Review Article

Investigating The Impact Of Electromagnetic Waves On Human And Animal Bodies And Ways To Protect Them

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Abstract

Background: Electromagnetic field generator use has significantly expanded recently, particularly in contemporary civilizations. As a result, numerous scientific groups and many nations throughout the world are interested in learning more about how electromagnetic waves affect the human body.

Method: Nearly all hours of the day and night, a large number of individuals are exposed to the electromagnetic fields of their places of employment and residence at varying intensities and frequencies. As a result, we have attempted to identify and introduce the many forms of electromagnetic fields, their effects on various bodily parts of humans and animals, as well as examine and investigate methods of avoiding them in this research. First, the different forms of electromagnetic waves are categorized in terms of their frequency range and their ionizing and non-ionizing properties are examined. Following an examination of their impacts on various bodily regions, the fundamental guidelines and rules of radiation safety are covered.

Results and Coclusion: Nearly everyone in the modern world of today uses technology like mobile phones, electrical devices, etc. and benefits from them. Since they are continually exposed to electromagnetic radiation, their health may be compromised. The damaging effects of these waves on various human and animal body components were examined in this study. The brain, eyes, and hearing are three of the most vital organs. Studies have shown that electromagnetic radiation can seriously harm these components. Mobile phones are the most widely utilized by people of all electromagnetic wave sources. First, the different forms of electromagnetic waves are categorized in terms of their frequency range and their ionizing and non-ionizing properties are examined. Following an examination of their impacts on various bodily regions, the fundamental guidelines and rules of radiation safety are covered.

Keywords: Electromagnetic Field, Frequency, Ionizing and Non-Ionizing rays

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Introduction

Humans are exposed to low-frequency electromagnetic fields as a result of the increased usage of electronic gadgets in daily life (1, 2). Therefore, significant study was done on the impact of these waves on biological systems as a result of advancements in science and technology (3-6), the creation of new technologies, and the presence of people exposed to these waves (7-8). Mobile and wireless phones, TVs, computers, microwave ovens, telecommunication towers, high pressure, and other technologies all create electromagnetic waves that humans are subjected to (9). According to scientific studies, prolonged exposure to these waves can result in a number of disorders, including cancer, infertility, tumors, and DNA and cell damage, some of which are discussed in the sections that follow this article. The biggest number of radiated waves is associated with mobile phones, and these radiations are split by factors including signal changes, radiation strength, and amount (10). One of the nations exposed to high-frequency GSM telephone mast radiation in residential areas is Germany (11). With a pulse of 218 Hz and a frequency range of 900 to 1800 MHz, cell phones operate. Iran is one among the majority of European and Asian nations who use this frequency range (12).

It should be highlighted that since mobile phone waves are non-ionizing, they are harmless (13-14). From the time they are three years old until the end of their life, many people are exposed to radiation due to the excessive use of this kind of communication (15). Following in utero exposure to 50 Hz radiation (an electromagnetic field of 650 mT), Udroiu et al. (16) found a significantly higher number of micronuclei in peripheral blood and liver samples of newborn rats. Micronuclei in peripheral blood lymphocytes of individuals who reside 80 meters from mobile phone stations are much greater than those of those who reside 300 meters from the source of radio frequency (RF) radiation, according to research by Zothansiama et al. (17). Depending on how long they were exposed to this radiation, employees who were exposed to microwave radiation at work experienced hematological alterations in their peripheral blood. The activity and/or concentration of glutathione (GT), catalase (CAT), and superoxide dismutase (SOD) were all found to have changed significantly. Increased lipid cross-oxidation (LPO) in peripheral blood lymphocytes of residents living close to cell phone base stations was also noted (17). Lai reviewed the literature and compiled data from several research, demonstrating how exposure to radiation at extremely low frequencies alters the activity of free radicals such reactive oxygen species (ROS) and nitrogen (RNS) as well as endogenous antioxidant enzymes. Exposure to electromagnetic radiation interferes with the immune and endocrine systems' ability to operate. Experimental research in this area has demonstrated that electromagnetic radiation exposure in lower hives exacerbates the viral process and lowers immunity. A rapid rise in composition is also brought on by adrenaline in the blood, which allows for the detection of effects such blood clotting. The issue is that these risk variables are covert and continue to go undetected. Circulatory system issues, headaches, eye, immunity, and sexual issues in a person exposed to an electromagnetic field put them at risk for contagious illnesses. Our eyes, brain, digestive system, urinary genetics, unseen blood for our organs, and immune system are all impacted by electromagnetic waves during the day.

In their discussion of many impacts on the neurological system, Kim et al. (18) covered the death of nerve cells, modifications to the myelin sheath, and alterations to ion channels.

