two decades, has also been reported [129, 130]. In addition, a recent case-control study found significant increases in breast cancer risk among Taiwanese women based on their use of smartphones and distance between the breast and placement of their smartphone [131].

D. Individual variations in exposure and sensitivity to RF-EMF

Assumption 7) *There are no differences among individuals, including children, in the absorption of RF-EMF and susceptibility to this radiation.*

Differences between children and adults regarding the absorption of radiofrequency electromagnetic fields when mobile phones are operated close to the head have been demonstrated and widely documented [132–137]. The main factors accounting for these dissimilar absorption rates include differences in anatomy, tissue dielectric properties, and physiology. Through finite-difference time-domain (FDTD) simulations, employing detailed computational anthropomorphic models, it is possible to find differences relating to anatomy and to dimensions of the head.

Since EMF penetration into human tissues can be in the order of a few centimeters, depending on the wavelength, the inner tissues in the brain clearly will receive a significantly higher dose in the smaller heads of children compared to adults, despite the total absorption and the peak spatial SAR (psSAR) calculated across the whole head varying by smaller amounts [132, 133, 138]. Fernández et al. [136] estimated that the cell phone radiation psSAR in the hippocampus was 30-fold higher in

children compared to adults, while the psSAR in the eyes was 5-fold higher in children; these differences were due largely to closer proximity to the cell phone antennas. The thinner dimensions of children's skulls also contribute to this difference [135], resulting in a psSAR around 2-fold higher in children's brains [134–137, 139] compared to adults.

Additionally, tissues of young mammals have higher conductivity and electrical permittivity than those of mature animals [140]. This also contributes to greater EMF penetration and absorption, resulting in further increases in the psSAR. The psSAR in the skull bone marrow of children was estimated to increase by 10-fold due to higher conductivity in this tissue [137]. Distance between the mobile device and the body tissues is important in characterizing tissue dosimetry. The National Agency ANFR of France recently released cell phone SAR test data for 450 cell phones. Ten gram psSARs increased by 10–30% for each millimeter of proximal placement of the cell phone to the planar body phantom (<http://data.anfr.fr/explore/dataset/das-telephonie-mobile/?disjunctive.marque&disjunctive.modele&sort=marque>).

Finally, it is important to note that simulations of tissue dosimetry consider only the physical parameters of the tissues; they do not consider biological processes occurring in living tissues. While children are growing, developing organs and multi-organ systems are more susceptible to adverse effects of environmental agents; finite-difference time-domain (FDTD) simulations do not address differences in organ or system susceptibility for exposures occurring during child development.

Assumption 8) *There are no differences among individuals in their sensitivity to RF radiation-induced health effects.*

All life is “electrosensitive” to some degree as physiological processes are dependent on both subtle and substantial electromagnetic interactions at every level, from the molecular to the systemic. Responses to multiple types of electromagnetic exposure reveal that there is a far broader range of EMF sensitivity than previously assumed, and subgroups of extremely hypersensitive subjects exist [141–151]. Given the adverse health effects noted in Assumption #1, including cardiomyopathy, carcinogenicity and neurological effects, the acute, conscious symptoms manifesting in some individuals should not be unexpected. The term currently and most frequently used within the medical profession to describe those who are acutely, symptomatically sensitive to non-ionizing radiation exposures is Electromagnetic Hypersensitivity (EHS).

EHS is a multisystem, physical response characterized by awareness and/or symptoms triggered by EMF exposures. Common symptoms include (but are not limited to) headaches, dizziness, sleep disturbance, heart palpitations, tinnitus, skin rashes, visual disturbance, sensory disturbance, and mood disturbance [152, 153]. These symptoms are reported in response to even extremely low intensity (orders of magnitude below current safety levels) EMFs of multiple types (in terms of frequency, intensity and waveforms). Commonly noticed triggers of frequent and persistent EHS symptoms are pulse-modulated RF emissions, modulated at extremely low frequencies. Common triggering sources include mobile phones, DECT cordless landlines, Wi-Fi/Bluetooth-enabled computers, Wi-Fi routers, smart meters, base station antennas, and household electrical items. EMF avoidance/mitigation is found to be the most effective way to reduce symptoms [154].

Guidelines for EHS diagnosis and management have also been peer-reviewed and concur that the mainstay of medical management is avoidance of anthropogenic electromagnetic fields [152, 155, 156]. Case histories detailing clinical presentations, EMF measurements and mitigation are also published [157], and biomarkers including elevated markers of oxidative stress, inflammatory markers and changes in cerebral blood flow continue to be explored [152].

EHS has been proven to be a physical response under blinded conditions [145, 151, 158, 159] and, in addition to these studies, acute EMF-induced changes in cognition, behavior, and physiology reactions have been observed in studies involving animals [27, 30, 160–172]; plus further references under Assumption 13), which cannot be biased by media-cultivated fears. These studies provide further evidence which invalidates the nocebo response (physical symptoms induced by fear) as causal regarding symptoms.

It should not be expected that all provocation studies will reliably demonstrate adverse reactions; however, suggestions that the nocebo response may cause EHS symptoms were claimed from provocation studies which failed to show a relationship between the EMF exposure and the reported symptoms [173]. The failures of these studies are explainable given the very poor methodology in the majority of them. There were failures to account for a multitude of essential factors that must be tailored to the individual, such as variable symptom onset and offset, the necessity for adequate washout periods, specificity of trigger frequencies and intensities, requirement for complete EMF hygiene during sham exposures, requirement for life-like exposures (e.g., pulse-modulated information-carrying waves), etc. For example, it has been shown that various frequency channels from GSM/

UMTS mobile phones affect the same human cells differently [174–177]. Similarly, EHS has been shown to be frequency dependent [151]. As noted above, meaningful provocation studies need to take into consideration multiple physical parameters of exposure, including frequency, modulation, duration of exposure, and time after exposure [155]; however, most provocation studies that have failed to establish causative connection between RFR exposure and EHS symptoms [173] used only one or two conditions with short-term exposures.

There are many issues with the nocebo response as a cause of EHS, not least of which is also the absence of the required temporal link. For the nocebo response to be the cause of EHS, awareness and concern of negative health impacts from EMFs must precede symptoms. But, in the majority of EHS persons this is not the case [178]. As public risk communication improves, this will no longer be verifiable; however, this has been importantly observed at the only point in time when it could have been – prior to generalized awareness of health detriments from non-ionizing radiation (NIR).

While recognizing that some vulnerable groups may be more susceptible to effects of NIR exposure, ICNIRP [179] acknowledged that their guidelines may not safely accommodate these sensitive subgroups:

“Different groups in a population may have differences in their ability to tolerate a particular NIR [Non-Ionizing Radiation] exposure. For example, children, the elderly, and some chronically ill people might have a lower tolerance for one or more forms of NIR exposure than the rest of the population. Under such circumstances, it may be useful or necessary to develop separate guideline levels for different groups within the general population, but it may be more effective to adjust the guidelines for the general population to include such groups. Some guidelines may still not provide adequate protection for certain sensitive individuals nor for normal individuals exposed concomitantly to other agents, which may exacerbate the effect of the NIR exposure, an example being individuals with photosensitivity”.

In 2020, ICNIRP [23] also noted that biological effects are not easily discernible from adverse health effects, and that their guidelines:

“...are not intended to protect against biological effects as such (when compensatory mechanisms are overwhelmed or exhausted), unless there is also an associated adverse health effect. However, it is not always easy to draw a clear distinction between biological and adverse health effects, and indeed this can vary depending on individual susceptibility”.

to specific situations. An example is sensory effects from nonionizing radiation exposures under certain circumstances, such as a tingling sensation resulting from peripheral nerve stimulation by electric or magnetic fields; magnetophosphenes (light flickering sensations in the periphery of the visual field) resulting from stimulation of the retina by electric fields induced by exposure to low-frequency magnetic fields; and microwave hearing resulting from thermoelastic waves due to expansion of soft tissues in the head which travel via bone conduction to the inner ear. Such perceptions may sometimes lead to discomfort and annoyance. ICNIRP does not consider discomfort and annoyance to be adverse health effects by themselves, but, in some cases, annoyance may lead to adverse health effects by compromising well-being. The exposure circumstances under which discomfort and annoyance occur vary between individuals."

Trivializing "discomfort" which is the pre-cursor to pain is not in keeping with WHO recommendations quoted by the same ICNIRP [23] document: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."

Discomfort is a sign that an organism is experiencing something which is compromising optimal health and although in some cases this can be trivial and reversible, in other cases it may not be reversed. There is an extremely broad range of both pain tolerance and also of pain perception among humans, and to achieve meaningful preventative health care, "discomfort" must be taken seriously and mitigated whenever possible. This is especially true in this case where symptoms such as headaches are being reported in response to mobile phone exposures at the same time as increased brain tumor risk is noted from those same exposures (see Assumption 6).

In reality, people with EHS are reporting far more serious health disruption than "discomfort" or "annoyance" and in some cases these symptoms are disabling [180, 181]. Increasingly, EHS is being recognized as a disability by national courts in France, Sweden, and Spain, which amplifies the requirement for safety guidelines that are deliberately accommodating to this more susceptible group [180].

E. Applied safety factors for RF-EMF-RF workers and the general population

Assumption 9) *A 50-fold safety factor for whole body exposure to RF radiation is adequate for protecting the general population to any health risks from RF radiation.*

Public health agencies in the US and worldwide apply multiple uncertainty factors to health effects data to establish exposure levels that are considered safe for the great majority of exposed populations [182–184]. Although guidelines for the use of uncertainty factors were developed for chemicals, they are also pertinent to other toxic agents, such as RFR. The uncertainty factors needed for toxic effects of RFR based on studies that demonstrate a no-observed-adverse-effect level (NOAEL) in experimental animals include:

- 1) Animal-to-human extrapolation. When data are based on studies in experimental animals, a factor of 3–10 is applied (for potential species differences in tissue dosimetry and response) unless there are convincing data demonstrating equivalent sensitivity in animals and humans. However, there is no evidence showing that humans are equally or less sensitive to RFR than animals that were used in studies from which exposure limits were established by the FCC and ICNIRP.
- 2) Adjustment for human variability. A second factor of 10 is used to account for interindividual variability in susceptibility (for instance, due to differences in age, sex, genetic variation, pre-existing diseases) to the toxic agent among the general population. It has been recognized that a factor of 10 for human variability is likely inadequate for sensitive subpopulations and may require an additional adjustment.
- 3) Extrapolation from short-term studies to lifetime exposure. An additional factor of 10 is applied for short-term studies, such as those used to establish exposure limits to RF radiation, to provide lifetime protection from chronic exposure. This is of particular importance considering the remarkably short periods over which RFR toxicity was originally assessed [10, 11].
- 4) Database insufficiencies. Finally, an uncertainty factor of 3-to-10 is applied for database inadequacy, i.e., for incomplete characterization of an agent's toxicity. The behavioral studies [10, 11] that were used to establish the FCC and ICNIRP exposure limits to RFR do not provide a full characterization of the effects of this type of radiation nor did they identify the most sensitive adverse effect of RFR exposures.

Basing exposure limits to RFR on the behavioral studies in rats and monkeys [10, 11, 90, 91] would require the application of a composite uncertainty factor of about 900 to 10,000 to be consistent with approaches used by public health agencies to establish protective exposure limits for workers and the general population. Based on the size of the needed uncertainty/safety factor, the

data sets used by the FCC and ICNIRP are clearly inadequate to establish RF exposure limits with reasonable confidence. The arbitrarily selected safety factors of 10 for workers and 50 for the general population by the FCC and ICNIRP are woefully inadequate for protecting exposed populations.

When uncertainty/safety factors are applied to a misrepresented threshold exposure value for adverse effects, the resulting level does not provide assurance of health protection for the general population exposed to that agent. Studies cited above [18, 22, 91, 92, 96] show that the whole-body SAR of 4 W/kg is not a threshold level for adverse effects caused by RFR. In a recent quantitative analysis of various adverse health effects from the NTP study, Uche and Naidenko [185] showed that the permissible whole-body SAR of 0.08 W/kg (based on a 50-fold reduction of the assumed threshold SAR of 4 W/kg) was 20–40-fold higher than health protective SAR values derived by benchmark dose modelling of NTP data for cardiomyopathy (following application of 10-fold safety factors for interspecies and intraspecies variability). The approaches used by these authors are consistent with methodologies recommended by the US Environmental Protection Agency for quantifying health risks for toxic and carcinogenic environmental agents [1, 182]. Thus, a 50-fold reduction of the assumed threshold whole-body SAR of 4 W/kg is inadequate to protect the health of the general population from exposure to RF radiation.

Assumption 10) *A 10-fold safety factor for whole body exposure to RF radiation is adequate for protecting workers to any health risks from RF radiation.*

When RFR exposure limits were implemented in 1997, the rationale given for the difference in safety factors for the general population (50-fold) and for workers (10-fold) was “based on the exposure periods of the two populations, rounded to one digit (40 work hours per week/168 hours per week = ~0.2)” [6]. In addition to differences in exposure periods between workers and the general population, ICNIRP rationalizes the appropriateness of the lower safety factor for workers because “occupationally-exposed individuals can be considered a more homogeneous group than the general population,” they are, “in general, relatively healthy adults within a limited age range,” and “occupationally-exposed individuals should be operating under controlled conditions and be informed about the risks associated with non-ionizing radiation exposure for their specific situation and how to reduce these risks” [23]. In contrast, “the general public are, in most cases, unaware of their exposure to non-ionizing radiation and, without education, cannot

reasonably be expected to take precautions to minimize or avoid any adverse effects of exposure.”

The assumption that workers are trained in understanding health risks associated with exposure to RFR and in mitigating those risks to the greatest possible degree is not correct because neither the FCC nor the ICNIRP guidelines recognize any health effects from RFR at SARs below 4 W/kg, and the exposure limits authorized by the FCC and ICNIRP do not consider health effects from long-term exposures [3, 5]. The only health effect addressed by the FCC and ICNIRP is tissue damage due to excessive heating from acute exposures. Thus, the 10-fold reduction from the threshold whole-body SAR calculated from acute behavioral studies in rats and monkeys is inadequate for protecting the health of workers exposed long-term to RFR (see comments under assumption #9). There are no data demonstrating the adequacy of this arbitrarily chosen safety/uncertainty factor for occupationally-exposed workers, while on the contrary, excess cancer risks have been associated with exposure to RFR workers who operate radar and communication systems in military and occupational settings [186].

Assumption 11) *Exposure of any gram of cube-shaped tissue up to 1.6 W/kg, or 10g of cube-shaped tissue up to 2 W/kg, (duration not specified) will not increase the risk of that tissue to any toxic or carcinogenic effects in the general population.*

Tissue dosimetry was analysed in the NTP study of cell phone RF radiation in rats and mice [187]. In rats, whole body exposures during the 10-minute on cycles were 1.5, 3.0, or 6.0 W/kg, and the brain and heart SARs varied from the whole-body SARs by about 7% to under 2-fold for the brain and heart, respectively. A quantitative risk assessment of the NTP tumor incidence data is needed to evaluate organ-specific cancer risk. The FDA [19] nomination to the NTP recognized the need for “large well-planned animal experiments to provide the basis to assess the risk to human health of wireless communications devices.” However, more than 3 years after an external peer-review of the NTP studies found “clear evidence of carcinogenic activity,” the FDA [109] has continued to downplay the importance of these findings and avoid conducting a quantitative risk assessment of the tumor data that they (the FDA) originally requested. In contrast to the FDA, Uche and Naidenko [185] analysed the NTP data on cardiomyopathy by a benchmark dose approach and found that the 10% extra risk level for this effect was in the range of a whole-body SAR of 0.2 to 0.4 W/kg. Thus, there is an increased risk (greater than 10%) of developing cardiomyopathy at local tissue SARs below 1.6 or 2.0 W/kg.

The peak spatial specific absorption rate (psSAR), as used by ICNIRP and the FCC, is an inadequate dosimetric of RF radiation at frequencies above 1 GHz. The psSAR is calculated by averaging fixed cubic volumes containing a given amount of mass, and assumes a homogeneous material with a given mass density. The ICNIRP recommendation is to average cubic volumes containing 10 g of tissue (10 g-psSAR), while the FCC recommendation is to average cubic volumes containing 1 g of tissue (1 g-psSAR). Current recommendations limit the use of psSAR to frequencies up to 6 GHz [3, 5].

An evaluation of the utility of using psSAR as a dosimetric parameter at different frequencies ranging from 100 MHz to 26 GHz and with cube sizes ranging from 10 mg to 10 g is shown in Additional file 2: Appendix 2. For the smaller cubes and lower frequencies, averaging in the cube does not underestimate the maximum value on the cube surface, but at higher frequencies the psSAR averaged on larger cubes can be several-fold lower than the psSAR averaged on smaller cubes. For example, at 2.45 GHz, averaging over a 10-g cube underestimates by 4 dB (approximately 2.5-fold) the psSAR averaged in smaller cubes, while for 5.8 GHz, averaging over a 10-g cube underestimates the psSAR by 12 dB (approximately 16-fold) compared with averaging in a 10-mg cube, and by 6 dB (approximately 4-fold) compared with averaging over a 1-g cube. When the frequency is increased, the underestimation of the psSAR averaged in larger cubes (e.g. 10 g or 1 g) compared to smaller cubes (e.g. 100 mg and 10 mg) becomes more pronounced. Considering the 10-g cube, the difference between the psSAR for 5.8 GHz EMF compared to 0.9 GHz EMF is around 7 dB (or approximately 5-fold underestimation). These large differences are due to reduced penetration of EMFs at higher frequencies. Therefore, the ICNIRP's 10 g-psSAR and FCC's 1 g-psSAR recommendations do not provide reliable dosimetric parameters to evaluate EMF absorption above 1 GHz.

The SAR averaging over a 10-g cube is also flawed for assessing carcinogenicity because it is too large a volume to focus on stem cells and their important role in carcinogenesis. Human stem cells were more sensitive to RFR exposures from GSM and UMTS mobile phones than lymphocytes and fibroblasts [175]. Instead of a random distribution of targets for carcinogenesis, localized distribution of SAR in smaller volumes is needed to more accurately characterize relationships between SAR and tumor induction. From the point of view of stem cell organization, the volume of SAR determinations may be especially important for setting safety limits for children, because most stem cells and their niches are spatially and temporally transient during brain development [188].

Assumption 12) *Exposure of any gram of cube-shaped tissue up to 8 W/kg, or 10 g of cube-shaped tissue up to 10 W/kg, (duration not specified) will not increase the risk of that tissue to any toxic or carcinogenic effects in workers.*

Based on the analyses of tissue dosimetry in the NTP study [187], organ-specific toxic and carcinogenic effects were observed in rats at local tissue SARs that were much lower than 8 or 10 W/kg [18]. The tissue dosimetry in the NTP study and the inadequacy of the local SAR as specified by ICNIRP and the FCC is described in assumption #9.

F. Environmental exposure to RF radiation

Assumption 13) *There is no concern for environmental effects of RF radiation or for effects on wildlife or household pets.*

While background levels of RF-EMF are increasing in the environment, including rural remote areas [189], neither the FCC nor the ICNIRP take into consideration effects of this radiation on wildlife. The constant movement of most wildlife species in and out of varying artificial EMF can result in high exposures near communication structures, especially for flying species such as birds and insects. There is a substantial amount of scientific literature on the disrupting effects of RFR on wildlife (e.g., [190–206]).

Many nonhuman species use Earth's geomagnetic fields for activities such as orientation and seasonal migration, food finding, mating, nest and den building [190]. For example, migratory bird species [191, 192], honeybees [193], bats [194], fish [195–197], and numerous other species sense Earth's magnetic fields with specialized sensory receptors. Mechanisms likely involved in magneto-reception include magnetic induction of weak electric signals in specialized sensory receptors [198], magneto-mechanical interactions with the iron-based crystal magnetite [194], and/or free-radical interactions with cryptochrome photoreceptors [191, 192]. Each of these sensing processes shows extreme sensitivity to low intensity changes in electromagnetic fields. For a fuller description of the mechanisms by which non-human species use magneto-reception to perform essential life activities see Levitt et al. [190].

The following studies represent a few of the many examples of the disrupting effects of low-level exposures to RF-EMF on magneto-reception and the natural behavior of wildlife. Oscillating magnetic fields have been reported to disrupt the ability of migratory birds to orient and navigate in Earth's geomagnetic field [199–202].

Garden warblers became disoriented by exposure to a weak oscillating magnetic field of 1.403 MHz at an intensity as low as 2–3 nT [200]. The orientation of European robins that use Earth's magnetic field for compass orientation was completely disrupted by exposure to electromagnetic noise in the frequency range of 50 kHz to 5 MHz or a broadband noise-modulated ELF covering the range ~2 kHz to ~9 MHz [199, 201]. RFR in the low MHz range (7.0 MHz of 480 nT or 1.315 MHz of 15 nT) has been shown to disable the magneto-reception avian compass as long as the exposure was present [202].

In addition to effects on migratory birds, Landler et al. [203] found that exposure to a low-level magnetic field (1.43 MHz at an intensity of 30–52 nT) disrupted the natural orientation of juvenile turtles hatched on land. GSM-modulated 900 MHz RF radiation caused ants to lose their visual and olfactory memory for finding food [166]. Navigational abilities of trout were reduced when reared under conditions in which magnetic fields were spatially distorted [204].

Activities of honeybees are also disrupted by exposure to RF radiation. GSM-modulated cell phone radiation (900 MHz) caused a reduction in egg laying by queen bees and depletion of beehive pollen and honey counts [205]. GSM-modulated cell phone radiation (900 MHz) reduced hatching and altered pupal development of honey queen bee larvae [206].

The lack of consideration of chronic low-level RF radiation exposure on wildlife could result in dangerously disruptive effects on fragile ecosystems and on the behavior and survival of species that have long existed in Earth's natural environment.

G. 5G (5th generation wireless)

Assumption 14) *No health effects data are needed for exposures to 5G; safety is assumed because penetration is limited to the skin ("minimal body penetration").*

Fifth generation (5G) wireless communication systems are being deployed worldwide to provide higher data transfer rates with shorter lag times between massive numbers of connected wireless devices. To provide faster transfer of large amounts of data (up to 20 gigabits per second peak data rates), the frequency range for 5G includes millimeter waves (30 to 300 GHz), in addition to carrier frequencies as low as 600 MHz. Extremely high frequency millimeter waves (MMW) that transmit large amounts of data to user devices are directed into narrow beams by line-of-sight transmission with beamforming antennas. Because millimeter waves do not penetrate solid structures such as building materials, hills, foliage, etc., and travel only short distances (a few hundred

meters), denser networks of base-stations with massive Multiple Input/Multiple Output (MIMO) transmitters and receivers in millions of small cell towers are being installed on structures such as utility poles. These features can lead to much closer proximity between humans and radiation-emitting antennas, and thereby change individual peak and average exposures to RFR.

For a 5G frequency of 26 GHz, EMF absorption is very superficial, which means that for typical human skin, more than 86% of the incident power is absorbed within the first millimeter. The skin penetration depth was computed as 1 mm based on the electrical conductivity of the skin and its electrical permittivity [5, 207]. This is expected to bring the SAR in this tissue well above the recommended limits ([208], and Additional file 2: Appendix 2). This is also expected to be harmful to very small species, such as birds and other small animals (e.g., insects) [209]. It is often claimed that because of its shallow penetration, exposure to high frequency 5G radiation is safe, and that the only effect is tissue heating [210]. However, this view ignores the deeper penetration of the ELF components of modulated RF signals, which are rated on the basis of heat alone, as well as the effects of short bursts of heat from pulsed signals [211, 212]. Within the first 1 mm of skin, cells divide to renew the stratum corneum (a consideration for skin cancer), and nerve endings in the dermis are situated within 0.6 mm (eyelids) to 3 mm (feet) of the surface (a consideration for neurological effects). Ultraviolet light, which exerts its action at a penetration depth of less than 0.1 mm [213, 214] is a recognized cause of skin cancer [87].

The higher the frequency of electromagnetic waves, the shorter the wavelength and the shallower the penetration of energy into exposed people or animals. For example, penetration depth in the human body is about 8 mm at 6 GHz and 0.92 mm at 30 GHz [5]. Because of the minimal depth of energy absorption at frequencies above 6 GHz, the FCC and ICNIRP have based exposure limits on power density instead of on SAR levels. The FCC [3] proposed a general localized power density exposure limit of 4 mW/cm² averaged over 1 cm² and not to exceed 30 minutes for 5G services up to 3000 GHz for the general population, claiming that this exposure is consistent with the peak spatial-average SAR of 1.6 W/kg averaged over any 1 g of tissue at 6 GHz. ICNIRP's [5] exposure limits for 5G are an absorbed power density of 200 W/m² (0.2 W/cm²) averaged over 4 cm² and a 6-minute interval for frequencies up to 30 GHz, and 400 W/m² (0.4 mW/cm²) averaged over 1 cm² and a 6-minute interval for frequencies of 30 GHz to 300 GHz.

Because of its minimal penetration, exposure to 5G radiation results in higher energy intensity on the skin and other directly-exposed body parts, such as the eye

cornea or lens. However, the skin, which is the largest organ in the human body, provides important functions such as acting as a protective physical and immunological barrier against mechanical injury, infection by pathogenic microorganisms, and entry of toxic substances. In addition, skin cancers, including basal cell carcinomas and squamous cell carcinomas, are the most prevalent human cancers, while melanomas are highly metastatic and increasing in prevalence. Although the high incidence of skin cancers are largely attributed to exposure to ultraviolet light, no studies have been reported on the effects of 5G radiation on (i) the skin's ability to provide protection from pathogenic microorganisms, (ii) the possible exacerbation of other skin diseases, (iii) promotion of sunlight-induced skin cancers, or (iv) initiation of skin cancer by itself. Information is also lacking on the effects of 5G radiation on nervous and immune systems which are also exposed even by the shallower penetration of MMW.

Another important factor is the maximum bandwidth with 5G radiation, which is up to 100 MHz in the frequency range of 450 MHz to 6 GHz, and up to 400 MHz in the ranges from 24 GHz to 52 GHz, compared to previous types of mobile communication where bandwidth is limited to 20 MHz. Because many studies indicated frequency-dependent, non-thermal RF effects from mobile communication RFR [43, 177] and for MMW effects [215, 216], the possibility of effective frequency windows for biological effects would increase with the increased bandwidth of 5G radiation.

Another consideration for effects of 5G exposures on human health is that radiation pulses created by extremely fast data transmission rates have the potential to generate bursts of energy that can travel much deeper than predicted by conventional models [217, 218]. Neufeld and Kuster [105] showed that repetitive pulses of data in bursts with short exposures to 5G can cause localized temperature spikes in the skin leading to permanent tissue damage even when the average power density values were within ICNIRP's acceptable safety limits. The authors urged the setting of new thermal safety standards to address the kind of health risks possible with 5G technology:

"The FIFTH generation of wireless communication technology (5G) promises to facilitate transmission at data rates up to a factor of 100 times higher than 4G. For that purpose, higher frequencies (including millimetre-wave bands), broadband modulation schemes, and thus faster signals with steeper rise and fall times will be employed, potentially in combination with pulsed operation for time domain multiple access...The thresholds for frequencies

above 10 MHz set in current exposure guidelines (ICNIRP 1998, IEEE 2005, 2010) are intended to limit tissue heating. However, short pulses can lead to important temperature oscillations, which may be further exacerbated at high frequencies (>10 GHz, fundamental to 5G), where the shallow penetration depth leads to intense surface heating and a steep, rapid rise in temperature..."

Areas of uncertainty and health concerns with 5G radiation include potential increase in skin cancer rates with (or possibly without) co-exposure to sunlight, exacerbation of skin diseases, greater susceptibility to pathogenic microorganisms, corneal damage or early development of cataracts, testicular effects, and possible resonant-enhanced absorption due to skin structures [219]. One of the complex technical challenges in relation to human exposure to 5G millimeter waves is that the unpredictable propagation patterns that could result in unacceptable levels of human exposure to electromagnetic radiation are not well understood [220]. Although MMW are almost completely absorbed within 1–2 mm in biologically-equivalent tissues, their effects may penetrate deeper in a live human body possibly by affecting signal transduction pathways. Thus, there are too many uncertainties with exposure to 5G to support an assumption of safety without adequate health effects data. There are no adequate studies on health effects from short-term or long-term exposures to 5G radiation in animal models or in humans.

Discussion

To develop health-based exposure limits for toxic and carcinogenic substances, regulatory agencies typically rely on available scientific evidence about the agent under review. In the mid- and late-1990s when the FCC [4] and the ICNIRP [9] initially established exposure limits for RFR, the prevailing assumptions were that any adverse effects from exposure to RFR were due to excessive heating because non-ionizing radiation did not have sufficient energy to break chemical bonds or damage DNA. However, non-thermal effects of RFR are demonstrated from studies that find different effects with exposure to continuous waves versus pulsed or modulated waves at the same frequency and the same SAR or power density, e.g., [221–226], and from studies that show adverse effects at very low exposure intensities, e.g., [78, 96].

Acute exposure studies conducted in rats and monkeys in the 1980s [10, 11] suggested that an SAR of 4 W/kg could be a threshold dose for behavioral effects. Because this SAR was associated with an approximate increase in body temperature of 1 °C, it was again assumed that no adverse health effects would occur if increases in core

body temperature were less than 1°C. From this putative threshold dose a “safety factor” of 10 was applied for occupational exposures and an additional factor of 5 (50x total) was applied for the general population, resulting in exposure limits in which the whole-body SAR was less than 0.4 W/kg for workers and 0.08 W/kg for the general population. However, realizing that local parts of the body could receive doses of RFR that were 10 to 20 times higher than the whole-body SARs, local peak exposure limits were set by the FCC at SARs 20-times higher than the whole-body SARs, i.e., 8 W/kg averaged over any 1-g of tissue for localized exposures for workers and 1.6 W/kg averaged over any 1-g for the general population [3, 4]. ICNIRP opted for partial body exposures that would not exceed 2.0 W/kg averaged over any 10g of cube-shaped tissue for the general population [5, 9]. To rationalize the smaller safety factor for workers (10-fold) versus the general population (50-fold), one claim made by ICNIRP [24] is that workers are informed about risks associated with non-ionizing radiation exposure and how to reduce these risks, whereas “the general public are, in most cases, unaware of their exposure to non-ionizing radiation and, without education, cannot reasonably be expected to take precautions to minimize or avoid any adverse effects of exposure.” From a public health perspective, the FCC and ICNIRP should make the public aware of their exposures to RFR and promote precautionary measures to minimize potential adverse effects, especially for children and pregnant women. Eight practical recommendations by the International EMF Scientist Appeal aimed at protecting and educating the public about potential adverse health effects from exposures to non-ionizing EMFs [227] are shown in Table 2.

The acute behavioral studies that provide the basis for the FCC’s and ICNIRP’s exposure limits lacked any information on potential effects of RF radiation that can occur after longer durations of exposure, and they did not address effects of carrier wave modulations used in wireless communications. Research on RFR conducted over

the past 25 years has produced thousands of scientific papers, with many demonstrating that acute behavioral studies are inadequate for developing health protective exposure limits for humans and wildlife, and that inherent assumptions underlying the FCC’s and ICNIRP’s exposure limits are not valid. First, 4 W/kg is not a threshold SAR for health effects caused by RFR exposures; experimental studies at lower doses and for longer durations of exposure demonstrated cardiomyopathy, carcinogenicity, DNA damage, neurological effects, increased permeability of the blood brain barrier, and sperm damage (see Assumptions 1–3). Multiple robust epidemiologic studies on cell phone radiation have found increased risks for brain tumors (Assumption 6), and these are supported by clear evidence of carcinogenicity of the same cell types (glial cell and Schwann cell) from animal studies. Even studies conducted by D’Andrea et al. [89, 90] before the limits were adopted found behavioral disruption in rats exposed to RFR for 14 or 16 weeks at mean SARs of 0.7 W/kg and at 1.23 W/kg. A combination of exposure duration and exposure intensity would be more appropriate for setting safety standards for exposure to RFR from mobile communication systems including mobile phones, base stations, and WiFi.

More than 120 studies have demonstrated oxidative effects associated with exposure to low intensity RFR (Additional file 1: Appendix 1). DNA damage that has been reported in studies of RFR was most likely caused by induction of oxidative stress, which is a key characteristic of human carcinogens [88], rather than by direct ionization (Assumption 2). The generation of reactive oxygen species has also been linked to DNA damage and the carcinogenicity of UVA radiation [87] and asbestos [228]. Despite the enormous amount of scientific evidence of low-dose effects of RFR, the IEEE [229] maintains that behavioral disruption is still the most sensitive and reproducible effect of RFR. It is this opinion that contributed to the FCC [3] and ICNIRP [5] reaffirming their previous exposure limits to RFR.

Table 2 Precautionary Measures Recommended by the International EMF Scientist Appeal

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- 1) Priority should be given to protect children and pregnant women
 - 2) Guidelines and regulatory standards should be strengthened
 - 3) Manufacturers should be encouraged to develop safer technologies
 - 4) The public should be fully informed about the potential health risks from electromagnetic energy and taught harm reduction strategies
 - 5) Medical professionals need to be educated about the biological effects of electromagnetic energy and be provided training on treatment of patients with electromagnetic sensitivity
 - 6) Governments need to fund training and research on electromagnetic fields and health that is independent of industry
 - 7) The media should disclose experts’ financial relationships with industry when citing their opinions regarding health and safety aspects of EMF-emitting technologies
 - 8) Radiation-free areas need to be established, especially for individuals with EHS
-

Other concerns about the current exposure limits for RFR are that they do not consider potential synergistic effects due to co-exposure to other toxic or carcinogenic agents, the impact of pulsed radiation or frequency modulations, multiple frequencies, differences in levels of absorption or of susceptibility by children, or differences among individuals in their sensitivity to RFR (see Assumptions 4, 5, 7, 8). Currently, children's cumulative exposures are much higher than previous generations and they continue to increase [230]. ICNIRP [23, 179] acknowledged that their guidelines do not accommodate sensitive subgroups and admit to difficulties separating "biological effects" from "health effects." Neurological symptoms, some of which are acknowledged by ICNIRP and currently being experienced by persons with EHS, are most certainly non-thermal "health effects" that need to be mitigated by providing environments with reduced exposures to anthropogenic EMF for hypersensitive individuals.

