Hello Students,

This resource packet includes a project that you can work on independently at home. You should also have project packets for some of the other courses you are enrolled in. These projects are standards-aligned and designed to meet the Remote Learning instructional minutes guidelines by grade band.

High school project packets are available for the following courses:

- English 1
- Algebra
- Biology
- US History
- English 2
- Geometry
- Chemistry
- World Studies
- English 3
- Algebra 2
- Physics
- Civics
- English 4

### HS Physics Project 3: Are new 5G networks safe for widespread use? (Part 2 of 2)

<table>
<thead>
<tr>
<th>Estimated Time</th>
<th>~225 minutes</th>
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<tbody>
<tr>
<td><strong>Grade Level Standard(s)</strong></td>
<td>HS-PS4-4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.</td>
</tr>
</tbody>
</table>
| **Caregiver Support Option** | ● Supporting reading of texts and evaluating the quality of each source in investigation three  
● Supporting constructing a scientific argument in the conclusion of the task. |
| **Materials Needed** | Writing Utensil, Paper/Notebook, Calculator |
| **Question to Explore** | Are new 5G networks safe for widespread use? |
| **Student Directions** | Students will use several different investigations into the nature of waves to determine if 5G networks are safe. More detailed directions are given in the task. Please write ALL responses on a separate sheet of paper or in your notebook. |

Lesson Credits - Phenomenon Introduction Adapted From: [HowToGeek: How Worried Should You Be About the Health Risks of 5G](https://www.howtogeek.com/) and [LiveScience: 5G Network - How It Works, and Is It Dangerous?](https://www.livescience.com/5g-network-works-dangers.html)
Introductory Activity: Evaluating Claims on the Safety of 5G Networks

The fifth generation of cellular technology, abbreviated 5G, aims to provide the next great leap in speed for wireless devices. This speed includes both the rate mobile users can download data to their devices and the latency, or lag, they experience between sending and receiving information. 5G aims to deliver data rates that are 10 to 100 times faster than current 4G networks. Users should expect to see download speeds on the order of gigabits per second (Gb/s), much greater than the tens of megabits per second (Mb/s) speeds of 4G.

"That's significant because it will enable new applications that are just not possible today," said Harish Krishnaswamy, an associate professor of electrical engineering at Columbia University in New York. "Just for an example, at gigabits per second data rates, you could potentially download a movie to your phone or tablet in a matter of seconds. Those type of data rates could enable virtual reality applications or autonomous driving cars." Mobile devices will be able to send and receive information in less than one-thousandth of a second, appearing instantaneous to the user. To accomplish these speeds, the rollout of 5G requires new technology and infrastructure. Several new 5G towers will need to be installed throughout the country to produce the new signal.

However, the introduction of 5G is currently raising concerns that there are significant health risks with this new, more powerful network. By now, you may have seen articles on Facebook or posts on other social media that claim that 5G is a dangerous escalation of traditional cellular technology, one packed with higher energy radiation that delivers potential damaging effects on human beings. Some 5G opponents contend that the new network generates radiofrequency radiation that can damage DNA and lead to cancer; cause oxidative damage that can cause premature aging; disrupt cell metabolism; and potentially lead to other diseases through the generation of stress proteins.

The debate about the safety of 5G continues to this day, and both sides of the argument present evidence to support their claims. With this being the case, in this task, we'll investigate the Driving Question, "Are new 5G networks safe for widespread use?"

1. Based on what you figured out in the first packet of this series, what is your current stance on 5G? Do you consider it safe, and would you want it installed in your neighborhood? Write your answer in your notebook.
**Task Overview** - To continue to figure out if the safety of 5G is supported by evidence, you will undergo one additional investigation (as continued from the previous packet) and use evidence from all of your investigations to support an argument on the safety of 5G networks.

**Investigation 3 - How can we evaluate all the different things people are saying about the safety of 5G?** So far, we have investigated what 5G is, where the electromagnetic (EM) radiation it uses falls on the EM spectrum, how different types of EM radiation interact with cells and organisms, and how specific types of EM radiation could potentially impact human health. With all of the new ideas you have uncovered, you will now use them to evaluate the validity and reliability of multiple sources of information regarding 5G wireless technology. To help us get started with this process, it will be helpful to have some guidelines on how to evaluate the reliability and validity of a source in science.

**Evaluating the Reliability And Validity Of Sources**

*Adapted from: University of Georgia - Finding Reliable Sources: What is a Reliable Source?*

A reliable source is one that provides a thorough, well-reasoned argument, discussion, or theory that is based on strong evidence. Not all sources of information are reliable. In fact, there is a large range of reliability of sources in our modern digital media world. The scale below gives some guidelines on how to evaluate the quality and reliability of a source.