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Sheppard et al.'s (19) study made use of the calcium washout from brain tissues as a result of exposure to ELF at specific frequencies and amplitude windows. In rat tests, Eberhardt et al. showed the effects of radiation exposure at 900 MHz radiofrequency on the permeability of the blood-brain barrier and neuronal damage. Carruba et al.'s (20) experimental findings indicated participants' EEGs experienced peaks due to the low-frequency pulsing of their cell phones. Benassi et al. (21) used Parkinson's illness as an example to demonstrate the impact that ELF has on neurodegenerative disorders. They found that SH-SY5Y cells' redox potential and thiol content significantly declined, while protein carbonylation increased. Bobkova et al. (22) noticed alterations in spatial memory and brain amyloid- in two animal models of Alzheimer's disease and documented similar findings. Terzi et al.'s review (23) outlined the cumulative neurodegenerative consequences. Children's signs of attention deficit and hyperactivity disorder were linked to extended mobile phone use. Pall has provided descriptions of several of the health hazards connected to Wi-Fi use (24) and the neuropsychiatric side effects of ELF exposure.

After reviewing the available research, Szmigielski came to the conclusion that prolonged exposure to weak radiofrequency radiation suppresses the same humoral or cellular functions of immunity, whereas short-term exposure can temporarily stimulate these functions. El-Gohary & Said (25) evaluated the effects of ELF and RF mobile phones on total leukocyte levels, lymphocytes, eosinophils, basophils, eutrophils, and monocytes, as well as on immunoglobulin levels (IgA, IgE, IgM, and IgG). Marshall and Heil (19) explore the effects of electrosmog on the receptors for vitamin D and 1,25-dihydroxyvitamin-D (1,25-D), which are linked to several inflammatory and autoimmune illnesses. According to research by Lushnikov et al., mice's ability to produce antibodies was damaged by repeated exposure to extremely high-frequency, low-intensity electromagnetic radiation (42.0 GHz with an energy flux density of 0.15 mW/ct2 for 20 minutes each day). In patients, Belpomme & Irigaray (26) observed mild inflammation, an inflammatory response including antibodies to O-myelin, and many oxidative stress indicators in 80% of patients with electro hypersensitivity. reproduction process. According to Saygin et al. (27), rats exposed to wireless frequencies (2.45 GHz) for three hours each day experienced pathologic abnormalities in their testicles. The percentage of sperm with aberrant morphology and leutropin levels reduced in males who often carried a cell phone in their trousers pockets, according to research by Schauer & Mohamad Al-Ali (28). One of the earliest researchers on "screen dermatitis," the skin damage caused by short-wave radiation, was Johansson. He claimed that continuous exposure increased the number of mastocytes in skin samples from individuals with electro hypersensitivity. A review of comparable effects was conducted by Cardona-Hernández et al. (29). Even while short-term skin contact only slightly alters the epidermis' homeostasis, it can nonetheless impair the skin's defenses. Esen & Esen discovered that when exposed to mobile phone radiation, face and scalp skin had a 200 ms longer protective reaction time. Skin damage was mostly observed on the patients' hands, particularly on the hand that the patient was using to handle their cell phone, according to Belpomme & Irigaray (26).

Wilen et al. contrasted the health of RF operators—an occupational group that is highly exposed to RF electromagnetic fields—and unexposed employees in another investigation of the state of workers' health. According to the study, time-integrated exposure parameters had an impact on

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symptoms including weariness, headaches, and a warm sensation in the hands. Compared to the control group, RF operators' heart rates were lower, and bradycardia occurrences were more common. Rats subjected to high microwave radiofrequency radiation (30 mW/cm2 for 15 minutes of exposure is quite strong, but the major goal was to reveal pathological alterations in the myocardium) exhibited lower heart rates than animals not exposed to the radiation. Exposed rats showed histological and structural changes in the myocardium, with swollen and irregularly arranged myocytes, as well as some chromatin condensation and dark spots in the nuclei (30).

Types of electromagnetic spectrum waves

Depending on the frequency, magnetic fields can either be alternating or persistent, produced by both natural and manmade sources. The Earth is surrounded by a constant magnetic field that has a strength between 25 and 65 microtesla as its natural source (31).

Vacuum-like conditions allow electromagnetic radiation to travel through them as well. The electromagnetic spectrum encompasses all types of electromagnetic radiation. The electromagnetic spectrum, in which radiations range in energy from the lowest level and highest wavelength to the highest level and lowest values. They are arranged by wavelength. Naturally, the potency of the radiation increases with its energy, which increases its risk. Figure 1 clearly depicts the electromagnetic wave spectrum. Depending on how they affect living things, electromagnetic waves are classified as ionizing or non-ionizing.