The debilitating effects and restrictions suffered by adults and children with EHS constitutes a contravention of the 2010 Equalities Act, Human Rights Act and other ethical and legal frameworks. Failure to respond and appropriately safeguard this group is already causing preventable morbidity, mortality and economic deficit due to lost workdays, compensations for health damages and increased healthcare costs. Conversely, accommodating this group by, as suggested by ICNIRP [179], acting to 'adjust the guidelines for the general population to include such groups' would not only lessen the negative impacts for people with EHS, but would also improve public health more broadly, given the other NIR-related health concerns that are highlighted in this paper.

Basing local tissue exposure limits on 1-g [3] or 10-g [5] cubes substantially underestimates the peak spatial SAR compared to basing local tissue exposure limits on smaller cubes (e.g., 100 mg or 10 mg), and therefore are not reliable dosimetric parameters to evaluate EMF absorption at frequencies above 1 GHz (Assumptions 11, 12). The volumes specified by the FCC and ICNIRP for local tissue SAR limits are too large to focus on stem cells which are important targets for carcinogenesis. To reduce health risks from exposures to RFR, limits for localized distribution of the SAR should be based on 100 mg, or preferably 10 mg cubes.

Another important deficiency raised in this paper is that neither the FCC nor ICNIRP addresses concerns for environmental effects of RFR on wildlife, even though there is extensive literature demonstrating the disrupting effects of RFR on wildlife behavior (Assumption 13).

The arbitrarily selected uncertainty/safety factors applied to the putative threshold SAR for RFR are woefully inadequate for protecting public health

(Assumptions 9, 10). Based on the way the US Environmental Protection Agency, the International Council for Harmonization, and the National Institute for Occupational Safety and Health (US NIOSH) apply uncertainty/safety factors to a no-observed-adverse-effect level (NOAEL) in experimental animals [182–184], the safety factor for RFR would be at least 900 to 10,000, which is 18 to 200 times larger than the safety factor recommended by the FCC and ICNIRP for the general population. This large safety factor is based on adjustments for human variability, lifetime exposure from short-term studies, and database insufficiencies that include incomplete characterization of the toxicity of RFR. Clearly, the acute behavioral studies that served as the basis for the current exposure limits for RFR are not suitable for characterizing human health risks associated with long-term exposure to this type of radiation. The NCRP report from 1986 [6] and the ANSI/IEEE document from 1992 [7] recognized that when future studies on biological effects of RFR become available including effects of chronic exposures or evidence of non-thermal interactions there will be a need to evaluate and possibly revise exposure standards. When the FCC [3] and ICNIRP [5] reaffirmed their exposure limits from the 1990s, they dismissed the scientific evidence that invalidated the assumptions that underlie the basis for those exposure limits. An independent re-evaluation of RFR exposure limits based on the scientific knowledge gained over the past 25 years is needed and is long overdue. This evaluation should be performed by scientists and medical doctors who have no conflicting interests and who have expertise in RF-EMF exposure and dosimetry, toxicology, epidemiology, clinical assessment, and risk assessment. Special precautions should be taken to ensure that interpretations of health effects data and the setting of exposure limits for RFR are not influenced by the military or the telecommunications industry. In the meantime, manufacturers should be obliged to develop safer technologies [227].

Finally, we note our concern about the worldwide deployment of 5G communication networks for faster transfer of large amounts of data, but with no adequate health effects studies demonstrating the safety of high frequency millimeter waves. Because of limitations of the penetration and distance of travel of millimeter waves, dense networks of base stations are being mounted on structures such as utility poles in highly populated cities. Also, because the absorption of EMF at frequencies above 6 GHz is minimal, ICNIRP [5] has specified absorbed power density (S_{ab}) as the dosimetric parameter for "heating effects" at the higher frequencies. S_{ab} is a function of the incident power density (S_{inc}) and the input reflection coefficient (Γ). In near field scenarios, the S_{inc} does not have a singular value; this is largely due

to the heterogeneous nature of human body tissues and their relevant parameters (such as the permittivity, equivalent conductivity, mass density), which vary in different body regions and with frequency. Therefore, unless a powerful EMF simulation method together with realistic human models are used, the S_{inc} and the reflection coefficient values would be difficult to accurately estimate, making the resulting S_{ab} unreliable.

The assumption that 5G is safe at the power density limits recommended by ICNIRP (50 W/m² and 10 W/m² averaged over 6 min for occupational and 30 min for public exposures, respectively) because of its minimal penetration into the body does not justify the dismissal of the need for health effects studies prior to implementing 5G networks. The new communication networks will result in exposures to a form of radiation that has not been previously experienced by the public at large (Assumption 14). The implementation of 5G technology without adequate health effects information raises many questions, such as: Will exposure to 5G radiation: (i) compromise the skin's ability to provide protection from pathogenic microorganisms? (ii) will it exacerbate the development of skin diseases? (iii) will it increase the risk of sunlight-induced skin cancers? (iv) will it increase the risk of damage to the lens or cornea? (v) will it increase the risk of testicular damage? (vi) will it exert deeper tissue effects either indirectly following effects on superficial structures or more directly due to deeper penetration of the ELF components of modulated RF signals? (vii) will it adversely affect wildlife populations? Answers to these questions and others that are relevant to human and wildlife health should be provided *before* widespread exposures to 5G radiation occur, not afterwards. Based on lessons that should have been learned from studies on RFR at frequencies below 6 GHz, we should no longer rely on the untested assumption that current or future wireless technology, including 5G, is safe without adequate testing. To do otherwise is not in the best interest of either public or environmental health.

Abbreviations

ANSI: American National Standards Institute; CDMA: Code-division multiple access; dB: Decibel; DECT: Digital enhanced cordless technology; EHS: Electromagnetic hypersensitivity; ELF: Extremely low frequency; EMF: Electromagnetic field; FCC: Federal Communications Commission; FDA: Food and Drug Administration; GHz: Gigahertz; GBM: Glioblastoma multiforme brain cancer; GSM: Global system for mobile communication; IARC: International Agency for Research on Cancer; ICNIRP: International Commission on Non-Ionizing Radiation Protection; IEEE: Institute of Electrical and Electronics Engineers; LTE: Long Term Evolution (4G); MMW: Millimeter wave; NCRP: National Council on Radiation Protection and Measurements; NIR: Non-ionizing radiation; nT: Nanotesla; NTP: National Toxicology Program; 8-OHdG: 8-hydroxy-2'-deoxyguanosine; psSAR: Peak spatial specific absorption rate; RFR: Radiofrequency radiation; ROS: Reactive oxygen species; SAR: Specific absorption rate; UMTS: Universal mobile telecommunications service (3G); UVR: Ultraviolet radiation; 5G: 5th generation wireless.

Supplementary Information

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Additional file 1: Appendix 1 Table 1. Studies demonstrating increased oxidative DNA damage and other indicators of oxidative stress at SAR < 4 W/kg.

Additional file 2: Appendix 2. On the inadequacy of the psSAR Dosimetric Parameter at Frequencies above 1 GHz. **Table 1.** Electric permittivity and electric conductivity of the gray matter. **Figure 1.** A block of gray matter radiated by different frequencies. The highlighted cubes are of 10 g, 1 g, 100 mg and 10 mg. **Fig. 2.** A block of gray matter radiated by different frequencies. The highlighted cubes are of 10 g, 1 g, 100 mg and 10 mg. **Fig. 3.** Electric field intensity averaged in each cube for different frequencies: in the left axis, the electric field is in dB and in the right axis the electric field is in V/m normalized to 100 V/m.

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 Ronald L. Melnick: National Toxicology Program, National Institute of Environmental Health Sciences (retired), Ron Melnick Consulting LLC, Logan, Utah, USA
 Anthony Miller: Dalla Lana School of Public Health (Professor Emeritus), University of Toronto, Ontario, Canada
 Joel M. Moskowitz: School of Public Health, University of California, Berkeley, California, USA
 Wenjun Sun: School of Public Health, Zhejiang University School of Medicine; Hangzhou, China
 Igor Yakymenko: National University of Food Technology, Kyiv Medical University, Ukraine

Authors' contributions

IB, AD, CF, LH, PH, KK, DM, EMB, RLM, and IY drafted the initial sections of this manuscript: by IB (factors affecting dosimetry), AD and CF (absorption in children versus adults, peak spatial specific absorption rate), LH (human brain cancer risk), KK (sperm damage), DM and DM (5G), EMB (electromagnetic hypersensitivity), RLM (cardiomyopathy, carcinogenicity, neurologic effects, safety factors), and IY (oxidative stress and DNA damage). IY prepared Appendix 1, and AD and CF prepared Appendix 2. The authors who drafted sections of the manuscript, as well as CB, KC, SD, EK, AM, JMM, and WS reviewed multiple manuscript drafts and made revisions. All authors reviewed and approved the final manuscript.

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[Comment] Health risks from radiofrequency radiation, including 5G, should be assessed by experts with no conflicts of interest

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Abstract

The fifth generation, 5G, of radiofrequency (RF) radiation is about to be implemented



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medical doctors, a moratorium on 5G deployment was requested until proper scientific evaluation of potential negative consequences has been conducted. This request has not been acknowledged by the EU. The evaluation of RF radiation health risks from 5G technology is ignored in a report by a government expert group in Switzerland and a recent publication from The International Commission on Non-Ionizing Radiation Protection. Conflicts of interest and ties to the industry seem to have contributed to the biased reports. The lack of proper unbiased risk evaluation of the 5G technology places populations at risk. Furthermore, there seems to be a cartel of individuals monopolizing evaluation committees, thus reinforcing the no-risk paradigm. We believe that this activity should qualify as scientific misconduct.

Introduction

Most politicians and other decision-makers using guidelines for exposure to radiofrequency (RF) radiation seem to ignore the risks to human health and the environment. The fact that the International Agency for Research on Cancer (IARC) at the World Health Organization (WHO) in May 2011 classified RF radiation in the frequency range of 30 kHz to 300 GHz to be a 'possible' human carcinogen, Group 2B [1,2], is being ignored. This has been recently exemplified in a hearing at the Tallinn Parliament in Estonia [3].

An important factor may be the influence on politicians by individuals and organizations with inborn conflicts of interests (COIs) and their own agenda in supporting the no-risk paradigm [4,5]. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has repeatedly ignored scientific evidence on adverse effects of RF radiation to humans and the environment. Their guidelines for exposure are based solely on the thermal (heating) paradigm and were first published in ICNIRP 1998 [6], updated in ICNIRP 2009 [7] and have now been newly published in ICNIRP 2020 [8], with no change of concept, only relying on thermal effects from RF radiation on humans. The large amount of peer-reviewed science on non-thermal effects has been ignored in all ICNIRP evaluations [9,10]. Additionally, ICNIRP has successfully maintained their obsolete guidelines worldwide.

COIs can be detrimental, and it is necessary to be as unbiased as possible when assessing health risks. There are three points that should be emphasized. Firstly, the evidence regarding health risks from environmental factors may not be unambiguous, and therefore informed judgements must be made. Furthermore, there are gaps in knowledge that call for experienced evaluations, and no conclusion can be reached without value judgements. Secondly, paradigms are defended against the evidence and against external assessments by social networks in the scientific community. Thirdly, the stronger the impact of decisions about health risks on economic, military and political interests, the stronger will stakeholders try to influence these decision processes.

Since the IARC evaluation in 2011 [1,2], the evidence on human cancer risks from RF radiation has been strengthened based on human cancer epidemiology reports [9–11], animal carcinogenicity studies [12–14] and experimental findings on oxidative mechanisms [15] and genotoxicity [16]. Therefore, the IARC Category should be upgraded from Group 2B to Group 1, a human carcinogen [17].

The deployment of the fifth generation, 5G, of RF radiation is a major concern in numerous countries, with groups of citizens trying to implement a moratorium until thorough research on adverse effects on human health and the environment has been performed. An appeal for a moratorium, currently signed by >390 international scientists and medical doctors, was sent to the European Union (EU) in September 2017 [18], currently with no EU response [19]. Several regions have implemented a moratorium on the deployment of 5G motivated by the lack of studies on health effects, for instance Geneva [20].

In the present article, the current situation in Switzerland is discussed as an example [21]. Additionally, the ICNIRP 2020 evaluation is discussed [8].

Evaluation of health risks in Switzerland

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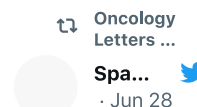
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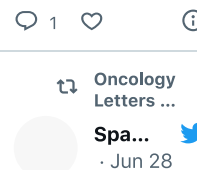
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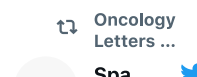
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2 1



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Several Swiss citizens have brought to our attention that Associate Professor Martin Rösli is the chair of two important government expert groups in Switzerland (directeur), despite possible COIs and a history of misrepresentation of science [22,23]. These groups are Beratende Expertengruppe NIS (BERENIS; the Swiss advisory expert group on electromagnetic fields and non-ionizing radiation) [24], and the subgroup 3, the Mobile Communications and Radiation Working Group of the Department of the Environment, Transport, Energy and Communications/Eidgenössisches Departement für Umwelt, Verkehr, Energie und Kommunikation, evaluating RF-radiation health risks from 5G technology [25,26].

The conclusions made in the recent Swiss government 5G report are biased and can be found here [27,28]. This 5G report concluded that there is an absence of short-term health impacts and an absence or insufficient evidence of long-term effects [see Table 17 (Tableau 17) on page 69 in the French version [27] and Table 17 (Tabelle 17) on page 67 in the German version [28]].

Furthermore, it was reported that there is limited evidence for glioma, neurilemmoma (schwannoma) and co-carcinogenic effects, and insufficient evidence for effects on children from prenatal exposure or from their own mobile phone use. Regarding cognitive effects, fetal development and fertility (sperm quality), the judgement was that the evidence on harmful effects is insufficient. These evaluations were strikingly similar to those of the ICNIRP [see Appendix B in ICNIRP 2020; 8]. Other important endpoints, such as effects on blood-brain barrier, cell proliferation, apoptosis (programmed cell death), oxidative stress (reactive oxygen species) and gene and protein expression, were not evaluated.

According to Le Courrier November 19, 2019, Martin Rösli presented the conclusion in an interview in the following way: *‘Sur l’aspect sanitaire pur, «le groupe de travail constate que, jusqu’à présent, aucun effet sanitaire n’a été prouvé de manière cohérente en dessous des valeurs limites d’immissions fixées», résume Martin Rösli, professeur d’épidémiologie environnementale à l’Institut tropical et de santé publique suisse’* [29]. [Regarding the health issue, the working group concludes that, until now, no health effect has been consistently proven below the given exposure limits, summarizes Martin Rösli, professor in environmental epidemiology at the Swiss Tropical and Public Health Institute].

This Swiss evaluation is scientifically inaccurate and is in opposition to the opinion of numerous scientists in this field [18]. In addition, 252 electromagnetic field (EMF) scientists from 43 countries, all with published peer-reviewed research on the biologic and health effects of nonionizing electromagnetic fields (RF-EMF) have stated that:

‘Numerous recent scientific publications have shown that RF-EMF affects living organisms at levels well below most international and national guidelines. Effects include increased cancer risk, cellular stress, increase in harmful free radicals, genetic damages, structural and functional changes of the reproductive system, learning and memory deficits, neurological disorders, and negative impacts on general well-being in humans. Damage goes well beyond the human race, as there is growing evidence of harmful effects to both plant and animal life’ [30].

We are concerned that the Swiss 5G report may be influenced by ties to mobile phone companies (COIs) by one or several members of the evaluating group.

COIs

Funding from telecom companies is an obvious COI. Martin Rösli has been a member of the board of the telecom funded Swiss Research Foundation for Electricity and Mobile Communication (FSM) organization and he has received funding from the same organization [31–33].

It should be noted that the FSM is a foundation that serves formally as an intermediate between industry and researchers. According to their website, among the five founders of FSM who *‘provided the initial capital of the Foundation’* four are telecommunications companies: Swisscom, Salt, Sunrise, 3G Mobile (liquidated in 2011). The fifth founder is ETH Zurich (technology and engineering university). There are only two companies

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annual donations that allow for both the management of the Foundation and research funding’ [34].

The same situation applies to being a member of ICNIRP (Table I) [35]. In 2008, the Ethical Council at Karolinska Institute in Stockholm stated that being a member of ICNIRP is a potential COI. Such membership should always be declared. This verdict was based on activities by Anders Ahlbom in Sweden, at that time a member of ICNIRP, but is a general statement (2008-09-09; Dnr, 3753-2008-609). In summary: *‘It is required that all parties clearly declare ties and other circumstances that may influence statements, so that decision makers and the public may be able to make solid conclusions and interpretations. AA [Anders Ahlbom] should thus declare his tie to ICNIRP whenever he makes statements on behalf of authorities and in other circumstances’* (translated into English).

	Table I. Members of the WHO core group and additional experts of the Environmental Health Criteria Document 2014 (54), EU SCENIHR 2015 (52), the SSM 2015–2020 (93) and ICNIRP commission or the Scientific Expert Group 1992–2020 (94).
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COIs with links to industry are of great importance; these links may be direct or indirect funding for research, payment of travel expenses, participation in conferences and meetings, presentation of research, etc. Such circumstances are not always declared as exemplified above. A detailed description was recently presented for ICNIRP members [22].

ICNIRP

ICNIRP is a non-governmental organization (NGO) based in Germany. Members are selected via an internal process, and the organization lacks transparency and does not represent the opinion of the majority of the scientific community involved in research on health effects from RF radiation. Independent international EMF scientists in this research area have declared that: *‘In 2009, the ICNIRP released a statement saying that it was reaffirming its 1998 guidelines, as in their opinion, the scientific literature published since that time has provided no evidence of any adverse effects below the basic restrictions and does not necessitate an immediate revision of its guidance on limiting exposure to high frequency electromagnetic fields. ICNIRP continues to the present day to make these assertions, in spite of growing scientific evidence to the contrary. It is our opinion that, because the ICNIRP guidelines do not cover long-term exposure and low-intensity effects, they are insufficient to protect public health’* [30].

ICNIRP only acknowledges thermal effects from RF radiation. Therefore, the large body of research on detrimental non-thermal effects is ignored. This was further discussed in a peer-reviewed scientific comment article [3].

In 2018, ICNIRP published *‘ICNIRP Note: Critical Evaluation of Two Radiofrequency Electromagnetic Field Animal Carcinogenicity Studies Published in 2018’* [36]. It is surprising that this note claims that the histopathological evaluation in the US National Toxicology Program (NTP) study on animals exposed to RF radiation was not blinded [12,13]. In fact, unfounded critique of the NTP study had already been rebutted [37]; however, this seems to have had little or no impact on this ICNIRP note casting doubt on the findings of the animal study: *‘This commentary addresses several unfounded criticisms about the design and results of the NTP study that have been promoted to minimize the utility of the experimental data on RFR [radiofrequency radiation] for assessing human health risks. In contrast to those criticisms, an expert peer-review panel recently concluded that the NTP studies were well designed, and that the results demonstrated that both GSM- and CDMA-modulated RFR were carcinogenic to the heart (schwannomas) and brain (gliomas) of male rats’* [37].

In contrast to the opinion of the 13 ICNIRP commission members, the IARC advisory group of 29 scientists from 18 countries has recently stated that the cancer bioassay in experimental animals and mechanistic evidence warrants high priority re-evaluation of

On July 11, 2018, ICNIRP released a draft on guidelines [39] for limiting exposure to time-varying electric, magnetic and electromagnetic fields (100 kHz to 300 GHz). It was open for public consultations until October 9, 2018. Appendix B was based on assessment of health risks based on a literature survey [39].

Surprisingly, the IARC classification of RF-EMF exposure as Group 2B ('possibly' carcinogenic to humans) from 2011 was concealed in the background material to the new ICNIRP draft on guidelines. Notably, one of the ICNIRP commission members, Martin Rösli [40], was also one of the IARC experts evaluating the scientific RF carcinogenicity in May 2011 [41]. He should be well aware of the IARC classification. The IARC classification contradicts the scientific basis for the ICNIRP guidelines, making novel guidelines necessary and providing a basis to halt the rollout of 5G technology.

Therefore, the ICNIRP provides scientifically inaccurate reviews for various governments. One issue is that only thermal (heating) effects from RF radiation are considered, and all non-thermal effects are dismissed. An analysis from the UK demonstrates these inaccuracies [4], also discussed in another article [5]. All members of the ICNIRP commission are responsible for these biased statements that are not based on solid scientific evidence.

ICNIRP release of novel guidelines for RF radiation

On March 11, 2020, ICNIRP published their novel guidelines for exposure to EMFs in the range of 100 kHz to 300 GHz, thus including 5G [8]. The experimental studies demonstrating a variety of non-thermal biological/health effects [9,10] are not considered, as in their previous guidelines [6,7]. Additionally, the ICNIRP increased the reference levels for the general public averaged over 6 min for RF frequencies >2–6 GHz (those that will be used for 5G in this frequency range), from 10 W/m² (Tables 5 and 7 in ref. no. 6) to 40 W/m² (Table 6 in ref. no. 8), which paves the way for even higher exposure levels to 5G than the already extremely high ones.

Background dosimetry is discussed in Appendix A of the ICNIRP 2020 guidelines [8]. The discussion on 'Relevant Biophysical Mechanisms' should be criticized. The only mechanism considered by ICNIRP is temperature rise, which may also occur with 5G exposure, apart from the established non-thermal biological/health effects [42,43]. It is well known among experts in the EMF-bioeffects field that the recorded cellular effects, such as DNA damage, protein damage, chromosome damage and reproductive declines, and the vast majority of biological/health effects are not accompanied by any significant temperature rise in tissues [44–47]. The ion forced-oscillation mechanism [48] should be referred to as a plausible non-thermal mechanism of irregular gating of electrosensitive ion channels on cell membranes, resulting in disruption of the cell electrochemical balance and initiating free radical release and oxidative stress in the cells, which in turn causes genetic damage [15,49]. The irregular gating of ion channels on cell membranes is associated with changes in permeability of the cell membranes, which ICNIRP admits in its summary [8].

Health risks are discussed in Appendix B of the ICNIRP 2020 guidelines [8]. Again, only thermal effects are considered, whereas literature on non-thermal health consequences is disregarded [9,10,50]. In spite of public consultations on the draft, the final published version on health effects is virtually identical to the draft version, and comments seem to have been neglected [19]. In the following section, Appendix B on health effects [8] is discussed.

Appendix B starts with: *'The World Health Organization (WHO) has undertaken an in-depth review of the literature on radiofrequency electromagnetic fields (EMFs) and health, which was released as a Public Consultation Environmental Health Criteria Document in 2014... Further, the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), a European Commission initiative, also produced a report on potential health effects of exposure to electromagnetic fields (SCENIHR 2015), and the Swedish Radiation Safety Authority (SSM) have produced several international reports regarding this issue (SSM 2015, 2016, 2018). Accordingly, the present guidelines have used these literature reviews as the basis for the health risk assessment associated with exposure to radiofrequency EMFs rather than providing another review of the*

In the last 11 years since its previous ICNIRP 2009 statement [7], ICNIRP has not managed to conduct a novel evaluation of health effects from RF radiation. However, as shown in Table I, several of the present ICNIRP members are also members of other committees, such as the EU Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), the Swedish Radiation Safety Authority (SSM) and the WHO, thus creating a cartel of individuals known to propagate the ICNIRP paradigm on RF radiation [4,5,22,51]. In fact, six of the seven expert members of the WHO, including Emelie van Deventer, were also included in ICNIRP [5,7]. Therefore, Emelie van Deventer, the team leader of the Radiation Programme at WHO (the International EMF Project), is an observer on the main ICNIRP commission, and SSM seems to be influenced by ICNIRP. Among the current seven external experts (Danker-Hopfe, Dasenbrock, Huss, Harbo Polusen, van Rongen, Rösli and Scarfi), five are also members of ICNIRP, and van Deventer used to be part of SSM.

As discussed elsewhere [5], it is unlikely that a person's evaluation of health risks associated with exposure to RF radiation would differ depending on what group the person belongs to. Therefore, by selecting group members, the final outcome of the evaluation may already be predicted (no-risk paradigm). Additionally, we believe that this may compromise sound scientific code of conduct.

The SCENIHR report from 2015 [52] has been used to legitimate the further expansion of the wireless technology and has been the basis for its deployment in a number of countries. One method, applied in the SCENIHR report, to dismiss cancer risks involves the selective inclusion of studies, excluding studies reporting cancer risks and including some investigations with inferior epidemiological quality. The report has been heavily criticized by researchers with no COI [53]: *'In January of 2015, the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) published its final opinion on (P)otential health effects of exposure to electromagnetic fields... SCENIHR has not answered the question it was appointed to investigate. The Committee has answered a different question, limiting its conclusions to whether certainty or causal effect is established, instead of possibility of health risks... Overall, SCENIHR has not conducted a scientific review process for judging possible health risks. This results in erroneous and deceptive conclusions by failing to conclude such possible health risks do exist. Evidence that SCENIHR has presented clearly and conclusively demonstrates that EMF health risks are possible, and in some cases are established. The Committee is obligated to draw to the attention of the European Commission that EMF is a new and emerging problem that may pose an actual or potential threat'.*

Regarding the SSM, only yearly updates are available and no overall evaluations are made. Therefore, no thorough review is presented. Over the years, the ICNIRP has dominated this committee (Table I). Therefore, it is unlikely that the opinion of the SSM will differ from that of the ICNIRP.

In 2014, the WHO launched a draft of a Monograph on RF fields and health for public comments [54]. It should be noted that the WHO issued the following statement: *'This is a draft document for public consultation. Please do not quote or cite'.* ICNIRP completely ignored that request and used the aforementioned document. The public consultations on the draft document were dismissed and never published.

In addition to van Deventer, five of the six members (Mann, Feychting, Oftedal, van Rongen, and Scarfi) of the Core Group in charge of the WHO draft were also affiliated with ICNIRP, which constitutes a COI (Table I). Scarfi is a former member of ICNIRP [5]. Several individuals and groups sent critical comments to the WHO on the numerous shortcomings in the draft of the Monograph on RF radiation. In general, the WHO never responded to these comments and it is unclear to what extent, if any, they were even considered. Nevertheless, the final version of the WHO 'in-depth review' has never been published. Instead, WHO made a call on October 8, 2019 (Emelie van Deventer), for systematic reviews to analyze and synthesize the available evidence: *'Through this Call, WHO invites eligible teams to indicate their interest in undertaking a systematic review on one (or more) of the following topics: SR1 - Effect of exposure to RF on cancer (human observational studies); SR2 - Effect of exposure to RF on cancer (animal studies); SR3 - Effect of exposure to RF on adverse reproductive outcomes (human*

impairment (human observational studies; SR6 - Effect of exposure to RF on cognitive impairment (human experimental studies); SR7 - Effect of exposure to RF on symptoms (human observational studies); SR8 - Effect of exposure to RF on symptoms (human experimental studies; SR9 - Effect of exposure to RF on biomarkers of oxidative stress; SR10 - Effect of exposure to heat from any source and pain, burns, cataract and heat-related illness'.

The authors of the present article were part of a team that applied to review SR1-human cancer. On December 20, 2019, the following reply was received from the WHO Radiation Programme: *'After careful review, we have decided to choose another team for this systematic review'.*

Transparency is of importance for the whole process. Therefore, a query was sent to the WHO requesting information regarding the following points: *'Who did the evaluation of the groups that answered the call? What criteria were applied? How many groups had submitted and who were these? Which groups were finally chosen for the different packages?'* In spite of sending the request four times, January 2, January 3, April 7 and April 30, 2020, there has been no reply from WHO. This appears to be a secret process behind closed doors. These circumstances have also been reported in Microwave News [55].

It is important to comment on the current ICNIRP evaluation. Notably, on February 27, 2020, two weeks before the ICNIRP publication, the WHO Team on Public Health, Environmental and Social Determinants of Health issued a statement on 5G mobile networks and health: *'To date, and after much research performed, no adverse health effect has been causally linked with exposure to wireless technologies'* [56]. This statement is not correct based on current knowledge [4,5,9–11,17,19] and was without a personal signature. The lack of research on 5G safety has been previously discussed [19]. Furthermore, there is no evidence that can 'causally link' an adverse effect to an exposure. Causality is no empirical fact, it is an interpretation.

In the following section, only one (cancer) of the eight different end points in the ICNIRP publication [8] is discussed, since it deals with our main research area.

viii) Cancer.

'In summary, no effects of radiofrequency EMFs on the induction or development of cancer have been substantiated.

Summary

The only substantiated adverse health effects caused by exposure to radiofrequency EMFs are nerve stimulation, changes in the permeability of cell membranes, and effects due to temperature elevation. There is no evidence of adverse health effects at exposure levels below the restriction levels in the ICNIRP [1998] guidelines and no evidence of an interaction mechanism that would predict that adverse health effects could occur due to radiofrequency EMF exposure below those restriction levels'.

Comments

The ICNIRP draft [39] has been previously described to some extent [19]. The published final version on health effects is virtually similar to the draft. It cannot be taken at face value as scientific evidence of no risk from RF radiation. One example is the following statement (p. 41): *'...a set of case-control studies from the Hardell group in Sweden report significantly increased risks of both acoustic neuroma and malignant brain tumors already after less than five years since the start of mobile phone use, and at quite low levels of cumulative call time'.*

This allegation is not correct according to our publication for glioma [11]. In the shortest latency group >1–5 years, the risk of glioma was not increased (odds ratio (OR), 1.1; 95% CI, 0.9–1.4) for use of wireless phones (mobile phone and/or cordless phone). There was a statistically significant increased risk of glioma per 100 h of cumulative use (OR, 1.011; 95% CI, 1.008–1.014) and per year of latency (OR, 1.032; 95% CI, 1.019–1.046) [11]. These published results are in contrast to the ICNIRP claims.

0.8-1.6) for use of wireless phones; the risk increased per 100 h of cumulative use (OR, 1.008; 95% CI, 1.002-1.014) and per year of latency (OR, 1.056; 95% CI, 1.029-1.085) [57]. Therefore, the allegation by ICNIRP is false.

It is remarkable that ICNIRP is uninformed and that their writing is based on a misunderstanding of the peer-reviewed published articles as exemplified above. Additionally, our studies [11,57] and another study by Coureau *et al* [58], as well as the IARC evaluation from 2011 [1,2], are not included among the references. Several statements by ICNIRP are made without any scientific references. On the other hand, the Danish cohort study on mobile phone use [59] is included, in spite of the fact that it was judged by IARC [1,2], as well as in our review [60], to be uninformative. A biased article written by authors including ICNIRP members, used to 'prove' the no-risk paradigm for RF radiation carcinogenesis [23], is cited by ICNIRP. Notably, the article has not undergone relevant peer-review and we believe that it should not have been published in its current version. The shortcomings in the aforementioned article are discussed in the following sections. As discussed below, another claim [23] is incorrect regarding increased risk of brain tumors associated with use of wireless phones: *'However, they are not consistent with trends in brain cancer incidence rates from a large number of countries or regions, which have not found any increase in the incidence since mobile phones were introduced'*.

The criticism of the ICNIRP draft guidelines from 2018 by the EMF call [61] can also be applied to the current ICNIRP publication. The call has been signed by 164 scientists and medical doctors, as well as 95 NGOs: *'The International Commission on Non-Ionizing Radiation Protection (ICNIRP) issued draft Guidelines on 11th July 2018 for limiting exposure to electric, magnetic and electromagnetic fields (100 kHz to 300 GHz).1 These guidelines are unscientific, obsolete and do not represent an objective evaluation of the available science on effects from this form of radiation. They ignore the vast amount of scientific findings that clearly and convincingly show harmful effects at intensities well below ICNIRP guidelines.2 The guidelines are inadequate to protect humans and the environment. ICNIRP guidelines only protect against acute thermal effects from very short and intense exposure. The guidelines do not protect against harmful effects from low-intensity and long-term exposure, such as cancer, reproductive harm, or effects on the nervous system, although these effects are convincingly shown to appear from chronic exposure at intensities below ICNIRP limits.2,3*

ICNIRP's mandate to issue exposure guidelines needs to be seriously questioned. ICNIRP is not independent of industry ties as it claims.12,13 Its opinions are not objective, not representative of the body of scientific evidence, but are biased in favor of industry. It is obvious from their reluctance to consider scientific findings of harm that ICNIRP protects industry, not the public health, nor the environment.

We ask the United Nations, the World Health Organization, and all governments to support the development and consideration of medical guidelines16, that are independent of conflict of interests in terms of direct or indirect ties to industry, that represent the state of medical science, and that are truly protective'.

In the recent report on ICNIRP published by two Members of the European Parliament it is concluded: *'That is the most important conclusion of this report: For really independent scientific advice we cannot rely on ICNIRP. The European Commission and national governments, from countries like Germany, should stop funding ICNIRP. It is high time that the European Commission creates a new, public and fully independent advisory council on non-ionizing radiation'* [22].

