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Health risks from exposure to electromagnetic waves radiation from 5G

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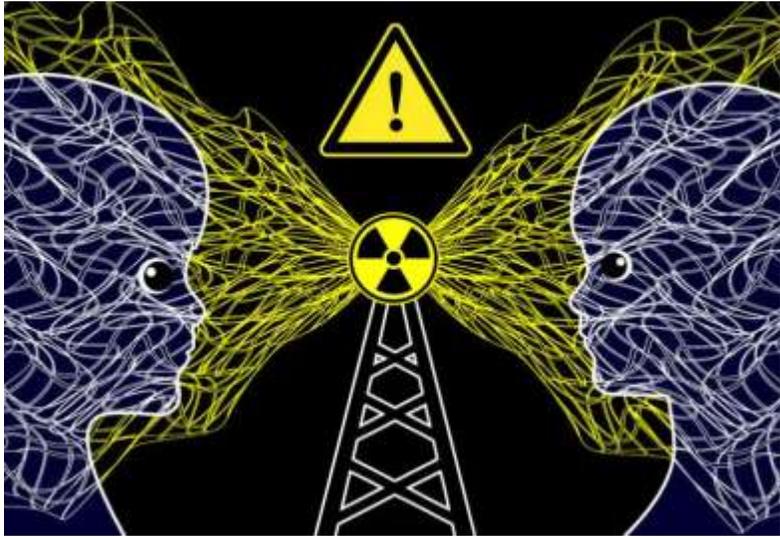
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Rodrigo Cuevas Terrones was born in Puebla, México, in 1977. He received a Bachelor degree in Mechatronics Engineering from the Centro Universitario Interamericano (CEUNI), in 2017. He has a Master of Engineering from the Benemérita Universidad Autónoma de Puebla (BUAP), in 2020. He is about to start his Ph.D. studies in Electronic Sciences at the Instituto Nacional de Astrofísica, Óptica y Electrónica (IANOE), at Tonanzintla, Puebla, México. His main research interests include Digital Electronics, Telecommunications and Digital Circuits Implementation in reprogrammable devices, such as FPGAs.



Are electromagnetic waves really harmful?



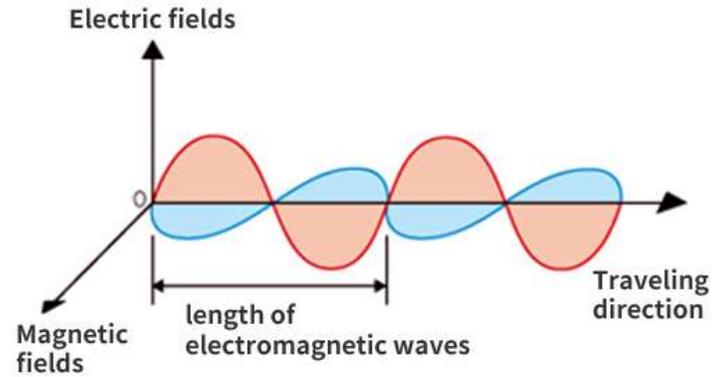
Currently, the growing concern of the population around the world makes necessary an analysis of the nature of electromagnetic waves and their effects on living beings, specially in wireless communications field.



Are electromagnetic waves really harmful?



Due to the nature of the information to be transmitted, the next generation of mobile telephony (5G) requires bands with higher frequencies than the current and previous generations for its operation, so it was needed to establish ranges of these that can be considered non-harmful in living beings.



Electromagnetic wave radiation is defined as a combination of oscillating magnetic and electric fields that propagate through space carrying energy from one place to another.



X-rays, radio waves, infrared rays, ultraviolet rays, and visible light are some of the most important types of electromagnetic radiation, and humans have learned to usefully produce and control them.

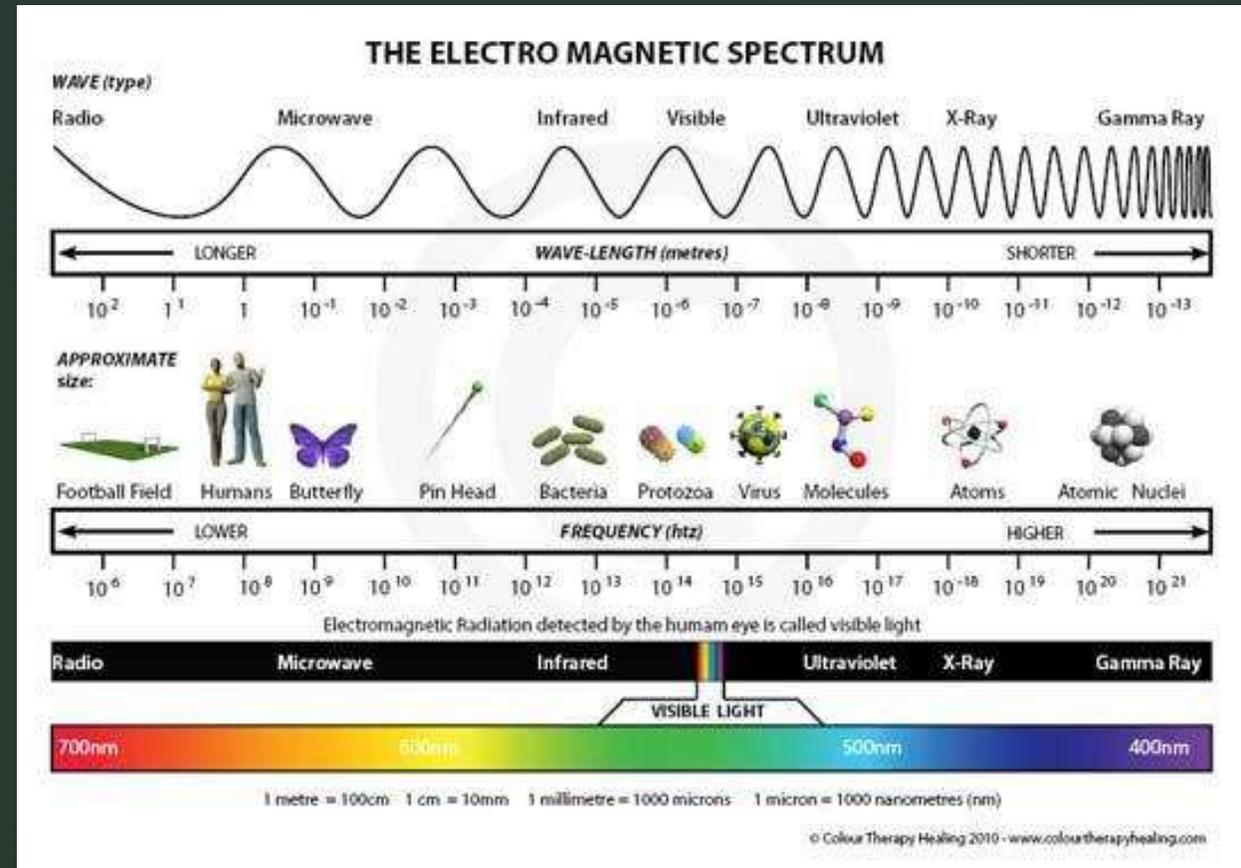
OBJECTIVE

▶ To present some of the results of previous studies about potential risks of the fifth generation of cellular telephony (5G); although there are no solid conclusions or hard data about the effect of this generation, it is already possible to know some of potential risks.



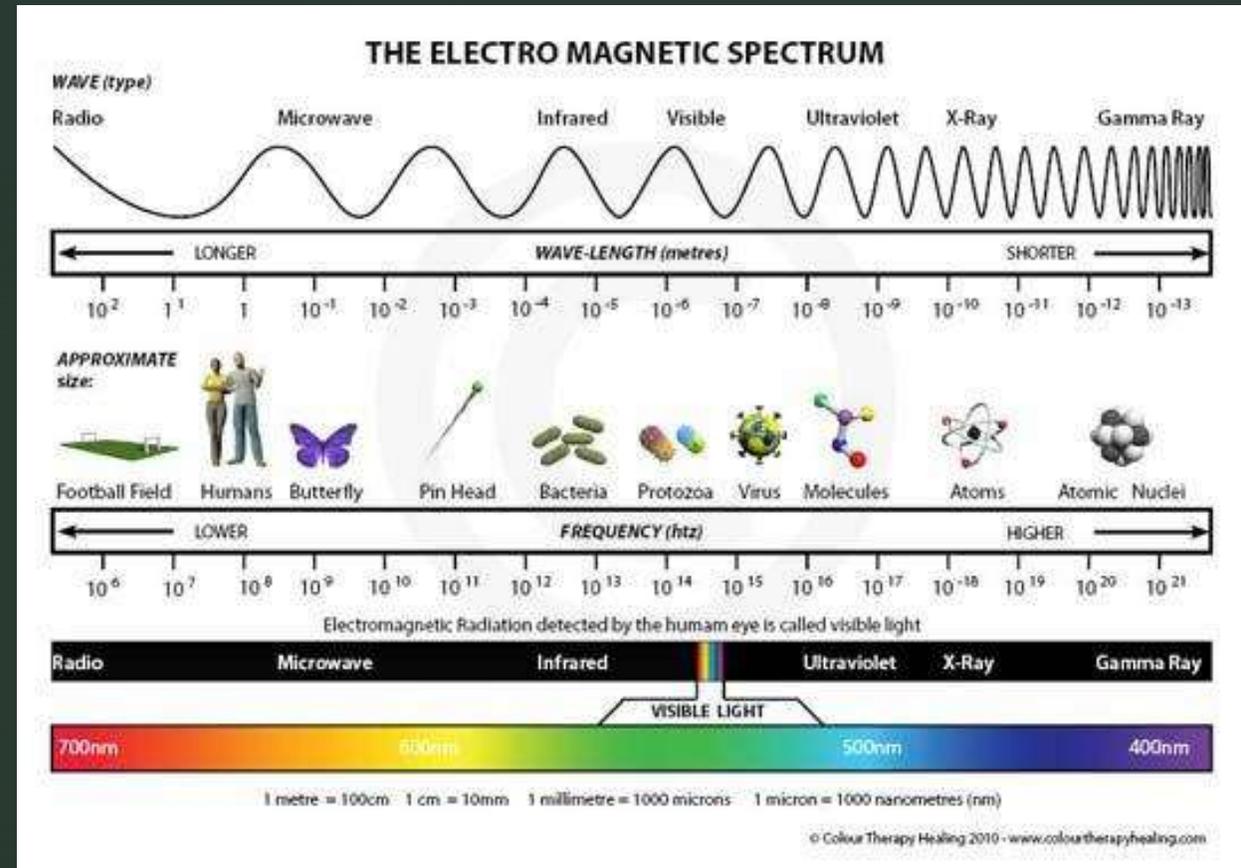
ELECTROMAGNETIC SPECTRUM

Electromagnetic spectrum is the set of frequency values of electromagnetic waves that humans have been able to detect and measure. Within this electromagnetic spectrum, there are (in order of lowest to highest frequency), radio waves (used for wireless communications, such as radio transmissions, TV, mobile telephony and mobile Internet), microwaves (used for detection radars, satellite transmissions, and domestic microwave ovens), infrared light, visible light, ultraviolet light, X rays and Gamma rays.