Ionizing waves (ionizer)

It is said to be ionizing if the beam's energy is such that it can ionize air atoms as it passes through the atmosphere or if it can break the chemical bonds in the tissue. Ionizing waves are extremely hazardous to human health because they alter genetic material and destroy DNA, both of which have direct and indirect biological impacts (32). Radiation has an ionizing power of at least 12.4 electron volts and a wavelength of less than 100 nm, both in terms of energy. Gamma rays and X rays are examples of high frequency, short wavelength, and very penetrating radiation.

Non-ionizing waves

They are a kind of radiation that lacks the power to ionize objects. There are various uses for these beams nowadays. Some of these rays are absorbed by the surroundings and mostly transform into heat when they are dispersed in the air or material environment. Radiation having a wavelength greater than 100 nm is among these rays. It is clear that non-ionizing rays, which include microwaves, radio waves, infrared rays, visible light rays, and ultraviolet rays, have electron energies below 12.4 volts. Researchers and experts believe that non-ionizing radiation (NIR), which is the production of energy at lower frequencies, poses no threat to human health. However, current data point to the possibility that specific NIR frequencies can hasten biological harm. The following two areas have received the majority of attention in research on the health risks of non-ionizing radiation (NIR) to humans: (2) Radio frequencies and microwaves produced by wireless communication technologies, cordless and cellular telephones, and other electrical materials. (1) Very low frequency (ELF) energy waves produced and emitted by power plants, power lines, and some electrical equipment. Table 1 lists some of the properties and sources of the electromagnetic wave spectrum.

The effect of electromagnetic waves on different parts of the body

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The unquestionable desirability and numerous benefits of this energy, which are briefly stated below, have been called into question by certain recent study and scientific results as the usage of technology and facilities based on the use of electromagnetic waves has increased. The results of the studies done have demonstrated that exposure to these waves might have negative biological impacts. Thermal and non-thermal impacts are separated among these biological effects. Non-thermal consequences include negative effects on heat shock proteins, placental blood flow, the blood-brain barrier, the activity of brain cell neurons, liver cells, and pattern change. Thermal impacts include eye damage and genital damage. It was mentioned that people sleep (33, 34-35).

Effect of electromagnetic waves on the brain

All interactions within the human brain are the product of neurons or nerve cells producing bioelectrical waves, and these waves are transmitted by extremely intricate and interconnected nerve fibers. As a result, any disruption to this process has the potential to impair brain and nerve activation as usual (36). The mind is often employed first, followed by the activation of other bodily parts, via magnetic waves created in the neural networks. Therefore, positioning the human brain close to a source of electromagnetic radiation can harm normal brain wave activity and impair normal function (37). For instance, the thermal impact of mobile phones can reach the brain up to three millimeters deep (38). The waves that are released by mobile phones are comparable to the waves that are emitted from microwaves and radar and encompass a broad spectrum of invisible and electromagnetic waves. Between 900 and 1100 MHz, the strength of mobile phone waves ranges, and much as a microwave oven warms food, the mobile phone likewise has a thermal impact and can reach three centimeters deep into the brain (39). Although these waves cannot travel through the thickness of bone in adults, they can pass through the cerebral cortex in youngsters, making mobile phone usage extremely risky for young people (40). The skin on the top level of the skull is impacted by mobile phone waves because of the effects they have on the brain (41). The brain's mobile wave penetration is depicted in Figure 2. Studies on the impact of electromagnetic waves on brain tumors have been conducted. Numerous studies have demonstrated that although the precise origins of brain tumors remain unknown, electromagnetic field elements have the power to alter the structure of the brain. Additionally, it has been determined that those who reside close to electric lines have a greater chance of developing meningioma. Tumors called cerebral meningiomas develop from the membrane linings of the brain and spinal cord.

Figure 3 depicts potential effects of mobile phone radiation on brain cells. The endothelial cells lining capillary blood vessels and the nerve cells in the brain tissue absorb mobile phone radiation in step one. Step 2: A yet-unidentified biophysical mechanism causes mobile phone radiation to directly or indirectly activate cellular stress kinase. The p38 MAPkinase alone or in conjunction with other kinases that are upstream or downstream of p38 MAPkinase can activate the stress response. Step 3: The kinase(s) activated by radiation from mobile phones phosphorylate hsp27 (hsp27-P).