- ⭐ ⭐ ⭐ Scholarly, peer-reviewed scientific articles or books that are written by scientific researchers for scholarly students and other researchers. These sources contain primary, original research with an extensive bibliography.
- ⭐ ⭐ Trade or professional articles or books that are written by practitioners in a field to impart practice-oriented information to professionals in the field. Beware of sources on the internet that look like trade/professional articles, but don't have reliable content.
- ⭐ ⭐ Magazine articles, books, and newspaper articles from well-established newspapers that are written for a general audience by authors or journalists who have consulted reliable sources and were vetted through an editor.
  - Newspapers and magazines often contain both researched news stories and editorial/opinion pieces that express the view of the writer. It is important to be able to distinguish between them.
  - Beware of sources on the internet that look like reputable magazines, and newspapers, but don't have reliable content.
  - Note that these sources are secondary sources, meaning they are journalistic interpretations of a primary article. Beware of potential bias or spin in the interpretation of the original source.
- ⭐ ⭐ Stars. Websites, Blogs, and Social Media. These sources can be reliable or unreliable, hoaxes or credible, and unintentional or deliberate misinformation. Researchers and other experts often use blogs and social media as a way to share their knowledge with the general public. However, anyone with computer access can post any idea they want to further any agenda they want. It's up to you to evaluate the quality of what you find in these sources. These sources are particularly notorious for false information.
1. Read through the given set of ten texts located in Appendix C of this packet, and annotate any information that you think will help you understand if 5G is safe or not.

2. After you read through the texts, sort them by how reliable you think they are. Assign them each a reliability rating based on the star system shown on the previous page & justify why you rated each source the way you did. Above the right is an example of a chart you can draw in your notebook. Make sure your chart addresses sources 1-10.

3. Choose 2 texts with the highest reliability rating that you gave that present opposing viewpoints on the safety of millimeter waves in 5G technology. In your notebook answer the following questions in a side by side chart.

<table>
<thead>
<tr>
<th>Source</th>
<th>Reliability Rating</th>
<th>Justify Your Choice of Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
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<tr>
<td>3</td>
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<table>
<thead>
<tr>
<th>Article 1</th>
<th>Article 2</th>
</tr>
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<tbody>
<tr>
<td>Title, Author &amp; Institution</td>
<td></td>
</tr>
<tr>
<td>What Agenda May the Author Have?</td>
<td></td>
</tr>
<tr>
<td>Claim the Author Makes Regarding 5G Safety with 2 pieces of evidence.</td>
<td></td>
</tr>
<tr>
<td>How does the author’s reasoning conflict with or confirm what you already know about how and why 5G is or is not safe?</td>
<td></td>
</tr>
<tr>
<td>Is there anything else that you’re skeptical of or particularly resonated with you?</td>
<td></td>
</tr>
</tbody>
</table>

4. Choose 2 texts with a low or medium reliability rating that you gave that present opposing viewpoints on the safety of millimeter waves in 5G technology. In your notebook answer the following questions in a side by side chart.

<table>
<thead>
<tr>
<th>Title, Author &amp; Institution</th>
<th>Article 1</th>
<th>Article 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>What Biases May Be Present?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Claim The Author Makes Regarding 5G Safety with 2 pieces of evidence.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How does the author’s reasoning conflict with or confirm what you already know about how and why 5G is or is not safe?</td>
<td></td>
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<tr>
<td>Is there anything else that you’re skeptical of or particularly resonated with you?</td>
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</table>

5. From the reliable sources that you identified, what new ideas can you conclude about how and why 5G may or may not be safe? Write your answer in your notebook.
Investigation 4: Engaging in Argument From Evidence - Constructing Final Arguments

Return to the four claims that students were arguing about in the beginning of this task. Choose the claim you think is most supported by the body of evidence you have now analyzed, and write a final argument that states which claim you most support, the evidence that supports this claim, and how and why you think this claim is most supported, including how and why the claim answers the question, “Are new 5G networks safe for widespread use?” Finally, record one alternative claim and provide one piece of evidence and reasoning that refutes this claim.

Complete the following on a separate sheet of paper:

1. **Claim:** Record which of the original claims you think is best supported by the evidence.
2. **Evidence:** Record at least three pieces of specific and appropriate evidence from the data sets analyzed.
3. **Reasoning:** Record how and why you think this claim is most supported, including how body fat is lost and where it goes when it is lost.
4. **Rebuttal:** Record one alternative claim from any of the ten texts provided and provide one piece of evidence and reasoning that refutes this claim.