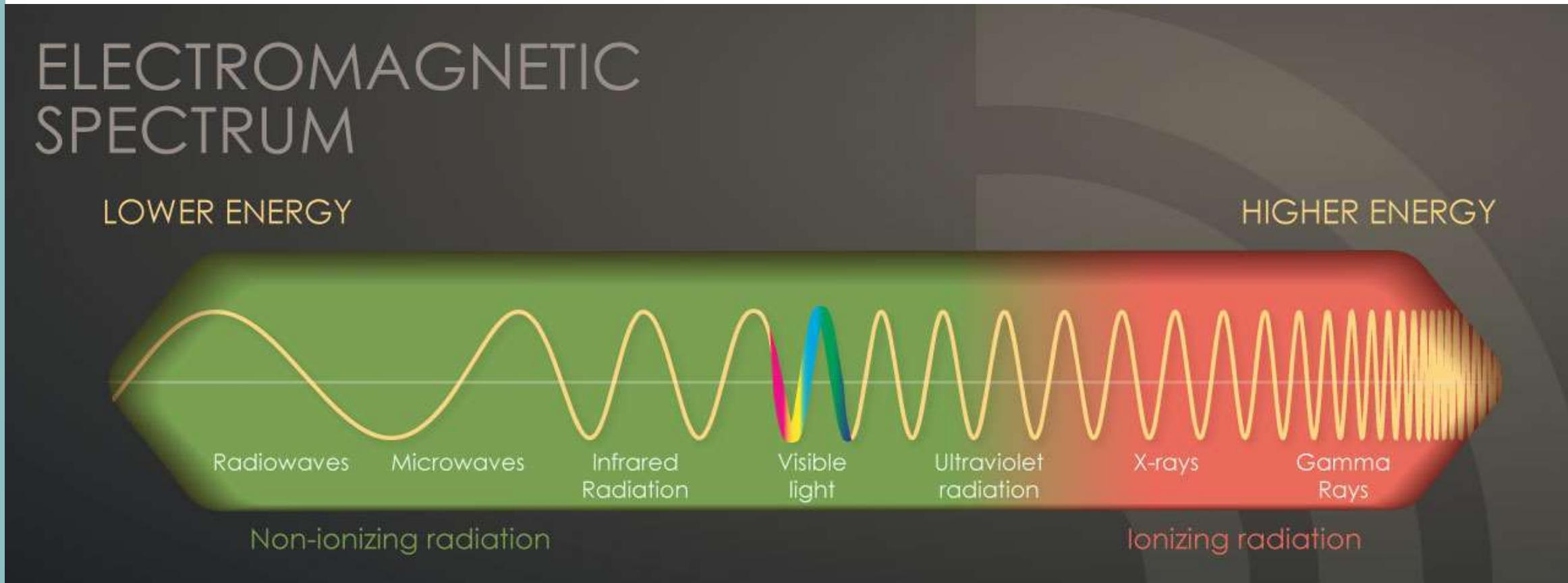


IONIZING AND NON-IONIZING RADIATION

The frequency of non-ionizing radiation is below the ultraviolet light threshold, which means that visible light and wave radiation with lower frequencies fall into this group. Ionizing radiation is found from the ultraviolet frequency light and includes X-rays and Gamma rays.



IONIZING RADIATION.



Ionizing radiation is electromagnetic wave radiation which frequency (and energy) is as high that it acquires the ability to extract electrons from atoms of matter through which it passes. This may result in a change in the molecular structure.

IONIZING RADIATION CELLULAR EFFECTS

Although recent radiobiology studies have found post-radiation cellular responses that appear to lead to genomic changes and / or cellular effects from epigenetic processes, the critical structure at the cellular level remains the Deoxyribonucleic Acid (DNA) molecule.



IONIZING RADIATION CELLULAR EFFECTS

The effects may consist of a single or double chain break, base changes, breakage of hydrogen bonds between the bases, etc.; the consequence is that the cell will undergo a mutation.



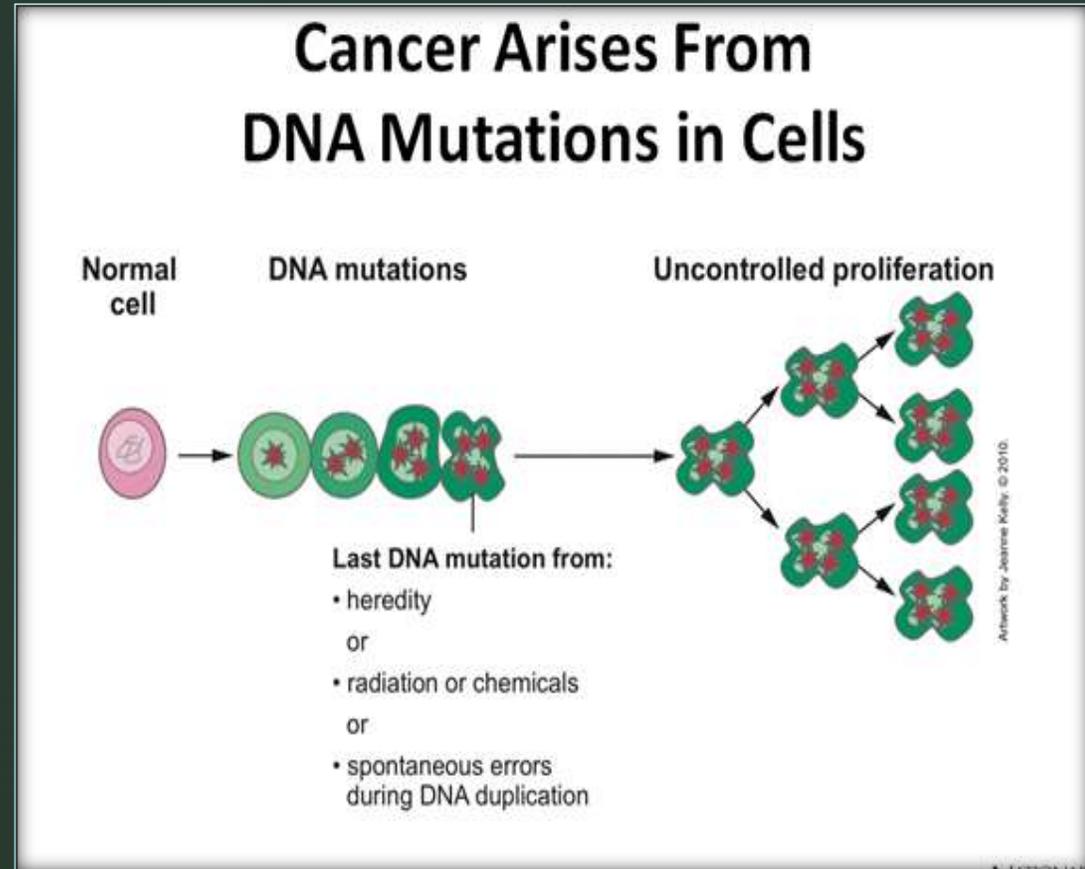
IONIZING RADIATION CELLULAR EFFECTS

One of three things can happen:

a) The mutation is repaired (without errors) and the cell continues its functions as if nothing had happened.

b) The cell “dies” (in radiobiology cell death means permanent loss of clonogenic capacity) due to apoptosis, necrosis, or senescence.

c) The cell survives mutated, that is, there are “repairs” with errors. This is the cause of mutations caused by exposure to ionizing radiation.



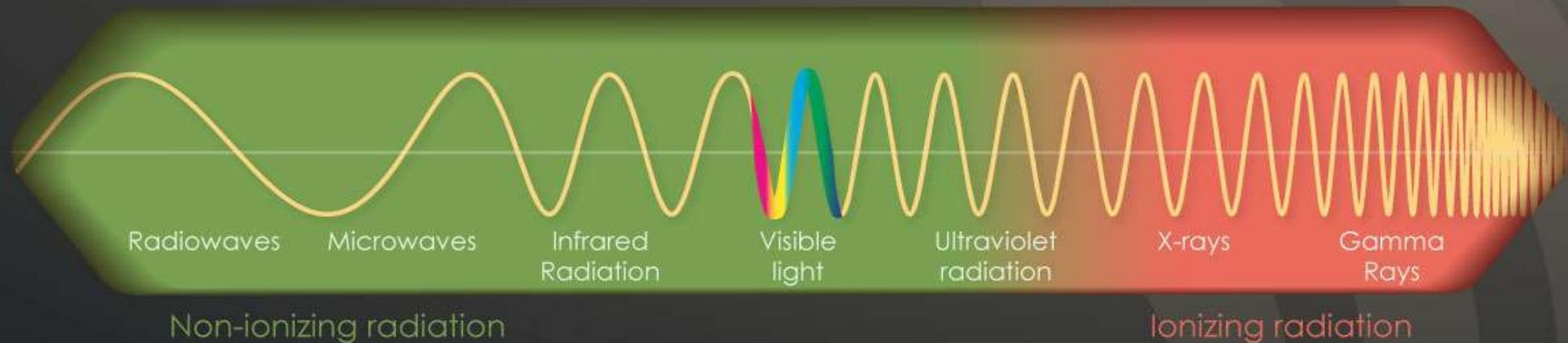
NON-IONIZING RADIATION.

Although non-ionizing radiation does not cause the aforementioned adverse effects, there are regulations (for each country internally and internationally) that determine maximum permitted levels of power with the aim of avoiding or minimizing possible damages caused by said radiation.