Hsp27 expression rises concurrently, which can have an additive and reinforcing impact by supplying additional hsp27 molecules to stimulate phosphorylation. Step 4. In conjunction with estrogen, the phosphorylated version of hsp27 changes bFGF secretion and synthesis while stabilizing endothelial cell stress fibers. Due to the occurrence of one or more of the following events, such as changes in endothelial cell shape and the formation of

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gaps between cells, the blood-brain barrier becomes more permeable. increased pinocytosis across the endothelium monolayer (maybe excessively high). endothelium cell lumenal surface bubble production (and shedding?) can block capillary blood flow, which can increase local blood pressure and make it easier for big molecules to pass through the endothelium monolayer. Endothelial cell gap creation in females is probably caused by the endothelium's secretion of bFGF, which induces endothelial cell dedifferentiation and proliferation in an endocrine way. When endothelial cells are encouraged to multiply, they constrict and leave spaces between them. Step 5: By forming a complex with the apoptosome or some of its constituent parts, the phosphorylated form of hsp27 blocks the activation of procaspase-9, which in turn prevents the activation of procaspase-3 and the suppression of the caspase-3-dependent apoptosis pathway. In order to avoid the demise of undesirable injured or altered cells, mobile phone radiation-induced phosphorylation of hsp27 in cells that are undergoing caspase-9/caspase-3 dependent apoptosis may be effective.

The effects of electromagnetic fields on the lymphatic system

High-frequency electromagnetic fields can lead to cancer as well as hematological and lymphatic disorders. The influence on leukemia is projected to be larger in maturity, with a higher prevalence of leukemia in adults and children living within 2 km of TV transmitting stations, according to shocking Australian research. Antonopoulos observed no cytogenetic damage brought on by the occurrence of cancer or the development of cancer cells while stimulating the cell cycle of human lymphocytes exposed to a 5 milliTesla magnetic field with a frequency of 50 Hz, while another experiment with a frequency of 50 Hz and 2 milliTesla magnetization reported changes in the number of lymphocyte cells (42). Chu observed an increase in the number of sister chromatid exchanges and the formation of micronuclei in the culture medium after exposing human lymphocytes to an electromagnetic field of 0.8 milliTesla and a frequency of 60 Hz for 24 hours (43). However, the electromagnetic field alone did not result in this change. In the concurrent examination of an electromagnetic field of 0.7 millitesla with a frequency of 60 Hz and ionizing radiation, Chu has also noted a rise in the frequency of point mutations in several genes.

Effects of electromagnetic field on fertility

In spermatozoa of wild boars subjected to electromagnetic radiation with a frequency of 50 Hz in an electromagnetic field higher than 0.5 milliTesla after 12 hours over the course of six days, Bernabn reported the destruction of acrosomes and the diminution of acrosome processes (44). He claims that extremely low frequency electromagnetic waves alter the structure and function of sperm and reduce fertility and the likelihood of conception (45). The ovarian follicle count, the effect on the endocrine system, and the decline in fertility in 30 female rats exposed to an electromagnetic field with a frequency of 50 Hz and an intensity of 15 Gauss for 4 days (6 hours per day) are also the subject of some experiments. It was intended to be highlighted (45). Pourlis, on the other hand, found no appreciable changes in the shape of sperm or eggs while studying various kinds of male and female laboratory model animals in the frequency range of 20, 50, and 60 Hz magnetic fields between 0.1 and 1.25 milliTesla and did not report cell death in the testis and ovary, spermatogenesis disorders, sperm count, or testis and ovary weight (46). Zare et al., however, reported the atrophy of seminiferous tubules and interstitial tissues as well as the loss of Leydig cells in the testis by exposing guinea pigs to electromagnetic fields

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of 0.013 and 0.207 microtesla for 2 and 4 hours over the course of 5 days completed (47).

Effects on bone and cartilage formation

Studies have shown that ligament tissue can occasionally benefit from modest electromagnetic fields. Takahito Sato and others, 48 In 2016, he did research in this area. On the left and right sides of the calvariae of Wistar rats used in this study, 4.8 mm-diameter bone defects were made. The left defect was the location of the active electrode, which was then subjected to five repetitions of a high-frequency electromagnetic stimulation lasting one second each. For two weeks, this was done twice every week. The control group did not stimulate the correct faults. Hematoxylin and eosin (HE) staining was used to create histological specimens for analysis after 8 weeks, and the rate of bone growth was calculated. In comparison to the control group, the experimental group's rate of bone growth was noticeably greater. These findings suggest that stimulation with high-frequency electromagnetic waves promotes bone growth in rat calvarial abnormalities.

The effect of electromagnetic waves on the eyes

The cornea of the eye lacks a system for controlling temperature and is extremely vulnerable to heat loss. Because of this, the cornea of the eye can absorb microwaves and suffer significant harm (49-50).