**Final Reflections**

5. What did you learn from this task about how scientists evaluate sources of information in order to make arguments?
6. How does this task make you think differently about cellular technologies and other technologies that use electromagnetic radiation?
### Appendix A - Glossary

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
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<tbody>
<tr>
<td>5G</td>
<td>The fifth generation of cellular technology; the successor of 4G LTE. Currently being unrolled worldwide with the promise of huge improvements in mobile data speed and capacity.</td>
</tr>
<tr>
<td>Gigabit</td>
<td>A bit is a single piece of digital information (a 0 or a 1). The SI prefix “Giga” means billion (1,000,000,000), so a Gigabit represents one billion binary digits.</td>
</tr>
<tr>
<td>Radio frequency</td>
<td>Frequency is a property of all waves, measured in Hertz, and represents the number of wave cycles per second. Within the electromagnetic spectrum, radio frequency waves have the lowest frequencies, lower than about 300 Gigahertz.</td>
</tr>
<tr>
<td>Electromagnetic spectrum</td>
<td>The electromagnetic spectrum represents all forms of light (electromagnetic radiation), visible or invisible. These are, in order from lowest to highest frequency: radio waves and microwaves, infrared (IR) light, visible light, ultraviolet (UV) light, x-rays, and gamma rays.</td>
</tr>
<tr>
<td>Gigahertz (GHz)</td>
<td>One billion wave cycles per second. $10^9$ Hertz.</td>
</tr>
<tr>
<td>Millimeter waves</td>
<td>The highest frequency radio waves (from about 30GHz to 300GHz). Millimeter waves carry more energy and are more easily absorbed by matter than lower-frequency radio waves. Used in 5G technology and airport security scanners, among other technologies. Also known as “extremely high frequency” (EHF) radio waves.</td>
</tr>
<tr>
<td>Radiation</td>
<td>Radiation may refer to radioactive alpha, beta, and gamma particles; it can also refer to the entire electromagnetic spectrum of light (which includes gamma radiation). In this packet, radiation will refer to the electromagnetic spectrum.</td>
</tr>
<tr>
<td>Ionizing radiation</td>
<td>Electromagnetic radiation with high enough energy to ionize (remove electrons from) matter. Gamma rays and x-rays are ionizing, and some high-frequency UV light is ionizing.</td>
</tr>
<tr>
<td>Non-ionizing radiation</td>
<td>Electromagnetic radiation with insufficient energy to cause ionization in most matter (lower-energy UV light, visible light, IR light, microwaves, and radio waves).</td>
</tr>
</tbody>
</table>
Appendix B: Investigation 10 Sources

Source 1: Facebook Post
Account Identity Anonymized

5G LAW PASSED while everyone was distracted... - S.893 SECURE 5G AND BEYOND ACT OF 2020 - Signed into law 116-129 on 3-23-2020, that will speed up the installation of 5G and protect profits!

Children had to be out of schools for the covert installation. Parents are you seeing what’s happening?

5G is 10,000 times the strength of 4G and uses the same frequency as a military weapon.

Symptoms of 5G radiation sickness include:

- shortness of breath,
- passing out,
- cold and flu symptoms,
- fever,
- increase cancer risk,
- foggy thinking,
- eye pain,
- nightmares,
- nausea,
- vomiting,
- diarrhea,
- headache,
- dizziness,
- disorientation
- weakness,
- fatigue,
- hair loss,
- bloody vomit and stools from internal bleeding
- infections
- low blood pressure

Stay woke people

Source 2 - A Quick Sense-Check on 5G & Health - Available at the Huawei Blog
Company Blog Post By Richard Griffiths. Published on Sept 12, 2019

There’s nothing that the Internet likes more than a good scare story. It’s so easy to generate an endorphin rush and boost your self-esteem by clicking the share button on a post that warns your hundreds of social media connections about the latest health controversy. Following my last post “5G for Beginners,” I have received a number of questions about the safety of 5G on human health. It turns out that the latest craze for Internet scare stories is on the subject of 5G. Like any technology breakthrough, it is right that 5G is scrutinised and rigorously tested
as long as that scrutiny is undertaken and validated by professional scientists. I am not one of these scientists. However I am a rational person who understands the need to check facts and logically assess evidence in context.

5G Is Just An Evolution Of 4G Mobile Radio Technologies - What we call 5G is a collection of improvements in mobile radio and network technologies that together can deliver much higher download speeds and much lower latency through the network than 4G technologies. These improvements are not in themselves ground-breaking new technologies like, for example, DNA Digital Storage that will eventually replace hard drives and flash memory. Because it builds on the knowledge of 2G, 3G, and 4G mobile technologies, 5G is a very well understood evolution of what went before. The clue was in the name given to 4G: Long Term Evolution or LTE. 5G may be New Radio, but it’s a relatively mature technology.

Government Regulators Are Licencing 5G Frequencies - It’s also important to understand that the focus of the Internet’s concerns is not about the 5G standard itself but rather the radio frequencies that are being allocated to it by government regulators worldwide. Many of these radio frequencies have been used for decades already for everything from satellite TV broadcasts to emergency services communications. Government regulators clear these frequencies and allocate them for 5G mobile phones. So before a mobile phone company can do anything with the 5G technology, the frequency is cleared, approved, and licenced by government regulators in markets around the world specifically for use in consumer mobile communications.