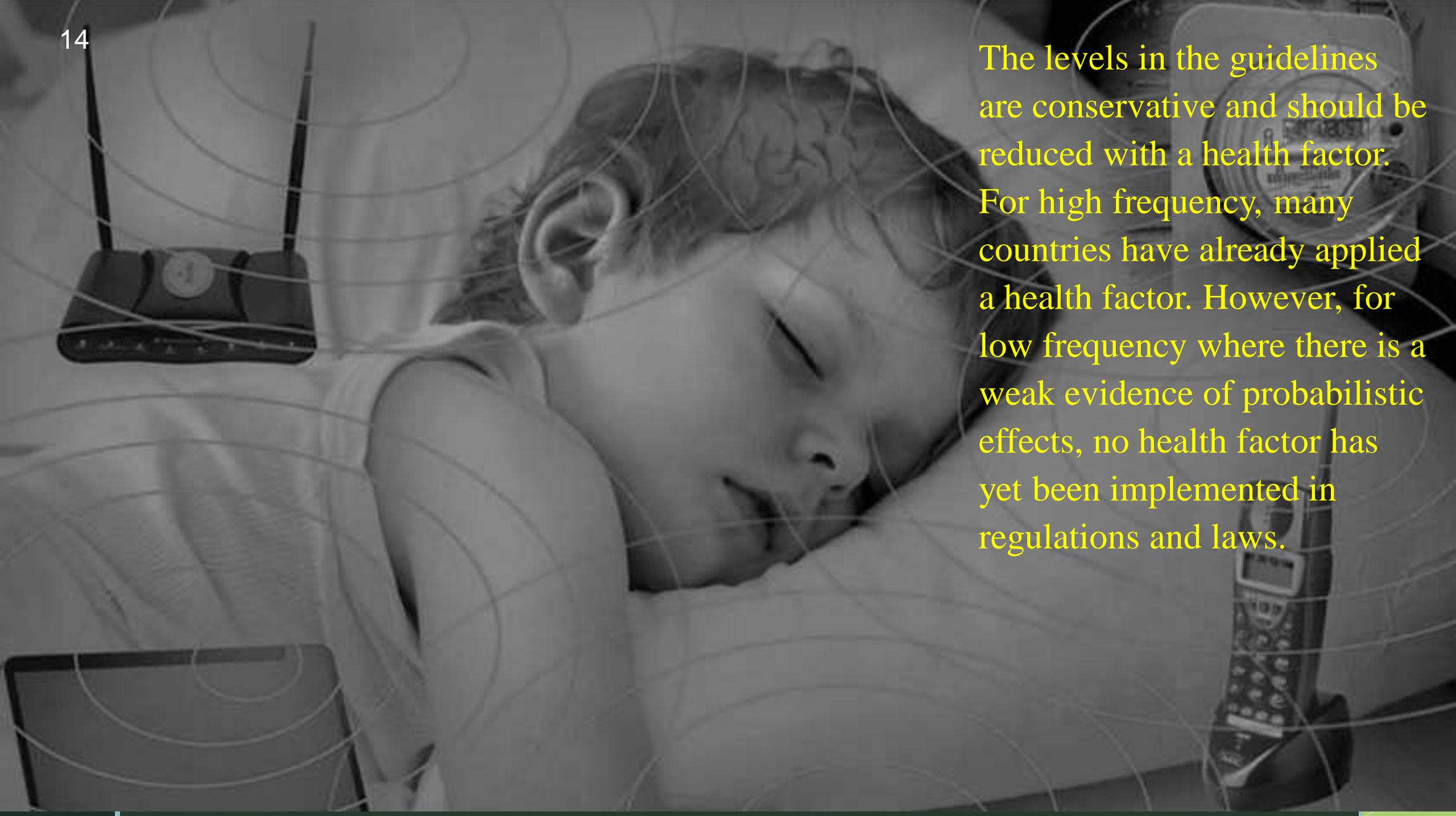
ELECTROMAGNETIC SPECTRUM

LOWER ENERGY

HIGHER ENERGY



The non-ionizing electromagnetic frequency spectrum is usually subdivided into low frequency from 0 to 3 kHz (US) or 10 kHz (EU), and high frequency or radiofrequency from 3 kHz – 300 GHz (US) or 10 kHz – 300 GHz (EU).



The levels in the guidelines are conservative and should be reduced with a health factor. For high frequency, many countries have already applied a health factor. However, for low frequency where there is a weak evidence of probabilistic effects, no health factor has yet been implemented in regulations and laws.

SPECIFIC ABSORPTION RATE (SAR)



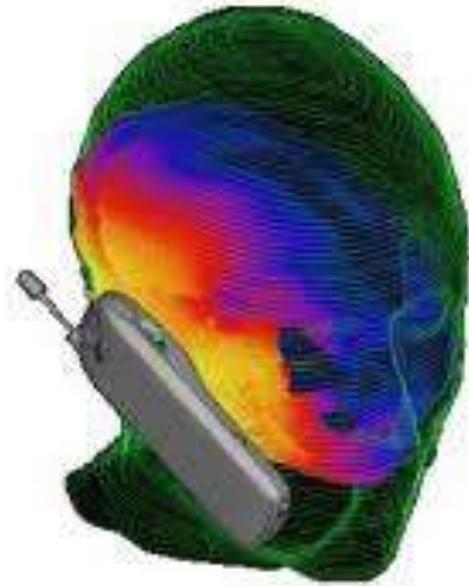
Specific Absorption Rate (SAR) is an established measure to refer to the amount of electromagnetic waves absorbed by a living organism.

SPECIFIC ABSORPTION RATE (SAR)



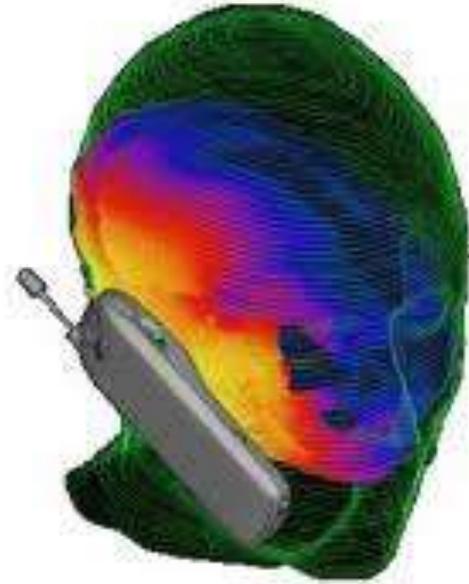
Exposures to Microwaves (MW, 300 MHz-300 GHz) vary in many parameters, including SAR. With increased SAR, so-called thermal effects of MW are usually observed that result in significant MW-induced heating. SAR is the determinant main factor of thermal MW effects.

SPECIFIC ABSORPTION RATE (SAR)



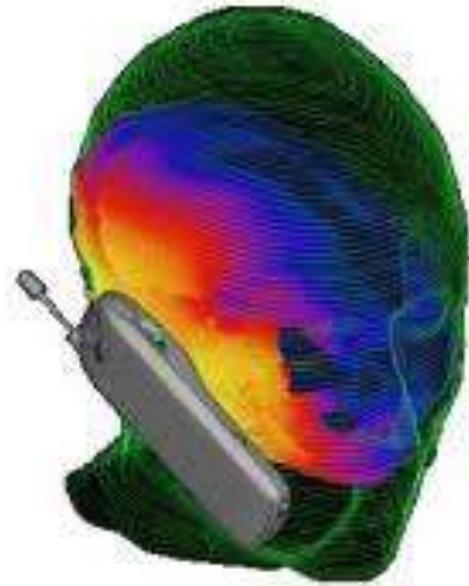
The mobile phone SAR values are usually obtained when the phone is positioned about 2 cm from the head, a condition which is not usually maintained during mobile phone calls.

SPECIFIC ABSORPTION RATE (SAR)



MW effects are classified into thermal and non-thermal; it is not based on physics of interaction between MW and biological tissues, but rather reflects experimental observation of heating induced by MW exposure, which at SAR levels higher than 2 W/kg may result in thermal injury.

SPECIFIC ABSORPTION RATE (SAR)



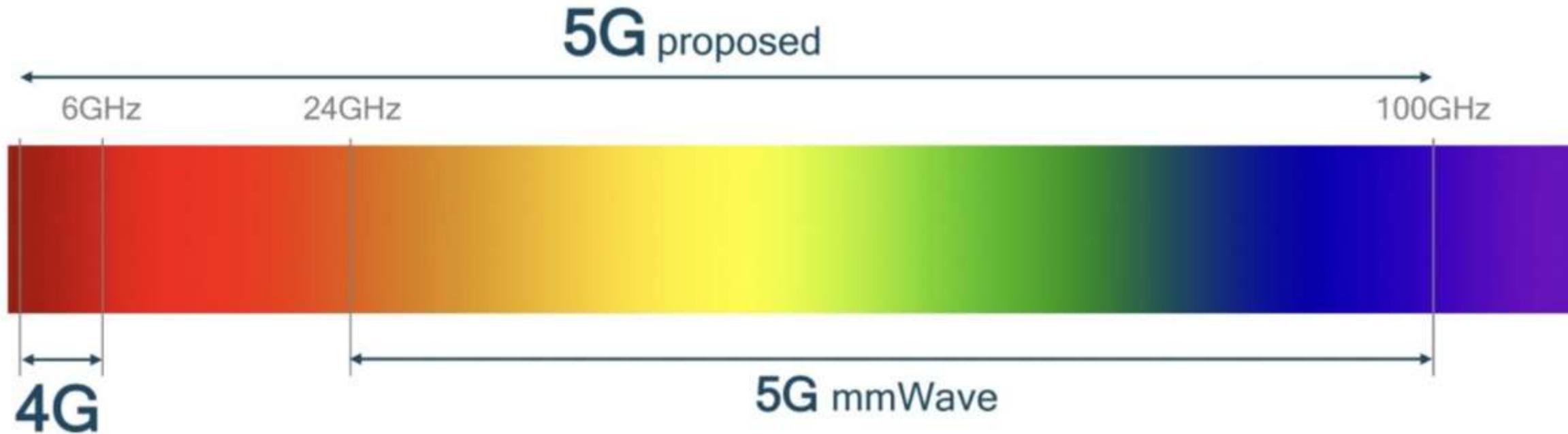
Slight temperature increase is also observed in the head tissues during exposure to mobile handset radiation, but this increment is too weak to produce thermal injury and even to be sensed by the exposed subjects while some mobile phone users reported sensation of warmth around the ear.

SPECIFIC ABSORPTION RATE (SAR)



Some authors have reported pioneering data on the NT effects of Millimeter Waves (MMW, 30-100 GHz, wavelength 1-10 mm in vacuum, to be used in 5G mobile communication) upon exposure of various biological objects.