The effect of electromagnetic waves on the ear

The parts of the head and neck often come into the most contact with the apparatus (51). The distance between the eyes and ears and the cell phone is crucial because of this. Acoustic neuroma is one of the significant hearing issues brought on by mobile phone use for extended periods of time (52-53).

The effect of electromagnetic waves on the kidney

According to the research, mobile phones have an impact on renal health as well. According to these investigations, the medullar tubules are less impacted than the cortical renal tubular epithelium (54, 55, 56-57).

The effect of electromagnetic waves on the skin

Every person should take care of their skin. Human skin, on the other hand, serves as a defense against the negative impacts of cell phones. Studies have revealed, however, that the impacts of cell phones may even result in changes to the skin. (58-59).

The effect of electromagnetic waves on the neurological diseases

The development and beginning of disorders that impact the neurological system can be brought on by DNA damage. The inability of nerve cells to divide is one of their distinctive qualities that sets them apart from other cells. Cancer cells can develop when DNA is damaged in dividing cells. The DNA damage to neuron cells, however, primarily impacts the function of the cells or results in their death because neuron cells cannot reproduce. Glia cells, on the other hand, which make up the nervous system's supporting tissue, may divide. As a result, cancer may result from DNA damage in these regions (60).

The effect of electromagnetic waves on the testis

The human body's organs with poor temperature regulation include some. Men's testicles are one of these organs. Men's oligospermia has been detected in certain studies' early findings (61). In a recent research from 1999, Dasdag and colleagues found that using mobile phones caused histological alterations in the testes of mice, and that their

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rectal temperature was statistically greater than that of typical rats (74).

The effect of electromagnetic waves on the hormones

Video display units (VDUs) are now among the EMF producers that have an impact on people due to the increased usage of computers in daily life. For instance, it has been shown that electromagnetic waves from monitors raise levels of adrenocorticotropic hormone (ACTH) and reduce levels of melatonin in the human body (62).

The effect of electromagnetic field radiation on carcinogenesis

According to some scientists, low-frequency electromagnetic radiation damages DNA and promotes cancer by causing mutations in a manner similar to that of ionizing radiation (63). Electromagnetic radiation has been cited in several other research as a contributing element to the continued growth and advancement of cancer cells in cell populations (64). In a another experiment, long-term exposure of lab animals to electromagnetic fields at a frequency of 60 Hz did not result in cancer or mutations (65). Huevel's experiences also demonstrate that extremely low frequency electromagnetic radiation is not genotoxic and does not contribute to the genesis of cancer, but it can promote the multiplication and expansion of cancer cells (66). Raskmark also noted an increase in the rate of proliferation in cells exposed to an electromagnetic field of 80 microtesla with a frequency of 50 Hz (67), but no change in the rate of proliferation and differentiation in bone marrow cells exposed for one to three days to an electromagnetic field of 100 microtesla with a frequency of 50 Hz (68), while significant changes in the growth of human adenocarcinoma cell lines exposed for two hours and forty-five minutes (69). Additionally, Kein demonstrated that the simultaneous application of a low-frequency magnetic field and a chemical that promotes the growth of cancer, such as probol ester, alters the morphology of cells in a culture medium (70).

Ways of protection against electromagnetic waves

Currently, the majority of the world's population resides in a sea of electromagnetic waves, or, to put it another way, the globe is a giant microwave in which we live alongside plants and animals. The usage of electromagnetic force is unavoidable in the modern environment. Because without these advantages, this power is indispensable. Mobile phones, wireless internet (WiFi), medical imaging equipment, and other items that produce electromagnetic waves are all commonly utilized in today's contemporary society. The inside design of the X-ray tube, which is typical of radiography and radiology tubes, is shown in Figure 4. Therefore, it is important to consider ways to reduce the negative impact that electromagnetic waves have on human health.

Examples of ways to lessen exposure to electromagnetic fields include using optical fiber cables instead of wireless communication in communication networks, avoiding wireless communication altogether, keeping wireless phones and mobile phones away from the body, cutting down on the length of the conversation if using wireless phones or mobile phones, avoiding the use of microwave ovens, and avoiding the use of wireless computers. Some broad guidelines and rules for radiation protection against ionizing and non-ionizing radiation are listed in Table 3 (71).

Conclusion

Nearly everyone in the modern world of today uses technology like mobile phones, electrical devices, etc. and benefits from them. Since they are continually exposed to electromagnetic

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radiation, their health may be compromised. The damaging effects of these waves on various human and animal body components were examined in this study. The brain, eyes, and hearing are three of the most vital organs. Studies have shown that electromagnetic radiation can seriously harm these components. Mobile phones are the most widely utilized by people of all electromagnetic wave sources. Consequently, research on the effects of mobile phone radiation on human health was also conducted. Studies show that this radiation can harm the brain, eyes, hearing, and other organs in addition to causing infertility. Because of this, scientists are working to find ways to lessen and limit the harm that these waves do. As a result, by adhering to a few guidelines and rules, we can lessen the effects that these waves have on our bodies.