Other examples of scientific misrepresentation

Published article

This section discusses an article with conclusions not substantiated by scientific evidence, representing a biased evaluation of cancer risks from mobile phone use and is an example of lack of objectivity and impartiality [23]. The aforementioned report was used by ICNIRP 2020 [8] to validate that no risks have been found for brain and head

The aforementioned article has numerous severe scientific deficiencies. One is that the results on use of cordless phones as a risk factor for brain tumors are not discussed. In fact, detailed results on cordless phones in studies by Hardell *et al* (11,57) are omitted.

When discussing glioma risk, all results on cumulative use of mobile phones, as well as ipsilateral or contralateral use associated with tumor localization in the brain, are omitted from the figures in the main text. Some results in the article by Rösli *et al* (23), such as cumulative use, can be found in the Supplementary Material, although the increased risk among heavy users is disregarded (11,57,58,62). In Supplementary Figure 4, all odds ratios regarding long-term (≥ 10 years) use of mobile phones are above unity (>1.0) for glioma and neuroma (23). No results are provided for ipsilateral mobile phone use (same side of tumor localization and mobile phone use), which is of large biological importance. Results on cumulative use, latency and ipsilateral use are especially important for risk assessment and have shown a consistent pattern of increased risk for brain and head tumors (11,57).

In the aforementioned article, recall bias is discussed as the reason for increased risk (23). The studies by Hardell *et al* (11,57) included all types of brain tumors. In one analysis, meningioma cases in the same study were used as the 'control' entity (11), and still a statistically significant increased risk of glioma was identified for mobile phone use (ipsilateral OR, 1.4; 95% CI, 1.1-1.8; contralateral OR, 1.0; 95% CI, 0.7-1.4) and for cordless phone use (ipsilateral OR, 1.4; 95% CI, 1.1-1.9; contralateral OR, 1.1; 95% CI, 0.8-1.6). If the results were 'explained' by recall bias, similar results would have been obtained for both glioma and meningioma. Thus, this type of analyses would not have yielded an increased glioma risk. Also, for acoustic neuroma a statistically significant increased risk was found using meningioma cases as 'controls' (57). Therefore, the results in the studies by Hardell *et al* (11,57) cannot be explained by a systematic difference in assessment of exposure between cases and controls. These important methodological findings were disregarded by Rösli *et al* (23).

In the analyses of long-term use of mobile phones, a Danish cohort study on mobile phone use is included (59), which was concluded to be uninformative in the 2011 IARC evaluation (1,2). A methodological shortcoming of the aforementioned study was that only private mobile phone subscribers in Denmark between 1982 and 1995 were included in the exposure group (59). The most exposed group, comprising 200,507 corporate users of mobile phones, were excluded and instead included in the unexposed control group consisting of the rest of the Danish population. Users with mobile phone subscription after 1995 were not included in the exposed group and were thus treated as unexposed at the time of cut-off of the follow up. No analysis of laterality of mobile phone use in relation to tumor localization was performed. Notably, this cohort study is now included in the risk calculations, although Martin Rösli was a member of the IARC evaluation group and should have been aware of the IARC decision. The numerous shortcomings in the Danish cohort study, discussed in detail in a peer-reviewed article (60), are omitted in the article by Rösli *et al* (23).

Regarding animal studies, a study by Falcioni *et al* (14) at the Ramazzini Institute on RF radiation carcinogenesis is only mentioned as a reference, but the results are not discussed. In fact, these findings (14) provide supportive evidence on the risk found in human epidemiology studies (3), as well as the results in the NTP study (12,13).

Furthermore, for incidence studies on brain tumors, the results are not presented in an adequate way. There is a lot of emphasis on the Swedish Cancer Register data (63,64), but the numerous shortcomings in the reporting of brain tumor cases to the register are not discussed. These shortcomings have been presented in detail in a previous study (63), but are disregarded by Rösli *et al* (23).

There is clear evidence from several countries regarding increasing numbers of patients with brain tumors, such as in Sweden (63,64), England (65), Denmark (66) and France (67).

The article by Rösli *et al* (23), does not represent an objective scientific evaluation of brain and head tumor risk associated with the use of wireless phones, and should thus be disregarded. By omitting results of biological relevance and including studies that

in vivo, and epidemiological studies does not indicate an association between MP [mobile phone] use and tumors developing from the most exposed organs and tissues’.

Röösli *et al* [23], disregard the concordance of increased cancer risk in human epidemiology studies [11,57,58,62] animal studies [12–14,68,69] and laboratory studies [15,16,37]. It is unfortunate that the review process of the aforementioned article has not been of adequate quality. Finally, there is no statement in the article of specific funding of this particular work, which is not acceptable. Only a limited number of comments on general funding are provided. It is not plausible that there was no funding for the study. We believe that, due to its numerous limitations, the aforementioned article should not have been published.

CEFALO

In 2011, a case-control study on mobile phone use and brain tumor risk among children and adolescents termed CEFALO was published [70]. The study appears to have been designed to misrepresent the true risk, since the following question regarding cordless phone use was asked: *‘How often did [child] speak on the cordless phone in the first 3 years he/she used it regularly?’*.

There are no scientific valid reasons to limit the investigation to the first 3 years. The result is a misrepresentation and a wrong exposure classification, since Aydin *et al* [70] willingly omitted any increase in the child’s use of and exposure from cordless phone radiation after the first 3 years of use. This unscientific treatment of cordless phone exposure was not mentioned in the article other than in a footnote of a table and in the methods section [70]; however, no explanation was provided: *‘Specifically, we analyzed whether subjects ever used baby monitors near the head, ever used cordless phones, and the cumulative duration and number of calls with cordless phones in the first 3 years of use’*.

Since previous studies have demonstrated that these phone types, in addition to mobile phones, increase brain tumor risk [11,57], we believe that the exclusion of a complete exposure history on the use of cordless phones represents scientific misconduct.

In a critical comment the authors of the present study wrote: *‘Further support of a true association was found in the results based on operator-recorded use for 62 cases and 101 controls, which for time since first subscription >2.8 years yielded OR 2.15 [95% CI 1.07-4.29] with a statistically significant trend (P = 0.001). The results based on such records would be judged to be more objective than face-to-face interviews, as in the study that clearly disclosed to the interviewer who was a case or a control. The authors disregarded these results on the grounds that there was no significant trend for operator data for the other variables - cumulative duration of subscriptions, cumulative duration of calls and cumulative number of calls. However, the statistical power in all the latter groups was lower since data was missing for about half of the cases and controls with operator-recorded use, which could very well explain the difference in the results’* [71].

Our conclusion was that: *‘We consider that the data contain several indications of increased risk, despite low exposure, short latency period, and limitations in the study design, analyses and interpretation. The information certainly cannot be used as reassuring evidence against an association, for reasons that we discuss in this commentary’* [71].

This is in contrast to the authors that claimed that the study was reassuring of no risk in a press release from Martin Röösli, July 28, 2011: *‘Kein erhöhtes Hirntumorrisiko bei Kindern und Jugendlichen wegen Handys... Die Resultate sind beruhigend’* [‘No increased brain tumour risk in children and adolescents for mobile phone users... The results are reassuring’] [72].

A similar press release was issued by Maria Feychting at the Karolinska Institute in Stockholm stating: *‘Reassuring results from first study on young mobile users and cancer risk... The so called CEFALO study does not show an increased brain tumor risk for young mobile users’* [73]. Considering the results and the numerous scientific shortcomings in the study [70], the statements in these press releases are not correct.

There is no doubt that several individuals included in [Table I](#) are influential, being members, as well as having consulting assignments, in several organizations, such as ICNIRP, BERENIS, the SSM, the Program Electromagnetic Fields and Health from ZonMw in the Netherlands, and the Rapid Response Group for the Japan EMF Information Center [\[74\]](#).

In fact, there appears to be a cartel of individuals working on this issue [\[75\]](#). Associate Professor Martin Rösli has had the chance to provide his view on the content of the present article relating to him. The only message from him was in an e-mail dated January 16, 2020: *'Just to be clear, all my research is funded by public money or not-for-profit foundations [foundations]. I think you will not help an important debate if you spread fake news'*. Obviously, as described in the present article, his comment is not correct considering his funding from the telecom industry [\[76,77\]](#).

As shown in [Table I](#), few individuals, and mostly the same ones, are involved in different evaluations of health risks from RF radiation and will thus propagate the same views on the risks in agencies of different countries associated with the ICNIRP views [\[4,5\]](#). Therefore, it is unlikely that they will change their opinions when participating in different organizations. Furthermore, their competence in natural sciences, such as medicine, is often low or non-existent due to a lack of education in these disciplines [\[2\]](#). Therefore, any chance for solid evaluations of medical issues is hampered. Additionally, it must be concluded that if the 'thermal only' dogma is dismissed, this will have wide consequences for the whole wireless community, including permissions for base stations, regulations of the wireless technology and marketing, plans to roll out 5G, and it would therefore have a large impact on the industry. This may explain the resistance to acknowledge the risk by ICNIRP, EU, WHO, SSM and other agencies. However, the most important aspects to consider are human wellbeing and a healthy environment. Telecoms can make profit in a variety of ways, and wireless is just one of them. They have the capacity to maintain profits by using different techniques, such as optical fiber, that will provide more data with less RF radiation exposure. Particularly when considering the liability, they are incurring in their misguided insistence of wireless expansion that may ultimately catch up to them in the form of lawsuits, such as those previously experienced by asbestos and tobacco companies [\[78,79\]](#).

A recent book describes how deception is used to capture agencies and hijack science [\[80\]](#). There are certain tools that can be used for this. One is to re-analyze existing data using methods that are biased towards predetermined results [\[23\]](#). For example, this can be performed by hiring 'independent experts' to question scientific results and create doubt [\[81,82\]](#). As clearly discussed in a number of chapters of the books [\[80–82\]](#), front groups may be created to gain access to politicians and to influence the public with biased opinions. Other methods may involve intimidating and harassing independent scientists that report health risks based on sound science, or removing all funding from scientists who do not adhere to the no-risk pro-industry paradigm. Another tool would be economic support and courting decision makers with special information sessions that mislead them on science and mask bribery [\[3,5,19,80–82\]](#). An industry with precise marketing goals has a big advantage over a loose scientific community with little funding. Furthermore, access to regulatory agencies and overwhelming them with comments on proposed regulations is crucial [\[3\]](#). To counteract all these actions is time consuming and not always successful [\[19\]](#). Nevertheless, it is important that these circumstances are explored and published in the peer-reviewed literature as historical notes for future use.

Based on the Swiss and ICNIRP experiences, some recommendations can be made. One is to include only unbiased and experienced experts without COIs for evaluation of health risks from RF radiation. All countries should declare a moratorium on 5G until independent research, performed by scientists without any ties to the industry, confirms its safety or not. 2G, 3G, 4G and WiFi are also considered not to be safe, but 5G will be worse regarding harmful biological effects [\[42,83,84\]](#). The authors of the present article recommend an educational campaign to educate the public about the health risks of RF radiation exposure, and safe use of the technology, such as the deployment of wired internet in schools [\[85\]](#), as previously recommended by the European Council resolution

blood lymphocytes using the comet assay technique, and in buccal cells using the micronucleus assay, in individuals exposed to RF radiation from base stations [90].

Finally, an alternative approach to the flawed ICNIRP safety standards may be the comprehensive work of the European Academy for Environmental Medicine (EUROPAEM) EMF working group that has resulted in safety recommendations, which are free from the ICNIRP shortcomings [50]. Recently, the International Guidelines on Non-Ionising Radiation (IGNIR) have accepted EUROPAEM safety recommendations [91]. The Bioinitiative group has recommended similar safety standards based on non-thermal EMF effects [92]. WHO and all nations should adopt the EUROPAEM/Bioinitiative/IGNIR safety recommendations, supported by the majority of the scientific community, instead of the obsolete ICNIRP standards.

In conclusion, it is important that all experts evaluating scientific evidence and assessing health risks from RF radiation do not have COIs or bias. Being a member of ICNIRP and being funded by the industry directly, or through an industry-funded foundation, constitute clear COIs. Furthermore, it is recommended that the interpretation of results from studies on health effects of RF radiation should take sponsorship from the telecom or other industry into account. It is concluded that the ICNIRP has failed to conduct a comprehensive evaluation of health risks associated with RF radiation. The latest ICNIRP publication cannot be used for guidelines on this exposure.

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Authors' contributions

LH and MC contributed to the conception, design and writing of the manuscript. Both authors read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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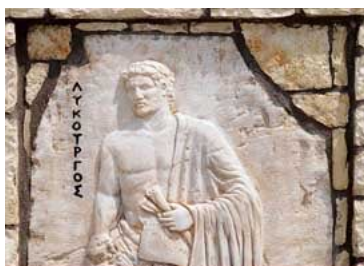


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There is no doubt that the discovery of cellular oncogenes changed our views on the most devastating of human diseases: cancer. That is the reason why it is considered the most significant discovery of the 20th century. From the time of Hippocrates, the father of medicine who first described cancer, until the discovery of cellular oncogenes, very little progress had been made concerning an explanation to the causes of cancer, its diagnosis and treatment. The fact that under the category of cancer approximately 200 forms of diseases are included affecting almost every part of the human body, made it difficult to pinpoint the cause as well as control its result. However, the development of a variety of technological achievements, namely tissue culture, recombinant DNA technology, gene transfer techniques and so on, made the ideological approach feasible. By using the above techniques, it was possible to isolate human oncogenes; in other words, the genes responsible for the creation of benign or malignant growth of human tumours (oncos).

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NEW YORK TIMES

NOVEMBER 5, 2022

What Are Those Mysterious New Towers Looming Over New York's Sidewalks?

As the city upgrades to 5G wireless, the streetscape is changing. Not everyone is impressed.



A new 5G tower on Mulberry Street in Manhattan's Chinatown. Credit...Amir Hamja for The New York Times



By [Dodai Stewart](#)

Published Nov. 5, 2022Updated Nov. 6, 2022

A [curiously futuristic tower](#) recently appeared on the corner of Putnam and Bedford Avenues in the Bedford-Stuyvesant neighborhood of Brooklyn. A gray column topped by a perforated casing, at a whopping 32 feet tall, it reaches higher than the three-story brick building behind it.

Sixty-year-old Marion Little, who owns Stripper Stain & Supplies, the hardware store that has operated on that corner for 17 years, said that he and his neighbors had received no warning. One day there were workers outside; then the tower materialized.

“We were shocked because we had no idea what it was,” Mr. Little said. Since it’s right outside his store, people keep asking him about it. “They’ve been emailing me, calling me weekends, Facebooking me, like, ‘Yo, what’s that?’ and I’m sitting there like, ‘I have no clue.’”

The object in question is a [new 5G antenna tower erected by LinkNYC](#), the latest hardware in New York’s sweeping technological [upgrade](#).

New York City has an agreement with CityBridge, the team behind [LinkNYC](#), that involves installing [2,000 5G towers](#) over the next several years, an effort to help eliminate the city’s “internet deserts.” Ninety percent will be in underserved areas of the city — neighborhoods in the Bronx, Brooklyn, Queens, Staten Island and above 96th Street in Manhattan.

Once the towers are activated, residents will have access to free digital calling and free high-speed Wi-Fi as well as 5G service. Many of the locations were previously home to pay phones.

According to officials in the city’s Office of Technology and Innovation, [40 percent of New York City households lack the combination of home and mobile broadband](#), including 18 percent of residents — more than 1.5 million people — who lack both.

The 5G towers, as well as fiber cables underground, will make up an infrastructure that carriers like AT&T and Verizon can use to provide better service to customers. Most of the towers, including the one on Mr. Little’s corner, have not yet been activated.

But as is often the case when something new appears on the New York City streetscape, people seem startled by the large structures — and some [have expressed unfounded fears about 5G](#). They’re concerned about the towers’ sheer size and, in some cases, the wrecked views from third-floor windows. Mr. Little also questioned the practicality of placing the tower on his corner at the B26 bus stop: “The buses turn here,” he said. “It’s going to be easy to miscalculate and hit the thing.”

Another 5G tower popped up in Fort Greene, on the corner of Vanderbilt and Myrtle Avenues, again, by a bus stop — the B69. It looms alongside a three-story residential building with a ground-level liquor store.

Mark Malecki, 26, who moved to New York City in mid-October from Richmond, Va., has an intimate view framed by his third-floor bedroom window. “I wasn’t even quite sure what it was,” he said.



The new tower at the corner of at Bedford and Putnam Avenues in Bedford-Stuyvesant caught residents by surprise. Credit...Amir Hamja for The New York Times

Just down the street lives Renee Collymore, a 50-year-old Brooklynite who said her family is “four generations deep in this neighborhood” and who serves as the Democratic liaison for the 57th Assembly District in Fort Greene. She [has been wary of the tower since it appeared this summer](#).

As the head of the Vanderbilt Avenue Block Association, Ms. Collymore said, “Never have I heard one mention of residents asking for a tower to be placed where we live.” She plans to hold a meeting about it.

“Before this tower came, I had fine service,” Ms. Collymore continued. “What, a call dropped every now and then? So what. You keep going.”

In Manhattan's Chinatown, where a tower cropped up on the corner of Mulberry and Bayard Streets, one resident of a nearby building declared it a "monstrosity."

"Who wants to look at something like that?" she asked.

The towers are not the only 5G antennas being installed in New York City. Others are going up on city property, like traffic lights and streetlamps.

At the end of September, jackhammering could be heard outside of the six-story brick building on the Upper East Side where Chelsea Formica, 32, lives with her husband, Joe, and their infant son.

Ms. Formica was in New Jersey visiting her mother when Joe called. "He was like, 'Hey, you know, they put something up outside of our window. I'm just laying here on the couch and it's pretty big.'" Then Ms. Formica got home. "I was like, 'Oh, my God,' freaking out. It's huge. It's so big."

Workers for the telecommunications company ExteNet had installed a cylindrical object roughly the size of a human being: a 5G antenna that is 63 inches tall and 21 inches in diameter, according to the company. It is accompanied by a box that is 38 inches high, 16 inches wide and 14 inches deep — about the size of a filing cabinet or a night stand.

The imposing antenna is mounted on top of a slender pole, three stories high — more than 30 feet in the air — and right in front of Ms. Formica's living-room window. It's also just steps away from where their 5-month-old baby sleeps, which makes Ms. Formica uncomfortable.

"People say that it is safe; the F.C.C. says it's safe and everything," she said. "We're just worried that it's so close to my son's bedroom."

Alex Wyglinski, the associate dean of graduate studies and a professor of electrical and computer engineering at Worcester Polytechnic Institute, said residents need not worry. He noted that 5G is non-ionizing radiation, on the opposite end of the spectrum from ionizing rays that people need protection from, like UV rays and X-rays.

In addition, Dr. Wyglinski said, the tower "cannot just blast energy everywhere. It's going to be hyper-focused points of energy going directly to your cellphone."

And while the towers are tall, "you'll get used to it," he said. Just like streetlights and traffic lights, he added, "this will get integrated into the cityscape."

Ms. Formica and her next-door neighbor Virginie Glaenzer, whose window view is also dominated by the antenna, took a measuring tape to the sidewalk and discovered that the newly installed pole is slightly less than 10 feet away from the building, a distance that typically triggers a community notification process, according to [the agreement between New York City and ExteNet](#).

Image



From her apartment window on the Upper East Side, Virginie Glaenzer has a close-up view of a new 5G antenna. Credit...Amir Hamja for The New York Times

Ms. Glaenzer and Ms. Formica contacted their local representatives and handed out fliers [urging their neighbors to do the same](#). They would like to see the antenna removed — or at least moved across the street, alongside the Asphalt Green turf field and not next to a residential building.

Julie Menin, the New York City Council member who represents Ms. Formica, Ms. Glaenzer and the rest of [District 5](#), said that she has, on behalf of her constituents, asked the city to hire a third party to conduct emissions tests on the antennas to ensure that they comply with federal regulations, and the city's Office of Technology and Innovation has agreed to do so.

Ms. Formica said she wouldn't feel comfortable living next to it once it is turned on. She isn't sure she would move out, she said, but she would consider her options. "I think I would look into a lawyer."

As for Ms. Glaenzer, she laughed as she pointed to some crystals she'd placed in a bowl on the windowsill in front of the antenna. "They're supposed to remove the radiation," she said, shrugging. "You're just holding on to whatever you have."

Bayonne White

1745 Carrie Hills Lane
La Habra Heights
CA 90631
562-697-0515

December 5, 2022

County of Los Angeles
County Board of Supervisors

Re: Subject of Placing 5G and other Telecommunication relay devices on private properties

I am writing to you to voice my concern about an important decision you are considering regarding approving or rejecting the ability of telecommunication companies to pay private property owners to place 5G and other active radio wave producing instruments on properties without concern for the damages which may result from exposure.

I encourage each of you to study carefully the science of what happens to life forms when exposed to these these 5G and other transmitters in close range, especially to young children and sensitive individuals.

DO NO HARM is paramount.

Your decisions must recognize that it is against common sense and decency to approve actions which are known to cause physical harm.

Also, what you decide on this matter should not be rushed to avoid a general public study and input.

I respectfully request your consideration of my comments.

Please postpone your decision on approval of allowing harmful telecommunication devices which may be harmful to healthy life.

Submitted on December 5, 2022 by Bayonne White.

P: (626) 381-9248
F: (626) 389-5414
E: info@mitschtsailaw.com



139 South Hudson Avenue
Suite 200
Pasadena, California 91101

VIA PUBLIC COMMENT PORTAL & E-MAIL

December 3, 2022

Celia Zavala, Executive Officer
COUNTY OF LOS ANGELES BOARD OF SUPERVISORS
KENNETH HAHN HALL OF ADMINISTRATION
500 West Temple Street, Room 383
Los Angeles, CA 90012
Em: executiveoffice@bos.lacounty.gov

Re: Legal and Policy Issues Relating to Proposed Amendments to Title 16 & 22 (Vote on Final Passage Scheduled for December 6, 2022)

Honorable Members of the Los Angeles County Board of Supervisors:

This firm represents Fiber First Los Angeles County, which is a collection of public interest organizations and county residents. We are supplying this as a final plea before imminent action. The Board is scheduled to consider final passage of Staff-proposed and industry-supported amendments to Titles 16 and 22 on December 6, 2022. On behalf of Fiber First Los Angeles County (“FFLA”) we urge that you do **not** adopt these revisions. Doing so will lead to irreversible harm to your constituents and the environment. These proposed amendments violate state law, both procedurally and substantively.

County Staff contends these radical changes are necessary, indeed mandatory, but their claims are false and misleading. This memo briefly refutes these false claims and sets out practical and lawful solutions.

1. False Claim # 1: The County’s “hands are tied” and the FCC requires these amendments.

Response:

A. Nothing in the Communications Act (47 U.S.C. §§151, *et seq*) or Federal Communications Commission rules (47 C.F.R. Parts 1-101 generally or Part 1 Subparts I and U in particular) preempts CEQA¹ or any state environmental laws.² FFLA has previously provided a legal memorandum on CEQA, and it is attached for your convenience. As noted therein, shot clock rules do not even apply to the ordinance process, so there is no reason to rush these amendments. The FCC has expressly held that its rules do not preempt state-law-required

¹ Public Resources Code, section 21000 *et seq.* (CEQA). Statutory references are to the Public Resources Code. References to “CEQA Guidelines” or “Guidelines” are to the regulations promulgated by the Secretary of the Natural Resources Agency found in title 14 of the California Code of Regulations beginning at section 15000.

² *Friends of the Eel River v. North Coast Railroad Authority* 3 Cal.5th 677, 720 (2017) (finding that federal law does not pre-empt a state agency’s CEQA environmental review obligations); *County of Butte v. Department of Water Resources* 13 Cal. 5th 612, 634, 514 P.3d 234 (2022).

environmental requirements;³ it is just that all required procedures must be completed within the shot clock period. FFLA's red-line (attached) to the Staff's proposed ordinances solves most concerns about CEQA processing by requiring that the applicant perform all necessary evaluations prior to filing the application.

B. 47 U.S.C. §332(c)(7)(B)(iv) does provide that a local zoning authority may not regulate personal wireless facilities "on the basis of environmental effects of radiofrequency emissions." But there is no indication that Congress intended to preempt state environmental laws like CEQA, which are expressly recognized and approved in National Environmental Policy Act (NEPA) and the National Historic Preservation Act (NHPA). These are co-equal federal statutes to the Communications Act. *In re Accelerating Wireless Broadband Deployment*,

³ See *In re Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Inv.*, 33 FCC Rcd 3102, 3132 ¶77 (March 30, 2018), rev'd other grnds *United Keetoowah Band of Cherokee Indians in Oklahoma*, 933 F.3d 728, 744 (D.C. Cir. 2019):

Finally, nothing we do in this order precludes any review conducted by other authorities—such as state and local authorities—insofar as they have review processes encompassing small wireless facility deployments.[n152] The existence of state and local review procedures, adopted and implemented by regulators with more intimate knowledge of local geography and history, reduces the likelihood that small wireless facilities will be deployed in ways that will have adverse environmental and historic preservation effects.[n153]

n.152 The record refers to a range of such requirements that exist under state or local law. See, e.g., *City of Boston et al. Ex Parte Letter* at 8 (stating appreciation that this order "does not intend to preempt state and local environmental and historical review, and thus leaves open the possibility that states and localities may be able to provide protections that had been provided through the Section 106 and NEPA processes" and noting that "many states have their own versions of NEPA and Section 106"); Letter from Scott K. Bergmann, CTIA, to Marlene H. Dortch, FCC, WT Docket No. 17-79, at 3 (filed Mar. 16, 2018) (the actions taken here do not "mean that small wireless facilities can be deployed by private parties without environmental and historic protections; state and local zoning, environmental, and historic preservation requirements will continue to apply"); Letter from Kenneth S. Fellman, counsel for Colorado Communications and Utility Alliance et al., to Marlene H. Dortch, FCC, WT Docket No. 17-79, Attach. At 5 (filed Oct. 19, 2017) (discussing Colorado state rights-of-way and Denver zoning requirements for wireless facilities); National League of Cities Comments, Attach. At 4 (discussing examples of factors that local authorities consider in connection with right-of-way access, including environmental and aesthetic considerations); National League of Cities et al. Request for Extension of Time at 3 (filed July 7, 2017) (observing that several states have enacted small wireless facility siting laws); see also, e.g., 2017 Pole Replacement Order, 32 FCC Rcd 9760, 9769-70, para. 23 (noting state law requirements for the handling of human or burial remains). Although this order does not preclude otherwise-existing review by other authorities, it also does not eliminate otherwise-existing limitations on that review, see, e.g., *City of Boston et al. Ex Parte Letter* at 8 (discussing limits under 47 U.S.C. § 1455), but instead leaves the preexisting status quo in place at this time.

n.153 We recognize that state and local procedures do not mirror the review required under Section 1.1312 of the Commission's rules in all respects. But these procedures nevertheless act as an independent check and show that our action today will not have the effect of authorizing indiscriminate deployment. To the extent that review provided for under state and local law differs, those differences presumably reflect the judgment of state and local lawmakers as to the type of review required for a particular geographic area. We thus find no basis to ignore the role of state and local procedures based on differences in their scope or application cited by commenters. See, e.g., Missouri SHPO Comments at 4; Texas Historical Commission Comments at 3; *City of Boston et al. Mar. 14, 2018 Ex Parte Letter* at 8-9.

supra n.152. Compliance with CEQA evaluation requirements is not “regulation on the basis of environmental effects.” Thus, Los Angeles County has a legal obligation under state law at least to inform itself on the overall environmental impacts of the proposed code amendments to Titles 16 & 22, and then specifically whether and how the structure and/or emissions from a proposed facility will contribute to these significant environmental effects.

2. False Claim # 2: The BOS decision is categorically exempt from CEQA.

Response:

CEQA contains various classes of categorical exemptions for projects that are unlikely to have environmental impacts. See PRC § 21084; CEQA Guidelines § 15354. These exemptions are to be construed narrowly and are not to be expanded beyond the scope of their plain language. See *Save Our Carmel River v. Monterey Peninsula Water Mgmt. Dist.* 141 Cal.App.4th 677, 697 (2006); *Castaic Lake Water Agency v. City of Santa Clarita* 41 Cal.App.4th 1257 (1995); *Wildlife Alive v. Chickering* 18 Cal.3d 190, 205 (1976). They must also be construed in light of their statutory authorization, which limits such exemptions to classes of projects that have been determined not to have significant effects on the environment – ensuring categorical exemptions are interpreted in a manner affording the greatest environmental protection. *Azusa Land Reclamation Co. v. Main San Gabriel Basin Watermaster* 52 Cal.App.4th 1165, 1192 (1997).

The County claims that the project “will establish application requirements and development standards for wireless facilities within the unincorporated County, including authorization for modifications to existing facilities as well as for minor alterations to land with the construction or conversion of small structures,” and that such actions fall “within a class of projects that have been determined not to have a significant effect on the environment and which meet the criteria for [Class 1 and Class 3 Exemptions to CEQA review].” November 15, 2022, Los Angeles County Department of Regional Planning Letter to Board of Supervisors, at page 5.

The County claims that the project is exempt from CEQA review because it qualifies for a Class 1 exemption, which consists of “the operation, repair, maintenance, permitting, leasing, licensing, or minor alteration of existing public or private structures, facilities, mechanical equipment, or topographical features, involving negligible or no expansion of existing or former use.” CEQA Guidelines § 15301. The County also claims that the project is exempt from CEQA review because it qualifies for a Class 3 exemption, which consists of the “construction and location of limited numbers of new, small facilities or structures; installation of small new equipment and facilities in small structures; and the conversion of existing small structures from one use to another where only minor modifications are made in the exterior of the structure.” CEQA Guidelines § 15303

Under the Class 1 exemption, the key consideration is that such actions would occur to *existing* facilities. Yet as the Proposed Ordinance makes abundantly clear, the small cell facilities may be built on *new* infrastructure. Proposed Ordinance at pages 7, 8, 9, 30, 32, 38, 40. This means that, under the Proposed Ordinance, new support structures may be constructed to serve these facilities. The Proposed Ordinance also makes clear that macro facilities may be built. Proposed Title 22 amendment at 30. Such construction is clearly not exempted under Class 1. And although it is seemingly permissible under Class 3, a closer analysis demonstrates otherwise.

The Class 3 exemption states that only a project proposing a “*limited* number of new, small facilities or structures” can be exempted from environmental review under CEQA. (emphasis added) What the County should be required to demonstrate in order for the project to qualify under the Class 3 exemption is the *amount* of structures that would be required to be constructed in order to fulfill the needs of the project. There are likely thousands of facilities that will need to be built throughout the county in order to fulfill the needs of the project. Because a categorical exemption should be interpreted “to afford the fullest possible protection to the environment within a reasonable scope of the statutory language,” the project does not satisfy this exemption. *Save Our Carmel River v. Monterey Peninsula Water Management Dist.* 141 Cal.App.4th 677, 697 (2006); *San Lorenzo Valley Community Advocates for Responsible Education v. San Lorenzo Valley Unified School Dist.* 139 Cal.App.4th 1356, 1382 (2006); *County of Amador v. El Dorado County Water Agency* 76 Cal.App.4th 931, 966 (1999) (“exemptions are construed narrowly and will not be unreasonably expanded beyond their terms”).

Regardless, even if the proposed Ordinances (Titles 16 & 22) fit within the confines of the Class 1 and 3 exemptions, they are still ineligible for a categorical exemption from CEQA. CEQA Guidelines Section 15300.2(a) limits Class 3 exemptions by location. A project that might otherwise be insignificant in its environmental impact may, in a particularly sensitive environment, be significant. CEQA Guidelines, § 15300.2(a). Los Angeles County is known to have many environmentally sensitive areas. For example, the Significant Ecological Areas “are officially designated areas within LA County with irreplaceable biological resources.”⁴ The quantity of wireless facilities that will be constructed and implemented, as well as the location of such construction and implementation, may pose a potentially significant risk to environmentally sensitive areas and habitats throughout the county.

Moreover, the facts governing this project are distinguishable from the cases that find no result in impacts on a resource of critical concern. For example, in *Citizens for Environmental Responsibility v. State ex rel. 14th Dist. Ag. Assn.*, the court held that there will be no impact on a resource of critical concern because “the event will utilize existing arenas, horse barns and other facilities; no construction or physical alterations of the grounds are proposed.” 170 Cal.Rptr.3d 8, 15 (2014). There, the environmental setting in which the proposed project was situated was well defined. Here, the environmental setting is not clear, as the project will span all different areas of the county. As such, environmental review should be conducted on each permit to ensure that the construction of each of the facilities, including macro facilities, do not have adverse impacts on environmentally sensitive areas.

Categorical exemptions do not apply when the cumulative impact of successive projects of the same type and same place over time may be significant. Guidelines, § 15300.2(b). The County wholly bypassed any discussion of potentially cumulative impacts that would result from the implementation and operation of the project, including what the effects would be if multiple facilities, including macro facilities, are constructed in the same neighborhood at the same time.

Moreover, cases in which the categorical exemptions have been upheld are distinguishable from the facts here. For example, in *San Francisco Beautiful v. City and County of San Francisco*, the Class 3 categorical exemption was applied to the installation of 726

⁴ <https://planning.lacounty.gov/site/sea/maps/>

telecommunications equipment boxes on city property. 226 Cal.App.4th 1012, 1021-1022 (2014). The exemption has also been applied to the installation of small new telecommunications equipment on numerous existing small structures in scattered locations. *Robinson v. City and County of San Francisco* (2012) 208 Cal.App.4th 950, 956. Noticeably different from the facts in the present matter, such cases dealt with small devices/boxes that were installed on *pre-existing* structures. Here, the Proposed Ordinance posits the construction of *new* structures; and of these, not all facilities will be small in size. Rather, the Proposed Ordinance anticipates macro-facilities which will be subject to ministerial review (Proposed Ordinance at page 30). Such facilities will be constructed in quantities that are not known, and whose construction may produce cumulative environmental impacts to the surrounding communities.