SPECIFIC ABSORPTION RATE (SAR)

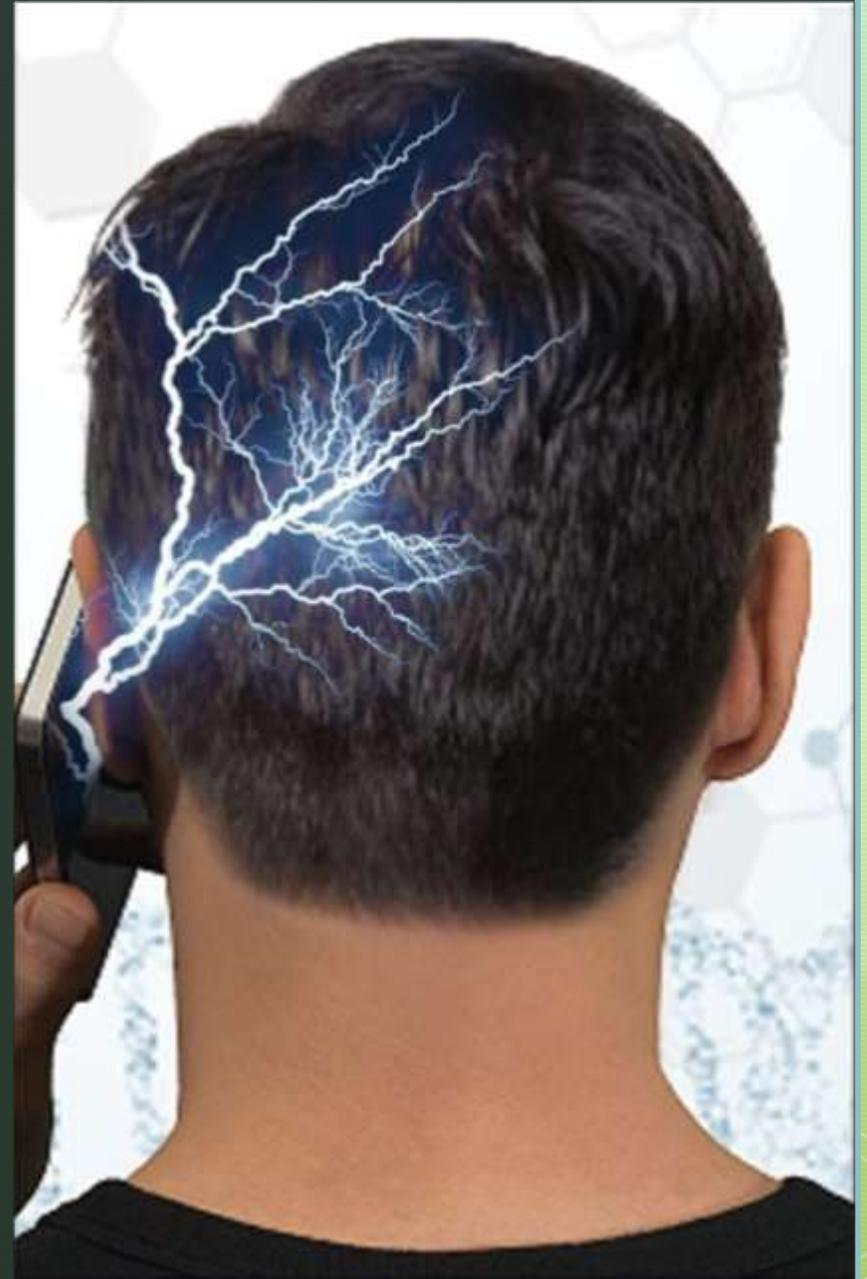


In these and subsequent studies, the observed spectra of MMW action were found to have the following regularities:

- (1) Strong dependence on frequency (frequency windows of resonance type),
- (2) Specific Power Density (PD) threshold below which no effect was observed, and above which the effects of exposure depended only weakly on power over several orders of magnitude (so-called sigmoid or S-shaped dependence).
- (3) Occurrence of MMW effects depended on the duration of exposure, a certain minimum duration of exposure was necessary for an effect to manifest itself.

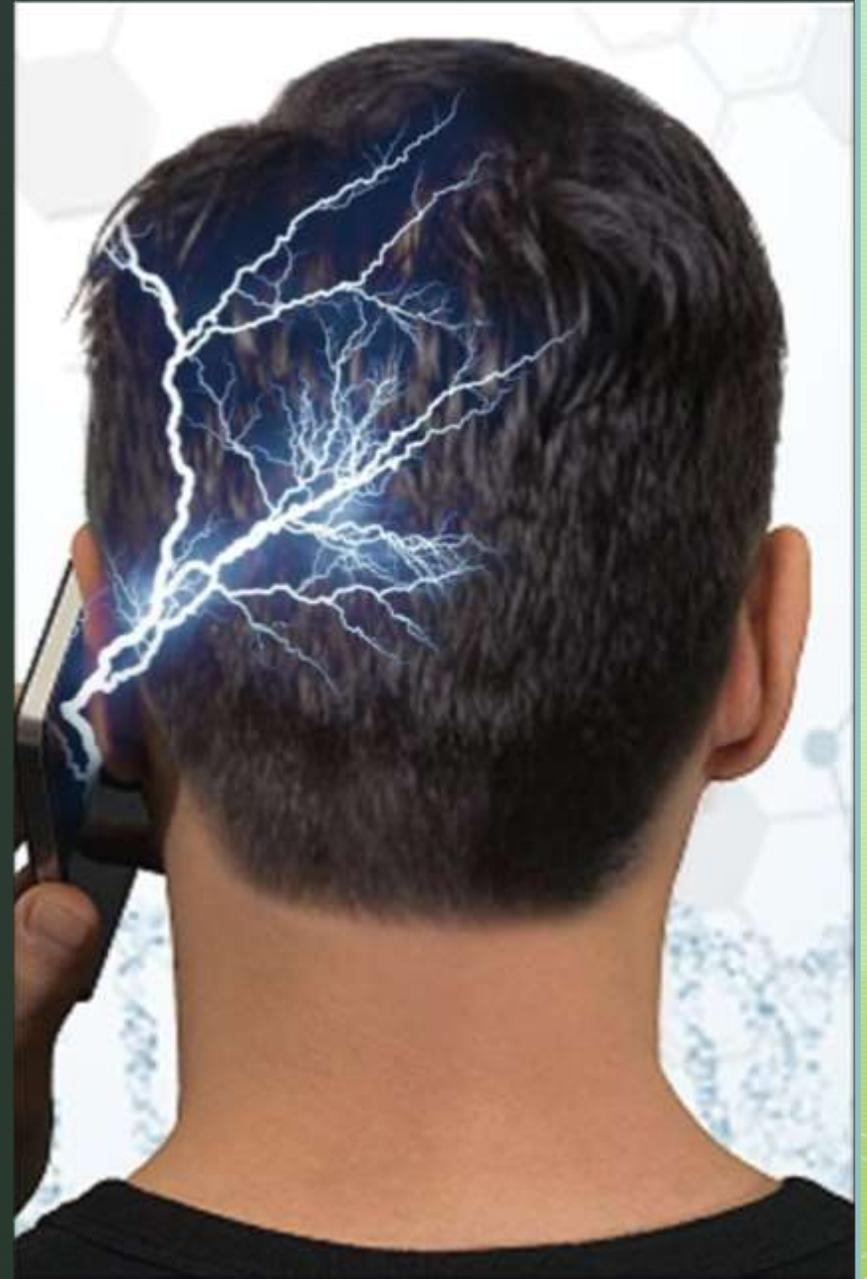
MOBILE PHONE GENERATIONS AND USED FREQUENCIES

So, given the growing concern about the damage that new wireless communication technologies could produce in the organism, the question continues: are current wireless communications dangerous or not?



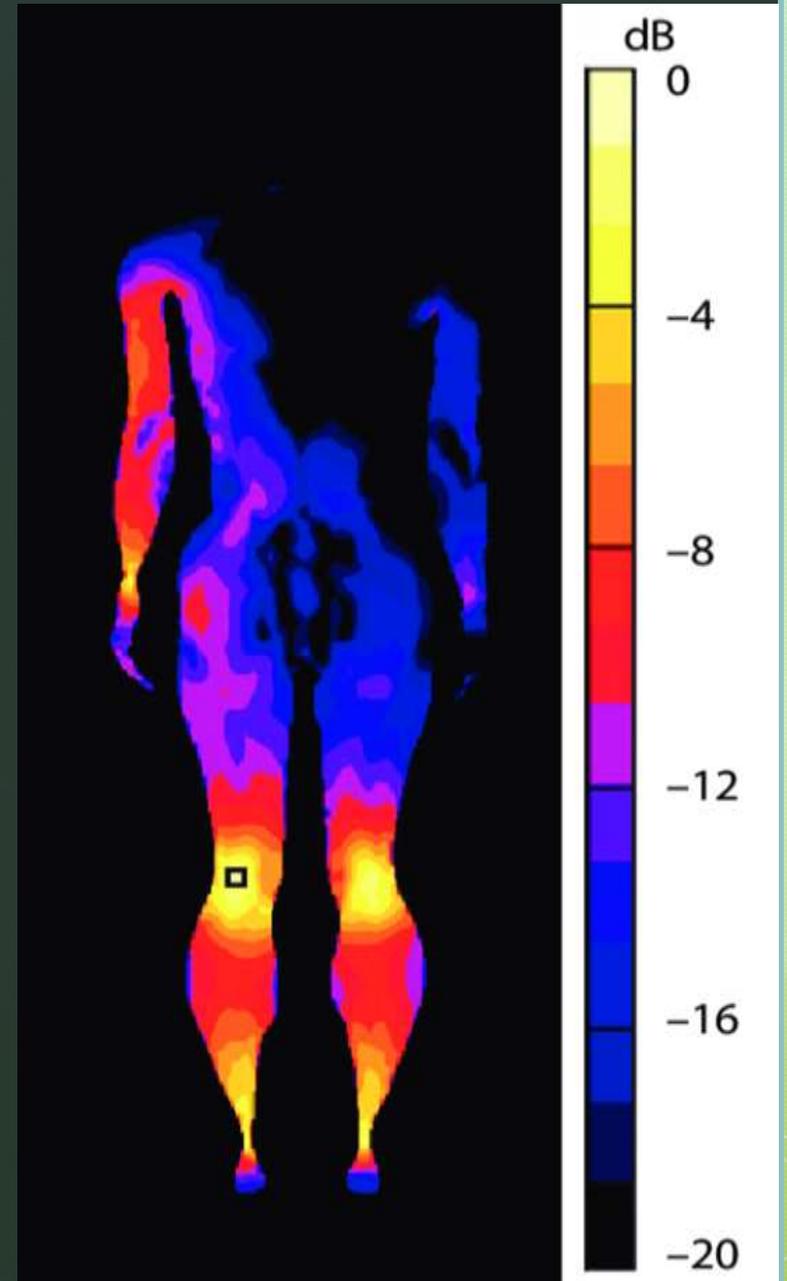
MOBILE PHONE GENERATIONS AND USED FREQUENCIES

From 1G to 5G, the migration from each generation to the next has been mainly conditioned to the type of access scheme used and the services that the new generation is capable of providing. These services determine the need to have higher frequencies each time.