5G In Two Frequency Bands - In general, 5G is being licenced in two frequencies: c-band around 3.5 GHz and mm-wave between 30-300 GHz. Most operators around the world are launching 5G in c-band and primarily US operators launching commercial services in mm-wave. Some operators are launching 5G services on the exact same frequencies that are used elsewhere for 2G, 3G, or 4G services. The point is that the term “5G” is meaningless when the Internet actually wants to talk about the characteristics of the different frequencies it utilises. So we will stop talking about 5G and instead talk about radio frequencies.

The Characteristics Of 5G Frequencies - When we get to mm-wave frequencies the signal has no chance of getting through walls, buildings, trees, and sometimes even heavy rain. It does not mean that the radio waves from those sites must be more powerful as we go up the frequencies. It means that operators have to build more and more mobile sites to give the same coverage. In data-hungry South Korean cities, the mobile antennas are only about 300 meters from each other creating a very dense network for the lower 4G frequencies that can also be utilised for the higher 5G frequencies. In other countries, these 4G network sites can be kilometres apart and new ones will be needed for 5G.

5G’s C-band Frequency Is Surrounded By Wi-Fi - Mobile phone signals are classified as “non-ionizing” radio waves- the same as the TV signals that have surrounded us for decades. This means they do not possess enough energy to affect the thing they are passing through or bouncing off. Another non-ionizing radio is Wi-Fi, which also surrounds us. Wi-Fi is interesting because your home router probably transmits in two frequency bands at 2.4 GHz and 5 GHz, neatly sandwiching our 3.5 GHz c-band 5G signals. Wi-Fi operating in these frequencies is everywhere – our bedrooms, coffee shops,
and even airplanes. We complain when it is not present. Yet it sends signals over a frequency that is higher than our new c-band 5G and we happily plug new Wi-Fi routers in our homes to get faster speeds.

**Power-Efficient Antennas** - We discussed how c-band and mm-wave are higher frequencies than those used for previous generations of mobile technology. This means that the antennas themselves are physically smaller and the signal does not reach so far. The answer is not to increase the power of the transmission. This has led to the development of two new types of 5G antenna. The first is the small cell. This, as the name suggests, is a small square unit that looks like a Wi-Fi device that incorporates four 5G transmitters and four receivers. They are deployed indoors at places like airports or sports stadiums where there are high densities of people needing a connection and the physical structure blocks the reception of 5G frequencies. A public building may need thousands of such low-power small cells to provide adequate 5G coverage.

**Conclusion** - Over the last 30 years, there has not been a global epidemic of unexplained physiological illnesses that can be attributed to the ubiquitous use of mobile phones operating on any frequency. This does not mean that we can stop scrutinising new technologies and new uses of radio waves. But it does mean that there’s no specific evidence that we are heading towards a scary unknown universe as depicted by some as a result of 5G. So, in summary, feel free to upgrade your phone to the latest 5G model utilising non-ionising frequencies licenced by your government regulator specifically for mobile communications and employing the latest power-efficient antennas without worry. No matter what the latest Internet meme scares you into believing.

*Huawei Technologies Co., Ltd. is a Chinese multinational technology company. It provides telecommunications equipment and sells consumer electronics, smartphones and is headquartered in Shenzhen, Guangdong, China. Richard Griffiths is the Vice President of Consulting at Huawei.*

**Source 3 - Ten Things You Can Do To Reduce The Cancer Risk From Cell Phones**

**Available At:** [Safer Phone Zone](#)

1. Children should only use cell phones next to their heads for emergencies. Children’s skulls are thinner than adults’ and their brains are still developing. Hence, radiation from cell phones penetrates more deeply into their brains and is likely to cause more damage. Texting (while holding the phone away from their body) is still fine for kids!

2. While talking on your cell phone, try to keep the cell phone away from your body as much as possible. The amplitude of the electromagnetic field (radiation) is one fourth the strength at a distance of two inches and fifty times lower at three feet. Whenever possible, use the speaker-phone mode or a wired headset (not a Bluetooth).

3. Avoid using your cell phone when the signal is weak or when moving at high speed, such as in a car or train, as this automatically increases power to a maximum as the phone repeatedly attempts to connect to a new relay antenna.

4. Avoid carrying your cell phone on your body at all times. Do not keep it near your body at night such as under the pillow or on a bedside table, particularly if pregnant. You can also put it on “flight” or “off-line” mode, which stops electromagnetic emissions.
5. If you must carry your cell phone on you, make sure that the keypad is positioned toward your body and the back is positioned toward the outside so that the transmitted electromagnetic fields move away from you rather than through you.

6. Only use your cell phone to establish contact or for conversations lasting a few minutes, as the biological effects are directly related to the duration of exposure. For longer conversations, use a land line with a corded phone, not a cordless phone, which also uses electromagnetic emitting technology similar to that of cell phones.