The Environmental Determination is defective because it does not “cit[e] the evidence on which [the lead agency, here presumably the County] relie[s] in reaching that Conclusion.” *Union of Med. Marijuana Patients*, (2019) 7 Cal. 5th at 1171, 1186, citing *Muzzy Ranch Co. v. Solano County Airport Land Use Com.* (2007) 41 Cal.4th 372, 380, 386-387, 60 Cal. Rptr. 3d 247, 160 P.3d 116. “The exemption can be relied on only if a factual evaluation of the agency’s proposed activity reveals that it applies... whether a particular activity qualifies for the commonsense exemption presents an issue of fact, and [] the agency invoking the exemption has the burden of demonstrating it applies.” *Muzzy*, 41 Cal. 4th at 386. An agency’s duty to provide such factual support “is all the more important where the record shows, as it does here, that opponents of the project have raised arguments regarding possible significant environmental impacts.” *Id.* When facts for the basis of such are in dispute, reviewing courts will generally only uphold the agency’s decision to utilize the exemption when it is supported by substantial evidence. *See, e.g., Holden v. City of San Diego* 43 Cal. App. 5th 404, 410 (2019). Here, the City has not provided *any* evidence regarding environmental impacts. This alone is fatal to the environmental determination.

3. False Claim # 3: The FCC shot clock rules require ministerial review.

Response: They do not. Nothing in the FCC rules preempt a state from conducting discretionary review or prohibit notice and adjudicative processes for any wireless facility other than those qualifying as an “exempt facility” (“minor modification”) and therefore “shall issue” under federal law. *See* 47 C.F.R. §§ 1.6100. The FCC rules do as a practical matter require that state or local processes be compressed as necessary to meet the shot clock requirements. Again, the FFLA red-lines provide the means to accomplish due process within the state and federal shot clock requirements.

In this vein, we note that Gov’t Code §65964.1(a)(2) expressly contemplates public notice as one condition for its “deemed approved” remedy, and Gov’t Code §65850.6(6) contemplates discretionary review and at least one public hearing. The legislature knows the difference between hearings-based discretionary review and “administrative, nondiscretionary review.” Applications to place an emergency standby generator, however, are by statute required to be administrative and nondiscretionary, e.g., “ministerial.” Gov’t Code 65850.75(b). “Exempt” facilities are also “shall approve” and thus ministerial as a matter of federal law. All other wireless-facility-related applications are discretionary and require notice and hearing.

4. False Claim # 4: The FCC requires, and state law allows, dispensing with residents' due process rights.

Response:

We have addressed the FCC rules and state law above. The only wireless facilities that are lawfully subject to ministerial review are “exempt facilities” (minor modifications) and back-up generators. There is no legal basis for dispensing with public involvement for any other application type, whether they be small cells or colocations in public right-of-way or public property or any other kind.

Each wireless application will have a direct impact on those nearby. It will affect property values. Many facilities will be eyesores no matter how much they attempt to be concealed or camouflaged. They do affect the environment in many ways, even if one wrongly ignores the RF emissions they will generate. They present significant fire and other safety risks. Eliminating public notice and the opportunity for hearing will violate fundamental fairness, substantive and procedural due process rights under the California and U.S. Constitution and deprive local residents of their right to participatory democracy by having local concerns addressed within a context of nation-wide endeavors. *D. C. Fed'n of Civic Asso. v. Volpe*, 434 F.2d 436, 440-42 (1970).

5. False Claim # 5: As a practical administrative matter, the LACRPD does not have the staff or budget to comply with CEQA.

Response: This is silly and false. Los Angeles County handles complicated land use applications all the time. It has more than sufficient funds to develop and implement a balanced process that allows for timely processing on a discretionary basis that still meets all shot clock mandates. There is no justification or excuse for jettisoning environmental and other procedural processes that allow public participation. If the Staff truly cannot handle the burden, then the County can require wireless applicants to pay the cost of contract wireless consultants that will assist in the review.

7. False Claim # 7: Passing Titles 16 and 22 amendments will solve the Digital Divide.

Response: In fact, it will do just the opposite. Wireless broadband will not deliver high-quality, high efficiency, highly reliable, high speed broadband to disadvantaged and traditionally underserved communities. It is an inferior technology requiring constant updating in order to avoid obsolescence within just a few years after installation. The consumer pricing for the same quantity of data is far higher than for the preferred alternative – optical fiber to the premises.

8. False Claim # 8: Exposing the public, including children, disabled persons, and pregnant women to continuous, aggregate, and cumulative high levels of non-ionizing radiation is safe, because the FCC's maximum exposure guidelines say so.

Response: An extensive body of peer reviewed scientific papers from many countries confirms that such exposure is unsafe, and particularly dangerous to these highly vulnerable populations. It also negatively affects birds, insects, and other animals. This is precisely the class of impacts that a CEQA Environmental Review and Impact must address. The FFLA CEQA memo provides citations to some of this material on pages 9-15. Just this past Friday a new study was published in *Frontiers in Public Health* suggesting “damaging non-human species at ecosystem and biosphere levels across all taxa from rising background levels of anthropogenic

non-ionizing electromagnetic fields (EMF) from 0 Hz to 300 GHz.” [Low-level EMF effects on wildlife and plants: What research tells us about an ecosystem approach, Levitt BB, Lai HC and Manville AM II. \(2022\), Front. Public Health 10:1000840. doi: 10.3389/fpubh.2022.1000840.](#)

9. False Claim # 9: There will be no significant environmental impacts from the implementation of Titles 16 and 22 because the LACRPD has conducted a due diligence investigation and concluded so.

Response: The LACRPD has not conducted any due diligence whatsoever, because its legal position is Titles 16 and 22 are categorically exempt from CEQA. The FFLA CEQA memo sets out significant adverse environmental risks, and the County must evaluate them before it passes these ordinances.

10. False Claim # 10: Blanketing LAC with small cell and macro cell towers authorized under Titles 16 and 22 will enable LAC residents to call 911 in case of fire and to respond to fires more resiliently.

Response: Small cell and macro towers have been well documented to cause fires⁵. Fire and Utility Consultant Susan Foster submitted comments showing that four (4) major wildfires have been started, in whole or in part, by telecommunications equipment in Southern California alone in the last 15 years.⁶ Two (2) of those fires, Malibu Canyon Fire (2007) and Woolsey Fire (2018), were in Los Angeles County and caused over \$6 billion in damages, injured multiple firefighters, and took the lives of three people attempting to escape. The parties responsible for the fires were Southern California Edison (SCE) (the main utility servicing Los Angeles County), AT&T, Verizon, Sprint (now T-Mobile) and NextG (now Crown Castle). It was SCE's own telecommunications company that was responsible in large part for the Woolsey Fire. They did not repair critical parts of the telecommunications infrastructure noted on a telecommunications inspection. Six months later the \$6 billion fire ignited. All parties involved in the initiation of these two LA County fires were accused by the CPUC of attempting to impede the fire investigations.⁷

A categorical exemption for CEQA could not come at a worse time. LAC is asking the parties who impeded fire investigations of the very fires they initiated to police themselves when coming into LAC. Titles 16 and 22 fail to require evaluation of electrical, structural, fire and building code safety upfront before the tower receives a permit. This is a lost opportunity for LAC to prevent fires. [See Malibu's [Resolution 21-17](#) for model of upfront requirements.]

It is a false narrative that small cells or additional macro towers are needed to call 911 in the event of fire. 911 calls are routed through macro towers. Small cells do not serve this function. We do not need more macro towers unless there is a gap in coverage because macro

⁵ California Fires and Firefighters, November 15, 2022, PROTECTING LA COUNTY’S FUTURE: HOW FIRE RISKS FROM TELECOMMUNICATIONS EQUIPMENT, CLIMATE CHALLENGES & A DANGEROUS SHIFT AWAY FROM ENVIRONMENTAL REVIEW THREATEN LOS ANGELES COUNTY’S FUTURE.

⁶ *Id.*, p. 11.

⁷ *Id.*, p. 5.

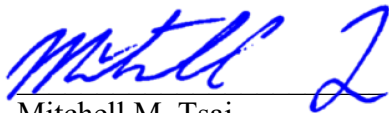
towers essential to each carrier's network are already backed up pursuant to CPUC rules.⁸ When the power has been cut, intentionally or unintentionally, backup systems already in place or generators immediately brought in will provide 72-hours of macro tower use. Small cells, because they are in the public right-of-way, are more likely to be granted waivers with respect to the backup plan because diesel-powered generators and large battery packs in the public right-of-way create their own hazards.

11. False Claim # 11: There is no practical and immediate alternative to the Wireless Solution.

Response: This claim is blatantly false. Optical Fiber First (“OFF”) provides a safe, faster, more cybersecure, more private,⁹ more energy efficient, climate change friendly solution that is immediately available, and, in fact, already paid for by ratepayers and taxpayers. Billions of dollars of prioritized federal funding are immediately available under the [Broadband Equity, Access, and Deployment Program \(BEAD\)](#) program if Los Angeles County decides to implement this beneficial solution. The BOS/LACRPD careful assessment of the OFF alternative solution is legally required under CEQA.

Conclusion: On December 6, the BOS must vote to postpone its final decision on Titles 16 and 22, and order the LACRPD to begin preparing a comprehensive Environmental Review and Impact Assessment, as required under CEQA. The proposed ordinances must be extensively revised using the red-line changes supplied by FFLA.

Sincerely,



Mitchell M. Tsai
Attorneys for Fiber First Los
Angeles County

CC: Bruce Durbin, Department of Regional Planning (ordinance@planning.lacounty.gov); Yolanda Duarte-White, Chair, Regional Planning Commission (ELuna@planning.lacounty.gov); Mark Pestrella, P.E., Los Angeles County Public Works, Director (mpestrella@dpw.lacounty.gov); and Dawyne R. Harrison, Interim County Counsel (reply@counsel.lacounty.gov, Contact_Us@counsel.lacounty.gov).

Attachments:

Fiber First Los Angeles County (Sept. 23, 2022) Memorandum RE: Legal Issues Under CEQA, NEPA, and NHPA Presented by Proposed Amendments to Title 16 and 22 Ordinances (Exhibit A);

⁸ California Public Utilities Commission, Rulemaking 18-03-011, DECISION ADOPTING WIRELESS PROVIDER RESILIENCY STRATEGIES, Decision 20-07-011 July 16, 2020.

⁹ Board final approval will enable infrastructure that allows wireless telecom providers to surveil and convert citizen's most private personal information, including highly sensitive information concerning children, without informed consent. See webinar, "[Citizen Rights and Remedies Under the Shadow of 5G Surveillance and Behavioral Modification](#)."

Fiber First Los Angeles County (Sept. 9, 2022) Letter

EXHIBIT A



101 South Topanga Canyon Blvd. #1705, Topanga, CA 90290
www.FiberFirstLA.org • info@FiberFirstLA.org

MEMORANDUM

To: Los Angeles County Board of Supervisors/Department of Regional Planning
From: Fiber First Los Angeles County
Re: **Legal Issues Under CEQA, NEPA, and NHPA Presented by Proposed Amendments to Title 16 and 22 Ordinances**
Date: September 23, 2022

The following is an analysis of various legal issues under the California Environmental Quality Act (CEQA), the National Historic Preservation Act (NHPA) and related California state laws, and the National Environmental Policy Act (NEPA) arising from proposed wireless facilities ordinances (amending County Code Titles 16 and 22) now before the Los Angeles Board of Supervisors (BOS) as a result of recommendations by the Department of Regional Planning (LACDRP).

Fiber First Los Angeles (FFLA) contests the Proposed Environmental Determination, which states:

PROPOSED ENVIRONMENTAL DETERMINATION

DETERMINATION DATE: March 23, 2022
PROJECT NUMBER: 2021-002931
PERMIT NUMBER(S): RPPL2021007939 Permit Number
SUPERVISORIAL DISTRICT: 1-5
PROJECT LOCATION: Countywide
OWNER: N/A
APPLICANT: Los Angeles County
CASE PLANNER: Alyson Stewart, Senior Regional Planner,
ordinance@planning.lacounty.gov

Los Angeles County ("County") completed an initial review for the above-mentioned project. Based on examination of the project proposal and the supporting information included for the project, the County proposes that an Exemption is the appropriate environmental documentation under the California Environmental Quality Act (CEQA). This project (Ordinance) qualifies for a Categorical Exemption, (Class 1 – Existing Facilities, and Class 3 – New Construction or Conversion of Small Structures) under the California Environmental Quality Act (CEQA) and County environmental guidelines. The project includes authorization for modifications to existing facilities as well as for

*minor alterations to land with the construction or conversion of small structures.
Both actions will not have a significant effect on the environment.*

I. Executive Summary

The county staff recommends that the Board find that the action on wireless-related provisions through Amendments to County Codes Titles 16 and 22 is exempt from any environmental or historical evaluation based on a purported Categorical Exemption, (Class 1 – Existing Facilities, and Class 3 – New Construction or Conversion of Small Structures) under the California Environmental Quality Act (CEQA) and County environmental guidelines. We disagree.

1. There will be massive and irreversible adverse environmental consequences if the staff-recommended amendments are adopted.
2. The claimed Categorical Exemptions do not apply for any purpose.
3. Even if the Categorical Exemptions do apply generally, the BOS action will fall within specific Exceptions to the Exemptions, specifically, [CEQA Guidelines Section 15300.2](#)¹:
 - (a) Location. Classes 3, 4, 5, 6, and 11 involving significant impacts on particularly sensitive environments
 - (b) Cumulative Impacts.
 - (c) Significant Effects. Arising from unusual circumstances
 - (f) Historical Resources. Substantial adverse change to a historic resource.
4. The extensive federal involvement in Los Angeles County triggers NEPA’s “small handle doctrine,” which will necessitate a separate NEPA compliant Environmental Impact Statement (EIS). The BOS is the “co-lead agency,” as this term is interpreted under NEPA, in close consultation and collaboration with several federal agencies that are most engaged in providing funding to Los Angeles County.
5. There are a substantial number of registered and otherwise recognized historical sites and places located in Los Angeles County that are specially protected, and subject to Section 15300.2 Exceptions as well as provisions of NHPA and court decisions.
6. To the extent staff claims CEQA is preempted in whole or in part by the Communications Act (47 U.S.C.) Title III they are incorrect. Nothing in that statute or any FCC rule promulgated thereunder preempts the Board’s duty to perform a compliant programmatic Environmental Impact Report (EIR) for both proposed ordinances and the individual projects they countenance.
7. The FCC’s shot clock rules have no relevance to the ordinance drafting process for Titles 16 and 22. They apply only to decisions involving individual applications. The shot clock rules do not pre-empt state or local due process notice and hearing requirements, although they do compress the available time for final disposition.

¹ <https://casetext.com/regulation/california-code-of-regulations/title-14-natural-resources/division-6-resources-agency/chapter-3-guidelines-for-implementation-of-the-california-environmental-quality-act/article-19-categorical-exemptions/section-153002-exceptions>.

8. The BOS cannot avoid its heavy environmental responsibilities under CEQA, NEPA, and NHPA by pushing the process into Ministerial Site Review. All permits must remain subject to traditional Conditional Use Permit review.

II. Legal Analysis

The LACDRP's proposed Environmental Determination recommendation is fatally defective as a matter of CEQA law in two fundamental respects. First, the staff asserts that the proposed Code Amendments to Titles 16 and 22 are Categorically Exempt, which in CEQA language means that their environmental impacts are so negligible as not to justify even preparing an Initial Environmental Review, much less a Negative Declaration. The staff ignores, however, that categorical exemptions are construed narrowly. Aptos Residents Ass'n v. Cty. of Santa Cruz, (2018) 20 Cal. App. 5th 1039, 1046, 229 Cal. Rptr. 3d 605, 612. The county must determine the cumulative impact of all reasonably expected wireless facilities that will be authorized pursuant to the ordinances. Id. The extensive evidence of serious environmental impacts presented below belies any notion the operation of the contemplated ordinances could not possibly have a significant effect on the environment.

Union of Med. Marijuana Patients, Inc. v. City of San Diego, (2019) 7 Cal. 5th 1171, 1184-87, 250 Cal. Rptr. 3d 818, 825-27, 446 P.3d 317, 323-25 (quotation marks, citations and footnotes omitted) provides a good overview of the statutory regime:

2. CEQA generally

CEQA was enacted to advance four related purposes: to (1) inform the government and public about a proposed activity's potential environmental impacts; (2) identify ways to reduce, or avoid, environmental damage; (3) prevent environmental damage by requiring project changes via alternatives or mitigation measures when feasible; and (4) disclose to the public the rationale for governmental approval of a project that may significantly impact the environment. CEQA embodies a central state policy to require state and local governmental entities to perform their duties so that major consideration is given to preventing environmental damage. CEQA prescribes how governmental decisions will be made when public entities, including the state itself, are charged with approving, funding – or themselves undertaking – a project with significant effects on the environment.

CEQA review is undertaken by a lead agency, defined as the public agency which has the principal responsibility for carrying out or approving a project which may have a significant effect upon the environment. A putative lead agency's implementation of CEQA proceeds by way of a multistep decision tree, which has been characterized as having three tiers. First, the agency must determine whether the proposed activity is subject to CEQA at all. Second, assuming CEQA is found to apply, the agency must decide whether the activity qualifies for one of the many exemptions that excuse otherwise covered activities from CEQA's environmental review. Finally, assuming no applicable exemption, the agency must undertake environmental review of the activity, the third tier. We examine the three-tier process in more detail below.

CEQA's applicability: When a public agency is asked to grant regulatory approval of a private activity or proposes to fund or undertake an activity on its own, the agency must first decide whether the proposed activity is subject to CEQA. In practice, this requires the agency to conduct a preliminary review to determine whether the proposed activity constitutes a “project” for purposes of CEQA. If the proposed activity is found not to be a project, the agency may proceed without further regard to CEQA.

Exemption from environmental review: If the lead agency concludes it is faced with a project, it must then decide whether the project is exempt from the CEQA review process under either a statutory exemption or a categorical exemption set forth in the CEQA Guidelines. The statutory exemptions, created by the Legislature, are found in section 21080, subdivision (b). Among the most important exemptions is the first, for “[m]inisterial” projects, which are defined generally as projects whose approval does not require an agency to exercise discretion. The categorical exemptions in Guidelines sections 15300 through 15333 were promulgated by the Secretary for the Natural Resources Agency in response to the Legislature’s directive to develop “a list of classes of projects that have been determined not to have a significant effect on the environment.” If the lead agency concludes a project is exempt from review, it must issue a notice of exemption citing the evidence on which it relied in reaching that conclusion. The agency may thereafter proceed without further consideration of CEQA.

Environmental review: Environmental review is required under CEQA only if a public agency concludes that a proposed activity is a project and does not qualify for an exemption. In that case, the agency must first undertake an initial study to determine whether the project may have a significant effect on the environment.” If the initial study finds no substantial evidence that the project may have a significant environmental effect, the lead agency must prepare a negative declaration, and environmental review ends. If the initial study identifies potentially significant environmental effects but (1) those effects can be fully mitigated by changes in the project and (2) the project applicant agrees to incorporate those changes, the agency must prepare a *mitigated* negative declaration. This too ends CEQA review. Finally, if the initial study finds substantial evidence that the project may have a significant environmental impact and a mitigated negative declaration is inappropriate, the lead agency must prepare and certify a full and complete EIR before approving or proceeding with the project.

In Farmland Protection Alliance v. County of Yolo, 71 Cal. App 5th 300 (2021) the Appellate Court held that if **any** aspect of a project entails a significant environmental impact, a Negative Declaration, or Mitigated Negative Declaration cannot cure this fundamental deficiency and a full EIR is thereby required. As explained below, in addition to qualifying for a Cumulative Impacts Exception, proposed Titles 16 and 22 also effectively meet the requirements of the Historic Resource Exception, which like Cumulative Impacts does not require the analysis of the “unusual circumstances” test of the Supreme Court in Berkeley. Historic Resources are considered so important that if a single historic resource is seriously threatened the entire asserted Exemption collapses.

A. Ministerial Exemption

Proposed Titles 16 and 22 contemplate a comprehensive Ministerial Site Review that is inappropriate as a general matter. This Ministerial Site Review does not comply with CEQA. It allows unfettered discretion by the LACRPD and fails to apply strict criteria for each permit application. Further, it presumes there will always be an insignificant environmental impact, when it is highly likely many individual wireless facilities subject to the process will, in fact, have a significant impact.

CEQA Guidelines 14 CCR § 15369 defines “Ministerial”:

"Ministerial" describes a governmental decision involving little or no personal judgment by the public official as to the wisdom or manner of carrying out the project. The public official merely applies the law to the facts as presented but uses no special discretion or judgment in reaching a decision. A ministerial decision involves only the use of fixed standards or objective measurements, and the public official cannot use personal, subjective judgment in deciding whether or how the project should be carried out. Common examples of ministerial permits include automobile registrations, dog licenses, and marriage licenses. A building permit is ministerial if the ordinance requiring the permit limits the public official to determining whether the zoning allows the structure to be built in the requested location, the structure would meet the strength requirements in the Uniform Building Code, and the applicant has paid his fee.

CEQA Guidelines 14 CCR §15002(i) states:

(i) Discretionary Action. CEQA applies in situations where a governmental agency can use its judgment in deciding whether and how to carry out or approve a project. A project subject to such judgmental controls is called a "discretionary project." See Section 15357.

(1) Where the law requires a governmental agency to act on a project in a set way without allowing the agency to use its own judgment, the project is called "ministerial," and CEQA does not apply. See Section 15369.

(2) Whether an agency has discretionary or ministerial controls over a project depends on the authority granted by the law providing the controls over the activity. Similar projects may be subject to discretionary controls in one city or county and only ministerial controls in another. See Section 15268.

CEQA Guidelines 14 CCR § 15300.1 provides:

§ 15300.1. Relation to Ministerial Projects.

Section 21080 of the Public Resources Code exempts from the application of CEQA those projects over which public agencies exercise only ministerial authority. Since ministerial projects are already exempt, Categorical Exemptions should be applied only where a project is not ministerial under a public agency's statutes and ordinances. The inclusion of activities which may be ministerial within the classes and examples contained in this article shall not be construed as a finding by the Secretary for resources that such an activity is discretionary.

The draft ordinances' contemplated "Ministerial" review process does not meet the applicable definitions and treatment that are required before a project is exempt from CEQA review.

B. The claimed Categorical Exemptions do not apply

The LACDRP proposed Environmental Determination implicitly accepts that the ordinance drafting process here is a "project" for purposes of CEQA (step 1) because it undertakes step 2. We expressly agree that this ordinance exercise is a CEQA project. Staff, however, manifestly errs at step 2.

We first note that the draft Environmental Determination is defective because it does not "cit[e] the evidence on which [the lead agency, here presumably the County] relie[s] in reaching that Conclusion." Union of Med. Marijuana Patients, supra, 7 Cal. 5th at 1186, *citing Muzzy Ranch Co. v. Solano County Airport Land Use Com.* (2007) 41 Cal.4th 372, 380, 386-387, 60 Cal. Rptr. 3d 247, 160 P.3d 116. "The exemption can be relied on only if a factual evaluation of the agency's proposed activity reveals that it applies... whether a particular activity qualifies for the commonsense exemption presents an issue of fact, and [] the agency invoking the exemption has the burden of demonstrating it applies." Muzzy, 41 Cal. 4th at 386. An agency's duty to provide such factual support "is all the more important where the record shows, as it does here, that opponents of the project have raised arguments regarding possible significant environmental impacts." Id. This alone is fatal to the proposed Environmental Determination. But there are additional issues.

Exemption Class 1 pertains to "existing facilities" when the project involves negligible or no expansion of an existing use. Every type of wireless facility (other than exempt facilities covered by Section 6409 of the federal Spectrum Act, 47 U.S.C. Section 1455 and its implementing regulations at 47 C.F.R. Section 1.6100) that will be authorized under the proposed ordinance will either involve a new facility or a new use on an existing facility.

The Title 22 changes address, for example, new towers on public property other than highways or on private property. *See, e.g.*, proposed 22.140.E.b.i.² d. The Title 16 amendments contemplate the leasing of public infrastructure and allow for new or replacement poles to which new facilities will be attached. *E.g.*, proposed 16.25.030.E.3.d., 16.25.050.E. New poles or structures are not existing facilities.³ Even when existing county infrastructure is used the wireless facility will be a non-negligible "new use."

Exemption Class 3 consists of construction and location of limited numbers of new, small facilities or structures; installation of small new equipment and facilities in small structures; and the conversion of existing small structures from one use to another where only minor modifications are made in the exterior of the structure. This exemption does not apply because the ordinances will allow for construction and location of thousands of facilities. It is foreseeable that there may be many more applications than the 700 "small cabinets" involved in S.F.

² This provision addresses potential towers on the grounds of historical properties, a matter clearly not within any categorical exemption.

³ The staff does not rely on Class 2 for an exemption, but this also does not apply because the replacement structure will not have the same purpose or capacity.

Beautiful v. City & Cty. of S.F., (2014) 226 Cal. App. 4th 1012, 172 Cal. Rptr. 3d 134⁴ or the “transformer boxes” in McCann v. City of San Diego, (2021) 70 Cal. App. 5th 51, 89, 285 Cal. Rptr. 3d 175.⁵ More than minor modifications will be required. The draft ordinances provide for ministerial approval of thousands of wireless projects, so the scope is much greater than the 13 microcell sites addressed in Aptos. The ordinances expressly contemplate that facilities will be placed in scenic rural areas – not just neighborhoods or the urban core. They also expressly allow facilities on, in or near to historical resources. Los Angeles County General Plan Goal C/NR 14⁶ requires mitigation of impacts to historic resources, inter-jurisdictional collaboration, preservation of historic resources and it mandates that “proper notification and recovery processes are carried out for development on or near historic ... resources.” Exemption Class 3 does not apply.

C. Applicable California Judicial Standards

Even if the exemptions apply this is an unusual circumstance, and there is a reasonable possibility of a significant effect due to this circumstance. The significant effect is so substantial that the effect itself is an unusual circumstance. There are therefore applicable exceptions to the exemptions.

CEQA Guidelines Section 15300.2⁷ provides explicit exceptions to the exemptions section upon which the staff relies. The most relevant sections are:

- (a) Location. Classes 3, 4, 5, 6, and 11 are qualified by consideration of where the project is to be located -a project that is ordinarily insignificant in its impact on the environment may in a particularly sensitive environment be significant.
- (b) Cumulative Impact. All exemptions for these classes are inapplicable when the cumulative impact of successive projects of the same type in the same place, over time is significant.
- (c) Significant Effect. A categorical exemption shall not be used for an activity where there is a reasonable possibility that the activity will have a significant effect on the environment due to unusual circumstances...

⁴ These projects will involve more obtrusive antennas, wiring and associated equipment on various structures more than 10 feet above the ground and sometimes equipment on the ground.

⁵ McCann involved a “mitigated negative declaration” not a claimed categorical exemption. Notably, the McCann court found that San Diego did not adequately address whether the project would have a significant impact due to greenhouse gas emissions. 70 Cal. App. 5th 51, 91. The staff recommendation here suffers the same defect. As explained below, the projects contemplated by the ordinances will lead to more electric utility consumption that will, in turn, generate additional greenhouse gas emissions.

⁶ https://planning.lacounty.gov/assets/upl/project/gp_final-general-plan.pdf#page=163.

⁷ <https://casetext.com/regulation/california-code-of-regulations/title-14-natural-resources/division-6-resources-agency/chapter-3-guidelines-for-implementation-of-the-california-environmental-quality-act/article-19-categorical-exemptions/section-153002-exceptions>.

(f) Historical Resources. A categorical exemption shall not be used for a project which may cause a substantial adverse change in the significance of a historical resource.⁸

As explained above and in more detail below, the proposed action falls well within exceptions (a), (b) and (f) and easily meets the “unusual circumstances” test in (c), as established by the California Supreme Court. Historical resources are involved so (f) applies as well.

In Berkeley Hillside Pres. v. City of Berkeley, (2015) 60 Cal. 4th 1086, 184 Cal. Rptr. 3d 643, 343 P.3d 834 the California Supreme Court addressed the scope of exceptions under the “unusual circumstances test” under Exception (c):

A party invoking the exception may establish an unusual circumstance without evidence of an environmental effect, by showing that the project has some feature that distinguishes it from others in the exempt class, such as its size or location. In such a case, to render the exception applicable, the party need **only** show a reasonable possibility of a significant effect due to that unusual circumstance. Alternatively, ... a party may establish an unusual circumstance with evidence that the project will have a significant environmental impact. That evidence, if convincing, necessarily also establishes “a reasonable possibility that the activity will have a significant effect ... due to unusual circumstances.

60 Cal. 4th at 1105.⁹

Berkeley applies only to Exception (c). The other listed Exceptions are more liberally interpreted and applied. As explained below, the cumulative impacts even in a single location, which could be a neighborhood where permitted towers under Title 22 are densified will be significant. This distinguishes the present situation from prior situations where the environmental risks were clearly limited. The proposed Titles 16 and 22 propose to use Ministerial Site Review for a huge number of specific sites under comprehensive plans written by the telecom providers.¹⁰ As explained below, FFLA will be able to present overwhelming evidence that there is more than a reasonable probability, indeed an almost certain likelihood, that there will be a massive environmental impact.

D. Proper Application CEQA Exemptions and Exceptions

Statutory interpretation requires harmonization of different statutes and multiple parts of the same statute to reconcile potential conflicts and give optimal effect to legislative intent. In the present instance, the staff is asking the Board to ignore the framework California courts have developed to constrain arbitrary overuse of claimed Categorical Exemptions and Negative

⁸ See Committee to Save the Hollywoodland Specific Plan v. City of Los Angeles (2008) 161 Cal.App.4th 1168, 1186 [“a categorical exemption is not applied to projects that may cause a substantial adverse change in the significance of a historic resource.”]

⁹ The majority deemed the above analysis consistent with the concurring opinion’s “central proposition” that the exception applies where there is evidence that a project *will* have a significant effect.” 60 Cal. 4th at 1106.

¹⁰ There are already thousands of sites in the incorporated and unincorporated parts of Los Angeles County, and one provider alone wants to install more than 1,300 new facilities. See <https://pw.lacounty.gov/tul/streetlights/?action=small-cell>; <https://data.lacity.org/City-Infrastructure-Service-Requests/Small-Cell-Locations/3nrm-mq6k>; <https://www.crowncastle.com/communities/los-angeles-ca>.

Declarations. Here, staff does not even get to the point of a Negative Declaration analysis – which makes the error even more egregious.

The Third District Court of Appeal (in a unanimous opinion authored by Justice Robie) recently reaffirmed that Cal. Pub. Res. Code § 21151 requires a “full EIR” whenever a project may have any significant environmental effect; it thus reversed the trial court’s judgment that had allowed a deficient revised Mitigated Negative Declaration (MND) and its mitigation measures to remain intact while ordering Yolo County to also prepare an EIR limited to addressing only the project’s impacts on three species of concern (tricolored blackbird, valley elderberry longhorn beetle, and golden eagle). The court reversed and remanded with instructions to issue a peremptory writ directing the County to set aside its MND approval and to prepare a full EIR. Farmland Protection Alliance v. County of Yolo, (2021) 71 Cal. App. 5th 300, 286 Cal. Rptr. 3d 227.

Boiled down to the essentials, the Court of Appeal held that neither CEQA nor its interpretive case law authorize a “limited EIR” at the “third tier” of the CEQA review process, nor do they provide any authority for “an order splitting the analysis of a project’s environmental impacts across two types of environmental review documents,” such as the deficient MND and the “limited EIR” ordered by the trial court in that case. Rather, once substantial evidence is presented that a project might have a significant environmental impact in any area, a negative declaration is inappropriate and a “full EIR” is required. While the CEQA remedies statute ([Public Resources Code, §21168.9](#)¹¹) is intended to provide flexibility in facilitating compliance with CEQA, judicial remedies cannot avoid “the heart of the Act – the preparation of an environmental impact report for the project.” Yolo involved an MDR but the principles articulated in that case still directly and forcefully guide the unusual circumstances test to the proposed “Project” – here the two ordinances at hand.

The Court held that “if *any* aspect of the project triggers preparation of an environmental impact report, a full environmental impact report must be prepared in accordance with the definition of [an EIR in Public Resources Code] section 21061.” (*Citing San Bernardino Valley Audubon Society v. Metropolitan Water Dist.* (1999) 71 Cal.App.4th 382, 402 & fn. 11; *Muzzy*, *supra* at 381.

E. Unassessed Environmental Impacts

The proposed amendments to Code Titles 16 and 22 (henceforth, “Project”) and the associated Facility Design Guidelines raise a wide range of unaddressed but substantiated grave environmental risks that meet the unusual circumstances test. Further, since there are historical resources in issue there can be no exemption. These risks are:

- Human Health;
- Wildlife—fauna and plants;
- Historic sites;
- Wildfires, earthquakes, floods leading to lack of resilience;
- Plastic faux trees (including monopines) and other plastic faux products;
- Energy use and wasteful consumption;
- Especially sensitive environmental areas.

¹¹ <https://codes.findlaw.com/ca/public-resources-code/prc-sect-21168-9/>.

The Project, if approved, represents a massive, unprecedented assault on human populations and the environment which distinguishes it from individual applications or locations covered by the CEQA Exceptions.