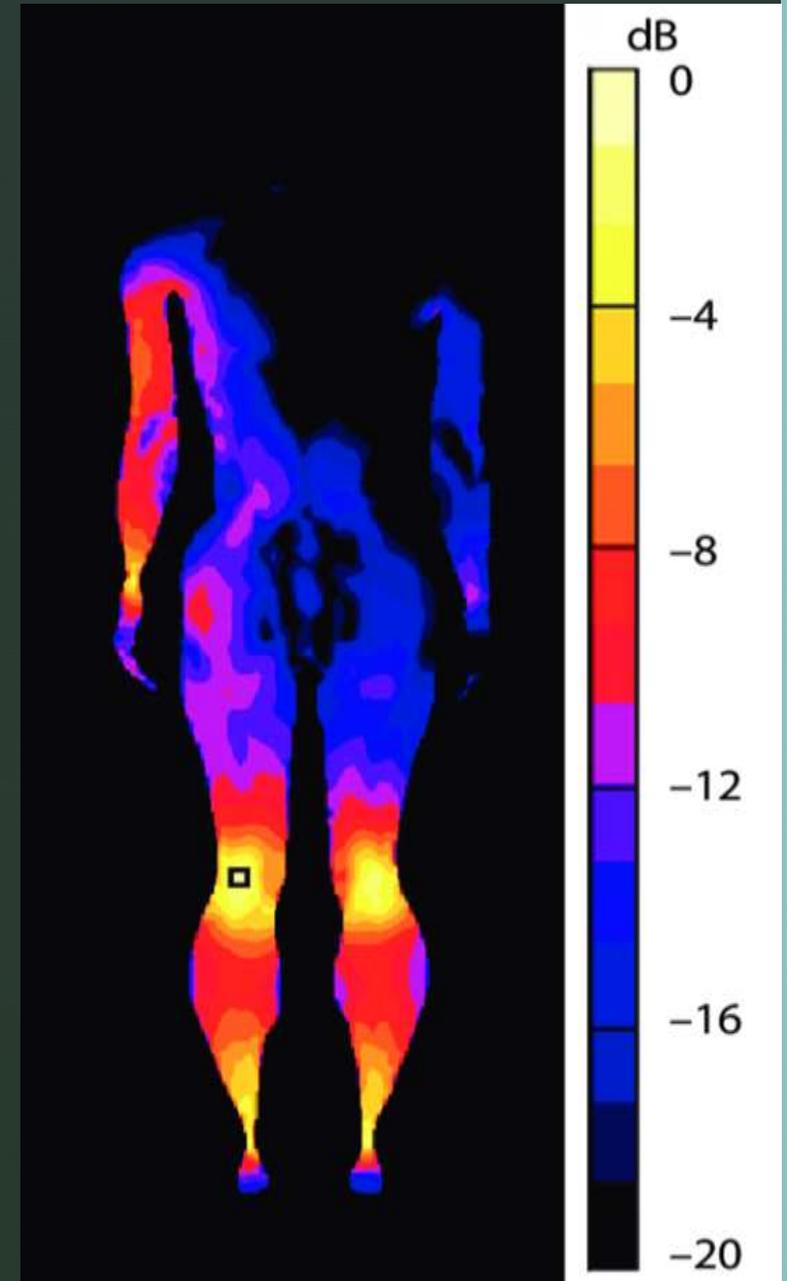
MOBILE PHONE GENERATIONS AND USED FREQUENCIES

Most current discussion regarding MW health effects is focused on the 5G mobile communication, which is promptly enrolled in different countries and uses frequency ranges similar to 2G/3G/4G plus MMW.



MOBILE PHONE GENERATIONS AND USED FREQUENCIES

Except for considering penetration of 5G/MMW into biologically equivalent tissues being in thermodynamical equilibrium, the response of live human body should also be considered. Alive body represents a complicated system with fundamental frequencies; many of them lie in the MMW range.



MOBILE PHONE GENERATIONS AND USED FREQUENCIES

To what extent the 5G technology and the Internet of Things will affect the human health is definitely not known. However, the health effects of chronic MMW exposures may be more significant than for any other frequency range.

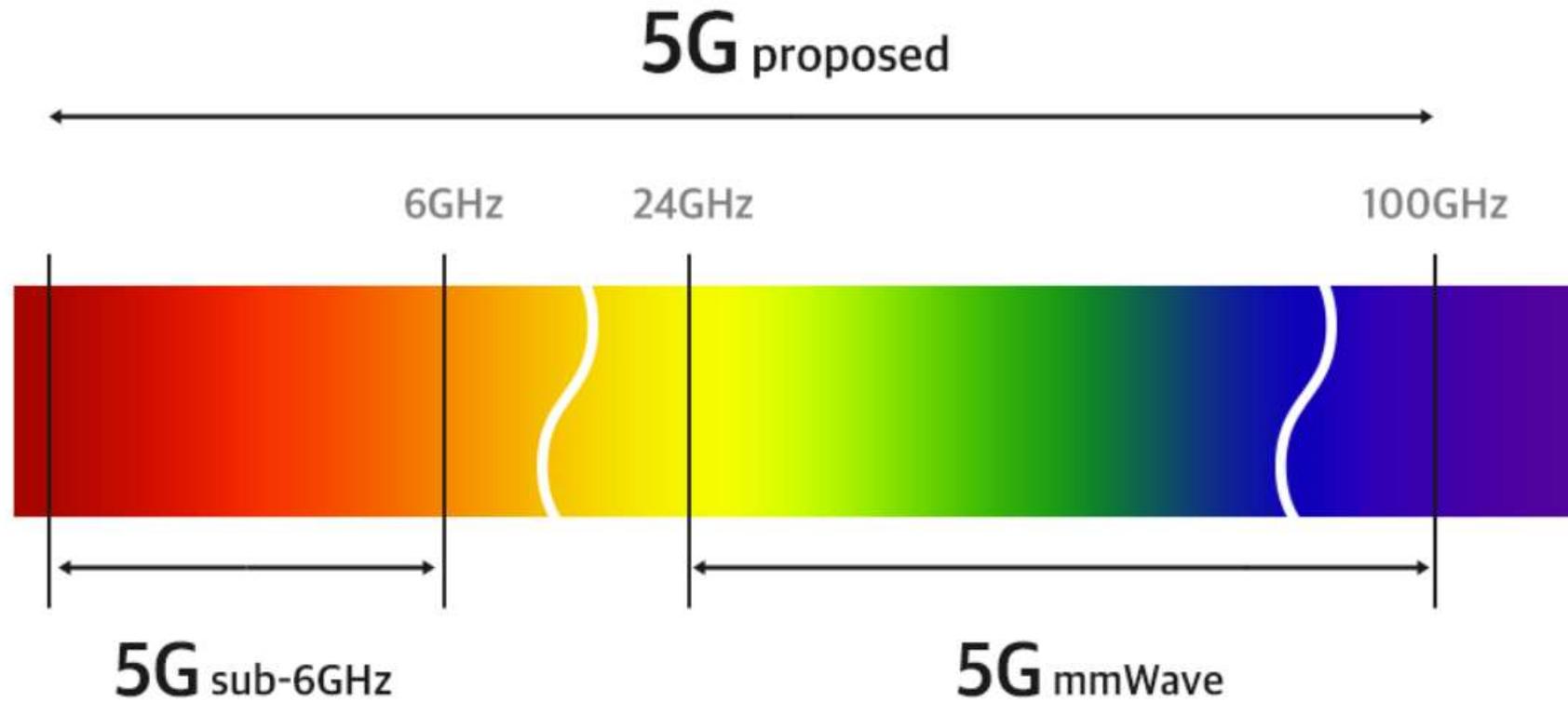


MOBILE PHONE GENERATIONS AND USED FREQUENCIES

From the health perspectives, implementation of the 5G technology is premature. Extended research with chronic exposure of human cells, animals and man is needed to exclude the potentially harmful of 5G signals.