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Ethical Consideration:

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References

1. Narita K, Hanakawa K, Kasahara T, Hisamitsu T, Asano K. Induction of apoptotic cell death in human leukemic cell line, HL-60, by extremely low frequency electric magnetic fields: analysis of the possible mechanisms in vitro. In Vivo (Athens, Greece). pp. 329-35. Jul. 1997
2. Mairs RJ, Hughes K, Fitzsimmons S, Prise KM, Livingstone A, Wilson L, et al. Microsatellite analysis for determination of the mutagenicity of extremely low-frequency electromagnetic fields and ionising radiation in vitro. Mutation Research/Genetic Toxicology and Environmental Mutagenesis. Volume 626, Issues 1-2, pp. 34-41. Jan. 2007
3. Mobasseri S, Soltani H. Impact of driving style on fuel consumption. Nature and Science. Nat Sci 2013. 11(12). pp. 87-9.
4. Mobasseri S, Soltani H. Traffic noise and it's measurement methods. Advances in Environmental Biology. pp. 1277-1285.Aug. 2014
5. Mobasseri S. Intelligent Circuit Application for Detecting the amount of Air in Automobile Tires. Iranian Patent, Patent no 83544. Aug. 2014
6. Mobasseri S. Intelligent Circuit Application for Monitoring the Employees Attendance. Iranian Patent, Patent no 83354. Jul. 2014
7. Winker R, Ivancsits S, Pilger A, Adlkofer F, Rüdiger H. Chromosomal damage in human diploid fibroblasts by intermittent exposure to extremely low-frequency electromagnetic fields. Mutation Research/Genetic Toxicology and Environmental Mutagenesis. pp. 43-99.Apr. 2005
8. Moulder JE. Power-frequency fields and cancer. Critical Reviews™ in Biomedical Engineering. Volume 26, Issue 1-2, pp. 1-116. 1998
9. Palicot J, Roland C. On the use of cognitive radio for decreasing the electromagnetic radiations. URSI2005. pp. 23-9.
10. Hutter H, Moshammer H, Wallner P, Kundi M. Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. Occupational and environmental medicine. 63:307-13.May. 2006
11. Haumann T, Münzenberg U, Maes W, Sierck P. HF-Radiation levels of GSM cellular phone towers in residential areas. 2nd International Workshop on Biological effects of EMFS2002. pp. 327-33.
12. Sicard E, Delmas-Benhia S.

[Downloaded from intjmi.com on 2026-11-17]

Introduction to GSM. 5th. Bedford Ma Bed Fordma Techonline Publication. pp.1-3. 2001