1. Human Health Effects

There is already an extensive and mounting body of peer reviewed studies from many countries on the health effects of exposing densified human populations from continuous cumulative RF/EMF radiation exposure from small cell and macro towers in addition to other RF radiation emitting devices. The present regulatory environment, especially as it relates to “microwave illness” or Electromagnetic Hypersensitivity (EHS), is uncertain. The bottom line is that harm to humans from radiofrequency radiation exposure is clearly foreseeable and the BOS has a high duty to proceed with precaution and heightened vigilance—the very opposite of the position taken by relying on a Category 3 Exemption and the attempt to blanket the unincorporated portions of the county using a Ministerial Exemption. A compendium of abstracts of the published scientific papers on radiofrequency and other non-ionizing magnetic fields is available at <https://bit.ly/EMF08102022>. The great majority of those published by independent (non-telecom funded) researchers shows significant risk.

2. Wildlife—Fauna and Plants

The effects of RF/EMF radiation exposure of fauna and plants is at present a regulatory no-man’s land. The FCC’s maximum radiation exposure rules do not address wildlife or plants. Bats and bees and other airborne species occupy air space in close proximity to transmitting cell tower antennas. Wireless network densification increases RFR levels ([El-Hajj & Naous, 2020](#)¹²) and with over [800,000 new cell sites](#)¹³ projected for the 5G buildout nationwide, environmental effects need to be properly examined, because ambient RFR is increasing in wildlife habitat.

A landmark three-part research review on effects to wildlife was published in *Reviews on Environmental Health in 2021* by U.S. experts, including former U.S. Fish and Wildlife senior biologist Albert Manville. The authors reviewed and cited more than 1,200 scientific references. These experts concluded that the evidence was adequate to trigger urgent regulatory action. The review found adverse biological effects to wildlife from even very low intensity non-ionizing radiation emissions at multiple orders of magnitude below current FCC-allowed levels ([Levitt et al., 2021a](#)¹⁴, [Levitt et al., 2021b](#)¹⁵, [Levitt et al., 2021c](#)¹⁶).

Comprehensive documentation of the biological effects of non-ionizing electromagnetic radiation to flora and fauna has never before been undertaken to this degree in any previous publication. These three experts divide their science and findings with urgent warnings into three parts: Part 1 identifies ambient EMF adverse effects on wildlife and notes a particular urgency regarding millimeter wave emissions and the pulsation/modulation used in 5G technologies. Part 2 explores natural and man-made fields, animal magnetoreception mechanisms, and pertinent studies to all wildlife kingdoms. Part 3 examines current exposure standards, applicable laws, and future directions. Their conclusions after this expansive review of the science are neither

¹² <https://ieeexplore.ieee.org/document/9221314>.

¹³ <https://docs.fcc.gov/public/attachments/DOC-354323A1.pdf>.

¹⁴ <https://pubmed.ncbi.nlm.nih.gov/34047144/>.

¹⁵ <https://pubmed.ncbi.nlm.nih.gov/34243228/>.

¹⁶ <https://doi.org/10.1515/reveh-2021-0083>.

equivocal nor speculative. This environmental research review is a clarion call to develop regulations that ensure wildlife and its habitat are protected. The abstract summarizes the findings:

- Numerous studies across all frequencies and taxa indicate that low-level EMF exposures have numerous adverse effects, including on orientation, migration, food finding, reproduction, mating, nest and den building, territorial maintenance, defense, vitality, longevity, and survivorship. Cyto-toxic and geno-toxic effects have long been observed. It is time to recognize ambient EMF as a novel form of pollution and develop rules at regulatory agencies that designate air as ‘habitat’ so EMF can be regulated like other pollutants. Wildlife loss is often unseen and undocumented until tipping points are reached. A robust dialog regarding technology’s high-impact role in the nascent field of electroecology needs to commence. Long-term chronic low-level EMF exposure standards should be set accordingly for wildlife, including, but not limited to, the redesign of wireless devices, as well as infrastructure, in order to reduce the rising ambient levels.
- Numerous individual studies on impacts to flora and fauna have been published over the last two years, notably several on pollinators and insects.
- Two studies used scientific simulations to quantify the amount of power absorbed into the bodies of various insects for different RFR frequencies. In January 2020 researchers published “Radio-frequency electromagnetic field exposure of Western Honey Bees” in Scientific Reports on the absorption of RFR into honey bees at different developmental stages with phantoms simulating worker bees, a drone, a larva, and a queen (Thielens et al., 2020). The simulations were combined with measurements of environmental RF-EMF exposure near beehives in Belgium in order to estimate realistic exposures. They found absorbed RF-EMF power increases by factors of up to 16 to 121 when the frequency is increased from 0.6 GHz to 6 GHz for a fixed incident electric field strength. The implications of the impacts to bees – an ecologically and economically important insect species – are widespread and consequential.
- In October 2021 a second simulation study with far-reaching implications “Radio-frequency exposure of the yellow fever mosquito (*A. aegypti*) from 2 to 240 GHz” published in PLOS Computational Biology simulated the far field exposure of a mosquito between 2 and 240 GHz and found the power absorption into the mosquito is 16 times higher at 60 GHz than at 6 GHz at the same incident field strength. This increase is even larger (by a factor of 21.8) for 120 GHz when compared to 6 GHz. The authors conclude “higher absorption of EMF by yellow fever mosquitoes, which can cause dielectric heating and have an impact on behaviour, development and possibly spread of the insect.”
- In 2020, a report by Alain Hill of the biological effects of non-ionizing radiation on insects found that mobile communications was a critical factor in weakening the insect world along with pesticides and habitat loss. (Khan et al., 2021) found the *Apis Cerana* bee becomes very passive at a certain level of frequencies and power.

- In May 2021, Spanish biologist Alfonso Balmori published “Electromagnetic radiation as an emerging driver factor for the decline of insects” in Science of The Total Environment. Balmori found that electromagnetic radiation threatens insect biodiversity worldwide. He documents the sufficient evidence of effects of non-thermal, non-ionizing radiation on insects, at well below the limits allowed by FCC guidelines, and warns that action must be taken now before significant new deployment of new technologies (like with 5G) is undertaken. He cautions that the loss of insect diversity and abundance will likely provoke cascading effects on food webs and ecosystem services.
- A November 2021 review of the effects of millimeter waves, ultraviolet, and gamma rays on plants found many non-thermal effects specifically from millimeter waves (Zhong et al. 2021). (The paper examined the millimeter range 30 to 300 GHz which overlaps with FCC’s limits 300 kHz to 100 GHz.) Millimeter-wave irradiation stimulated cell division, enzyme synthesis, growth rate, and biomass. The review highlights how different doses and durations provoked dynamic morphophysiological effects in plants. Seed pretreatment with weak microwaves or millimeter wave irradiation altered root physiology. Different effects were observed in different plants and the authors state that, “the discordance of proteomic changes in different plants is reasonable, since different plants have a distinct tolerance to stress. Moreover, the cell tissues from soybeans and chickpeas used for proteomic analysis were different, which implies that tissue-specific or organ-specific responses of plants under millimeter-wave irradiation might exist and require further investigation.” This review adds to the published analysis confirming non thermal effects from RFR. While these frequencies may have beneficial uses in agriculture, the adverse impact to trees and plants in close vicinity to transmitting antennas must be addressed.

There are massive risks to the environment from the heedless deployment of wireless radiation. The proposed ordinances will facilitate even more, without acknowledgement of the science on the subject. These environmental effects within Los Angeles County must be acknowledged and addressed in any Environmental Determination. They cannot be ignored or brushed off in any potential Categorical Exemptions, Negative or Modified Negative Declaration. As a matter of law an Environmental Impact Report is required.

3. Wildfires, earthquakes, floods lead to lack of resilience

a. Wildfire

Four major wildfires have been initiated, in whole or in part, by telecommunications equipment in Southern California in the last 15 years. Cumulatively, these fires have caused over \$6 billion in damages, destroyed over 2000 homes, cost 5 lives, severely burned firefighters and civilians and triggered the largest mass evacuation in California history. These fires are:

- 1) [Guejito Fire](#) (2007)¹⁷ in San Diego which became part of the Witch Creek Fire, the [worst fire in San Diego history](#),¹⁸ causing the largest mass evacuation in California's history of nearly [1,000,000 people](#).¹⁹
- 2) The [Malibu Canyon Fire](#) (2007)²⁰: Three utility poles overloaded with equipment from Sprint (now T-Mobile), AT&T, Verizon and NextG (now owned by Crown Castle) snapped in the wind and ignited the grass below. [All four carriers as well as Southern California Edison](#),²¹ the utility that services Los Angeles County, were accused by the CPUC of attempting to mislead fire investigators.
- 3) [Woolsey Fire](#) (2018)²²: A telecommunications lashing wire came loose igniting at least one of the two ignition points for the [\\$6 billion fire](#).²³ Southern California Edison (SCE) was cited for 28 violations by the CPUC. One critical violation involved the failure by SCE to mark as a priority the repair of a broken communication line and broken telecommunications lashing wire. The broken equipment was found during a May 2018 telecommunications inspection. Without priority designation for repair, this known electrical hazard remained in disrepair. In November 2018, the broken Edison telecommunications equipment was involved as part of the ignition of the month-long fire.
- 4) [Silverado Fire in Irvine](#) (2020)²⁴ involved SCE and a [T-Mobile lashing wire](#).²⁵ Silverado merged with a second fire causing the evacuation of 130,000 people.

RF stimulates combustible terpene production in conifers. In currently ongoing litigation in the Federal Court (Eastern District) [Eisenstecken et al. v Tahoe Regional Planning Agency](#)²⁶, plaintiffs cite several studies confirming that RF radiation stimulates terpene production in conifers. Terpenes are a combustible and flammable compound. They represent a significant fire hazard.

FFLA has already provided evidence of the high but unassessed wildfire risks that would be allowed by the adoption of Titles 16 and 22 amended ordinances. Others have produced evidence

¹⁷ https://www.supremecourt.gov/DocketPDF/18/18-1368/98044/20190430151930791_18-petitionforawritofcertiorari.pdf.

¹⁸ <https://www.sandiego.gov/fire/about/majorfires/2007witchcreek>.

¹⁹ <https://www.kpbs.org/news/midday-edition/2017/10/16/2007-firestorms-ravaged-san-diego-county>.

²⁰ <https://www.dwt.com/-/media/files/blogs/broadband-advisor/2022/01/jan-20/cpuc-decision-21-10-019.pdf><https://www.dwt.com/-/media/files/blogs/broadband-advisor/2022/01/jan-20/cpuc-decision-21-10-019.pdf>.

²¹ <https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M077/K126/77126214.PDF>.

²² <https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/safety-and-enforcement-division/investigations-wildfires/sed-investigation-report---woolsey-fire---redacted.pdf>.

²³ <https://timesofsandiego.com/business/2018/11/28/6-billion-is-estimated-damage-from-woolsey-fire-in-la-and-ventura-counties/>.

²⁴ https://www.theepochtimes.com/law-firm-seeks-clients-to-sue-socal-edison-over-silverado-fire_3639317.html.

²⁵ <https://www.wxii12.com/article/power-company-equipment-woolsey-fire-california/34540269#>.

²⁶ <https://casetext.com/case/eisenstecken-v-tahoe-regl-planning-agency/>.

that the proposed wireless “Resilience Hubs” are the very worst, least resilient technology to be relying upon during power outages or earthquakes.²⁷

By relying on the proposed exemption, the staff is basically asserting these concerns are not even worthy of consideration, but there is no evidence that the LACDRP even examined them.²⁸

F. Energy use and wasteful consumption

Mobile service is energy intensive. The transition to 5G, whether 5G NR (non-standalone) or 5G Standalone NR, will exacerbate this situation until newer and far more efficient equipment can be designed and deployed, and 5G networks can fully implement use of their emerging “sleep mode” capability.²⁹ But even with “sleep mode” the energy consumption profile will still be high.

Environmental Heath Trust provides an [extensive summary](#) of this and much more evidence on the topic, with citation to recent sources on its website.³⁰ All this energy consumption will translate into far more greenhouse gas output, thereby contributing to existing climate issues. An EIR is required to assess the additional greenhouse load that will flow from the operation of thousands of wireless facilities these ordinances will permit.

G. Plastic faux trees (including monopines) and other plastic faux products

Monopines and other toxic faux products designed to camouflage macro cell towers produce microplastic waste that is being scattered, and will increasingly be scattered, all over Los Angeles County. The mechanism is straightforward. The faux plastic falls off the towers via weather, wind, etc. onto the ground, then gets washed away into the storm drain system and other discharge channels. It is standard industry practice to replace faux plastic on macro towers every

²⁷ In April 2022, the BOS voted in favor of a “Safety Upgrade” to the General Plan and included Wireless Resilience Hubs (WRH) as an important component of this Safety Upgrade. The stated purpose of a WRH is to help LA County address more effectively power outages, wildfires, floods, and other public emergencies. However, there is evidence that WRH will actually make Los Angeles County less safe during these emergencies, because intensive use of cell phones and other wireless devices during emergencies will actually further compromise the power grid. The proposed proliferation of cell towers authorized and encouraged by the amendments to Titles 16 and 22 under Ministerial Site Review will “hard wire” the problem, because local ordinances by California law must be “consistent” with the General Plan. An immediately available alternative proposed by Fiber Free Los Angeles and other concerned organizations is to accelerate the deployment of Resilience Hubs based on Optical Fiber to the home and workplace, supported by funding under the BEAD and other federal and state programs. See Tim Schoeche, “Reinventing Wires: <https://gettingsmarteraboutthesmartgrid.org/pdf/Wires.pdf>; <https://www.nytimes.com/2019/10/28/business/energy-environment/california-cellular-blackout.html>.

²⁸ The proposed Environmental Determination does not mention any matters of concern. It just baldly states there are two applicable Categorical Exemptions without providing any evidence in support. *But see* [Union of Med. Marijuana Patients](#) at 1186; [Muzzy](#), 41 Cal.4th at 380. In addition, faux plastic trees may present an additional fire risk in this respect. <https://www.firehouse.com/rescue/article/10544313/plastics-polymerization-what-firefighters-need-to-know>.

²⁹ [The 5G Dilemma: More Base Stations, More Antennas—Less Energy? 5G networks will likely consume more energy than 4G, but one expert says the problem may not be as bad as it seems](#), Dexter Johnson, IEEE Spectrum (Oct. 3, 2018), available at <https://spectrum.ieee.org/will-increased-energy-consumption-be-the-achilles-heel-of-5g-networks>. For “sleep mode” background see Ericsson, [A technical look at 5G energy consumption and performance](#), Frenger and Tano (Sept. 19, 2019), available at <https://www.ericsson.com/en/blog/2019/9/energy-consumption-5g-nr>.

³⁰ <https://ehtrust.org/science/reports-on-power-consumption-and-increasing-energy-use-of-wireless-systems-and-digital-ecosystem/>.

five years, up to 10,000 pounds per tower. Microplastics on these faux macro towers contain lead and other carcinogenic materials proscribed under Proposition 65. [Scientific studies](#)³¹ confirm evidence of microplastics in human and animal lungs and blood. There is no evidence that the LACDRP is even familiar with the problem, much less seriously addressed it. The issue is currently being litigated in *Eisenstecken et al. v Tahoe Regional Planning Agency*.³²

H. Cumulative Impacts

Section 15300.2 of the CEQA Guidelines clearly provides for an Exception to the Exemption for cumulative impacts. It states:

All exemptions for these classes are inapplicable when the cumulative impact of successive projects of the same type in the same place, over time is significant. Moreover, a strong line of [judicial decisions in California](#)³³ recognizes that a valid EIR must include a careful analysis of cumulative impacts. Massive cumulative impacts is another unusually dangerous condition of the proposed Project.

For purposes of 15300.2 in this matter “projects of the same type” means any of the many “wireless facilities” that will be covered by Title 16 or 22. “The same place” means all of Los Angeles County. See *Aptos, supra* (the “same type” was DAS and “same place” was “Day Valley”). The Board must assess the cumulative impact of all the individual wireless facility projects the proposed ordinances will authorize. As noted above, these wireless facilities are not being proposed willy-nilly. They are part and parcel of a wireless plan developed by the telecom providers and their installers with a single purpose to blanket all of Los Angeles County without any consideration of the cumulative impact of each component segment of this larger plan. This is precisely the kind of “project” that CEQA and its Cumulative Effects Exception intend an agency to carefully scrutinize with heightened environmental awareness and sensitivity of an EIR process.

I. Piecemealing and Segmentation

CEQA [Guidelines explicitly prohibit piecemealing](#)³⁴ as a strategy to circumvent CEQA’s EIR requirements. Section 21159.27. PROHIBITION AGAINST PIECEMEALING TO QUALIFY FOR EXEMPTIONS states: “A project may not be divided into smaller projects to qualify for one or more exemptions pursuant to this article.” The specific intention of the Project is to encourage piecemealing under an accelerated Ministerial Site Review. The staff’s asserted Exemption cannot stand.

³¹ <https://drive.google.com/file/d/127Ud8b5nTZuT3meINAFi0ngbj2NQyPa0/view?usp=sharing>.

³² On September 7, 2022 the Lahontan Regional Water Quality Control Board (LRWQCB) officially opened an investigation of hazardous waste discharges of microplastic and other toxics emitted from monopine cell towers. The LRWQCB issued Requests for Information on six faux plastic macro cell tower sites operated by Verizon and other telecom companies. Currently, there is a Zero Discharge Standard under the Clean Water Act and California Porter-Cologne Act. Discharges of hazardous waste from monopines into Lake Tahoe have been ignored for many years, and at last the LRWQCB is seriously investigating the past practice and proposals for new developments referenced in *Eisenstecken et al. v. TRPA*. Although Lake Tahoe represents a unique national treasure, there are many historic sites and environmentally sensitive areas in Los Angeles County that must be protected from microplastic hazardous waste discharges into the air, land, and water from faux plastic macro cell towers. See e.g. <https://drive.google.com/file/d/1GycVZ8Uhv8reweII64dnQ4VHIKNiMlcS/view?usp=sharing>.

³³ https://www.co.shasta.ca.us/docs/libraries/resource-management-docs/eir/hatchet-ridge/ch_4_otheranalyses.pdf.

³⁴ https://resources.ca.gov/CNRALegacyFiles/ceqa/docs/2014_CEQA_Statutes_and_Guidelines.pdf.

J. Especially sensitive environmental areas

Los Angeles County is replete with environmentally sensitive areas, including parts of the Coastal Zone and the Santa Monica Mountains, all of which are identified in the General Plan. Several are expressly mentioned in, for example, proposed 22.26.E.1.b. The Significant Ecological Area (SEA) Program is a [component of the Los Angeles County Conservation/Open Space Element](#).³⁵ The imposition of Ministerial Site Review will create an unnecessary conflict with these other important State and County policies and programs, which would otherwise be harmonized and balanced under the established Conditional Use Permit framework. One major purpose of the move to “ministerial” is to avoid dealing with such things. But this you cannot do, unless and until the Board addresses the environmental impact as part of the ordinance drafting process. Even then environmental analysis of certain projects will still be required.

K. Unexamined Alternatives

CEQA: CEQA Guidelines § 15126.6 explicitly states: “An EIR need not consider every conceivable alternative to a project. Rather, it must consider a reasonable range of potentially feasible alternatives that will foster informed decision making and public participation.” (See https://planning.lacity.org/eir/SwanHall/DEIR/Chapters/7_Alternatives.pdf).

Environmentally safe, energy efficient, resilient, climate change friendly optical fiber to the home and workplace is an alternative solution to the Digital Divide. The Board should express the same policy decision as the current federal administration: wireless solutions are a less preferred alternative. Wireless should be deployed only where it is necessary, not everywhere in heedless fashion. CEQA requires that each potentially feasible alternative be examined, but the proposed Environmental Determination completely avoids any such effort.

L. Federal and State Policy

Local government agencies like the Board are constrained by and must respect directly applicable federal statutes.³⁶

1. NEPA “Small Handle Doctrine”

There is quite likely more federal funding and engagement in Los Angeles County than any other California county or quite possibly in the U.S. Specifically, the American Rescue Plan Act provides \$1.9 billion in federal funding to assist economic recovery. Substantial funding is also forthcoming under the NTIA policy announced in May 2022. Federal funding under the 2021 Infrastructure Investment and Jobs Act is also being directed to support efforts such as a [Community Wireless Network in Los Angeles County](#). Other federal statutes are possibly applicable as well. This extensive federal involvement triggers NEPA’s “small handle” application which necessitates a NEPA review in addition to a CEQA review on the revisions of Titles 16 and 22 which will alter forever the health and well-being of Los Angeles County residents and its environment. Moreover, the Council on Environmental Quality strongly encourages [close coordination between NEPA and CEQA environmental reviews](#)³⁷. This is

³⁵ <https://planning.lacounty.gov/sea/faqs>.

³⁶ The telecoms repeatedly claim the federal laws they like must be obeyed. But other federal laws preclude the permit review process and substance that they and staff champion.

³⁷ https://opr.ca.gov/docs/NEPA_CEQA_Handbook_Feb2014.pdf.

another unique circumstance of the present Project which precludes BOS' reliance on the Exemption.

References:

- <https://ceo.lacounty.gov/recovery/arp/>
- <https://www.jstor.org/stable/24115016>
- <https://splaw.com/wp-content/uploads/2020/10/CEQ-New-NEPA-Regulations.pdf>
- https://opr.ca.gov/docs/NEPA_CEQA_Handbook_Feb2014.pdf

M. Climate Change Impact Assessment

CEQA Guidelines explicitly require [climate change impact analyses](#).³⁸ As the presumable lead agency, the county must analyze the greenhouse gas emissions of this project. This “project” relates to two ordinances that will govern how wireless facilities are permitted so any environmental inquiry must assess not only the quantity of emissions and how that quantity of emissions compares to statewide or global emissions but also the project’s effect on climate change.

The precedent that the staff is recommending encourages the Board to allow massive deployment of wireless macro towers and other RF radiation emitting devices under Ministerial Site Review. This reckless policy will have massive negative environmental repercussions in Los Angeles County. Moreover, other counties in California and possibly in other states will cite this precedent to justify similar actions. The collective adverse impacts of hundreds of such projects throughout the U.S. could very well contribute to an adverse climate change impact. CEQA Guidelines 15064.4, subd (a)-(c) require a full inquiry and conclusion that uses appropriate modeling and reflects evolving scientific knowledge and the state’s regulatory regime. A flat assertion of a Categorical Exemption, without any evidentiary support, simply does not suffice.

N. Cost/Benefit Analysis

California courts sometimes look to NEPA and federal decisions for guidance. Friends of Mammoth v. Board of Supervisors (1972) 8 Cal.3d 247, 260–261; Bowman v. City of Berkeley (2004) 122 Cal.App.4th 572, 591 (CEQA is patterned on NEPA; NEPA cases can be persuasive authority for interpreting CEQA). It is therefore noteworthy that NEPA regulations require cost/benefit analyses in assessment of alternatives. [40 C.F.R. § 1502.22 Cost-benefit analysis](#)³⁹ states:

If the agency is considering a cost-benefit analysis for the proposed action relevant to the choice among alternatives with different environmental effects, the agency shall incorporate the cost-benefit analysis by reference or append it to the statement.

The present situation of the proposed amendments to Titles 16 and 22 presents an excellent opportunity to coordinate CEQA and NEPA practices. NEPA cases can be persuasive in interpreting CEQA when CEQA is unclear (Wildlife Alive v. Chickering (1976) 18 Cal.3d 190, 202-203). CEQA amplifies NEPA practice but does not rely on it. There are provisions for coordinating CEQA review with NEPA and other types of review (CEQA Guidelines section 15004 (c)) Although CEQA does not explicitly require cost-benefit analysis as does NEPA, the

³⁸ <https://opr.ca.gov/ceqa/ceqa-climate-change.html>.

³⁹ <https://www.law.cornell.edu/cfr/text/40/1502.22>.

County of Los Angeles can benefit from and rely upon a NEPA cost benefit analysis in reaching an informed decision as part of fulfilling its CEQA obligations.

Moreover, the staff's claimed Exemption blindly relies on a plethora of unchallenged false claims advanced by the telecom providers. These false claims include:

- The environmental impacts are trivial;
- Radiation exposure levels of children in schools, disabled persons, elderly, and pregnant women are safe;
- Blanketing Los Angeles County, especially underserved communities with macro towers and other radiative emitting devices will close the Digital Divide;
- Wireless devices are energy saving;
- Wireless hubs will promote community network resilience during power outages.

Each such claim is incorrect. At least one federal court has rejected a NEPA EIS on the grounds that the EIS included false statements.⁴⁰

O. Other Applicable Federal Laws

The staff's abuse of claimed Exemptions will place the BOS in direct violation of other important federal statutes. Here are two examples.

1. National Historic Preservation Act (NHPA).

The proposed Wireless Facility Design Guidelines address the incursion of small cell and macro towers on historic sites and related properties. For example:

Historic resources and landmarks.

- No new facilities shall be permitted on or within historic resources or structures listed or eligible for listing on the national, state, or county historic registers.
- Existing facilities located on or within historic resources or structures listed or eligible for listing in any historic registers shall be located and designed to eliminate impacts on the historic resource.
- A Historic Resource Assessment, prepared to the satisfaction of the Director, may be required for a facility to be located on a site containing an eligible resource to identify impacts to historic resources, and identify mitigation to minimize impacts.⁴¹

The Title 22 Wireless Ordinance Summary states:

Development Standards for All Facilities (except small cell facilities).

⁴⁰ See *Natural Res. Def. Council v. U.S. Forest Serv.*, 421 F.3d 797, 811–13 (9th Cir. 2005) (finding that the agency's use of inflated, inaccurate, and misleading data violated NEPA).

⁴¹ Proposed Section 22.140.700.E.1.b.v allows the Director to use individual judgment on whether to require more information and/or impose mitigation measures as a condition of the permit. Despite the staff's desire to move to a "ministerial" review, this is a discretionary act for CEQA purposes. See *Protecting Our Water & Env'tl. Res. v. Cty. of Stanislaus*, (2020) 10 Cal. 5th 479, 489, 268 Cal. Rptr. 3d 148, 153, 472 P.3d 459, 464.

Facilities may not be placed on historically significant buildings or structures. They may be placed elsewhere on the property containing historic buildings or structures, provided a Historic Resource Assessment is prepared and submitted.

The Project, however, sets up an accelerated process under Ministerial Site Review that still does not fully implement federal and state law regarding historical resources.

2. Identification of Historic Sites in Los Angeles County

The recognized historic sites in Los Angeles County can be found at:

https://ohp.parks.ca.gov/?page_id=21427 and <https://hlrc.lacounty.gov/>.

Existing County Code Ch. 22.124 recognizes and protects some “historic districts.” The proposed Tit. 22 revisions do provide mitigating measures for those districts, but there are several state and nationally recognized historic districts that have not gone through the county 22.124 process. The View Park site in [Angela Sherick-Bright v. Los Angeles County](#)⁴² is one of these. To be consistent with how the current and proposed amended Titles 16 and 22 apply, we must recognize that some nationally or state recognized places (landmarks or districts) are not accepted for full protection under Chapter 22.124 (Historic Preservation), but are still protected (by way of an exception to any exemption) under state and federal law. There are “historic resources (as defined in current 22.14) that are not, for example, an “historic district” as defined in 22.14 because they have not been recognized by the Board under 22.124, and thus covered by Ch. 22.82.

It appears the drafters of the proposed wireless ordinances are aware of this. *See* proposed Section 22.140.E.1.b.v. which uses “historic resources,” the broader term. But what the draft ordinance fails to deal with is existing Section 22.82.030.B:

Notwithstanding [Section 22.300.020](#) (Application of Community Standards Districts to Property), where an ordinance establishing or amending a historic district imposes development standards, limitations, conditions or regulations which are inconsistent with those otherwise imposed by this [Title 22](#), the development standards, limitations, conditions, and regulations set forth in the ordinance establishing or amending the historic district shall supersede any inconsistent provisions in this [Title 22](#).

A specific provision on development for a particular county 22.124/22.82 district ordinance and preservation plan should prevail over the proposed new provisions. That may or may not be the drafter’s intent, however. The proposed language is ambiguous. If the intent is to preserve the specific provisions for existing 22.124/22.82 districts, then it is true there will no impact as to these districts. However, there are many other historic resources not yet recognized in 22.124/22.82, and there will certainly be a significant environmental impact on them. CEQA Guidelines §15300.2(f) provides that any claimed Categorical Exemption does not apply because of the historical resources exception.

More important, the drafters clearly recognize there will be an impact on historical resources, whether part of the 22.124/22.82 regime or not. There are specific draft terms addressing historical resources. It appears the drafters attempted to provide some mitigating provisions, but

⁴² <https://drive.google.com/file/d/1pfnYIhHB2IbhmYh59nJUTR8y9PbhRlnZ/view?usp=sharing>.

staff has not provided any facts in support of the proposition there will still be no significant impact on any historical resource. This could, in theory, form the basis of a Modified Negative Declaration, if the mitigating steps are sufficient. But staff did not go that far; it just incorrectly asserts the Categorical Exemption, implying thereby no historic analysis is required.

3. Federal Clean Water Act/California Porter Cologne Acts.

As noted, the Project will permit unregulated wide diffusion of toxic faux plastic and micro plastic and related plastic waste, lead, and other toxic and carcinogenic materials listed under Proposition 65. The toxic wastes are being carried by strong winds and deposited on land, in or near lakes, streams, and coastal waters. They will penetrate ground water aquifers used for drinking water. They will expose animals and plants in environmentally sensitive areas. They will enter food chains. The widespread discharge of such toxic materials is subject to a Zero Discharge Standard as implemented in California through State, Regional, and Local Water Quality Boards, which are governed by California's Porter Cologne Act. The BOS Project completely ignores this unique and imminent environmental hazard.

P. Federal and State Shot Clock Regulations.

An unstated but obvious reason for the staff's effort to "streamline" the process through ministerial treatment instead of the currently-required Conditional Use process is that the FCC and state legislatively imposed "shot clock" rules require strict deadlines for a final decision. If the deadline is not met, the status for many wireless facility categories will be "deemed approved." FFLA acknowledges this practical problem.

It is important to understand that **the "shot clock" rules *do not apply* to the ordinance drafting process.** They pertain only to individual (or bundled) permit applications seeking land use approval.

The environmental rules FCC establishes when it is complying with NEPA are qualitatively different than the rules FCC promulgates under its Title III authority. The "preemption" in 47 U.S.C. 332(c)(7)(B)(iv) is in Title III. It provides that a state or local government may not "regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's regulations concerning such emissions." This provision speaks only to "radio frequency emissions" and does not in any way inhibit inquiry into the other environmental effects of the facilities – visual effects, greenhouse gas emissions, camouflage shedding of microplastics, lead and other carcinogenic materials. The FCC's NEPA rules are in 47 C.F.R. Part 1, Subpart I and do not derive from Title III. Instead these rules are mandated by NEPA, which is an entirely different statute. That is why the FCC has directly held that its NEPA related rules do not preempt state law equivalents like CEQA. *See In re Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Inv.*, 33 FCC Rcd 3102, 3132 ¶77 (March 30, 2018), *rev'd other grnds United Keetoowah Band of Cherokee Indians in Oklahoma*, 933 F.3d 728, 744 (D.C. Cir. 2019):

...Finally, nothing we do in this order precludes any review conducted by other authorities—such as state and local authorities—insofar as they have review processes encompassing small wireless facility deployments.¹⁵² The existence of state and local review procedures, adopted and implemented by regulators with more intimate knowledge of local geography and history, reduces the

likelihood that small wireless facilities will be deployed in ways that will have adverse environmental and historic preservation effects.¹⁵³

^{n.152} The record refers to a range of such requirements that exist under state or local law. See, e.g., City of Boston et al. Ex Parte Letter at 8 (stating appreciation that this order “does not intend to preempt state and local environmental and historical review, and thus leaves open the possibility that states and localities may be able to provide protections that had been provided through the Section 106 and NEPA processes” and noting that “many states have their own versions of NEPA and Section 106”); Letter from Scott K. Bergmann, CTIA, to Marlene H. Dortch, FCC, WT Docket No. 17-79, at 3 (filed Mar. 16, 2018) (the actions taken here do not “mean that small wireless facilities can be deployed by private parties without environmental and historic protections; state and local zoning, environmental, and historic preservation requirements will continue to apply”); Letter from Kenneth S. Fellman, counsel for Colorado Communications and Utility Alliance et al., to Marlene H. Dortch, FCC, WT Docket No. 17-79, Attach. At 5 (filed Oct. 19, 2017) (discussing Colorado state rights-of-way and Denver zoning requirements for wireless facilities); National League of Cities Comments, Attach. At 4 (discussing examples of factors that local authorities consider in connection with right-of-way access, including environmental and aesthetic considerations); National League of Cities et al. Request for Extension of Time at 3 (filed July 7, 2017) (observing that several states have enacted small wireless facility siting laws); see also, e.g., 2017 Pole Replacement Order, 32 FCC Rcd 9760, 9769-70, para. 23 (noting state law requirements for the handling of human or burial remains). Although this order does not preclude otherwise-existing review by other authorities, it also does not eliminate otherwise-existing limitations on that review, see, e.g., City of Boston et al. Ex Parte Letter at 8 (discussing limits under 47 U.S.C. § 1455), but instead leaves the preexisting status quo in place at this time.

^{n.153} We recognize that state and local procedures do not mirror the review required under Section 1.1312 of the Commission’s rules in all respects. But these procedures nevertheless act as an independent check and show that our action today will not have the effect of authorizing indiscriminate deployment. To the extent that review provided for under state and local law differs, those differences presumably reflect the judgment of state and local lawmakers as to the type of review required for a particular geographic area. We thus find no basis to ignore the role of state and local procedures based on differences in their scope or application cited by commenters. See, e.g., Missouri SHPO Comments at 4; Texas Historical Commission Comments at 3; City of Boston et al. Mar. 14, 2018 Ex Parte Letter at 8-9.