7. Switch sides regularly while communicating on your cell phone to spread out your exposure. Before putting your cell phone to the ear, wait until your correspondent has picked up. This limits the power of the electromagnetic field emitted near your ear and the duration of your exposure.

8. When possible, communicate via text messaging rather than making a call, to limit the duration of exposure and the proximity to the body.

9. Avoid using your cell phone in places like a bus, where you can passively expose others to your phone’s electromagnetic fields.

10. Choose a device with the lowest SAR possible (SAR = Specific Absorption Rate, which is a measure of the strength of the magnetic field absorbed by the body). SAR ratings of contemporary phones by different manufacturers are available by searching for “sar ratings cell phones” on the internet.

Source 4 - 5G Wireless Communication and Health Effects—A Pragmatic Review Based on Available Studies Regarding 6 to 100 GHz - Available From: International Journal of Environmental Research and Public Health


The introduction of the fifth generation (5G) of wireless communication will increase the number of high-frequency-powered base stations and other devices. The question is if such higher frequencies (in this review, 6–100 GHz, millimeter waves, MMW) can have a health impact. This review analyzed 94 relevant publications performing in vivo or in vitro investigations. Each study was characterized for: study type (in vivo, in vitro), biological material (species, cell type, etc.), biological endpoint, exposure (frequency, exposure duration, power density), results, and certain quality criteria. Eighty percent of the in vivo studies showed responses to exposure, while 58% of the in vitro studies demonstrated effects. The responses affected all biological endpoints studied. There was no consistent relationship between power density, exposure time, or frequency, and the effects of exposure.

From this observation, however, no in-depth conclusions can be drawn regarding the biological and health effects of MMW exposures in the 6–100 GHz frequency range. The studies are very different and the total number of studies is surprisingly low. The reactions occur both in vivo and in vitro and affect all biological endpoints studied. There does not seem to be a consistent relationship between intensity (power density), exposure time, or frequency, and the effects of exposure.

It is also noteworthy that there is no trend towards a classic dose-response pattern where stronger or more frequent effects would be caused by higher exposure levels. Some authors refer to their study
results as having “non-thermal” causes, but few have applied appropriate temperature controls. The question therefore remains whether warming is the main cause of any observed MMW effects?

In order to evaluate and summarize the 6–100 GHz data in this review, we draw the following conclusions:

- Regarding the health effects of MMW in the 6–100 GHz frequency range at power densities not exceeding the exposure guidelines, the studies provide no clear evidence, due to contradictory information from the in vivo and in vitro investigations.
- Regarding the possibility of “non-thermal” effects, the available studies provide no clear explanation of any mode of action of observed effects.
- Regarding the quality of the presented studies, too few studies fulfill the minimal quality criteria to allow any further conclusions.

In summary, the available studies do not provide adequate and sufficient information for a meaningful safety assessment, or for the question about non-thermal effects. There is a need for research regarding local heat developments on small surfaces, e.g., skin or the eye, and on any environmental impact. Our quality analysis shows that for future studies to be useful for safety assessment, design and implementation need to be significantly improved.

Myrtill Simkó is the Scientific Director at SciProof International in Osterlund, Sweden. She leads, initiates, coordinates, and advises international research projects in the Safety of Emerging Technologies.

Mats-Olof Mattsson is a Senior Executive and Research Scientist at SciProof International in Osterlund, Sweden.

Source 5 - We Have No Reason to Believe 5G Is Safe - Available at Scientific American

Opinion Article By Joel M. Moskowitz, PhD. Published on October 17, 2019

The telecommunications industry and their experts have accused many scientists who have researched the effects of cell phone radiation of “fear mongering” over the advent of wireless technology’s 5G. Since much of our research is publicly-funded, we believe it is our ethical responsibility to inform the public about what the peer-reviewed scientific literature tells us about the health risks from wireless radiation.

The chairman of the Federal Communications Commission (FCC) recently announced through a press release that the commission will soon reaffirm the radio frequency radiation (RFR) exposure limits that the FCC adopted in the late 1990s. Yet, since the FCC adopted these limits based largely on research from the 1980s, the preponderance of peer-reviewed research, more than 500 studies, have found harmful biologic or health effects from exposure to RFR at intensities too low to cause significant heating. Citing this large body of research, more than 240 scientists who have published peer-reviewed research on the biologic and health effects of nonionizing electromagnetic fields (EMF) signed the International EMF Scientist Appeal, which calls for stronger exposure limits. The appeal makes the following assertions:

“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."