13. Kundi M, Mild KH, Hardell L, Mattsson M-O. Mobile telephones and cancer—a review of epidemiological evidence. Journal of Toxicology and Environmental Health, Part B. pp. 351-84.Jul. 2004
14. Khurana VG. Cell phone and DNA story overlooked studies. science.Volume 322, Issue 5906, p. 1325.Nov. 2008
15. Calvente I, Fernandez M, Villalba J, Olea N, Nuñez M. Exposure to electromagnetic fields (non-ionizing radiation) and its relationship with childhood leukemia: a systematic review. Science of the total environment. Volume 408, Issue 16, pp. 3062-3069. Jul 2010
16. Udroiu I., Cristaldi M., Ieradi L.A., Bedini A., Giuliani L., Tanzarella C. Clastogenicity and aneuploidy in newborn and adult mice exposed to 50 Hz magnetic fields. Int. J. Rad. Biol.pp. 561-567.Jan. 2006
17. Zothansiama, Zosangzuali M., Lalramdinpuii M., Jagetia G.C. Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base stations. Electromagnetic Biology & Medicine,pp. 295-305.Jun. 2017
18. Kim J.H., Lee J.-K., Kim H.-G., Kim K.-B., Kim H.R. Possible Effects of Radiofrequency Electromagnetic Field Exposure on Central Nerve System, Biomol. Ther.pp. 265-275.May. 2019
19. Marshall T.G., Rumann Heil T.J. Electrosmog and autoimmune disease. Immunol. Res 2017. pp. 129-135.
20. Carrubba S., Frilot C. 2nd, Chesson A.L. Jr., Marino A.A. Mobile-phone pulse triggers evoked potentials. Neurosci. Lett. Volume 469,Issue 1, pp. 164-168. Jan. 2010
21. Benassi B., Filomeni G., Montagna C., Merla C., Lopresto V., Pinto R., Marino C., Consales C. Extremely Low Frequency Magnetic Field (ELF-MF) Exposure Sensitizes SH-SY5Y Cells to the Pro-Parkinson's Disease Toxin MPP (.). Mol. Neurobiol.pp. 4247-4260. 2016
22. Bobkova N.V., Novikov V.V., Medvinskaya N.I., Aleksandrova I.Y., Nesterova I.V., Fesenko E.E. Effect of weak combined static and extremely low-frequency alternating magnetic fields on spatial memory and brain amyloid-β in two animal models of Alzheimer's disease. Electromagn. Biol. Med. pp.127-137. Apr. 2018
23. Terzi M., Ozberk B., Deniz O.G., Kaplan S. The role of electromagnetic fields in neurological disorders. J. Chem. Neuroanat.,pp. 77-84. Apr. 2016
24. Pall M.L. Wi-Fi is an important threat to human health. Environmental Research,pp. 405-416. Jul. 2018
25. El-Gohary O.A., Said M.A. Effect of electromagnetic waves from mobile phone on immune status of male rats: possible protective role of vitamin D. Can. J. Physiol. Pharmacol.pp. 1-20. Sep. 2017
26. Belpomme D., Irigaray P.Electrohypersensitivity as a Newly Identified and Characterized Neurologic Pathological Disorder: How to Diagnose, Treat, and Prevent It. Int. J. Mol. Sci.Mar. 2020
27. Saygin M., Asci H., Ozmen O., Cankara F.N., Dincoglu D., Ilhan I. Impact of 2.45GHz microwave radiation on the testicular inflammatory pathway biomarkers in young rats: The role of gallic acid. Environ. Toxicol.pp. 1771-1784. Aug. 2016
28. Schauer I., Mohamad Al-Ali B. Combined effects of varicocele and cell phones on semen and hormonal parameters. Wien Klin Wochenschr, pp. 335-340. 2018
29. Cardona-Hernández M.A., Fierro-Arias

[Downloaded from intjmi.com on 2026-11-17]

L., Cabrera Pérez A.L., Vidal-Flores A.A. Efectos de la radiación electromagnética en la piel (Effects of electromagnetic radiation on skin). Dermatol. Rev. Mex.pp. 292-302.Jul. 2017

30. Zhang X., Gao Y., Dong J., Wang S., Yao B., Zhang J., Hu S., Xu X. (et al.) The Compound Chinese Medicine "Kang Fu Ling" Protects against High Power Microwave-Induced Myocardial Injury. PLoS One, Volume 9,Issue 7, e 101532. Jul. 2014
31. WorldHealthOrganization(WHO).Static fields. Environmental Health Criteria 232. Geneva. Jun. 2006.
32. Khurana VG, Teo C, Kundi M, Hardell L, Carlberg M. Cell phones and brain tumors: a review including the long-term epidemiologicdata. Surgical neurology. pp. 205-214.Sep. 2009
33. Cotgreave, Ian A., "Biological stress responses to radio frequency electromagnetic radiation: are mobile phones really so (heat) shocking?" Archives of Biochemistry and Biophysics, Volume: 435, Issue: 1, pp. 227-240. Mar. 2005
34. Hiroyuki Nakamura et al., "Nonthermal effects of mobile-phone frequency microwaves on uteroplacental functions in pregnant rats", Reproductive Toxicology, Vol. 17, Issue 3, pp. 321–326. May-June. 2003
35. Leif G. Salford et al., "Permeability of the blood-brain barrier induced by 915 MHz electromagnetic radiation, continuous wave and modulated at 8, 16, 50 and 200 Hz", Bioelectrochemistry and Bioenergetics, Volume 30, pp. 293–301. Mar. 1993
36. Jin Shi and Quan Xue, Senior Member, IEEE,Dual-Band and Wide-Stopband Single-Band

Balanced Bandpass Filters With High Selectivity and Common-Mode Suppression,Digital Object Identifier Volume 58, Issue 8, pp. 2204-2212. Jul. 2010