There is no evidence NEPA or 47 U.S.C. Title III was intended to preempt CEQA. In fact, Congress intended NEPA and CEQA to be closely [coordinated and integrated](#) within a larger federal/state environmental framework. So any analysis required by CEQA for this project, or any of the hundreds of wireless facility application projects the draft ordinances contemplate, must still be obtained.

It is true a local jurisdiction cannot “regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission’s regulations concerning such emissions.” That is the result of a federal statute (47 USC §332(c)(7), which, again is in Title III), not an agency rule. Even so, that does not mean the local jurisdiction is federally preempted from informing itself of the environmental impact from emissions that will flow from the permits it issues. Information gathering to produce required knowledge is not “regulation.” Even if the county cannot “regulate” RF emissions, nothing in any federal or state law prevents the Board from informing itself, and thus also the public, about the emissions that will occur because of the permits the County will grant pursuant to the contemplated ordinances.

CEQA compliance is not “regulation on the basis of environmental effects.” While CEQA has a substantive mandate (Public Resources Code section 21081), it is mainly procedural in nature, not substantive like the specifics of a zoning ordinance or design guidelines. A fully compliant CEQA analysis of the substantive ordinance and guideline outcomes is still fully required, and the Board must take a meaningful look at the true environmental impact of the proposed action. This means that any Initial Study must look at the impact of additional RF emissions on humans and the rest of the environment. It must also consider the extent to which the operation of thousands of additional wireless facilities will further increase greenhouse gas emissions and result in other toxins like lead or microplastics going into the environment.

4. California Shot Clock Rules as Applied to CEQA Exception Analysis

There are cases that stand for the premise that there must be a CEQA decision prior to commencing the Permit Streamlining Act’s (PSA) time limits for acting on a “complete application.” Eller Media Co. v. City of Los Angeles (2001) 87 Cal.App.4th 1217, 1221 [noting the Permit Streamlining Act measures all time limits for final approval or disapproval of an application in terms of the environmental review process established by CEQA]; *see also* § 65950, subd. (a); Riverwatch v. County of San Diego (1999) 76 Cal.App.4th 1428, 1440–1441 [discussing exceptions to PSA time limits, stating “CEQA itself contains no automatic approval provisions and its time limits are directory rather than mandatory.”] However, unfortunately, AB 57 enacted shot clocks that do not have the same provisions that allow CEQA review to be completed as the Permit Streamlining Act does.⁴³ Therefore, the new rules might- and likely do- override the directory nature of CEQA-based time limits. Even so, as the article at this link indicates it is unclear what happens when a permit is deemed approved in this context. Nonetheless any CEQA-required process must be completed, even if under a compressed schedule.

In sum, the federal and state shot clock rules raise complex legal questions, but they will only arise in individual permit applications. The FCC rules defer to the state; some California cases recognize that a CEQA analysis must precede the initiation of the shot clock, but the PSA appears to supersede these cases. At the same time, NEPA is the superior federal statute and CEQA was enacted to extend Congress’ intention to foster “little NEPAs.” The Board cannot frustrate or undermine the federal and state policies that check against the abuse of Exemptions.

⁴³ See <https://www.westerncity.com/article/brave-new-world-cell-antennas-california-what-you-need-know-about-ab-57>.

To be sure, the ordinance provisions must be constructed to allow, indeed assure, any applicable shot clock is met because there are negative consequences when they are not. But nothing in federal law or any state law allows or requires that fundamental procedural due process or property rights and the environment be sacrificed at the shot clock altar. Notice and an opportunity for hearing must be provided, so ministerial treatment is not allowed.

III. Conclusion

The proposed amendments to Titles 16 and 22 will inevitably result in the blanketing of Los Angeles County with small cell and macro towers installed in high densified residential communities, rural areas and many environmentally sensitive and vulnerable historic sites. This ill-conceived, wireless industry promoted project will have massive human health and environmental consequences and threaten over 1,000 historic sites and resources in Los Angeles County. The staff failed even to consider, much less evaluate, any of these risks and wrongly contends that it has no legal obligation to do so. There is not a shred of evidence the Planning Division has consulted with the California state authorities that are responsible for the protection and stewardship of historical resources. Rather, by a flick of the administrative finger, the entire wireless enterprise – or at least that which is most urgent for humans and the environment – is careless and wrongly gifted over to “ministerial” treatment and thus exempted from meaningful evaluation.

The staff also asserts a Category 3 Exemption under the CEQA Guidelines. This memo explains why that Exemption does not contemplate or allow the wholesale environmental destruction that will result from the amended Titles 16 and 22. The staff’s reliance on this section is refuted by the extremely unusual circumstances that attend the project, which will disqualify any reliance on this Exemption.

Any potentially applicable Exemption is overridden as this memorandum documents by two Exceptions to the Exemption: the Exception for Historic Resources, and Cumulative Effects. Because the documented environmental and health risks are so grave, a Negative Declaration or Mitigated Negative Declaration will not suffice. The BOS must prepare a Comprehensive Programmatic Environmental Impact Report as required by CEQA. This EIR should also require ongoing monitoring and mitigation of identified impacts.

The BOS must also recognize that the proposed Project is not a small and insignificant County initiative. Because of the extensive federal involvement, including significant funding and services in Los Angeles County like airports, roads, crime prevention, weather forecasting and other basic functions, various federal laws are immediately applicable. The most directly relevant of these is NEPA. The BOS is legally required as the co-lead agency to consult and collaborate closely with a lead federal agency (or agencies), most prominently in this instance the Department of Transportation, FAA, and/or other concerned federal agencies in preparing a Comprehensive Environmental Impact Assessment.

The rigorous environmental review required for the Project is not preempted by federal law, in particular the 1996 Telecommunications Act (“Communications Act”) for several reasons. First, nothing in that statute indicates that states are preempted from informing themselves of the environmental and health effects, even if they are preempted from regulating the facilities causing these harms. Second, the Communications Act does not preempt or supersede other federal statutes, including most relevant here NEPA, NHPA, Americans with Disabilities Act and the Clean Water Act, all of which are triggered by the extensive federal presence. Third, it is

a core principle of American jurisprudence that whenever possible, any statutes in apparent conflict must be “harmonized.” If CEQA, NEPA and Communications Act mandates are effectively harmonized, the result will be a fair and effective solution for balancing broadband infrastructural development, addressing the needs of internet-underserved communities, and protecting Los Angeles County’s living environment.

EXHIBIT B



September 9, 2022

Members of the Board of Supervisors
Los Angeles County
500 West Temple St.
Los Angeles, CA 90012

Dear Board of Supervisors:

The Board of Supervisors will be considering whether to amend County Code of Ordinances Titles 16 and 22 as requested by the Department of Regional Planning sometime this fall. We have reviewed the proposed amendments and believe certain changes are necessary to comport with California and Federal law and to reflect better policy outcomes. Attached for your consideration are red-lined recommended changes to the proposed amendments, designed to help preserve and implement rights and duties assigned to you by Congress and the Legislature.¹ These recommendations include:

- Create consistency in treatment of facilities in County-owned right-of-way (subject to Chapter 16.25, with the Road Commissioner as the initial permitting authority), and those not in right-of-way (subject to Title 22, with the Regional Planning Commission or the Director as initial permitting authority), unless there are technical or legal reasons for different substantive treatment.
- Maintenance of the Conditional Use permit process (rather than “ministerial” resolution) for several wireless facility request types. “Ministerial” treatment is only appropriate for “exempt facilities,” colocation facilities and backup power.
- Improvements to the information an applicant must provide in the application for permit. Most critically it requires information about the applicant’s efforts to minimize the risk of fire and structural failure.
- More specification on location preferences.
- Additional permit conditions.
- Protection of historical resources consistent with federal and state law that is lacking in the Department’s proposal.

¹ Please note: Our edits did not undertake to update the land use tables in Chapters 22.18 – 22.26 to reflect our substantive revisions to other Chapters. Our edits show up as blue (or purple depending on each screen). The red is staff’s most recent update to its earlier proposal, which is black text. Underlining means it is new or edited language from the existing LA County Code, whether originally proposed by staff or us.

The federal Communications Act recognizes local governments' historical land use authority over the siting, construction, and modification of wireless telecommunications facilities in the United States. Congress specifically preserved the authority of local governments to exercise control over these activities in their communities. 47 U.S.C. 332(c) clearly states

“Except as provided in this paragraph, nothing in this Act shall limit or affect the authority of a State or local government or instrumentality thereof over decisions regarding the placement, construction, and modification of personal wireless service facilities.”

The Act specifies five exceptions. Local governments may not:

1. Unreasonably discriminate among providers of functionally equivalent services;
2. Prohibit or have the effect of prohibiting the provision of personal wireless services;
3. Fail to act on any application to place, construct or modify a wireless facility within a reasonable period of time;
4. Deny an application to place, construct or modify a wireless facility without a written record supported by substantial evidence;
5. Regulate the placement, construction or modification of a wireless facility based on environmental effects of radiofrequency emissions.

The state Legislature has delegated broad land use authority to counties, although it has also imposed some specific limits and responsibilities for wireless facilities, including those in public right-of-way (the topic of the proposed amendments to Title 16). Other than these exceptions, local governments may adopt whatever provisions are appropriate for their communities. With the sudden proliferation of wireless antennas related to the deployment of the next generation of wireless telecommunications, many local governments like Los Angeles County are revising and updating their zoning codes to avail themselves of the powers preserved for them by Congress.

Importantly, safety belongs to the local municipality to regulate. Revisions of the County Code present an excellent opportunity for members of the Board to ensure that special safety concerns unique to their districts are properly addressed, particularly those related to electrical, structural and fire code safety in the unique LA County climate. As you may be aware, telecommunications equipment has been implicated in several recent and devastating California wildfires.

We are aware that the Board has been advised that small cells are needed in neighborhoods in order to call 911 in the event of an emergency. **This is not correct.** Macro towers, not small cells, are the predominant network routing source for 911 calls. Government Code Sec. 65850.75 provides that emergency standby generators for macro cell tower sites are a permitted use and our revisions implement that legislation. The CPUC has established a Resiliency Plan [Order Instituting Rulemaking Regarding Emergency Disaster Relief Program. Rulemaking 18-03-011] requiring 72-hour backup power. Small cells will be given a waiver because of the impracticality and danger of having portable generators in the public right-of-way. Residential areas do not have to be smothered in small cells to ensure reliable 911 availability because the nearest macro tower will service emergency calls.

Wireless companies and site developers will always choose antenna locations that are the least expensive and most convenient for them, regardless of the needs or desires of the community. The provisions we recommend in the accompanying "redline" are designed to help the County effectively manage the deployment of wireless technology by providing clarity and guidance to applicants, ensure the facility is necessary at the proposed site to supply needed coverage in the community, and minimize the impact of deployment on residential communities.

We will be happy to meet with you or your designated representatives to provide additional information, examples of other cities that have adopted similar provisions, or discuss other options which may be available to you.

Sincerely,

A handwritten signature in dark ink, appearing to read 'DAW', with a long horizontal flourish extending to the right.

Douglas A. Wood
Campaign Co-Coordinator
Fiber First LA County

DW:nl
enclosure

CC: Bruce Durbin, Regional Planning Department

ATTACHMENT

TITLE 22 ORDINANCE – Fiber First Revisions to Proposed Ordinance

ORDINANCE NO. _____

An ordinance amending the Los Angeles County Code Title 22 – Planning and Zoning to establish regulations for personal wireless service facilities ~~on private property~~ not located within a county highway in the unincorporated areas of Los Angeles County and associated provisions.

The Board of Supervisors of the County of Los Angeles ordains as follows:

SECTION 1. Chapter 22.14 is hereby amended to read as follows:

22.14.230 – W.

...

Wireless facility. The following terms are defined for the purposes of Section 22.140. ~~650700~~ (Wireless Facilities).

Associated equipment. As defined in 47 C.F.R. Section 1.6002(c), or any successor provisions, equipment, switches, wiring, cabling, power sources, shelters or cabinets associated with an antenna, located at the same fixed location as the antenna, and when collocated on a structure, is mounted or installed at the same time as such antenna.

Antenna facility. As defined in 47 C.F.R. Section 1.6002(d), or any successor provisions, an antenna and associated equipment.

Architectural tower. A stand-alone tower that incorporates architectural elements and is constructed for the purpose of supporting and concealing wireless facilities, such as a faux belfry, minaret, cupola, water tower or tank, silo or other agricultural-type structure, clock tower, windmill, or another similar structure.

Base station. As defined in 47 C.F.R. Section 1.6100(b)(1), or any successor provision, a structure or equipment at a fixed location that enables FCC-licensed or authorized wireless communications between user equipment and a communications network. A base station includes a structure where a wireless facility may co-locate on, but is not built for the sole or primary purpose of supporting a wireless facility. This term does not include a tower or any equipment associated with a tower.

Collocation. As defined in 47 C.F.R. Section 1.6002(g)(1) and (2), or any successor provision, (1) mounting or installing an antenna facility on a pre-existing structure, and/or (2) modifying a pre-existing structure for the purpose of mounting or installing an antenna facility on that structure.

Eligible Facilities Request. As defined in 47 C.F.R. Section 1.6100(b)(3), or any successor provision, a request for modification of an existing tower or base station that, within the meaning of the Spectrum Act, does not substantially change the physical dimensions of that tower or base station, and involves collocation, removal, or replacement of transmission equipment. For the purposes of eligible facilities requests, collocation is as defined in 47 C.F.R. Section 1.6100(b)(2), or any successor provisions. **Faux rock outcroppings.** Artificial rocks that are used to conceal a wireless facility and are designed to mimic actual rocks typically found in proximity to the proposed project site and appropriate for that location.

Faux tree. An artificial tree that is used to conceal a wireless facility and is designed to mimic an actual tree typically found in proximity to the proposed project site and appropriate for that location.

FCC. The Federal Communications Commission or its lawful successor.

Macro facility. A wireless facility that does not meet the requirements of a small cell facility or an eligible facilities request.

Personal wireless services. As defined in 47 U.S.C. Section 332(c)(7)(C)(i), or any successor provision, commercial mobile services, unlicensed wireless services, and common carrier wireless exchange access services.

Personal wireless services facility. As defined in 47 U.S.C. Section 332(c)(7)(C)(ii), or any successor provision, a wireless facility that is used for the provision of personal wireless services.

Public right-of-way. As defined in Section 12.08.300.

Review authority. The Director for Ministerial permits and the Commission or Hearing Authority for Conditional Use Permits, subject to any appeal to higher authorities within the County.

Small cell facility. As defined in 47 C.F.R. Section 1.6002(l), or any successor provision, a “small wireless facility” is a personal wireless services facility that meets the following conditions:

1. The facility is mounted on a structure up to 50 feet in height, including antennas, as defined in 47 C.F.R. Section 1.1320(d), or is mounted on a structure and extends no more than 10 percent in height above other adjacent structures, whichever is greater;
2. Each antenna associated with the facility, excluding associated antenna equipment (as defined under “antenna” in 47 C.F.R. Section 1.1320(d)), is no more than three cubic feet in volume;
3. All other wireless equipment associated with the structure, including the wireless equipment associated with the antenna and any pre-existing associated equipment on the structure, is no more than 28 cubic feet in volume;
4. The facility does not require antenna structure registration under 47 C.F.R. Part 17;
5. The facility is not located on Tribal lands, as defined under 36 C.F.R. Section 800.16(x); and
6. The facility does not result in human exposure to radiofrequency radiation in excess of the applicable safety standards specified in 47 C.F.R. Section 1.1307(b).

Substantial change. As defined in 47 C.F.R. Section 1.6100(b)(7).

Support structure. As defined in 47 C.F.R. Section 1.6002(m) for “structure”, a pole, tower, base station, or other building, whether or not it has an existing antenna facility, that is used or to be used for the provision of personal wireless service (whether on its own or comingled with other types of services).

Temporary facility. A wireless facility used to provide personal wireless services on a temporary or emergency basis, such as, but not limited to, for a large-scale special event, following a duly proclaimed local or state emergency as defined in Section 8558 of the California Government Code, or during repair, maintenance, or upgrading of existing facilities. Temporary facilities include without limitation, cells on wheels (COW), sites on wheels (SOW), cells on light trucks (COLTs), or other similar wireless facilities, and:

1. That will be in place for no more than six months (or such other longer time as the County may allow in light of the event or emergency);
2. For which required notice is provided to the FAA;
3. That do not require marking or lighting under FAA regulations;
4. That will be less than 200 feet in height; and
5. That will either involve no excavation or involve excavation only as required to safely anchor the facility, including footings and other anchoring mechanisms, by no deeper than 24 inches below ground if the ground is undisturbed, or no deeper than 12 inches above the depth of any previous disturbance if the ground is disturbed.

Tower. A structure that is built for the sole or primary purpose of supporting any FCC-licensed or authorized antennas, including on-site fencing, equipment, switches, wiring, cabling, power sources, shelters, or cabinets associated with that tower but not installed as part of an antennas. This definition does not include utility poles.

Wireless facility. The antenna facility used for the provision of personal wireless services at a fixed location, including, without limitation, any associated support structure(s).

...

SECTION 2. Section 22.16.030 is hereby amended to read as follows:

22.16.030 – Land Use Regulations for Zones A-1, A-2, O-S, R-R, and W.

...

C. Use Regulations.

1. Principal Uses. Table 22.16.030-B, below, identifies the permit or review required to establish each principal use.

TABLE 22.16.030-B: PRINCIPAL USE REGULATIONS FOR AGRICULTURAL, OPEN SPACE, RESORT AND RECREATION, AND WATERSHED ZONES						
	A-1	A-2	O-S	R-R	W	Additional Regulations
Transportation, Electrical, Gas, Communications, Utilities, and Public Service Uses						
...
Wireless facilities, in compliance with Section 22.140.650.C.1700.D.1	SPR	SPR	SPR	SPR	SPR	Section 22.140.650700
Wireless facilities, in compliance with Section 22.140.650.C.2700.D.2	CUP	CUP	CUP	CUP	CUP	Section 22.140.650700

TABLE 22.16.030-B: PRINCIPAL USE REGULATIONS FOR AGRICULTURAL, OPEN SPACE, RESORT AND RECREATION, AND WATERSHED ZONES						
	A-1	A-2	O-S	R-R	W	Additional Regulations
Transportation, Electrical, Gas, Communications, Utilities, and Public Service Uses						
...

Wireless facilities, in compliance with Section 22.140.650.C.1700.D.1 — Section SPR SPR SPR SPR SPR

TABLE 22.16.030-B: PRINCIPAL USE REGULATIONS FOR AGRICULTURAL, OPEN SPACE, RESORT AND RECREATION, AND WATERSHED ZONES						
	A-1	A-2	O-S	R-R	W	Additional Regulations
Wireless facilities, in compliance with Section 22.140.650.C.2700.D.2	CUP	CUP	CUP	CUP	CUP	22.140.650700

Wireless facilities, in compliance with Section 22.140.650.C.2700.D.2 — Section CUP CUP CUP CUP CUP

22.140.650.C.2700.D.2 — 22.140.650700

SECTION 3. Section 22.18.030 is hereby amended to read as follows:

22.18.030 – Land Use Regulations for Zones R-A, R-1, R-2, R-3, R-4 and R-5.

...

C. Use Regulations.

1. Principal Uses. Table 22.18.030-B, below, identifies the permit or review required to establish each principal use.

TABLE 22.18.030-B: PRINCIPAL USE REGULATIONS FOR RESIDENTIAL ZONES							
	R-A	R-1	R-2	R-3	R-4	R-5	Additional Regulations
Transportation, Electrical, Gas, Communications, Utilities, and Public Service Uses							
...
Wireless facilities, in compliance with Section 22.140. 650.C.1700.D.1	SPR	SPR	SPR	SPR	SPR	SPR	Section 22.140. 650700
Wireless facilities, in compliance with Section 22.140. 650.C.2700.D.2	CUP	CUP	CUP	CUP	CUP	CUP	Section 22.140. 650700

TABLE 22.18.030-B: PRINCIPAL USE REGULATIONS FOR RESIDENTIAL ZONES

	R-A	R-1	R-2	R-3	R-4	R-5	Additional
Regulations							
Transportation, Electrical, Gas, Communications, Utilities, and Public Service Uses							
...
Wireless facilities, in compliance with							Section

SPR SPR SPR SPR SPR SPR

Section 22.140. ~~650.C.1700.D.1~~ 22.140.650700

Wireless facilities, in compliance with Section

CUP CUP CUP CUP CUP CUP

Section 22.140. ~~650.C.2700.D.2~~ 22.140.650700

SECTION 4. Section 22.20.030 is hereby amended to read as follows.

22.20.030 – Land Use Regulations for Zones C-H, C-1, C-2, C-3, C-M, C-MJ, and C-R.

...

C. Use Regulations.

1. Principal Uses. Table 22.20.030-B, below, identifies the permit or review

required to establish each principal use.

TABLE 22.20.030-B: PRINCIPAL USE REGULATIONS FOR RESIDENTIAL ZONES								
	C-H	C-1	C-2	C-3	C-M	C-MJ	C-R	Additional Regulations
Transportation, Electrical, Gas, Communications, Utilities, and Public Service Uses								
...
Wireless facilities, in compliance with Section 22.140.650.C.1700.D.1	SPR	SPR	SPR	SPR	SPR	SPR	SPR	Section 22.140.650700
Wireless facilities, in compliance with Section 22.140.650.C.2700.D.2	CUP	CUP	CUP	CUP	CUP	CUP	CUP	Section 22.140.650700

TABLE 22.20.030-B: PRINCIPAL USE REGULATIONS FOR COMMERCIAL ZONES

	C-H	C-1	C-2	C-3	C-M	C-MJ	C-R	Additional Regulations
Transportation, Electrical, Gas, Communications, Utilities, and Public Service Uses								
...
Wireless facilities, in compliance with Section 22.140.650.C.1700.D.1	SPR	SPR	SPR	SPR	SPR	SPR	SPR	Section 22.140.650700
Wireless facilities, in compliance with Section 22.140.650.C.2700.D.2	CUP	CUP	CUP	CUP	CUP	CUP	CUP	Section 22.140.650700

22.140.650700

22.140.650.C.1700.D.1

Wireless facilities, in

Section

compliance with Section CUP CUP CUP CUP CUP CUP CUP

22.140.650700

22.140.650.C.2700.D.2

SECTION 5. Section 22.22.030 is hereby amended to read as follows:

22.22.030 – Land Use Regulations for Zones M-1, M-1.5, M-2, and M-2.5.

...

C. Use Regulations.

2. Principal Uses. Table 22.22.030-B, below, identifies the permit or review required to establish each principal use.

TABLE 22.22.030-B: PRINCIPAL USE REGULATIONS FOR INDUSTRIAL ZONES					
	M-1	M-1.5	M-2	M-2.5	Additional Regulations
Transportation, Electrical, Gas, Communications, Utilities, and Public Service Uses					
...
Wireless facilities, in compliance with Section 22.140. 650.C.1700.D.1	<u>SPR</u>	<u>SPR</u>	<u>SPR</u>	<u>SPR</u>	Section 22.140. 650700
Wireless facilities, in compliance with Section 22.140. 650.C.2700.D.2	<u>CUP</u>	<u>CUP</u>	<u>CUP</u>	<u>CUP</u>	Section 22.140. 650700

~~required to establish each principal use.~~

SECTION 6. Section 22.22.040 is hereby amended to read as follows:

22.22.040 - Land Use Regulations for Zone M-3.

A. Permitted Uses. Premises in Zone M-3 may be used for any use, except that a use listed in Subsections B and C, below, is permitted only as provided in such sections, below, and uses listed in Subsection D, below, are prohibited. In addition, the following uses are permitted in Zone M-3:

1. Grading projects, with off-site transport up to 100,000 cubic yards of material, subject to Section 22.140.240 (Grading Projects).
2. One mobilehome or recreational vehicle on the same lot may be permitted for up to six consecutive months in any 12-month period if it is legally being used as a caretaker's residence for a use that requires the continuous supervision of a caretaker.
3. Use of property to gain access to any lawfully maintained use.

4. Wireless facilities, in compliance with Section 22.140.650.B.1700.D.1. 700 and Chapter 22.158.

B. Conditional Use Permit. If a Conditional Use Permit (Chapter 22.158) application has first been approved, premises in Zone M-3 may be used for:

1. Any use that is listed under Zone M-2 in Section 22.22.030 (Land Use Regulations for Zones M-1, M-1.5, M-2, and M-2.5) that requires a Conditional Use Permit application and is subject to the same limitations and conditions as in Zone M-2.

2.

2. The following additional uses:

a. Mobilehomes used as caretaker residences for a period of longer than six consecutive months in any 12-month period, in compliance with Section 22.140.140 (Caretaker Residences, including Mobilehomes).

C. Other Permits Required. If an application for a specified permit has first been approved, premises in Zone M-3 may be used for the following:

1. Adult Businesses, as provided by Chapter 22.150 (Adult Business Permits).

2. Cemeteries, as provided in Chapter 22.154 (Cemetery Permits).

3. Explosives storage, as provided in Chapter 22.164 (Explosives Permits).

4. Surface mining operations, as provided in Chapter 22.190 (Surface Mining Permits).

5. Wireless facilities, in compliance with Section 22.140.650.B.2700.D.2. 700 and Chapter 22.158.

SECTION 7. Section 22.22.050 is hereby amended to read as follows:

Section 22.22.050 – Land Use Regulations for Zones B-1 and B-2.

Table 22.22.050-A, below, identifies the permit or review required to establish each use.

TABLE 22.22.050-A: LAND USE REGULATIONS FOR ZONES B-1 AND B-2			
	B-1	B-2	Additional Regulations
...
Wireless facilities	-	-	-

SECTION 8. Chapter 22.24 is hereby amended to read as follows:

22.24.030 – Land Use Regulations for Rural Zones.

C. Use Regulations.

1. Principal Uses. Table 22.24.030-B, below, identifies the permit or review

required to establish each principal use.

TABLE 22.24.030-B: PRINCIPAL USE REGULATIONS FOR RURAL ZONES			
	C-RU	MXD-RU	Additional Regulations
Transportation, Electrical, Gas, Communications, Utilities, and Public Service Uses			
...
Wireless facilities, in compliance with Section 22.140.650.C.1700.D.1	SPR	SPR	Section 22.140.650700
Wireless facilities, in compliance with Section 22.140.650.C.2700.D.2	CUP	CUP	Section 22.140.650700

TABLE 22.24.030 B: PRINCIPAL USE REGULATIONS FOR RURAL ZONES

	C-RU	MXD-RU	Additional Regulations
Transportation, Electrical, Gas, Communications, Utilities, and Public Service Uses			
...
Wireless facilities, in compliance with Section 22.140.650.C.1700.D.1	SPR	SPR	Section 22.140.650700
Wireless facilities, in compliance with Section 22.140.650.C.2700.D.2	CUP	CUP	Section 22.140.650700

SECTION 9. Section 22.26.020 is hereby amended to read as follows:

22.26.020 – Institutional Zone.

...

B. Land Use Regulations.

...

3. Use Regulations.

a. Principal Uses. Table 22.26.020-B, below, identifies the permit or review required to establish each use.

TABLE 22.26.020-B: LAND USE REGULATIONS FOR ZONE IT		
		Additional Regulations
Transportation, Electrical, Gas, Communications, Utilities, and Public Service Uses		
...
Wireless facilities, in compliance with Section 22.140. 650.C.1700.D.1	SPR	Section 22.140. 650 700
Wireless facilities, in compliance with Section 22.140. 650.C.2700.D.2	CUP	Section 22.140. 650 700

~~review required to establish each use.~~

SECTION 10. Section 22.26.030 is hereby amended to read as follows:

22.26.030 – Mixed Use Development Zone.

...

B. Land Use Regulations.

...

3. Use Regulations.

a. Principal Uses. Table 22.26.030-B, below, identifies the permit or review required to establish each use.

TABLE 22.26.030-B: PRINCIPAL USE REGULATIONS FOR ZONE MXD		
		Additional Regulations
Transportation, Electrical, Gas, Communications, Utilities, and Public Service Uses		
...
Wireless facilities, in compliance with Section 22.140. 650.C.1700.D.1	SPR	Section 22.140. 650 700
Wireless facilities, in compliance with Section 22.140. 650.C.2700.D.2	CUP	Section 22.140. 650 700

SECTION 11. Section 22.26.040 is hereby amended to read as follows:

Section 22.26.040 – Specific Plan Zone.

...

B. Land Use Regulations.

...

a. 3. Wireless Facilities. If a zone or land use category within a Specific Plan is silent with regard to wireless facilities, the Director may accept an application for a wireless facility if the Director determines that a wireless facility is similar to another use permitted within such zone or land use category, in accordance with the following: **consistent with the requirements in Chapter 22.140.700 and Chapter 22.158.** This provision shall not apply if the Specific Plan Zone is within a local coastal program.

a. If the wireless facility is in compliance with Section 22.140.650.B.1700.D.1, the Director may accept a Ministerial Site Plan Review application (Chapter 22.186); or

b. If the wireless facility is in compliance with Section 22.140.650.B.2700.D.2, the Director may accept a Conditional Use Permit application (Chapter 22.158);

c. This provision shall not apply if the Specific Plan Zone is within a local coastal program.

SECTION 12. Section 22.26.060 is hereby amended to read as follows:

22.26.060 – Parking Restricted Zone.

...

B. Land Use Regulations.

...

3. Use Regulations.

a. Principal Uses. Table 22.26.060-B, below, identifies the permit or review required to establish each principal use.

TABLE 22.26.030-B: PRINCIPAL USE REGULATIONS FOR ZONE P-R

		Additional Regulations
Transportation, Electrical, Gas, Communications, Utilities, and Public Service Uses		
...
Wireless facilities, in compliance with Section 22.140. 650.C.4700.D.1	SPR	Section 22.140. 650700
Wireless facilities, in compliance with Section 22.140. 650.C.2700.D.2	CUP	Section 22.140. 650700

~~review required to establish each principal use.~~

SECTION 13. Section 22.140. ~~650700~~ is hereby added to read as follows:

22.140. ~~650700~~ Wireless Facilities

A. Purpose. This purpose of this Section is to:

~~Facilitate wireless communications service providers~~ Establish permitting procedures for the installation, operation, and modification of wireless facilities not in areas within a local coastal program, and to provide equitable, high quality wireless communications service infrastructure to serve the current and future needs of the County's residents, visitors, businesses, and local governments quickly, effectively, and efficiently.

~~1. Establish streamlined permitting procedures for the installation, operation,~~
~~1. and modification of wireless facilities, within the covered area while~~
~~protecting the environment and public health, safety and welfare of the County residents, and maintaining the County's rights to manage the reasonable~~
~~deployment of wireless infrastructure.~~

2. Comply with all applicable federal and state laws and regulations regarding wireless facilities. This section is not intended to, nor shall it be interpreted or applied to: (a) prohibit or effectively prohibit any wireless telecommunications service provider's ability to provide reasonable and necessary wireless communications services; (b) prohibit or effectively prohibit any entity's ability to provide reasonable and necessary interstate or intrastate telecommunications service; (c) unreasonably discriminate among providers of functionally equivalent services; (d) deny any request for authorization to place, construct or modify wireless telecommunications service facilities solely on the

basis of environmental effects of radio frequency emissions so long as such wireless facilities comply in every instance and regard with all FCC's regulations concerning such emissions; (e) prohibit any collocation or modification that the County may not deny under federal or state law; or (f) otherwise authorize the County to preempt any applicable federal or state law.

3. Establish standards and location preferences to regulate the placement, design, and aesthetics of wireless facilities to minimize visual ~~and~~, physical and other impacts to surrounding properties.

~~4.~~ Comply with all applicable federal and state laws and regulations regarding wireless facilities.

B. Applicability. This Chapter applies to all personal wireless service facilities located on private property and public property, except for small cell facilities to be located ~~in the public right-of-way~~ within a Highway which are subject to Chapter 16.25 (Small Cell Facilities) in Title 16 (Highways) of the County Code. Wireless facilities shall be permitted in all zones except Zones B-1 and B-2, subject to the required application ~~as specified in Subsection~~ for approval of a Ministerial or Conditional Use permit, as applicable.

~~§1.~~ Where another regulation in Title 22 applies to a personal wireless service facility, that regulation shall take precedence over this Section.

2. This Section shall not apply to areas within a local coastal program.

C. Exemptions. The following shall be exempt from the provisions of this Section, provided they satisfy applicable Fire, Electrical and Safety Code requirements:

1. A single ground- or building-mounted antenna not exceeding the maximum height permitted by this Chapter, including any mast, subject to the following restrictions:

a. A satellite dish antenna 39.37 inches or less in diameter and (a) intended for the sole use of a person occupying the same parcel to receive direct broadcast satellite service, including direct-to-home satellite service, or to receive or transmit fixed wireless signals via satellite or (b) a hub or relay antenna used to receive or transmit fixed wireless services that are not classified as

telecommunications services, is permitted anywhere on a lot provided it is no higher than needed to receive or transmit an acceptable quality signal and in no event higher than 12 feet above the roofline.

b. A non-satellite dish antenna 39.37 inches or less in diameter or diagonal measurement and (a) intended for the sole use of a person occupying the same parcel to receive video programming services via multipoint distribution services, including multichannel multipoint distribution services, instructional television fixed services, and local multipoint distribution services, or to receive or transmit fixed wireless signals other than via satellite or (b) a hub or relay antenna used to receive or transmit fixed wireless services that are not classified as telecommunications services, is permitted anywhere on a lot.

Amateur radio antennas that are in compliance with Section 22.140.040 (Amateur Radio Antennas).