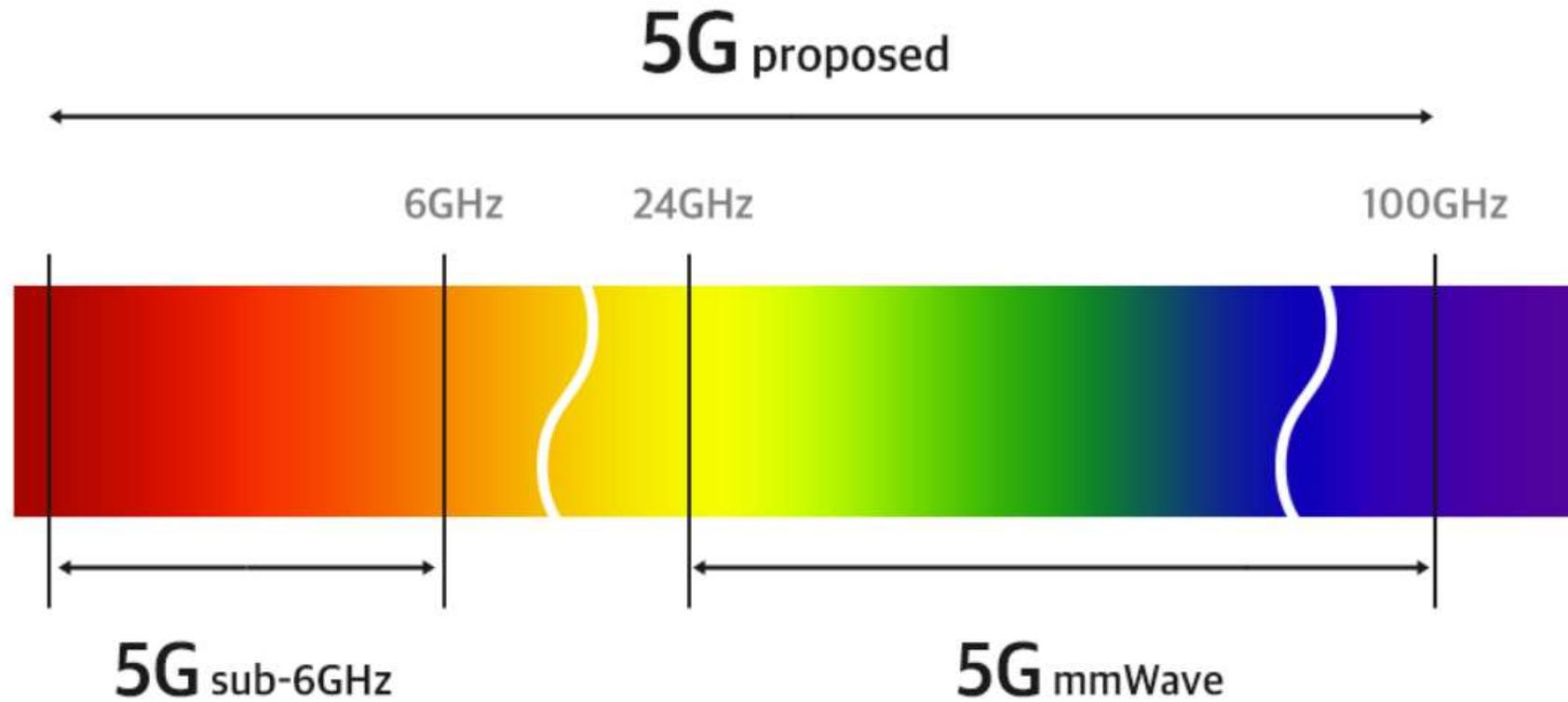


5G TECHNOLOGY



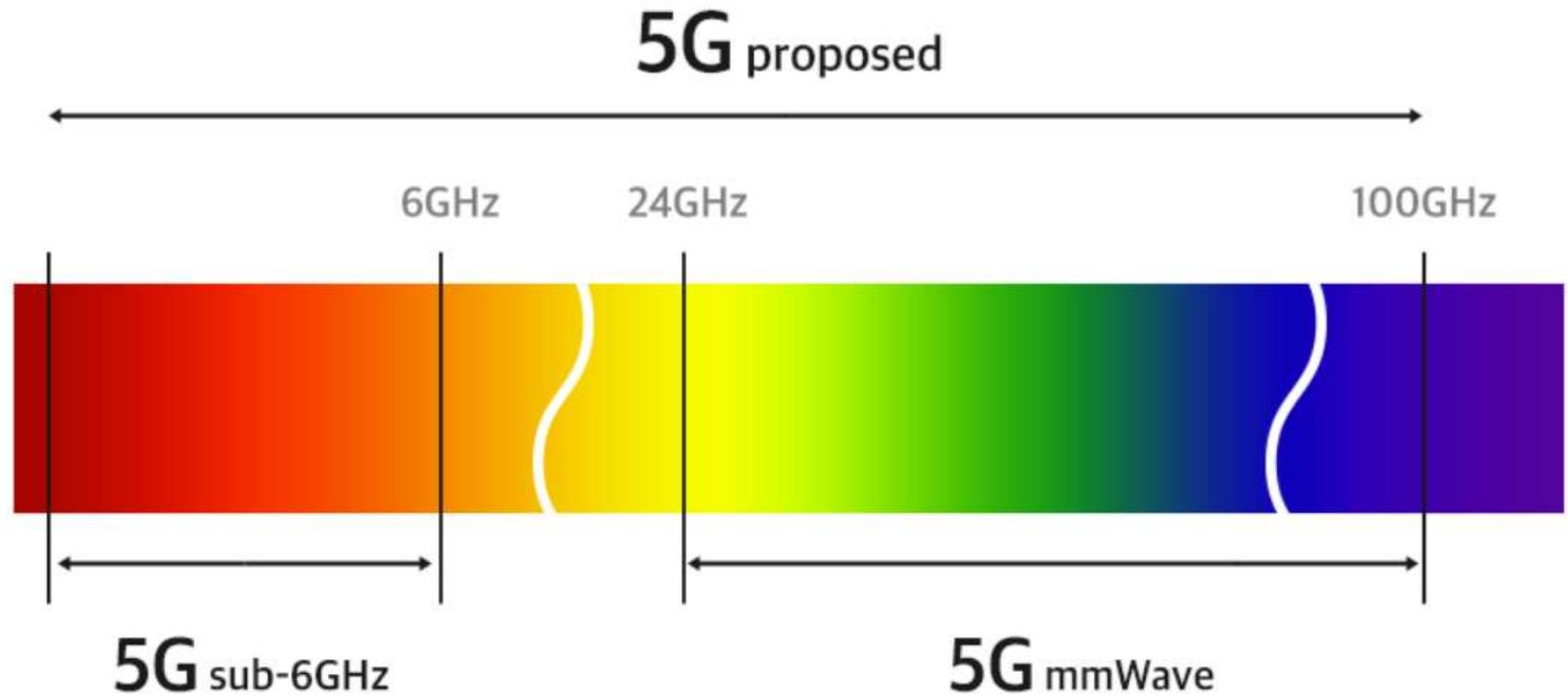
5G technology needs spectrum in three key frequency bands to provide greater coverage and include all use cases. The three bands are below 1 GHz, from 1 to 6 GHz, and above 6 GHz.

5G TECHNOLOGY



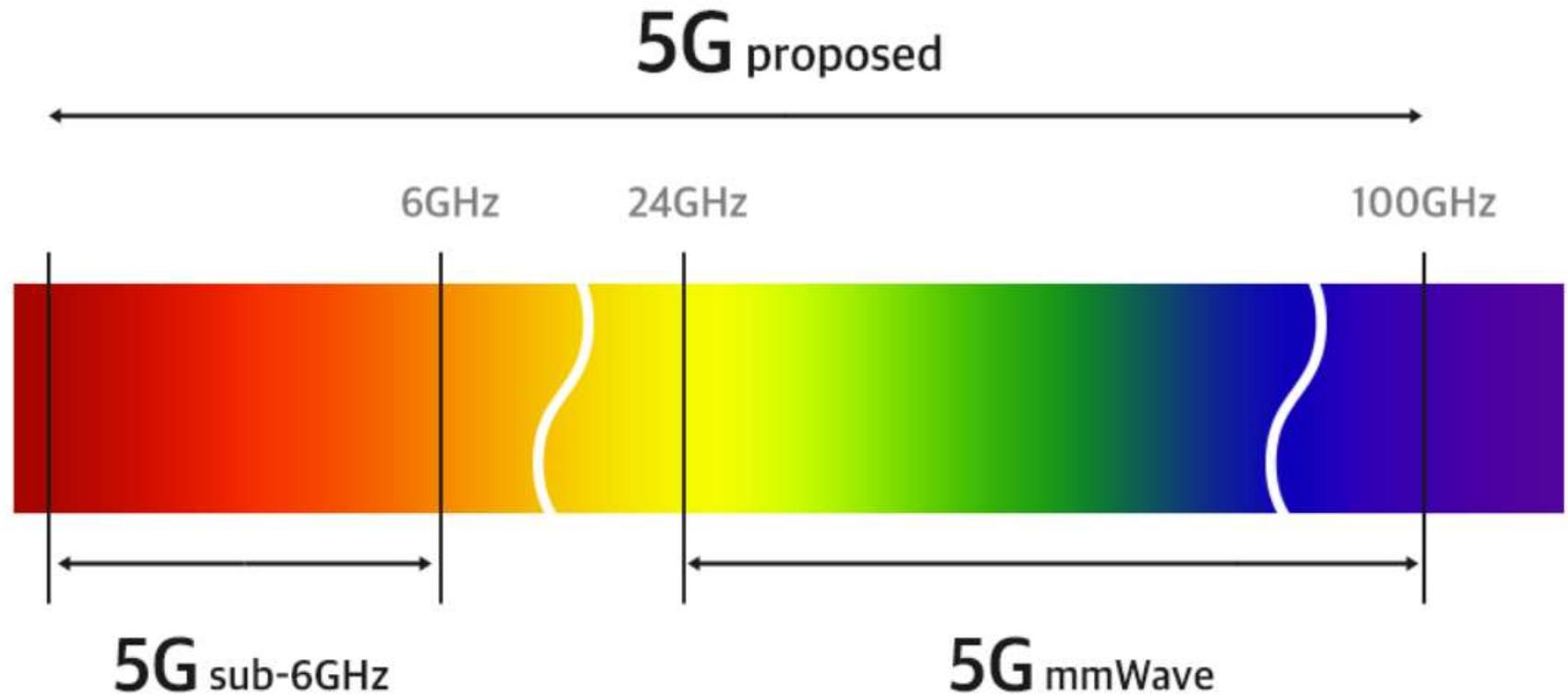
Below 1 GHz: This spectrum will be used to provide broad coverage in urban, suburban, rural areas and contribute to the support of Internet of Things services.

5G TECHNOLOGY



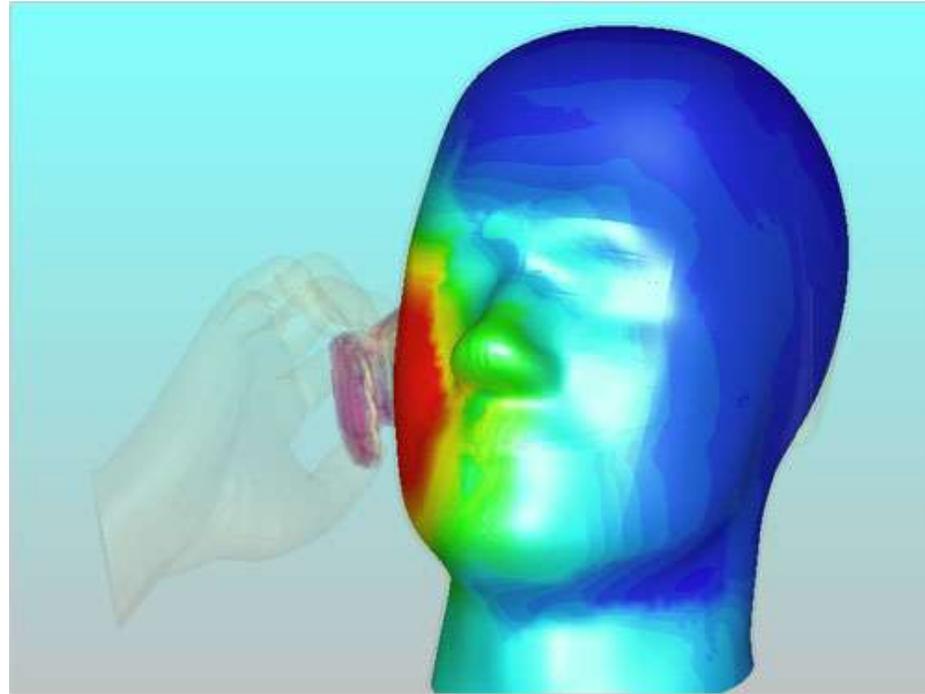
1 to 6 GHz: This spectrum offers a good combination of coverage and capacity benefit, and includes the range between 3.3 and 3.8 GHz, which is expected to be used to develop the first 5G services.