The scientists who signed this appeal arguably constitute the majority of experts on the effects of nonionizing radiation. They have published more than 2,000 papers and letters on EMF in professional journals. The World Health Organization's International Agency for Research on Cancer (IARC) classified RFR as "possibly carcinogenic to humans" in 2011. Last year, a $30 million study conducted by the U.S. National Toxicology Program (NTP) found "clear evidence" that two years of exposure to cell phone RFR increased cancer in male rats and damaged DNA in rats and mice of both sexes. The Ramazzini Institute in Italy replicated the key finding of the NTP using a different carrier frequency and much weaker exposure to cell phone radiation over the life of the rats.

Based upon the research published since 2011, including human and animal studies and mechanistic data, the IARC has recently prioritized RFR to be reviewed again in the next five years. Since many EMF scientists believe we now have sufficient evidence to consider RFR as either a probable or known human carcinogen, the IARC will likely upgrade the carcinogenic potential of RFR in the near future.

Nonetheless, without conducting a formal risk assessment or a systematic review of the research on RFR health effects, the FDA recently reaffirmed the FCC's 1996 exposure limits in a letter to the FCC, stating that the agency had "concluded that no changes to the current standards are warranted at this time," and that "NTP's experimental findings should not be applied to human cell phone usage." The letter stated that "the available scientific evidence to date does not support adverse health effects in humans due to exposures at or under the current limits."

The latest cellular technology, 5G, will employ millimeter waves for the first time in addition to microwaves that have been in use for older cellular technologies, 2G through 4G. Given limited reach, 5G will require cell antennas every 100 to 200 meters, exposing many people to millimeter wave radiation. 5G also employs new technologies (e.g., active antennas capable of beam-forming; phased arrays; massive multiple inputs and outputs, known as massive MIMO) which pose unique challenges for measuring exposures. Millimeter waves are mostly absorbed within a few millimeters of human skin and in the surface layers of the cornea. Short-term exposure can have adverse physiological effects in the peripheral nervous system, the immune system and the cardiovascular system. The research suggests that long-term exposure may pose health risks to the skin (e.g., melanoma), the eyes (e.g., ocular melanoma) and the testes (e.g., sterility).

Since 5G is a new technology, there is no research on long-term health effects, so we are "flying blind" to quote a U.S. senator. However, we have considerable evidence about the harmful effects of 2G and 3G. Little is known about the effects of exposure to 4G, a 10-year-old technology, because governments have been remiss in funding this research. Meanwhile, we are seeing increases in certain types of head and neck tumors in tumor registries, which may be at least partially attributable to the proliferation of cell phone radiation. These increases are consistent with results from case-control studies of tumor risk in heavy cell phone users.
5G will not replace 4G; it will accompany 4G for the near future and possibly over the long term. If there are synergistic effects from simultaneous exposures to multiple types of RFR, our overall risk of harm from RFR may increase substantially. Cancer is not the only risk as there is considerable evidence that RFR causes neurological disorders and reproductive harm, likely due to oxidative stress.

As a society, should we invest hundreds of billions of dollars deploying 5G, a cellular technology that requires the installation of 800,000 or more new cell antenna sites in the U.S. close to where we live, work and play? Instead, we should support the recommendations of the 250 scientists and medical doctors who signed the 5G Appeal that calls for an immediate moratorium on the deployment of 5G and demand that our government fund the research needed to adopt biologically based exposure limits that protect our health and safety.

Joel M. Moskowitz, PhD, is director of the Center for Family and Community Health in the School of Public Health at the University of California, Berkeley. He has been translating and disseminating the research on wireless radiation health effects since 2009 after he and his colleagues published a review paper that found long-term cell phone users were at greater risk of brain tumors. His Electromagnetic Radiation Safety website has had more than two million page views since 2013. He is an unpaid advisor to the International EMF Scientist Appeal and Physicians for Safe Technology.

Source 6 - 5G Confirmed Safe By Radiation Watchdog - Available From: The Guardian, a Major British Newspaper By Alex Hern, Technology editor, Published on Thu 12 Mar 2020

5G is safe, according to the international body in charge of setting limits on exposure to radiation, which has updated its advisory guidelines for the first time in more than 20 years. The International Commission on Non-Ionizing Radiation Protection (ICNIRP), the Germany-based scientific body that assesses the health risks of radio broadcasts, called for new guidelines for millimetre-wave 5G, the most high-frequency version of the telecommunications standard.

But in practice, that form of 5G, which is in use in the US and will be coming to Europe, still has output levels significantly below the new maximum. Dr Eric van Rongen, the ICNIRP chair, said: “We know parts of the community are concerned about the safety of 5G and we hope the updated guidelines will help put people at ease. “The guidelines have been developed after a thorough review of all relevant scientific literature, scientific workshops and an extensive public consultation process. They provide protection against all scientifically substantiated adverse health effects due to [electromagnetic field] exposure in the 100 kHz to 300 GHz range.”