~~2. "Like kind" equipment replacements, exchanges, or upgrades to an~~

~~3.2. existing cabinet, vault, or shroud, or generator that do not increase pre-existing visual or noise impacts, are substantially similar in appearance and the same or less in size, dimensions, and weight, and have the same or less radio frequency (RF) emissions to the ten existing and approved equipment. This exemption does not apply to generators.~~

4.3. The following temporary facilities that will be placed for less than seven consecutive days, provided any necessary building permit or other approval is obtained and the property owner's written consent is provided to the County:

- a. Facilities installed and operated for large-scale events;
- b. Facilities needed for coverage during repairs, upgrades, or the temporary relocation of an existing and already-approved facility; and
- c. Emergency generators to provide auxiliary power to wireless facilities for seven or fewer days, provided they are to be located on private property, and complies with the Noise Ordinance in Title 12 and Fire Code (Title 32) of the County Code.

D. Application Requirements.

1. Ministerial Site Plan Review. A Ministerial Site Plan Review (Chapter 22.186, Type I) application is required to authorize the following:
 - ~~a. — Installation and operation of a small cell facility located on private property and public property that is not a public right of way;~~
 - ~~b. — An Eligible Facilities Request, as defined in Section 22.14.230(W), for an existing facility, which does not include a small cell facility located in the public right of way which instead is subject to Chapter 16.25 (Small Cell Facilities) of the County Code, that was previously approved with a Ministerial Site Plan Review (Chapter: 22.186);~~
 - ~~c. — A macro facility on an existing support structure that meet all standards in Subsection E, below, and does not require a waiver;~~
 - ~~c.a. Installation and operation of a temporary facility other than those described in Subsection DC.3, belowB.4, above; and~~
 - ~~d.c. Placement and operation of an emergency generator to provide auxiliary power to a wireless facility for more than seven days but no more than 90 days, provided the generator is not located in the public right of way, and complies with the Noise Ordinance in Title 12 and Fire Code (Title 32) of the County Code.~~
 - ~~d. The process set out in Chapter 22.186 and Chapter 22.226 shall be used, except that the Director shall give notice (or require the applicant to give notice) to all property owners and residents within the Notification Radius in Section 22.222.160.B that they have the opportunity to comment on whether the application proves entitlement to the permit.~~
 - ~~e. The Director shall provide a notice of decision to the applicant and all persons who provided comment. The Director's decision on entitlement may be appealed to the appropriate Appeal Body.~~
2. Conditional Use Permit. A Conditional Use Permit (Chapter 22.158) application is required to authorize the following:
 - a. Installation and operation of a new macro facility not installed on an existing structure.

b. A macro facility on an existing support structure, that meets all standards in Subsection E, below, and does not require a waiver;

b.c. Installation and operation of a small cell facility located on private property and public property that is not within a Highway as defined in Section 16.04.100;

c.d. Installation and operation of any wireless facility, of any type, that requires a waiver from one or more of the requirements in this Chapter or the design standards and guidelines specified in Subsection E, below.

3. Revised Exhibit "A". A Revised Exhibit "A" (Chapter 22.184) application is required to collocate a macro facility on an existing structure with an approved and unexpired discretionary permit that currently hosts another macro facility, or to make modifications to an existing macro facility with an approved and unexpired discretionary permit, including an Eligible Facilities Request for the macro facility. Certain conditions prescribed as part of the approval of the discretionary permit shall not be binding for modifications to a facility as part of an Eligible Facilities Request only to the extent that the request seeks to rectify those conditions (i.e., size, dimensions, or height), and all other conditions shall continue to apply.

~~4. For every new application, the applicant shall prepare and submit to the Director a report on the radio frequency emissions levels of each wireless facility demonstrating that such emissions comply with adopted FCC guidelines.~~

4. The Director may create and publish application forms that each applicant for a Ministerial Permit or Conditional Use Permit must use. If no such form is available, then the applicant must submit all documents, information, and any other materials necessary to allow the review authority to make required findings and ensure that the proposed facility will comply with this Chapter and applicable laws and not endanger the public health, safety, or welfare. Unless prohibited by state or federal law each application for Conditional Use Permit or Ministerial Permit must include, at minimum:

a. A statement signed by a person with legal authority to bind the applicant attesting under penalty of perjury to the accuracy of the information

provided in the application. If the attester is not an authorized employee of the applicant, then the attester must demonstrate that it is an authorized agent of the applicant, with lawful Power of Attorney from the applicant;

b. Contact information for:

i. Applicant and their representatives;

ii. Owner of proposed wireless communications facility;

iii. If different from facility owner, the identity of the person or entity responsible for operating the proposed wireless facility;

iv. The property owner or owner of the structure on which the proposed wireless facility would be installed;

v. Names, addresses, telephone numbers, and email addresses of anyone acting on behalf of the applicant with regard to the application;

vi. The name, address and phone number of all persons that prepared or assisted in preparing the application and any required reports;

c. The postal address, parcel number, or utility pole identifier of the property;

d. GIS coordinates;

e. If the personal wireless facility will be located within a private easement, proof that the terms of the easement allow occupation by the applicant and the use being requested or that the real property owner consents to the occupation and use;

f. The location of any residences, residential care facility or public or private school within 1,000 feet of the project site;

g. Documentation that notice consistent with that required by Government Code Sections 65090-65094 and as provided by Section 22.222.110 has been or will be provided, using the Notification Radius provisions in Section 22.222.150.B.

h. A depiction of the conspicuous sign measuring at least 9 inches by 12 inches that has been placed at the proposed location of each proposed facility installation.

- i. Local contact person for emergencies;
- j. Assessor's Parcel Number;
- k. Need or purpose the personal wireless facility is designed to fulfill;
- l. A siting analysis which identifies other feasible locations within or outside the County which could serve the area intended to be served by the facility;
- m. Color-coded carrier-generated RF Coverage (propagation) maps, at a scale no smaller than 1 inch (1") to a quarter (1/4) mile with all appropriate legends, showing the coverage for the highest and lowest frequencies to be used by the facility. Frequencies are to be stated numerically, not qualitatively. Provide a represented value in dB of each colors it specifically represents;
- n. Description as to why the desired location is superior to other similar locations, from a community perspective, including, but not limited to:
 - i. Description as to why the desired location is superior to other similar locations, from a community perspective;
 - ii. Proximity to residential buildings and descriptions of efforts to prevent any blocking of views of impressive scenes;
 - o. Proximity to residential buildings and descriptions of efforts to prevent any blocking of views of impressive scenes;
 - p. Written documentation demonstrating a good faith effort to locate the proposed facility in the least intrusive location in accordance with the location requirements of this Chapter;
 - q. Visual impact analyses with photo simulations including both "before" and "after" appearances, including the antenna and all associated equipment;
 - r. If the application is for a new tower, clear and convincing technical evidence by a carrier or wireless service provider justifying the total height of the proposed facility and the need for such to the exclusion of all reasonable alternatives;
 - s. An affirmation, under penalty of perjury, that the proposed installation will be FCC compliant, in that it will not cause members of the general public to be exposed to RF levels that exceed the emissions levels deemed safe by the FCC. A copy of the fully completed FCC form "A Local Government Official's Guide to

Transmitting Antenna RF Emission Safety: Rules, Procedures, and Practical Guidance: Appendix A” titled “Optional Checklist for Determination of Whether a Facility is Categorically Excluded” for each frequency band of RF emissions to be transmitted from the proposed facility upon the approval of the application. All planned radio frequency emissions on all frequency bands must be shown on the Appendix A form(s) attached to the application. All planned radio frequency emissions are to be entered on each Appendix A form only in wattage units of “effective radiated power.”

t. A statement detailing the frequency, modulation and class of service of radio or other transmitting equipment;

u. A copy of the FCC license applicable for the intended use of the proposed facilities;

v. A written statement of the applicant’s willingness to allow other carriers to co-locate on the proposed personal wireless service facility where technically and economically feasible and aesthetically desirable, subject to the qualification that colocation should not occur when public exposures from the resulting higher cumulative sources would exceed FCC limits;

w. A master plan showing the geographic service area for the proposed personal wireless facility installation(s), and all of applicant's existing, proposed and anticipated installations in the County, as well as a schedule of completion dates for each installation;

x. Explanation of all state and federal required environmental and historic evaluations or assessments and proof they have been satisfactorily performed, or proof that a categorical exemption applies and is supported by substantial evidence;

y. Detailed engineering plans, sealed by a California licensed professional engineer. The plans shall disclose, at minimum:

i. a list of all associated equipment necessary for its operation;

ii. load calculation;

iii. a one-line diagram of the electrical system;

iv. plot plan showing the location of the service disconnecting means;

v. short circuit and coordination study ("SCCS") calculated pursuant to the IEEE 551-2006: Recommended Practice for Calculating AC Short-Circuit Currents in Industrial and Commercial Power Systems or the latest version of that standard. The study must demonstrate the protection devices will ensure the equipment enclosure will not be breached. The SCCS must include analysis of Voltage Transient Surges due to contact of conductors of different voltages;

vi. sufficient information for the review authority to verify that the facility will comply with all applicable safety codes and provisions, including but not limited to the Fire Code, Electrical Code and Building Code;

i.vii. a demonstration that the personal wireless facility and its supporting structure will meet APCO ANS 2.106.1, Public Safety Grade Site Hardening Requirements.

E. Development Standards.

1. General Standards. All wireless facilities, except for facilities as part of Eligible Facilities Requests and Small Cell Facilities, shall comply with the following standards. If a waiver is required for one or more of these standards due to technical infeasibility, Subsection D.2.bd, above, shall apply.

a. Compliance with all regulations. The facility shall comply with state and federal requirements, standards and law.

b. Location.

i. Wireless facilities shall not encroach into any required setbacks for structures.

for structures.

ii. All new freestanding towers and monopoles shall be set back a minimum distance of at least one hundred and twenty (120) percent of the height of the tower or monopole from any property line abutting a residentially zoned property. This minimum setback is not subject to a waiver.

iii. In Residential Zones:

ii. ~~Wireless facilities, including but not limited to small cells, in the public right of way, wireless~~

(a) ~~facilities~~ shall be placed no ~~furtherless~~ than five feet from any common property line shared with adjoining lots, and shall be stealth or use concealment techniques.

(b) ~~Wireless facilities, including but not limited to small cells not in public right of way, are subject to required setbacks for structures.~~

~~iii-iv. Wireless facilities shall be located in compliance with the limitationsregulations as specified in Chapter 22.102 (Significant Ecological Areas), Chapter 22.104 (Hillside Management Areas, Division 10 (Community Standards Districts) and Division 11 (Non-Coastal Specific Plans), and Chapter 22.336 (Santa Monica Mountains North Area Community Standards District),where applicable. All wireless facilities to be located within the Santa Monica Mountains Coastal Zone shall be in compliance with all requirements in Chapter 22.44 (Santa Monica Mountains Local Implementation Program), and if applicable, Chapter 22.56 (Coastal Development Permits).~~

~~iv-v. New wireless facilities shall not be installed on buildings or structures listed or eligible for listing on the National, California, or County historic registers. New towers and support structures installed on the grounds of properties listed or eligible for listing on the National, California, or County historic registers shall be located and designed to eliminate impacts to the historic resource. A Historic Resource Assessment, prepared to the satisfaction of the Director, may be required for a facility to be located on a site containing an eligible resource to identify impacts to historic resources, and identify mitigation to minimize impacts.~~

~~d.-c. Height.~~

i. ~~In Industrial, Rural, Agricultural, Open Space, Resort-Recreation and Watershed Zones, the maximum height of a non-building-mounted wireless facility shall be 75 feet.~~

ii. ~~In all other zones except Zones R-1, R-2, and R-3, the maximum height of a non-building-mounted wireless facility shall be 65 feet. In~~

Zones R-1, R-2, and R-3, the maximum height of a wireless facility shall be 35 feet, and for a small cell facility not in the public right of way, the maximum height shall be 50 feet.

iii. In all other zones except Zones R-1, R-2, and R-3, the maximum height of a non-building-mounted wireless facility shall be 65 feet.

iv. The height of a wireless facility, including those located within an Airport Influence Area, shall comply with the applicable FAA requirements.

Airport Influence Area, shall comply with the applicable FAA requirements.

e-d. Design standards.

i. Cables. All cables that serve the wireless facility shall be located within the interior of the structure, sheathed, or hidden to the fullest extent technically feasible.

ii. Color. All pole-mounted equipment not concealed shall be treated

iii-ii. with exterior coatings of a color and texture to match the predominant visual background or existing architectural elements to visually blend in with the surrounding development.

iv-iii. Associated Equipment. Associated equipment shall not be visible, and, if placed on the ground, shall be located in an enclosed structure, such as a building or underground vault (with the exception of required electrical panels), or screened and secured by solid fencing, walls, and gates, and shall conform to the height of the applicable zone. Radio units need not shall be enclosed unless the applicant demonstrates technical infeasibility but in all instances shall be stealth.

v-iv. Fencing. Barbed wire shall be prohibited.

v. 2. Additional standards for monopoles. The facility shall comply with applicable utility facilities construction standards including but not limited to California Public Utilities Commission General Order 95 and APCO ANS 2.106.1, Public Safety Grade Site Hardening Requirements, or their successor provisions.

vi. The facility shall comply with applicable safety codes and provisions, including but not limited to the Fire Code, Electrical Code and Building Code.

2. Additional standards for monopoles.

a. To the extent technically feasible, antennas shall be mounted directly on the structure for a streamlined design. If mounting equipment shall be required to make the facility feasible, the maximum length of each mounting equipment, such as arm, bracket, or extension, shall be two feet from the structure.

b. Strand mounted antennas are prohibited.

~~b.c.~~ Wireless facilities designed as flagpoles are prohibited.

3. Additional standards for facilities mounted on structures other than towers or buildings. A facility mounted on a structure other than a tower or building, such as an architectural tower, bridge, pole sign, lamppost, monumental sign, outdoor advertising sign, stadium light, utility pole, water tank or windmill, shall comply with the following standards:

a. Non-ground mounted equipment shall be shrouded ~~and, if technically feasible,~~ or contained within the structure to the extent technically feasible. The applicant bears the burden of proving technical infeasibility to the satisfaction of the reviewing authority.
~~feasible, or contained within the structure to the extent technically feasible.~~

b. Cables shall be flush-mounted or fully sheathed to the structure to prevent visible gaps between the cables and the structure, ~~unless expressly prohibited by a state regulation. Cables shall not be visibly loose or spooled.~~

c. Shroud and cables shall be finished to match the structure exterior in ~~color.~~ color.

d. Architectural Towers. Architectural towers shall:

i. ~~i.~~ Completely conceal equipment, including antennas; and

ii. Blend in with the architecture of buildings located near the tower location.

4. Additional standards for roof-mounted facilities.

a. Roof-mounted facilities shall be completely concealed and not visible from any public right of way at ground level. Acceptable concealment includes screening or architectural features appropriate to the building such as parapets, penthouses, cupolas, steeples, chimneys, or architectural towers finished to match the building exterior.

~~b.~~ Chimneys and chimney-like textures as concealment shall be avoided for the roofs of commercial buildings.

5. Additional standards for facade-mounted facilities.

a. Facade-mounted equipment shall be flush mounted, architecturally integrated, or completely screened.

b. Architecturally integrated and screening elements shall be finished to match the building exterior.

F. Development Standards for Small Cell Facilities.

1. Setbacks.

~~a.~~ Small cell facilities shall not encroach into any required setbacks for structures.

~~b.a.~~ In Residential Zones, excluding the public right of way, Small cell facilities shall be placed no further closer than five feet from 1,000 to any common property line shared with adjoining lots: residential structure, residential care facility or public or private school.

2. Height and size. The height and size of the small cell facility shall not exceed the dimensions specified in Section 22.14.230 (W) for “small cell facility.”

3. Design standards.

The Director shall create, update, publish and maintain Design Guidelines for Wireless Facilities (“Guidelines”) to assist applicants and the public in interpreting and applying the standards and requirements in this Chapter. The Guidelines may provide additional or more granular requirements, but must, at minimum, reflect and implement the standards in this Chapter.

a. All antennas, cables, and equipment shall be concealed and ~~or~~ located within the antenna shrouds, pole, conduits, and other stealthing apparatus; to the extent technically feasible.

b. The small cell facility shall be finished with matching colors to blend in with the structure.

G. Modifications to Existing Macro Facilities. Existing macro facilities may be eligible for either:

1. A Ministerial Site Plan Review (Chapter 22.186) application if such facilities are redesigned with shorter mounting equipment that extends no more than two feet from the structure, or with removal of any existing mounting equipment, and with additional screening techniques, such as shrouds or walls, that blend in with the structure, including color and texture, and conforms to all standards in Subsection E, above, and does not require a waiver; or

2. A Revised Exhibit "A" (Chapter 22.184) application for modifications to a facility where such modifications will not bring the facility into conformity with the standards in Subsection E, above, or which requires a waiver.

3. An Eligible Facilities Request may be processed with a Ministerial Site Plan Review (Chapter 22.186) application if minor modifications will bring the facility in conformance with all standards in Subsection E, above, and does not require a waiver~~;~~, or a Revised Exhibit "A" (Chapter 184) application if the minor modifications will not bring the facility in conformance with the standards in Subsection E, above, or which may require a waiver. Otherwise, the Eligible Facilities Request may be processed with a Revised Exhibit "A," in accordance with Subsection D.3, above.

H. Standards for Wireless Facilities Subject to Conditional Use Permit. All facilities that are subject to a Conditional Use Permit (Chapter 22.158) pursuant to Subsection GD.2, above, shall comply with the following standards:
Subsection CD.2, above, shall comply with the following standards:

1. Location.

a. Preferred Locations. To better assist applicants, minimize unnecessary visual clutter, promote safety and limit other impacts to aesthetics

and community character, the preferred locations for personal wireless service facilities are as follows:

- i. Most Preferred: Industrial zones.
- ii. Less Preferred: Commercial zones
- iii. Least Preferred: Residential & Rural Zones

Applications that seek a permit involving a Least Preferred location may be approved if the applicant proves with clear and convincing evidence that the denial of an application would prohibit or effectively prohibit the provision of personal wireless services pursuant to 47 U.S.C. § 332(c)(7)(B)(i)(II) or otherwise violate applicable laws or regulations.

~~a.b.~~ Wireless facilities shall be located and designed to minimize visual impacts to vistas from adopted scenic highways and ridgelines.

~~b.c.~~ Wireless facilities shall be located to minimize visual impacts on adjacent residences and historic resources.

2. Design standards. Wireless facilities shall incorporate the following concealment measures appropriate for the proposed location:

a. Monopoles. Monopoles shall be designed as follows:

i. Monopoles shall be located to utilize existing natural or man-made features including topography, vegetation, buildings, or other structures in the immediate surroundings to provide the greatest amount of visual screening.

ii. If mounting equipment shall be required for the monopole, the maximum length of each mounting equipment, such as arm, bracket, or extension, shall be eight feet.

b. Faux Trees. Any proposed faux tree shall be designed as follows:

i. Wherever possible, faux trees shall be located within 50 feet of an existing grove of at least two live trees, and shall be similar in appearance to the species of the live trees.

ii. The faux tree species shall be appropriate for the location.

iii. Faux trees shed toxic microplastics and contain carcinogenic materials listed under Proposition 65. Applicants must disclose the chemical content of faux tree materials, effectively monitor their discharge into the environment, and take all effective measures to mitigate their adverse impacts. Annual reports shall be submitted under penalty of perjury certifying minimal environmental impacts and compliance with zero-discharge standard under the Clean Water Act and Porter-Cologne Act.

~~iii.iv.~~ Antennas shall be painted, coated, or covered to match their background (e.g., leaves, branches, or trunk) and shall not extend beyond the tree branches or fronds.

~~iv.v.~~ Faux branches or fronds shall conceal the antennas ~~as to~~ the extent technically feasible and shall be weather-resistant.

~~v.vi.~~ Faux bark cladding shall be provided from the ground to five feet beyond where the faux branches begin; above the faux bark cladding, the pole shall be painted a flat non-reflective paint of the same color as the bark cladding.

c. Faux Rock Outcroppings. Faux rock outcroppings, shall contain all equipment, including antennas, and shall be similar in appearance to real rocks in the immediate vicinity with respect to color, texture, and scale.

d. Architectural Towers. Architectural towers shall:

i. ~~iii.~~ Completely conceal equipment, including antennas; and

ii. ~~iv.~~ Blend in with the architecture of buildings located near the tower location.

I. Findings. If a wireless facility is subject to Subsection ~~GD~~.2, above, the following additional findings shall be made:

1. The facility complies with all applicable standards in this Section, ~~unless a waiver has been requested pursuant to Subsection L, below;~~

2. The design of the facility is the least visually intrusive that is technically feasible and appropriate for the location; and

3. For new wireless facilities, the location of the facility does not create a safety hazard.

J. Conditions of Approval. For wireless facilities subject to Subsection D.1 above the Director, and for wireless facilities subject to Subsection ED.2, above, the Commission or the Hearing Officer may impose conditions to ensure that the approval will be in accordance with the findings required by the application. Such conditions may involve any pertinent factors that could affect the establishment, operation, and maintenance of the facility., including, but not limited to. All permits (whether Ministerial or Conditional Use Permit) must, however, contain the following conditions absent a request for waiver:

1. Every five years, the permittee shall prepare and submit to the Director a report on the radio frequency emissions levels of each wireless facility demonstrating that such emissions comply with adopted FCC limitations for general population/uncontrolled exposure to such emissions when operating at full strength.

K. Wireless Facility Authorization Permit Duration. A Conditional Use Permit to authorize a wireless facility may be valid for a period of 15 years.

1. The permittee shall defend, indemnify, and hold harmless the county or any of its boards, commissions, agents, officers, and employees from any claim, action or proceeding against the county, its boards, commission, agents, officers, or employees to attack, set aside, void, or annul, the approval of the project, or to hold the county liable in whole or in part as a result of the engineering, design, construction or operation of the facility. The county shall promptly notify the provider(s) of any such claim, action or proceeding if the county bears its own attorney's fees and costs, and the county defends the action in good faith.

2. The permittee shall be strictly liable for interference caused by its facilities with county communications systems. The permittee shall be responsible for costs for determining the source of the interference, all costs associated with eliminating the interference (including but not limited to filtering, installing cavities, installing directional antennas, powering down systems, and

engineering analysis), and all costs arising from third party claims against the county attributable to the interference.

3. Subsequent submittals for this project shall be in substantial compliance with the plans date-stamped received by the Department of Regional Planning on . The project shall comply with all conditions of approval stipulated in the referral sheets attached to the agenda report for this project. In the event the project plans conflict with any condition of approval, the condition shall take precedence and revised plans shall be submitted and approved by the Director of Planning prior to plan check.

4. The permit and rights conferred in this approval shall not be effective until the permittee signs, notarizes and returns the Acceptance of Conditions Affidavit accepting the conditions set forth herein. The applicant shall file this form with the Department of Regional Planning within 30 days of this decision or prior to issuance of any development, conditional use, building, electrical or encroachment permit.

5. The applicant shall digitally submit a complete set of plans, including the items required in Condition No. 6 to the Department of Regional Planning for consistency review and approval prior to plan check and again prior to the issuance of any building or development permits.

6. The Notice of Decision (including the signed and notarized Acceptance of Conditions Affidavit) shall be copied in its entirety and placed directly onto a separate plan sheet(s) to be included in the development plans prior to submitting any development permits.

7. A Ministerial Permit or CPD issued under this Chapter shall be valid for a period of ten (10) years from issuance, unless pursuant to another provision of the Code or these conditions, it expires sooner or is terminated. At the end of ten (10) years from the date of issuance, such development or conditional use permit shall automatically expire, unless an extension or renewal has been granted. A person holding a permit must either (1) remove the facility within thirty (30) days following the permit's expiration (provided that removal of support structure owned by the county, a utility, or another entity authorized to maintain a

support structure need not be removed, but must be restored to its prior condition, except as specifically permitted by the county); or (2) prior to expiration, submit an application to renew the permit, which application must, among all other requirements, demonstrate that the impact of the wireless facility cannot be reduced. The wireless facility must remain in place until it is acted upon by the county and all appeals from the county's decision exhausted.

8. The installation and construction authorized by a permit shall be completed within three (3) years after its approval, or it will expire without further action by the county unless prior to the three (3) years the applicant submit an extension request and the county, in its sole discretion, grants a time extension for due cause. The installation and construction authorized by a permit shall conclude, including any necessary post-installation repairs and/or restoration to the property, within thirty (30) days following the day construction commenced. The permittee must provide written notice to county within ten (10) days after completing construction, and may not begin operations until all county and Fire Department (if applicable) inspections have been completed and the project is found to be consistent with the permit. The expiration date shall be suspended until an appeal and/or litigation regarding the subject permit is resolved.

9. The Director of Planning may grant up to four one-year extensions of the timeline, in Condition 8 above, for completing the installation and construction authorized by a development or condition use permit, if the Director of Planning finds that the conditions, including but not limited to changes in the wireless ordinance under which the permit approval was issued, have not significantly changed.

10. Any questions of intent or interpretation of any condition of approval will be resolved by the Director of Planning upon written request of such interpretation.

11. All structures shall conform to Los Angeles County Fire Department requirements and all other applicable environmental, health and safety laws.

Cultural Resources

12. In the event that potentially important cultural resources are found

in the course of geologic testing, work shall immediately cease until a qualified archaeologist can provide an evaluation of the nature and significance of the resources and until the Department of Regional Planning can review this information. Where, as a result of this evaluation, the Department of Regional Planning determines that the project may have an adverse impact on cultural resources, an evaluation of cultural resources shall be required.

13. If human bone is discovered, the procedures described in Section 7050.5 of the California Health and Safety Code shall be followed. These procedures require notification of the coroner. If the coroner determines that the remains are those of a Native American, the applicant shall notify the Native American Heritage Commission by phone within 24 hours. Following notification of the Native American Heritage Commission, the procedures described in Section 5097.94 and Section 5097.98 of the California Public Resources Code shall be followed.

Facility Conditions

14. All antennas shall meet the minimum siting distances to public/uncontrolled areas required for compliance with the FCC regulations and standards governing the environmental effects of radio frequency emissions. Permittee shall keep up-to-date on current information from the FCC in regards to maximum permissible radio frequency exposure levels. In the event that the FCC changes its guidelines for human exposure to radio frequency, permittee shall, within 30 days after any such change, submit to the Director a report prepared by a qualified engineer that demonstrates actual compliance with such changed guidelines. The Director may, at permittee's sole cost, retain an independent consultant to evaluate the compliance report and any potential modifications to the permit necessary to conform to the FCC's guidelines. Failure to submit the compliance report required under this condition, or failure to maintain compliance with the FCC's guidelines for human exposure to radio frequency at all times shall constitute grounds for permit revocation.

15. All antennas shall be located so that any person walking adjacent to the transmitting surface of the antenna will be walking on a grade, which is a

minimum of eight and one-half feet below the transmitting surface.

16. All antennas, equipment, and support structures shall be engineered and designed to prevent unauthorized climbing.

17. The wireless facility shall be erected, operated, and maintained in compliance with the general requirements set forth in the Guidelines and any specific requirements in the permit.

18. The antenna and electrical support equipment shall, at all times, be operated in a manner that conforms to the applicable health and safety standards, including those imposed by this Chapter 17.46 and the Guidelines.

19. Wireless communications facilities and equipment must comply with the applicable noise ordinances, and prevent noise and sound from being plainly audible at a distance of fifty (50) feet from the facility or within ten (10) feet of any residence.

20. The Director's approval is required if a generator is to be placed onsite for temporary or permanent use.

21. All non-ground-mounted equipment associated with the application shall be located no lower than eight feet above grade or ground level on the monopole or support structure.

22. The county or its designee may enter onto the facility area to inspect the facility upon 48 hours prior notice to the permittee. The permittee shall cooperate with all inspections and may be present for any inspection of its facility by the county. The county reserves the right to enter or direct its designee to enter the facility and support, repair, disable, or remove any elements of the facility in emergencies or when the facility threatens imminent harm to persons or property. The county shall make an effort to contact the permittee prior to disabling or removing any facility elements, but in any case, shall notify permittee within 24 hours of doing so.

23. Testing of any equipment shall take place on weekdays only, and only between the hours of 8:30 a.m. and 4:30 p.m., except that testing is prohibited on holidays that fall on a weekday. In addition, testing is prohibited on weekend days.

24. Permittee shall obtain and maintain throughout the term of the permit commercial general liability insurance with a limit of five million dollars (\$5,000,000) per occurrence for bodily injury and property damage and six million dollars (\$6,000,000) general aggregate including premises operations, contractual liability, personal injury, and products completed operations. The relevant policy(ies) shall name the county, its elected/appointed officials, commission members, officers, representatives, agents, and employees as additional insureds. A true and correct copy of the policy of insurance shall constitute proof of insurance required by this Subsection. Permittee shall use its best efforts to provide thirty (30) days' prior notice to the county of to the cancellation or material modification of any applicable insurance policy. Failure to maintain insurance consistent with this Condition shall automatically void the permit, and the permittee shall immediately deenergize and remove the facility from operation. The policy shall not have a pollution or other exclusion which excludes injuries or damages from EMF/RF exposures.

25. Prior to issuance of a county permit or encroachment permit, the permittee shall file with the county, and shall maintain in good standing throughout the term of the approval, a performance bond or other surety or another form of security for the removal of the facility in the event that the use is abandoned or the permit expires, or is revoked, or is otherwise terminated. The security shall be in the amount equal to the cost of physically removing the facility and all related facilities and equipment on the site, based on the higher of two contractor's quotes for removal that are provided by the permittee. The permittee shall reimburse the county for staff time associated with the processing and tracking of the bond, based on the hourly rate adopted by the county Board of Supervisors. Reimbursement shall be paid when the security is posted and during each administrative review.

26. Permittee shall not move, alter, temporarily relocate, change, or interfere with any existing structure, improvement, or property without the prior consent of the owner of that structure, improvement, or property. No structure, improvement, or property owned by the county shall be moved to accommodate

a permitted activity or encroachment, unless the county determines that such movement will not adversely affect the county or any surrounding businesses or residents, and the Permittee pays all costs and expenses related to the relocation of the county's structure, improvement, or property. Prior to commencement of any work pursuant to any permit, the permittee shall provide the county with documentation establishing to the county's satisfaction that the permittee has the legal right to use or interfere with any other structure, improvement, or property to be affected by permittee's facilities.

27. No possessory interest is created by a Ministerial Permit or Conditional Use Permit. However, to the extent that a possessory interest is deemed created by a governmental entity with taxation authority, permittee acknowledges that county has given to permittee notice pursuant to California Revenue and Taxation Code Section 107.6 that the use or occupancy of any public property pursuant to a development or conditional use permit may create a possessory interest which may be subject to the payment of property taxes levied upon such interest. Permittee shall be solely liable for, and shall pay and discharge prior to delinquency, any and all possessory interact taxes or other taxes, fees, and assessments levied against permittee's right to possession, occupancy, or use of any public property pursuant to any right of possession, occupancy, or use created by this development or conditional use permit.

28. If not already completed, permittee shall enter into the appropriate agreement with the county, as determined by the county, prior to constructing, attaching, or operating a facility on county-owned infrastructure. This permit is not a substitute for such agreement.

29. If a facility is not operated for a continuous period of three (3) months, the Ministerial Permit or Conditional Use Permit and any other permit or approval therefor shall be deemed abandoned and terminated automatically, unless before the end of the three (3) month period (i) the Director has determined that the facility has resumed operations, or (ii) the county has received an application to transfer the permit to another service provider. No later than ninety (90) days from the date the facility is determined to have ceased

operation, or the permittee has notified the Director of its intent to vacate the site, the permittee shall remove all equipment and improvements associated with the use and shall restore the site to its original condition to the satisfaction of the Director. The permittee shall provide written verification of the removal of the facilities within thirty (30) days of the date the removal is completed. If the facility is not removed within thirty (30) days after the permit has been discontinued pursuant to this subsection, the site shall be deemed to be a nuisance, and the county may cause the facility to be removed at permittee's expense or by calling any bond or other financial assurance to pay for removal. If there are two (2) or more users of a single facility or support structure, then this provision shall apply to the specific elements or parts thereof that were abandoned but will not be effective for the entirety thereof until all users cease use thereof.

30. In the event the county determines that it is necessary to take legal action to enforce any of these conditions, or to revoke a permit, and such legal action is taken, the permittee shall be required to pay any and all costs of such legal action, including reasonable attorney's fees, incurred by the county, even if the matter is not prosecuted to a final judgment or is amicably resolved, unless the county otherwise agrees, in its complete discretion, to waive said fees or any part thereof.

31. Interference with county communications systems and other governmental emergency systems is prohibited. Further, no permits issued pursuant to this chapter of the County Code establish any guarantee or warranty that Licensee's facility will be free from interference from county or third-party communication systems.

Construction

32. Installation hours shall be limited to Monday through Friday from 7:00 a.m. to 7:00 p.m. and Saturdays from 8:00 a.m. to 5:00 p.m. No installation activities shall be permitted on Sundays and county-designated holidays. The restricted work hours described in this condition do not apply to emergency maintenance necessary to protect health or property. The county may issue a Stop Work Order if permittee violates this condition. Construction activities shall

be conducted in compliance with, and abide by, all applicable safety codes and permit conditions.

33. All sites built to the standards of ANSI/APCO Public Safety Grade Site Hardening Requirements, also referred to as “APCO ANSI 2.106.1-2019”.

Site Specific Conditions

34. In the event that the electric service provider does not currently offer an alternative metering option, the permittee shall remove the above-grade electric meter when such option becomes available. Prior to removing the above-grade electric meter, the permittee shall apply for any encroachment and/or other ministerial permit(s) required to perform the removal. Upon removal, the permittee shall restore the affected area to its original condition that existed prior to installation of the equipment.