5G TECHNOLOGY



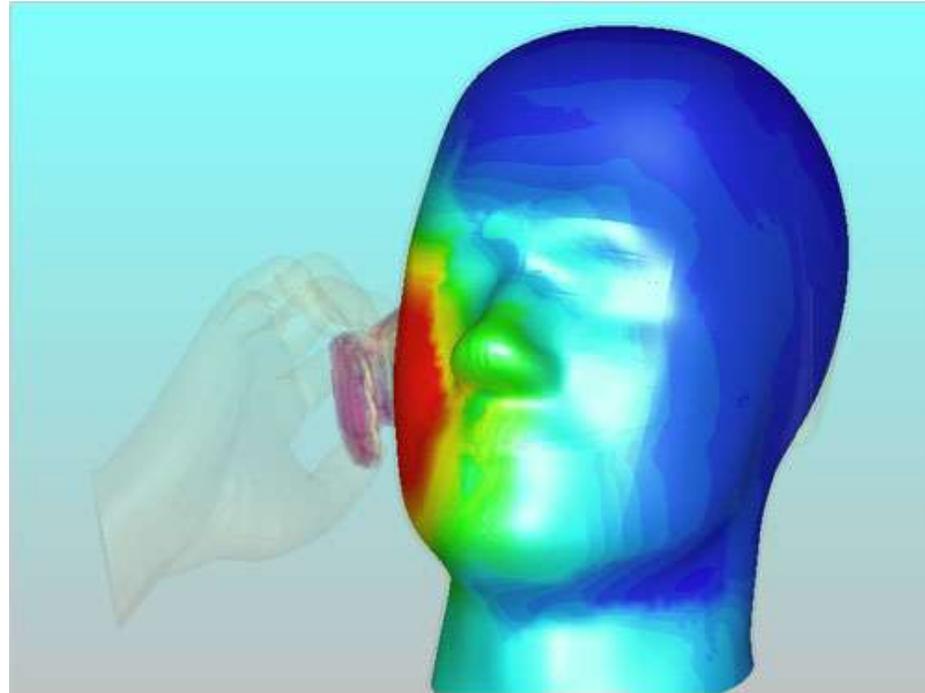
Above 6 GHz: This spectrum is required for ultra-fast broadband speeds contemplated for 5G. The focus will be on the bands above 24 GHz, including the 24 GHz and / or 28 GHz bands, which have sparked growing interest and can be easily implemented on the same device, due to their proximity. Furthermore, there is some interest in exploring the bands found in the frequencies from 6 to 24 GHz

5G TECHNOLOGY



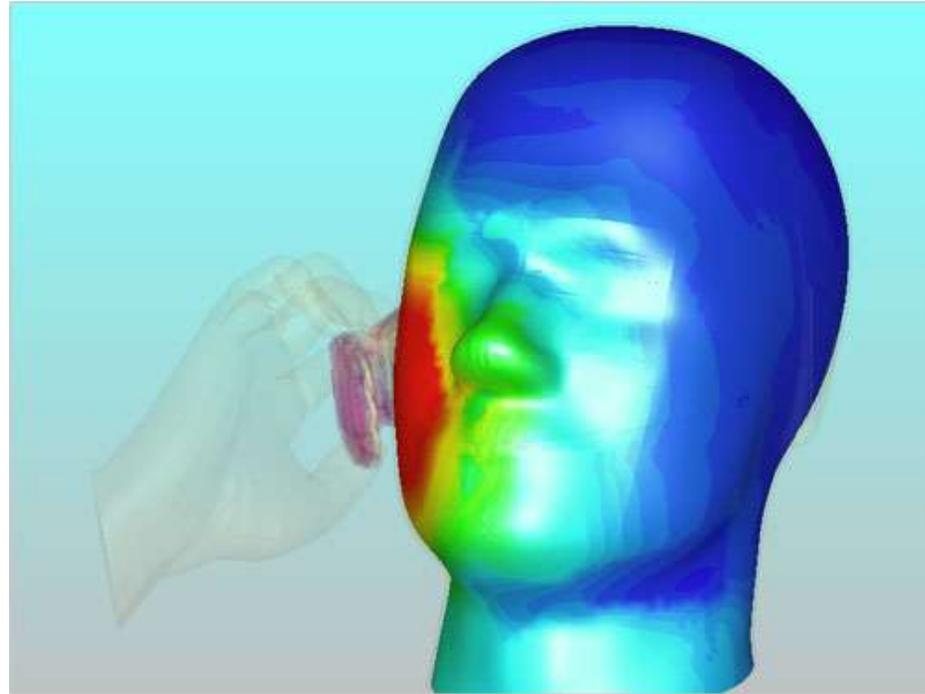
Exposure of humans to MMW can occur through 5G devices with frequencies above 6 GHz, and may be primarily on the skin and, to a lesser extent, on the eyes. This is due to the very low penetration depth of this MMW.

5G TECHNOLOGY



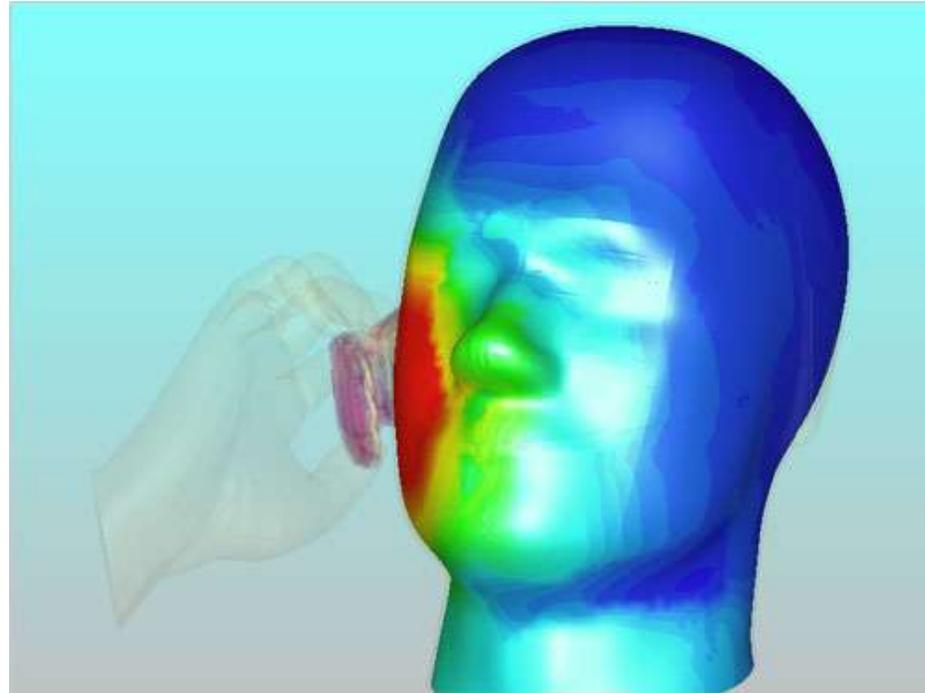
Due to the contradictory information from various lines of evidence that cannot be scientifically explained and given the large gaps in knowledge regarding the health impact of MMW in the 6–100 GHz frequency range at relevant power densities for 5G, research is needed at many levels.

5G TECHNOLOGY



The majority of studies with MMW exposures show biological responses. 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.

5G TECHNOLOGY



The following conclusions was reached:

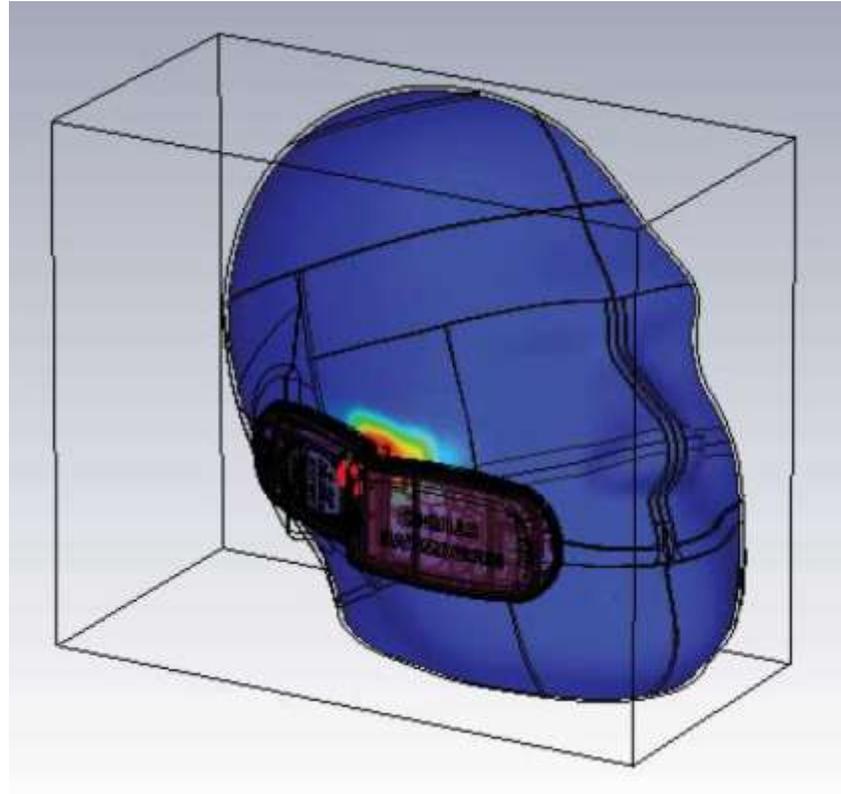
- a) Regarding the health effects of MMW in the 6–100 GHz frequency range at power densities not exceeding the exposure guidelines the studies provide no clear evidence, due to contradictory information from the in vivo and in vitro investigations.
- b) Regarding the possibility of “non-thermal” effects,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

5G TECHNOLOGY



Different investigations have been carried out on the effects of 5G radiation for different frequency values in the human brain. This has been achieved by using Computer Simulation Technology (CST) software by conducting simulations on a Specific Anthropomorphic Mannequin (SAM). A SAM is a model designed according to different international standards representing the average material properties of the head by calculating the SAR

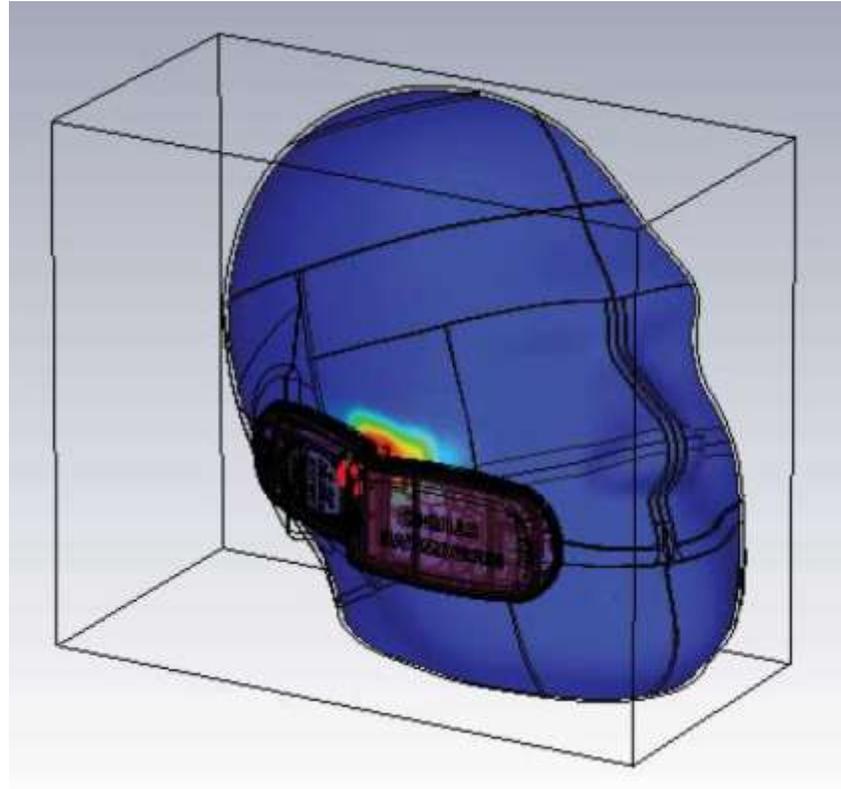
5G TECHNOLOGY



The most affected areas are the ones proximate to the antenna. It can be concluded that the SAR for first and second candidate are above the safety exposure.