The radio frequencies 5G uses in the UK are similar to those that have been used for mobile telephones since 1998, when ICNIRP published its first set of guidelines for EMF exposure. But millimetre-wave 5G, and other broadcast connections above the 6GHz band, “were not anticipated in 1998”, according to Dr Jack Rowley, the senior director for research and sustainability at GSMA, the industry body for mobile network operators.
Higher frequencies interact with organic tissue differently, dissipating more energy at the surface and penetrating less, which means the new standards take measurements across a smaller cross section, and specifically pay attention to the power absorbed by, rather than simply exposed to, a body.

“The most important thing is that the fundamental health risk assessment is unchanged,” Rowley said. “The limits that we had in 1998 are still protective now.”

In practice, both the old and new limits are unlikely to be breached in the conventional operation of a mobile phone network. Exposures from base stations hit about 1% of the maximum, Rowley said, while the testing regime for mobile phone handsets ensured that, when running at the maximum possible power, they hit about 50% of the upper limit. “In our day-to-day usage, however, it’s very similar to the base stations – about 1% of the maximum.”

Despite the overwhelming evidence that 5G, like earlier mobile standards, is safe for the public, a large community of sceptics fear it will cause – or already is causing – health problems, including, supposedly, coronavirus. There is no evidence to support a link between the two.

Source 7 - Twitter Posts - Account Identities Shown in Each Tweet

Donald J. Trump @realDonaldTrump
I want 5G, and even 6G, technology in the United States as soon as possible. It is far more powerful, faster, and smarter than the current standard. American companies must step up their efforts, or get left behind. There is no reason that we should be lagging behind on.........
8:35 AM - 21 Feb 2019

U.S. Dept. of Fear @FearDept - Apr 7
Here’s the most recent scientific review paper on #5G safety (May 2020).

“This article also presents evidence that the nascent 5G mobile networking technology will affect not only the skin and eyes, as commonly believed, but will have adverse systemic effects as well.”

Kostoff RH1, Heroux P2, Ashcroft MP3, Tarassova A4.

Abstract
This article identifies adverse effects of non-ionizing non-visible radiation (hereafter called wireless radiation) reported in the premier biomedical literature. It emphasizes that most of the laboratory experiments conducted to date are not designed to identify the more severe adverse effects reflective of the real-life operating environment in which wireless radiation systems operate. Many experiments do not include pulsing and modulation of the carrier signal. The vast majority do not account for synergistic adverse effects of other toxic stimuli (such as chemical and biological) acting in concert with the wireless radiation. This article also presents evidence that the nascent 5G mobile networking technology will affect not only the skin and eyes, as commonly believed, but will have adverse systemic effects as well.

159
digital.com
The more powerful, shortwave radiation of 5G will bring about more potent health issues, both because of the smaller, more powerful radiation, and also because of the location of

158
The problem is that cell phones and other devices emit electromagnetic fields of

344
292
643

Chicago Public Schools

Highlights
● Identifies a wide-spectrum of adverse health effects of non-ionizing non-visible radiation.
● Most laboratory experiments were not designed to identify the more severe adverse effects reflective of real-life conditions.
● Many experiments do not include the real-life pulsing and modulation of the carrier signal.
● Vast majority of experiments do not account for synergistic adverse effects of other toxic stimuli with wireless radiation.
● 5G mobile networking technology will affect not only the skin and eyes, but will have adverse systemic effects as well.

Abstract - This article identifies adverse effects of non-ionizing non-visible radiation (hereafter called wireless radiation) reported in the premier biomedical literature. It emphasizes that most of the laboratory experiments conducted to date are not designed to identify the more severe adverse effects reflective of the real-life operating environment in which wireless radiation systems operate. Many experiments do not include pulsing and modulation of the carrier signal. The vast majority do not account for synergistic adverse effects of other toxic stimuli (such as chemical and biological) acting in concert with the wireless radiation. This article also presents evidence that the nascent 5G mobile networking technology will affect not only the skin and eyes, as commonly believed, but will have adverse systemic effects as well.

The lead author on this publication, George Kostoff, received a Ph. D. in Aerospace and Mechanical Sciences from Princeton University in 1967, and subsequently worked for Bell Laboratories, the Department of Energy, the Office of Naval Research, and MITRE Corp. He has published over 200 peer-reviewed articles and is presently Research Affiliate at the Georgia Institute of Technology.

Source 9 - There's No Evidence 5G Is Going To Harm Our Health, So Let's Stop Worrying About It - Available From: The Conversation
Published By: Loughran, S. P. (2019). There's no evidence 5G is going to harm our health, so let's stop worrying about it. The Conversation, 2 August 1-3.

Abstract - Hype continues to surround the roll-out of 5G technology in Australia and across the world. While there is promise of faster network speeds, and talk of exciting technologies like driverless cars, there’s also a growing movement to stop the implementation of 5G due to concerns about the
effects it may have on our health. But the scientific evidence we’ve got assures us there’s no reason to worry. The radio frequencies powering 5G will be well below the exposure limits known to cause harm.