35. The permittee acknowledges that the county specifically includes conditions of approval related to (a) painting, coloring or finishing the equipment to match the monopole or support structure; (b) undergrounding all equipment to the extent possible; (c) installing equipment within shrouds, conduits and risers as concealment elements engineered and designed to integrate the wireless facility with the surrounding built and natural environment; and (d) specific structural, seismic, electrical, fire and operating/maintenance requirements. Any future modifications to the permittee’s wireless facility must maintain or improve all concealment elements and safety precautions.

36. Before the permittee submits any applications for construction, encroachment, excavation or other required permits in connection with this permit, the permittee must incorporate a true and correct copy of this permit, all conditions associated with this permit and any approved photo simulations into the project plans (collectively, the “Approved Plans”). The permittee must construct, install and operate the wireless facility in substantial compliance with the Approved Plans as determined by the Director or the Director’s designee. Any substantial or material alterations, modifications or other changes to the Approved Plans, whether requested by the permittee or required by other departments or public agencies with jurisdiction over the wireless facility, must be

submitted in a written request subject to the Director's prior review and approval, who may refer the request to the original review authority if the Director finds that the requested alteration, modification or other change substantially deviates from the Approved Plans or implicates a significant or substantial land-use concern.

37. The permittee shall install and at all times maintain in good condition a "Network Operations Center Information" and "RF Caution" sign on the utility pole no less than three (3) feet below the antenna (measured from the top of the sign) and no less than nine (9) feet above the ground line (measured from the bottom of the sign). Signs required under this condition shall be installed so that a person can clearly see the sign as he or she approaches within three (3) feet of the antenna structure. If any person on or within the property is or may be exposed to emissions that exceed applicable FCC uncontrolled/general population limits at any time the sign shall expressly so state, and provide instructions on how persons can avoid any such exposure. The sign shall also include the name(s) of the facility owner(s), equipment owner(s) and operator(s)/carrier(s) of the antenna(s), property owner name, as well as emergency phone number(s) for all such parties. The sign shall not be lighted, unless applicable law, rule or regulation requires lighting. No signs or advertising devices other than required certification, warning, required seals or signage, other signage required by law, this Chapter, any county or applicable state code or the Los Angeles County Fire Department Chief or his or her designee shall be permitted. The sign shall be no larger than two (2) square feet.

38. The permittee shall ensure that all signage complies with FCC Office of Engineering and Technology Bulletin 65, CPUC General Order 95 or American National Standards Institute C95.2 for color, symbol, and content conventions. All such signage shall at all times provide a working local or toll-free telephone number to its network operations center, and such telephone number shall be able to reach a live person who can exert transmitter power-down control over this site as required by the FCC.

39. In the event that the FCC changes any of radio frequency signage requirements that are applicable to the project site approved herein or ANSI

Z535.1, ANSI Z535.2, and ANSI C95.2 standards that are applicable to the project site approved herein are changed, the permittee, within 30 days of each such change, at its own cost and expense, shall replace the signage at the project site to comply with the current standards.

40. The permittee shall maintain the paint, color and finish of the facility in good condition at all times.

41. All improvements, including foundations, and appurtenant ground wires, shall be removed from the property and the site restored to its original pre-installation conditions within 90 days of cessation of operation or abandonment of the facility.

Build-Out Conditions.

42. Permittee shall not commence any excavation, construction, installation or other work on the project site until and unless it demonstrates that the project complies with these Conditions along with all applicable laws, regulations, codes and other rules related to public health and safety, including without limitation all applicable provisions in California Public Utilities Commission General Order 95 and this Chapter.

43. To the extent that a pole owner or any provision in the County Code or Guidelines require greater or more restrictive standards than California Public Utilities Commission General Order 95, if applicable, those standards shall control.

44. Permittee shall at all times maintain compliance with all applicable federal, State and local laws, regulations, ordinances and other rules, including Americans with Disabilities Act (ADA) requirements and Title 22, Chapter 22.182.

45. The permittee shall cooperate with all inspections. The county and its designees reserve the right to support, repair, disable or remove any elements of the facility in emergencies or when the facility threatens imminent harm to persons or property.

46. Permittee shall at all times maintain accurate contact information for all parties responsible for the facility, which shall include a phone number, street mailing address and email address for at least one natural person. All such contact information for responsible parties shall be provided to the Department of

Regional Planning at the time of permit issuance and within one business day of permittee's receipt of county staff's written request.

47. Permittee shall undertake all reasonable efforts to avoid undue adverse impacts to adjacent properties and/or uses that may arise from the construction, operation, maintenance, modification and removal of the facility.

48. The site and the facility must be maintained in a neat and clean manner and in accordance with all approved plans and conditions of approval.

49. Permittee shall promptly remove any graffiti on the wireless facility at permittee's sole expense within 48 hours after notice.

Prior to Operation

50. The applicant shall request a final Department of Regional Planning inspection and final building inspection immediately after the wireless facility has been installed and prior to the commencement of services.

51. Within thirty (30) calendar days following the installation of any wireless communications facilities, the applicant shall provide to the Department of Regional Planning with a field report prepared by a qualified engineer verifying that the unit has been inspected, tested, and is operating in compliance with FCC standards. Specifically, the on- site post-installation radiofrequency (RF) emissions testing must demonstrate actual compliance with the FCC OET Bulletin 65 RF emissions safety guidelines for general population/uncontrolled RF exposure in all sectors. For this testing, the transmitter shall be operating at maximum operating power, and the testing shall occur outwards to a distance where the RF emissions no longer exceed the uncontrolled/general population limit. Such report and documentation shall include the make and model (or other identifying information) of the unit tested, the date and time of the inspection, a certification that the unit is properly installed and working within applicable FCC limits, and a specific notation of the distance from the transmitter at which the emissions are equal to or less than the uncontrolled/general population limit.

52. The operation of the approved facility shall commence no later than one (1) month after the county completes its post-installation inspections of the facility, any issues with the facility are resolved, and the county receives the RF

testing report required in the condition of approval above, or the development or conditional use permit will expire without further action by the county.

Fixed Conditions

53. Violation of any of the conditions of this approval shall be cause for revocation and termination of all rights thereunder.

Eligible Facilities Requests

All permits for an eligible facilities requests shall be subject to the following conditions and all of the other conditions of approval placed on a Ministerial Permit or Conditional Use Permit, unless modified by the review authority:

54. Any permit granted in response to an application qualifying as an eligible facilities request shall be subject to the terms and conditions of the underlying permit.

55. The county's grant or grant by operation of law of an eligible facilities request permit constitutes a federally-mandated modification to the underlying permit or approval for the subject tower or base station. Notwithstanding any permit duration established in another permit condition, the county's grant or grant by operation of law of a eligible facilities request permit will not extend the permit term for the underlying permit or any other underlying regulatory approval, and its term shall be coterminous with the underlying permit or other regulatory approval for the subject tower or base station.

56. The county's grant or grant by operation of law of an eligible facilities request does not waive, and shall not be construed to waive, any standing by the county to challenge Section 6409(a) of the Spectrum Act, any FCC rules that interpret Section 6409(a) of the Spectrum Act, or any modification to Section 6409(a) of the Spectrum Act.

Small Cell Facilities

In addition to the other conditions of approval placed on a Ministerial Permit or Conditional Use Permit, all permits for a small cell facility shall be subject to the following additional condition, unless modified by the review authority:

57. The county's grant of a permit for a small cell facility request does not waive, and shall not be construed to waive, any standing by the county to challenge any FCC orders or rules related to small cell facilities, or any modification to those FCC orders or rules.

58. The permittee and the personal wireless facility shall comply with Americans with Disabilities Act (ADA) requirements and Title 22, Chapter 22.182.

~~KL~~. Waivers.

1. For ~~personal~~ wireless ~~service~~ facilities subject to Subsection ~~CDD~~.2, above, the Commission or Hearing Officer may grant a waiver to one or more of the development standards in this Section if the Commission or Hearing Officer determines that the applicant has established ~~through clear and convincing evidence~~ that the denial of an application would:

a. Prohibit or effectively prohibit the provision of personal wireless services pursuant to 47 U.S.C. § 332(c)(7)(B)(i)(II);

b. Otherwise violate applicable laws or regulations; or

~~c.~~ Require a technically infeasible design or installation of a wireless facility.

2. When a determination is made to grant a waiver, one or more of the applicable design or location standards may be waived, but only to the minimum extent required to avoid the prohibition, violation, or technically infeasible design or installation, and that does not compromise public safety.

SECTION 14. Section 22.250.010 is hereby amended to read as follows:

22.250.010 Filing Fees and Deposits.

A. For the purpose of defraying the expense involved in connection with any application or petition required or authorized by this Title 22, the following fees, as provided in Table 22.250.010-A, below, shall accompany the application or petition. Table 22.250.010-A may be referred to as the Filing Fee Schedule.

TABLE 22.250.010-A: FILING FEE SCHEDULE		
...	...	
Site Plan Review, Ministerial

	<u>Small cell wireless facilities on existing structures – for up to five facilities</u>	<u>\$500</u>
	<u>Small cell wireless facilities on existing structures– for each facility beyond the first five facilities</u>	<u>\$100</u>
	<u>Small cell wireless facilities on new structure – for each new structure</u>	<u>\$1,000</u>
...

~~Table 22.250.010-A may be referred to as the Filing Fee Schedule.~~

SECTION 15. Severability. If any section, subsection, provision, sentence, clause, phrase or word of this Ordinance is for any reason held to be illegal or otherwise invalid by any court of competent jurisdiction, such invalidity shall be severable, and shall not affect or impair any remaining section, subsection, provision, sentence, clause, phrase or word included within this Ordinance, it being the intent of the County that the remainder of the Ordinance shall be and shall remain in full force and effect, valid, and enforceable.

ATTACHMENT

TITLE 16 ORDINANCE – Fiber First Revisions to Proposed Ordinance

ORDINANCE NO. _____

An ordinance amending the Los Angeles County Code, Title 16 – Highways to establish regulations for small cell personal wireless service communication facilities in highways.

The Board of Supervisors of the County of Los Angeles ordains as follows:

SECTION 1. Chapter 16.25 is hereby added to Title 16 (Highways) of the County Code to read as follows:

CHAPTER 16.25 SMALL CELL WIRELESS COMMUNICATION FACILITIES

16.25.010 Purpose and Scope.

The purpose of this chapter is to establish procedures and standards for the installation and modification of Personal Wireless Service small cell wireless communication facilities (SCF) and Eligible Facilities Requests (EFRs) associated with a SCF located within a Highway as defined in highways-Section 16.04.100. Wireless facilities, including temporary wireless facilities, that are not SCF or Eligible Facilities pertaining to an SCF must comply with applicable provisions of Title 22 (Planning and Zoning) of the Los Angeles County Code, other applicable laws, ordinances and regulations, and obtain required approvals from county departments and public agencies. This chapter and Chapter 22.14 should be construed in pari materia.

16.25.020 Definitions.

The terms as used in this chapter are defined as follows:-, but should be read in pari materia with the definitions contained in Section 22.14.230-W:

A. Applicant. "Applicant" means a person or entity applying for a permit pursuant to this chapter to install, maintain, modify or remove SCF or Eligible Facilities pertaining

to an SCF within a Highway ~~to provide Personal Wireless Service.~~

B. Base station. "Base station" means a structure or equipment, as defined in 47 C.F.R. § 1.6100(b)(1), or any successor provision, at a fixed location within a Highway that enables FCC-licensed or authorized SCF wireless communications between user equipment and a communications network. This term does not include a tower or any equipment associated with a ~~tower~~.

C. C.F.R. "C.F.R." means the Code of Federal Regulations and references to such provisions in this chapter also includes successor provisions to those cited.

D. County infrastructure. "County infrastructure" means county-owned property, structures, objects, and/or equipment located within highways a Highway as defined in Section 16.04.100, including without limitation, free standing streetlights, traffic signals, and pedestrian lights.

E. Eligible Facilities Request. "Eligible facilities request" or "EFR" means a request for modification of an existing tower or base station that does not substantially change the physical dimensions of that tower or base station, and involves collocation, removal, or replacement of transmission equipment, as defined in 47 C.F.R. § 1.6100(b)(3) and within the meaning of the Spectrum Act or any successor provisions~~.~~
For the purposes of eligible facilities requests, collocation is as defined in 47 C.F.R. § 1.6100(b)(2), or any successor provisions.

F. FCC. "FCC" means the Federal Communications Commission or its lawful successor.

G. Owner. "Owner" means the party responsible for the SCF or Eligible Facility who is authorized to control and maintain the SCF or Eligible Facility, including the owner, licensee, or any other party who has authority and control over the SCF or Eligible Facility

and their successors and/or assigns.

H. Permittee. "Permittee" means any person or entity granted a permit in accordance with this chapter.

I. Personal wireless services. As defined in 47 U.S.C. Section 332(c)(7)(C)(i), or any successor provision, commercial mobile services, unlicensed wireless services, and common carrier wireless exchange access services.

J. Small cell wireless communication facility or SCF. "Small cell wireless communication facility" or "SCF" means a "small wireless facility" as defined in 47 C.F.R. 1.6002(l), and in any successor provisions: and meets the conditions:

1. The facility is mounted on a structure up to 50 feet in height, including antennas, as defined in 47 C.F.R. Section 1.1320(d), or is mounted on a structure and extends no more than 10 percent in height above other adjacent structures, whichever is greater;

2. Each antenna associated with the facility, excluding associated antenna equipment (as defined under "antenna" in 47 C.F.R. Section 1.1320(d)), is no more than three cubic feet in volume;

3. All other wireless equipment associated with the structure, including the wireless equipment associated with the antenna and any pre-existing associated equipment on the structure, is no more than 28 cubic feet in volume;

4. The facility does not require antenna structure registration under 47 C.F.R.

Part 17;

5. The facility is not located on Tribal lands, as defined under 36 C.F.R. Section 800.16(x); and

6. The facility does not result in human exposure to radiofrequency radiation in excess of the applicable safety standards specified in 47 C.F.R. Section 1.1307(b).

K. Substantial change. As defined in 47 C.F.R. Section 1.6100(b)(7).

K.L. Support structure. As defined in 47 C.F.R. Section 1.6002(m) for “structure”, a pole, tower, base station, or other building, whether or not it has an existing antenna facility, that is used or to be used for the provision of personal wireless service (whether on its own or comingled with other types of services). “Support structure” includes county infrastructure, streetlights, towers or utility poles.

L.M. Temporary SCF. “Temporary SCF” means an SCF intended or used to provide personal wireless services on a temporary or emergency basis, such as a large-scale special event in which more users than usual gather in a single location or following a duly proclaimed local or state emergency as defined in California Government Code Section 8558 requiring additional service capabilities. Temporary SCFs include without limitation, cells on wheels, sites on wheels, cells on light trucks, or other similar wireless facilities: (1) that will be in place for no more than six months (or such other longer time as the County may allow in light of the event or emergency); (2) for which required notice is provided to the FAA; (3) that do not require marking or lighting under FAA regulations; (4) that will not exceed the height limit in the applicable zone; and (5) that will either involve no excavation or involve excavation only as required to safely anchor the facility, as approved by the road commissioner.

M.N. Tower. “Tower” A structure that is built for the sole or primary purpose of supporting any FCC-licensed or authorized antennas as defined in 47 C.F.R. § 1.6100(b)(9), including on-site fencing, equipment, switches, wiring, cabling, power sources, shelters, or cabinets associated with that tower but not installed as part of an antenna. This definition does not include utility poles or light poles.

O. zz Wireless facility. The antenna facility used for the provision of personal wireless services at a fixed location, including, without limitation, any associated support

structure(s).

16.25.030 Permit required.

A. Permit. A permit issued pursuant to this chapter is required to authorize the installation, replacement, maintenance, modification or removal of any SCF in a Highway, including any temporary SCF, and any ~~eligible facilities requests~~ EFRs pertaining to an SCF that received approval pursuant to this Division 1. All other ~~eligible facilities requests~~ EFRs should be made pursuant to Title 22, ~~Chapter 22.14.140 and Chapter 22.158, as~~ applicable.

B. General Conditions: The general conditions for issuance of a permit under this section shall be the general conditions contained in Chapter 22.140.700 Wireless Facilities Section D.

C. Application-- Procedure

1. Application submittal. An applicant for an SCF shall submit an application for a permit on forms provided by the road commissioner, containing all information that is required in this chapter ~~and in~~, section 16.08 of this Division 1 and Section 22.141.700.D.4, and providing payment of all application fees required pursuant to this Division 1. The applicant shall identify the written approval for use of the support structure or base station proposed for SCF consistent with section 16.25.060 and provide supportive documentation to the satisfaction of the road commissioner.

2. Design guidelines and permit checklist. The road commissioner may develop and issue design guidelines for SCFs, permit conditions for SCFs and EFRs, and permit checklists for SCFs and EFRs implementing the provisions of this chapter. The completed permit application and checklists for SCFs and EFRs shall demonstrate compliance with this chapter ~~for the application to be deemed complete, and those guidelines.~~

3. Installation The application shall contain detailed engineering plans, sealed by a California licensed professional engineer. The plans shall include, at minimum:

- a. Address;
- b. GIS coordinates;
- c. a list of county infrastructure. If the SCF is all associated equipment necessary for its operation;
- d. a one-line diagram of the electrical system;
- e. load calculation;
- f. plot plan showing the location of the service disconnecting means;
- g. short circuit and coordination study ("SCCS") calculated pursuant to be mounted on new the IEEE 551-2006: Recommended Practice for Calculating AC Short-Circuit Currents in Industrial and Commercial Power Systems or replacement county infrastructure, engineered plans shall be submitted for approval by the latest version of that standard. The study must demonstrate the protection devices will ensure the equipment enclosure will not be breached. The SCCS must include analysis of Voltage Transient Surges due to contact of conductors of different voltages;
- a.h. sufficient information for the road commissioner or his designee to verify that the facility will comply with all applicable zoning and safety codes and provisions, including but not limited to Title 22 (Planning and Zoning), the Electrical Code (Title 27), Mechanical Code (Title 29), Fire Code Title 32, and Building Code (Title 32);
- i. a demonstration that the SCF and its supporting facility will meet APCO

ANS 2.106.1, Public Safety Grade Site Hardening Requirements.

3.4. Emergency work. For emergency SCF work, the permit application shall be submitted no later than one business day after the emergency SCF work is commenced.

4.5. Incomplete application. An application will be screened for completeness in conformity with this chapter, and applicable law, including any FCC-issued order(s). If the application is incomplete, the road commissioner shall notify the applicant in writing and specify the information or material(s) omitted from the application in a timely manner pursuant to any applicable law or order.

6. Notice and opportunity for hearing. The road commissioner shall verify that notice consistent with that required by Government Code Sections 65090-65094 and as provided by Section 22.222.110 is provided, using the Notification Radius provisions in Section 22.222.150.B. Notice pursuant to Government Code Section 25537 shall also be required. The road commissioner shall conduct a hearing prior to any issuance of the requested permit, using the procedures set out in Section 22.228.040.

5.7. Processing. An application shall be processed within the time period as specified by applicable law, including any FCC-issued order(s), in accordance with all applicable requirements and procedures for a permit identified in Title 16 – Highways, Division 1 – Highway Permits.

6.8. Decision on permit application. The road commissioner shall grant a permit when the road commissioner is satisfied that the SCF or EFR meets all applicable requirements for a permit under this chapter. Permits processed and granted pursuant to this chapter are subject to all provisions of Title 16 – Highways, Division 1 – Highway Permits, including the requirements of this chapter and any permit conditions imposed by

the commissioner. ~~The denial of a permit application shall be issued in writing and state the reasons for denial.~~ The road commissioner shall issue findings and decisions consistent with the requirements in Section 22.22.200. Provided, the road commissioner shall provide a notice to the supervisorial district office in which the property is located at least five working days prior to grant and issuance of the permit.

~~7.9.~~ Final decision. The road commissioner's decision on an application submitted pursuant to this Chapter shall be the final action of the county-, subject to any objection by the supervisorial district office in which the property is located within five working days pursuant to Government Code Section 25537(c)(3). In the event of such objection and consistent with Government Code 25537 and 25538.1, the permit shall be subject to final approval by the board of supervisors at a regular meeting.

GD. County authority over Highways. The county's grant of a permit for a SCF or EFR does not waive, and shall not be construed to waive, any claims, authority or standing by the county to challenge any FCC orders or rules related to SCF or EFR in a Highway.

16.25.040 Other requirements.

A. ~~A.~~ Other applicable permits. Prior to the issuance of a permit for a SCF or EFR, the applicant shall obtain all required county and public agency permits and approvals, as applicable-, except that, consistent with Section 22.140.B, a ministerial or conditional use permit under Section 22.140.D.1 or 2 is not required.

B. 4. Issuance of a permit for SCF or EFR issued under this Title does not excuse the applicant from any requirement to obtain the necessary approvals from any other authority, including but not limited to required permits or approvals from a municipality within the county.

B.C. Regional Planning. A SCF or EFR on a ~~new~~ support structure located or to be located in a Highway identified as a Scenic Highway in the County General Plan, or to be located within the boundaries of a Coastal Zone or Significant Ecological Area, or within 50 feet of a Significant Ridgeline, as described in Title 22 of the county code, shall obtain land use approvals from Regional Planning.

C.D. Pre-existing SCF in the Highways. Any existing SCF in a Highway as of the adoption date of this chapter shall remain subject to the provisions of the county code and any applicable master license agreement or authorization in effect prior to this chapter, unless and until the agreement or authorization for such SCF to remain in the Highway expires, at which time the provisions of this chapter shall apply. Notwithstanding the above, any existing SCF in a Highway is subject to provisions of Title 16 – Highways, Division 1 – Highway Permits of the county code.

D.E. Public use. Except as otherwise provided by applicable law, any use of a Highway or county infrastructure authorized pursuant to this chapter is subordinate to the county's use and use by the public.

E.F. Order of use. To the extent feasible, the SCF shall utilize support structures in this order of preference: 1. Existing support structures, other than traffic signal poles; 2. Replacement support structures; 3. Traffic signal poles; 4. New ~~towers.~~ support structures.

F.G. Compliance with law, permits and agreements. SCF owners and permittees shall comply with all applicable federal, state and local laws, regulations, and other rules, permits, conditions, and any agreement with the county related to SCF.

H. Consistency with Comprehensive EIS under CEQA/NEPA. All permits under this Section require a finding of consistency with any programmatic EIS prepared

pursuant to NEPA or CEQA. If the permitting authority and applicant believe the proposed project is Categorically Exempt or subject to a Negative Declaration, it shall provide an Interim Analysis demonstrating a good faith effort to justify such claim.

16.25.050 Development Standards for SCFs.

In order to obtain a permit, SCFs shall comply with the following development standards and the design guidelines and checklist developed by the road commissioner pursuant to section 16.25.030.B.2:

A. ~~A.~~—Support structure concealment. All SCFs shall be stealth, meaning designed to look like something other than a wireless facility. The SCF and associated equipment, including antennas, radios, and cables, shall be concealed on or within the support structure, consistent with the design guidelines for SCF.

B. ~~B.~~—Location.

1. Preferred Locations. To better assist applicants, minimize unnecessary visual clutter, promote safety and limit other impacts to aesthetics and community character, the preferred locations for personal wireless service facilities are as follows:

a. Most Preferred: Industrial zones

b. Less Preferred: Commercial zones

c. Least Preferred: Residential & Rural Zones

2. Applications that seek a permit involving a Least Preferred location may be approved if the applicant proves with clear and convincing evidence that the denial of an application would prohibit or effectively prohibit the provision of personal wireless services pursuant to 47 U.S.C. § 332(c)(7)(B)(i)(II) or otherwise violate applicable laws or regulations.

4.3. The location or placement of SCF shall not interfere with the use of the Highway; impede the flow of vehicular or pedestrian traffic; impair the primary use and

purpose of traffic signals, streetlights, utility poles, other support structures, signs, or other county infrastructure in the Highway; interfere with outdoor dining areas or emergency facilities; or otherwise obstruct the accessibility of the Highway. SCFs and associated equipment in the Highway shall comply with Americans with Disabilities Act (ADA) requirements~ [and Title 22, Chapter 22.182.](#)

[2.4.](#) Temporary facilities. In addition to the standards set forth in this section, temporary SCFs shall be located at least six feet from existing wireless communication facilities, support structures, or county equipment, and comply with Americans with Disabilities Act (ADA) requirements.

C. Structural integrity. All SCFs shall comply with applicable utility facilities construction standards including but not limited to California Public Utilities Commission General Order 95, [and APCO ANS 2.106.1, Public Safety Grade Site Hardening Requirements](#) or [their](#) successor provisions. A SCF and its associated equipment to be mounted on an existing support structure shall not compromise the structural integrity of the support structure. If the SCF or its equipment to be mounted on the support structure affects its structural integrity, a replacement support structure shall be installed that will accommodate the SCF and its associated equipment. If the proposed new or replacement support structure is county infrastructure, the structure shall adhere to all terms, conditions, and guidelines of any agreement or master license agreement between the county and the owner. If any SCF is requested to be placed on county infrastructure, then a structural analysis of the effect of such placement on the county infrastructure, including wind impacts on traffic signal poles and mast arms of traffic signals, shall be provided for review and approval to ensure there is no overburden on county [infrastructure.](#)

~~infrastructure.~~

D. Height. The combined height of the support structure and antenna(s) for a SCF shall not exceed the lesser of:

1. The height limitation in 47 C.F.R. 1.6002(l), and any successor provisions, or
2. The height of other support structures in the surrounding area, or
3. The height limit of the zone in which the new or replacement support structure is to be located.

In no event shall the antenna(s) on the support structure be placed lower than eight feet above the ground.

E. ~~E.~~ Placement of pole-mounted antennas and associated equipment.

1. Streetlights. Antennas or other associated equipment to be mounted on or integrated in a streetlight shall be placed in a manner that does not block or otherwise impede the illumination of the lighting to the ground.

2. Utility poles. If a cross-arm is the only technically feasible option to mount SCF and any associated equipment on a utility pole, then each side-arm assembly shall not extend further than four feet from the center of the pole in either direction. A ~~crossarm~~cross- arm shall not exceed a total length of eight feet. No additional extensions or mounting equipment are permitted between the side-arm and the pole. Antennas or associated equipment to be mounted on or integrated in a utility pole shall be placed in a manner that does not block or otherwise impede the illumination of street lighting to the ground.

3. All antennas or associated SCF equipment shall be installed at least five feet from any existing radio equipment on county infrastructure. If the county requires radio equipment to be installed on the support structure, the SCF antenna(s) and its

associated equipment shall be relocated to maintain the five feet separation at the cost of the permittee and/or owner.

F. Power supply. Co-mingling or sharing circuits used for county power service is prohibited.

G. Prohibition of generators. Separate, above-ground generators for SCFs shall be prohibited in any Highway.

H. Lighting. No SCF shall contain artificial lighting that is in addition to any existing illumination provided by the support structure, such as a streetlight luminaire, unless otherwise required by applicable county, state or federal regulations.

I. Strand mounting. Strand mounted antennas are prohibited.

I.J. Waiver of Development Standards.

1. Requests for waivers of any development standards identified in this section shall be made in writing to the road commissioner. A deposit pursuant to Chapter 16.10.130 shall be collected for a waiver request for consideration by the road commissioner to cover the county's review and processing costs.

2. The road commissioner may grant a waiver of the development standards if the applicant establishes ~~to the satisfaction of the road commissioner~~with clear and convincing evidence that the denial of such request would:

- a. Prohibit or effectively prohibit the provision of personal wireless services;
- b. Violate applicable laws, regulations or the written agreement or master license agreement with the county; or
- c. Require a technically infeasible design or installation of SCF.

When a waiver is granted by the road commissioner, the waived development

standard(s) may be waived only to the minimum extent required to avoid the prohibition, violation or technically infeasible design or installation, as determined by the road commissioner.

3. The road commissioner may deny a waiver request upon determining any one of the following apply:

- a. The request does not satisfy any condition in subsection I.2,
- b. A waiver from one or more development standards would result in a violation of applicable legal requirements, or
- c. The development standard is needed to maintain public safety or public use.

16.25.060 Authority to use Support Structures.

A. County Infrastructure. The placement of SCFs on county infrastructure in the Highway shall be subject to a written agreement or master license agreement with the county. The agreement shall specify the compensation to the county for use of the county infrastructure, including additional maintenance costs incurred by the county due to the placement of the SCF and associated equipment on county infrastructure. Any person or entity seeking an agreement or master license agreement with the county shall reimburse the county for all costs incurred in connection with its review of, and action upon such request. Such agreement or master license agreement shall be signed by the county and the owner prior to the issuance of a permit on county infrastructure pursuant to this chapter. Every agreement or master license agreement approved by the county for placement of SCF in the Highway shall be granted upon and be subject to such rules, regulations, restrictions, terms and conditions as are incorporated therein by reference, and except as otherwise expressly provided in the agreement or master license

agreement, is subject to the rules, regulations, restrictions, terms and conditions set forth in this chapter.

B. Other Support Structures. The placement of SCF on support structures in the Highway that is not county infrastructure shall be authorized by the entity that owns, operates and/or controls the support structure.

16.25.070 Violations, unpermitted facilities, revocations and relocations.

A. Violations. Any violation of this chapter, [including violations of federal, state, and country laws](#), by a permittee or owner shall be subject to the same penalties described in Chapter 16.28 of the county code. Penalties for violations of any agreement or master license agreement between the owner and the county, if applicable, are in addition to penalties for violations of the county code.

B. Unpermitted facilities. A SCF installed without a permit and/or authorization to utilize the support structure consistent with section 16.25.060, shall be removed within 90 days, following the issuance of a written notice from the road commissioner, or as otherwise determined by the road commissioner; provided that the support structure owned by the county, a utility, or other entity authorized to maintain the support structure in a Highway need not be removed, but the structure shall be restored to its condition prior to such unpermitted work, except as specifically allowed by the county. A permit shall be required for the removal of such SCF. All costs incurred by the county in connection with the removal shall be paid for by the owner.

C. Revocations. A permit may be revoked for failure to comply with applicable standards, law, or the agreement with the county. Upon revocation, the SCF shall be removed at the expense of the owner or permittee within 90 days or as determined by the road commissioner, or in accordance with the terms and conditions of a license

agreement between the owner and the county.

D. Relocations. A SCF shall be relocated within 90 days of a request by the county when the road commissioner determines a paramount need of the county, due to a change in street alignment, construction, expansion, permanent closure of a street, sale of county property, public improvement project, or other determination by the road commissioner. The owner of the SCF shall relocate the equipment at its own expense to an alternative location. Required permit(s), and other approvals as applicable, shall be obtained prior to relocation.

SECTION 3. Severability. If any section, subsection, provision, sentence, clause, phrase or word of this Ordinance is for any reason held to be illegal or otherwise invalid by any court of competent jurisdiction, such invalidity shall be severable, and shall not affect or impair any remaining section, subsection, provision, sentence, clause, phrase or word included within this Ordinance, it being the intent of the county that the remainder of the Ordinance shall be and shall remain in full force and effect, valid, and enforceable.

Subject: Vote NO on Dec. 6 to the Proposed Changes to Titles 16 and 22 (Agenda Item 80)

Message:

I oppose the proposed changes to Titles 16 and 22 of the L.A. County Code. Please vote NO on Dec. 6, and instead adopt the redline for Titles 16 and 22 that was submitted by Fiber First L.A.

I do not want a cell tower installed right outside my home without any prior notice, public hearing or opportunity to appeal, without any fire or safety scrutiny before the towers are built or without regard to critical environmental protections that keep us all safe. This sort of 'stealth installation' has been proceeding in my neighborhood and other nearby areas during the recent 'lockdowns' in particular, and I object to that having been done, particularly without public consultation. It is detrimental to health that these have been installed within incorporated cities in the county, such as where I live, and the negative effects should not be extended to unincorporated county areas. I demand that the following protections be implemented in regard to the proposed installation of wireless communications infrastructure, at minimum:

■ **Safeguard Due Process Rights:** The radiation emitted from cell towers is not safe for humans or the environment — therefore the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.

■ **Protect Us From Telecom Wildfires:** In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires and they cannot be fought until the grid has been cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of fire. The proposed revisions allow cell towers to be too close to homes, schools and daycare centers.

■ **Stick to Facts:** In case of emergency, should there be a loss of electricity, 911 calls would depend solely, or majorly, upon the macro towers that are already backed up (or are supposed to be ... are they in reality?) per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.

■ **Fiber First:** Invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections (or coaxial cable/equivalent "wired" as a second choice) rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Wireless technology utilizes at least ten times more power compared to wired technologies and is always slower, less reliable, and less secure than permanently-installed wired or wired-equivalent (e.g. fiber) communication infrastructure, and unnecessarily increases our general exposure to radiation sources which are never beneficial, always detrimental to health of living beings (except where deliberately and carefully applied by therapists in clinical settings).

Prioritize the health and safety of residents and the protection of the environment.
Please vote NO.

Dear Board of Supervisors, Vote No on item #80. NO to amendments of Title 16 and 22.

I don't believe you intend to harm your constituents and our environment. The planning commission staff and the telecom industry have gotten you to think that by passing these awful ordinances, you'll be making things better, like giving 911 emergency access or closing the digital divide or that the county is violating FCC regulations, NO TRUE!

However, if you pass these ordinances, you will be stripping constituents and our environment from VITAL rights. You will then be responsible and liable for not closing the digital divide, for consequences of electrical fires, polluting our environment, and bringing health harm, especially to our children.

I used to run a community garden but we were bullied, by Verizon and East LA Community Corporation, who sent Armed Guards, Yes armed guard and six police officers, to remove a small group of parents, grandparents, and children just to build a cellphone macro tower, DON'T LET THEM BULLYED YOU, STAND WITH YOUR PEOPLE, VOTE NO ON ITEM 80!

do not let telecom and planning staff bully you!! Vote No on item 80!