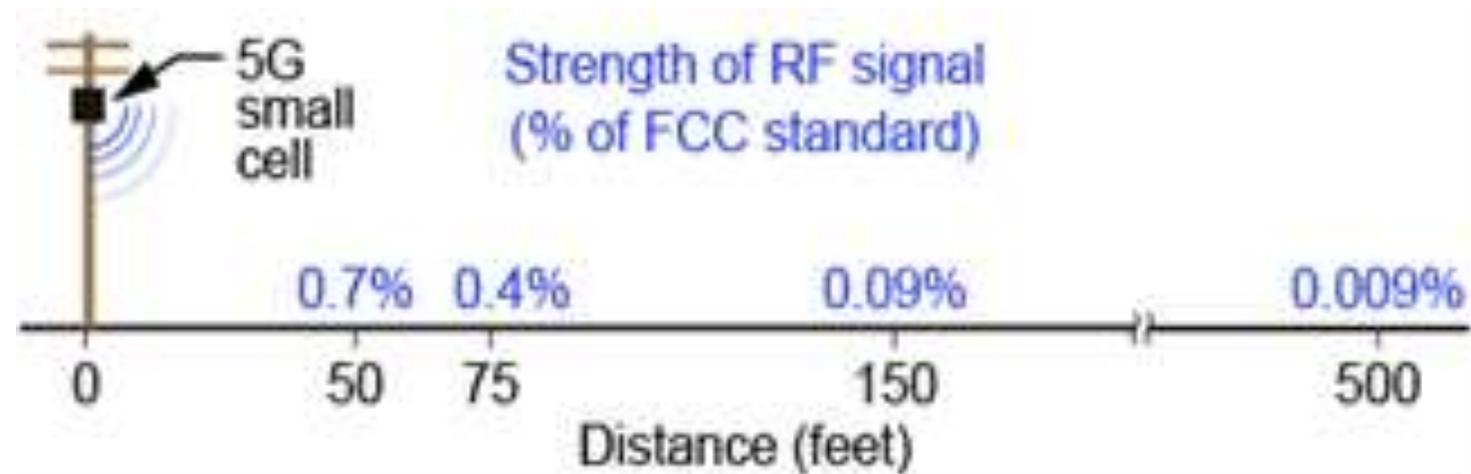
Moreover, the impact was negligible in areas not surrounding the mobile device.

5G TECHNOLOGY



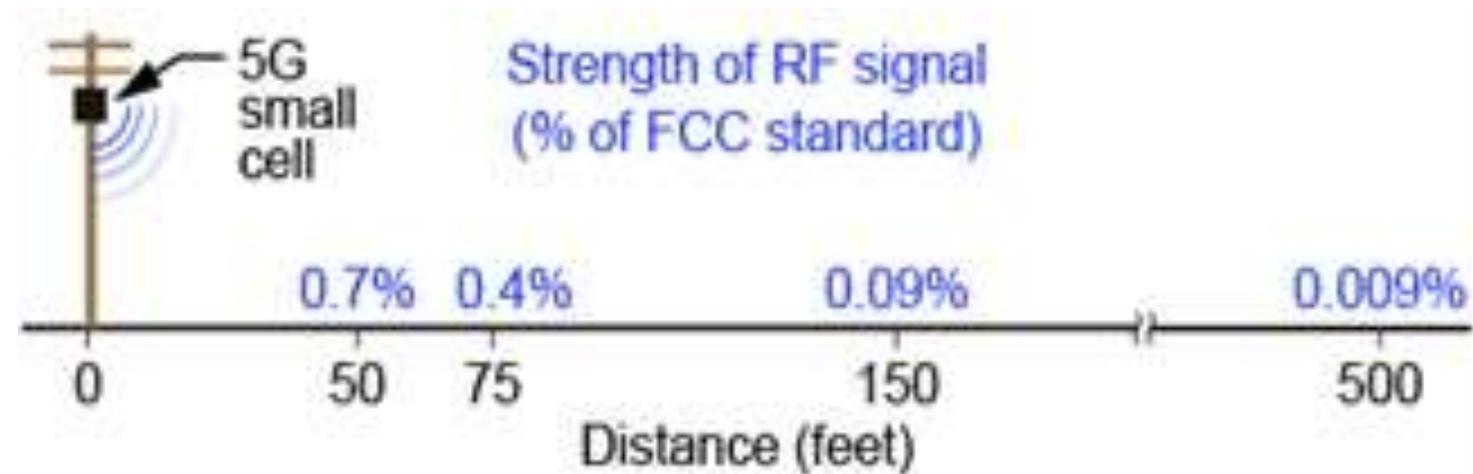
While at the lower frequencies (e.g. 2 GHz) and for short separation distances, the energy deposition is dominated by the coupling of the reactive near-field, at 24 GHz and above this factor is small and it becomes negligible for device to body separation distances larger than 1 cm.

5G TECHNOLOGY



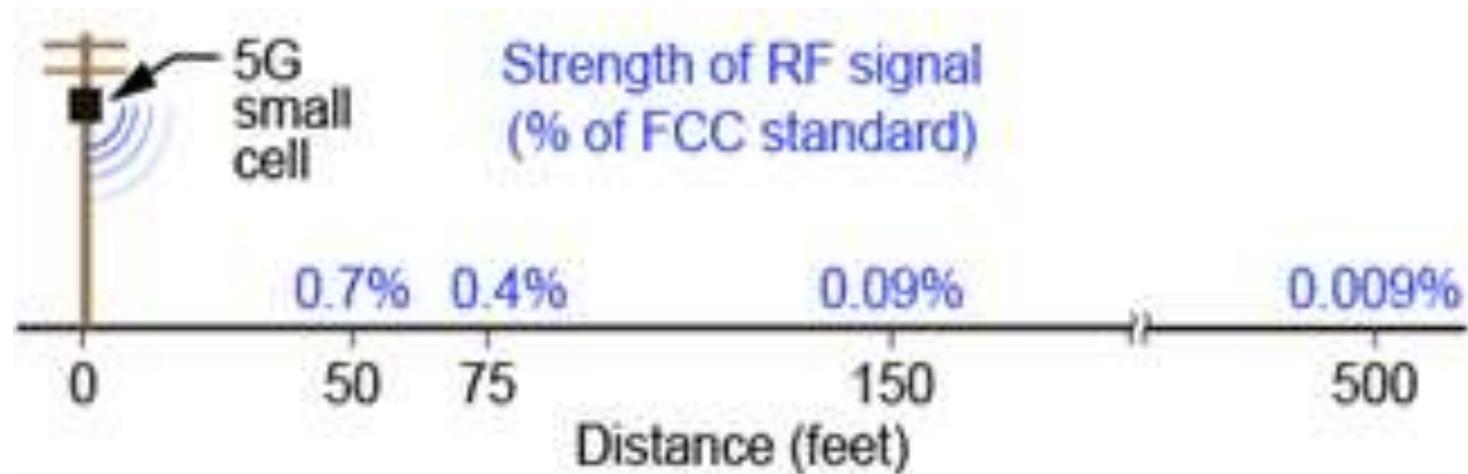
To provide context for understanding how the strength of wireless signals from a 5G small cell transmitter diminishes with distance, they calculated typical exposures from 60-watt ERP 5G source at 39 GHz mounted on a pole 25 feet above ground.

5G TECHNOLOGY



The signal strengths shows that exposures to RF from the small cell antenna are very low and diminish quickly with distance

5G TECHNOLOGY



To date, the only confirmed biological difference between exposures to RF frequencies less than 6 GHz and RF frequencies above 6 GHz is that at the higher frequencies the body's electrical properties better limit energy deposition to a shallow depth, largely confined to the skin. Thus, at frequencies above 6 GHz the hazard to be avoided is painful heating of the skin.

5G TECHNOLOGY



From a human health point of view, it appears that the possibility of a brain tumor has been the main cause for concern related to the extensive use of wireless devices, although the effects of Electro Magnetic Fields (EMF) exposure in new parts of the body are now being investigated (for example, eyes). Meanwhile, with the advent of 5G, more efforts have been made to understand the thermal and non-thermal effects of MMW exposure on the human body.

5G TECHNOLOGY



There could be some technical opportunities in 5G to raise awareness of wireless users' exposure and allow them to decide if they want to reduce it at the cost of, for example, lower Quality of Service (QoS)

CONCLUSIONS

The laws to establish regulations about the maximum limits allowed for 5G technology depend on the local regulations of each country; however, the large number of variables and factors that intervene in the process makes it very difficult and premature to know what will happen when 5G technology is implemented.

CONCLUSIONS

The truth is that, due to the working frequencies that are considered for the entire network, it is possible to estimate that the risk is relatively low. Currently, 2.4 GHz frequency is used for most digital communications, so the frequency ranges are far from the frequency values considered highly dangerous.

CONCLUSIONS

The present work is a compilation of some research reports carried out by different authors and institutions; although different procedures were carried out for their respective contributions, and these contributions provide valuable information on the subject, all authors agree on at least two conclusions:

CONCLUSIONS

- Health risks from exposure to radiation from electromagnetic waves of 5G technology are directly related to the distance to the transmitting stations, since the intensity of the signals emitted is inversely proportional to said distance, in addition to depending on the environment and transmission conditions, so each case is particular.

CONCLUSIONS

- It is necessary to carry out more exhaustive investigations, which will be achieved over time; to date, 5G technology has not yet been implemented in commercial services, and the real risks can be measured effectively to the extent that there is more infrastructure for this new generation.

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