What is 5G and How Does it Work? - 5G is the 5th generation of mobile phone technology. All generations of mobile phones work using what’s called electromagnetic energy. The specific type of electromagnetic energy used by mobile phones is known as radiofrequency, sometimes called radio waves.

This type of radiation is non-ionising, so it doesn’t damage our DNA like ionising radiation can, such as that from the sun or x-rays. Ionising means there’s enough energy to remove electrons from the atoms they are attached to. This makes them unstable and is something non-ionising radiation, such as that used by mobile phones, lacks the power to do.

Initially, 5G will use the same type of radio waves as used in 4G. But in the future it will operate at higher frequencies. Higher frequencies allow for faster connections and response times, while also increasing capacity for more users to be connected. The higher the frequency, the shorter the distance the radio waves travel. As the 5G frequencies will be higher than those used by previous mobile phone technologies, a lot more mobile phone base stations will be required.

Much of the public concern has centred around these two new elements – that the frequencies used will be higher, and that there will be more mobile phone base stations. While some people believe these two factors alone will lead to higher exposures, the reality is actually very different. Higher frequencies don’t travel as far, meaning exposure is not as deep as previous generation technologies. This results in more superficial exposures which are mostly absorbed by the skin rather than deeper in the body.

The idea that more base stations lead to higher exposures is also a common misconception. A larger number of base stations will actually provide a more efficient network. This means mobile phones can operate at a reduced power, which is likely to result in reduced overall personal exposure.

Research and Regulation - Importantly, we have no evidence of any established health effects from the exposures related to mobile phones, despite extensive research. This consensus has been reiterated by independent international expert bodies.

We know a lot about how radiofrequency interacts with the human body. Health effects occur from exposure when there is a large rise in body temperature. But this will only be seen at power levels far higher than those used in telecommunications, like from a microwave oven.

The temperature changes associated with mobile phones are very small, especially when compared with normal day-to-day or exercise-induced temperature variations.

5G is the next generation of mobile phone technology, and is currently being rolled out. From shutterstock.com
Exposures from mobile phones and their base stations are tightly regulated. In Australia, safety standards are set by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). These standards are based on the current scientific evidence. They also cover the new frequencies that will be used by 5G. Importantly, the safety limits are set well below levels known to cause harm. And although technology can legally run at the safety limit, in reality, exposures are typically hundreds of times below these safety limits.

**Challenging Misconceptions**
There is a lot of misinformation out there regarding 5G, and the electromagnetic energy associated with telecommunications more generally. While there’s no evidence of harm from such electromagnetic energy, there is evidence fear and anxiety can be harmful to our health and overall well-being. While anti-5G sentiment and campaigning might be well-intentioned, without the scientific evidence to back these sentiments, it’s likely doing more harm than good. The challenge we now face is counteracting the misinformation out there.

Sarah Loughran receives funding from The National Health and Medical Research Council of Australia (NHMRC). She is affiliated with the University of Wollongong, is currently a member of the WHO Environmental Health Criterion Evaluation Committee on Radiofrequency Fields, and the Scientific Expert Group of the International Commission on Non-Ionizing Radiation Protection (ICNIRP). She is also the director of the NHMRC Centre of Research Excellence, "Australian Centre for Electromagnetic Bioeffects Research".

**Source 10 - Towards 5G Communication Systems: Are There Health Implications?**
Available From: The International Journal of Hygiene and Environmental Health

**Abstract** - The spread of radiofrequency electromagnetic fields (RF-EMFs) is rising and health effects are still under investigation. RF-EMFs promote oxidative stress, a condition involved in cancer onset, in several acute and chronic diseases and in vascular homeostasis. Although some evidence is still controversial, the WHO IARC classified RF-EMF as “possible carcinogenic to humans”, and more recent studies suggested reproductive, metabolic and neurologic effects of RF-EMF, which are also able to alter bacterial antibiotic resistance. In this evolving scenario, although the biological effects of 5G communication systems are very scarcely investigated, an international action plan for the development of 5G networks has started, with a forthcoming increment in devices and density of small cells, and with the future use of millimeter waves (MMWs).

Preliminary observations showed that MMWs increase skin temperature, alter gene expression, promote cellular proliferation and synthesis of proteins linked with oxidative stress, inflammatory and metabolic processes, could generate ocular damages, and affect neuro-muscular dynamics. Further studies are needed to better and independently explore the health effects of RF-EMF in general and...
of MMW in particular. However, available findings seem sufficient to demonstrate the existence of biomedical effects, to invoke the precautionary principle, to define exposed subjects as potentially vulnerable and to revise existing limits. An adequate knowledge of pathophysiological mechanisms linking RF-EMF exposure to health risk should also be useful in the current clinical practice, in particular in consideration of evidence pointing to extrinsic factors as heavy contributors to cancer risk and to the progressive epidemiological growth of noncommunicable diseases.