37. Sara M Salvador, Elise C Fear, Michal Okoniewski, John R Matyas,Exploring joint tissues with microwave imaging, IEEE Transactions on Microwave Theory and Techniques. pp. 2307-2313. Jul 2010
38. David Ireland and Amin Abbosh, "Modeling Human Head at Microwave Frequencies Using Optimized Debye Models and FDTD Method" , pp. 2352-2355. Jan.2013
39. Mariya Lazebnik , Michal Okoniewski , John H. Booske and Susan C. Hagness , "Highly Accurate DebyeModelsforNormal and Malignant Breast Tissue Dielectric Properties At Microwave Frequencies , IEEE Microwave and WirelesComponents Letters, Volume 17, No 12, pp. 822-824. Dec. 2007
40. Electromagnetic Field Interaction With Biological Tissue and Cells , Jao Wang , April 2009
41. Dehghan B. Thermal and non-thermal effects of electromagnetic waves on human body parts. 3rd Iran Electrical and Electronics Engineering Conference. pp. 1-12. Apr-May. 2019
42. Antonopoulos A, Yang B, Stamm A, Heller WD, Obe G. Cytological effects of 50 Hz electromagnetic fields on human lymphocytes in vitro. Mutation Research Letters. Volume 346, Issue 3, pp. 151-157. Mar. 1995
43. Cho YH, Chung HW. The effect of extremely low frequency electromagnetic fields (ELF-EMF) on the frequency of micronuclei and sister chromatid exchange in human lymphocytes induced by benzo (a) pyrene. Toxicology letters. Volume 143, Issue 1, pp. 37-44. June. 2003
44. Bernabņ N, Tettamanti E, Russo V, Martelli A, Turriani M, Mattoli M, et al. Extremely low frequency electromagnetic field exposure affects fertilization outcome

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in swine animal model. Theriogenology. Volume 73, Issue 9, pp. 1293-1305. June 2010

45. Baharara J, Parivar K, Oryan Sh. and Ashraf AR. Effects of low frequency electromagnetic fields on gonads and fertility of female Balb/c mouse. Journal of Arak University of Medical Sciences. Volume 9,Issue 2, pp. 1-11. June. 2006
46. Pourlis AF. Reproductive and developmental effects of EMF in vertebrate animal models. Pathophysiology. Volume 16, Issue 2-3, pp. 179-189. Aug. 2009
47. Zare S, Alivandi S, Ebadi A. Histological studies of the low frequency electromagnetic fields effect on liver, testes and kidney in guinea pig. World Applied Sciences Journal. pp. 509-511. 2007
48. Takahito SATO , Tsutomu SUGAYA et al.Effects of High-frequency Electromagnetic Wave Stimulation on Bone Repair in Rat Calvaria Defects,J Oral Tissue Engin. pp. 59-64. 2016
49. Xu S, Zhou Z, Zhang L, Yu Z, Zhang W, Wang Y, et al. Exposure to 1800 MHz radiofrequency radiation induces oxidative damage to mitochondrial DNA in primary cultured neurons. Brain research. pp. 189-196. Jan. 2010
50. Lai H, Singh NP. Magnetic-field-induced DNA strand breaks in brain cells of the rat. Environmental health perspectives. pp. 687-694. May. 2004
51. Hyland GJ. Physics and biology of mobile telephony. Lancet. Volume 356, Issue 9244, pp. 1833-1836. Nov. 2000
52. Salahaldin AH, Bener A. Long-term and frequent cellularphone use and risk of acoustic neuroma. Int Tinnitus J. Volume 12, No 2, pp. 145-148. 2006
53. Balcı M, Devrim E, Durak I. Effects of mobile phones onoxidant/antioxidant balance in cornea and lens of rats. Curr Eye Res. Volume 32, Issue 1, pp. 21-25. 2007
54. Kang GH, Lee CH, Seo JW, Sung RH, Chung YH, Lee SK, et al.In-vivo study on the harmful effect of the extremely low frequency unipolar pulsating magnetic field in mice. Korean Med Sci. pp. 128-134. Dec. 1997
55. Pyrpasopoulou A, Kotoula V, Cheva A, Hytiroglou P, Nikolakaki E, Magras IN, Xenos TD, Tsiboukis TD, Karkavelas G. Bone morphogenetic protein expression in newborn rat kidneys after prenatal exposure to radiofrequency radiation. Bioelectromagnetics. Volume 25, Issue 3, pp. 216-227. Apr. 2004
56. Oktem F, Ozguner F, Mollaoglu H, Koyu A, Uz E. Oxidative damage in the kidney induced by 900-MHz-emitted mobile phone: protection by melatonin. Arch Med Res. Volume 36, Issue 4, pp. 350-355. Jul-Aug. 2005
57. Ozguner F, Oktem F, Armagan A, Yilmaz R, Koyu A, Demirel R, Vural H, Uz E. Comparative analysis of the protective effects of melatonin and caffeic acid phenethyl ester on mobile phone-induced renal impairment in rat. Mol Cell Biochem. Volume 276, pp. 31-37. Aug. 2005
58. Ozguner F, Aydin G, Mollaoglu H, Gokalp O, Koyu A, Cesur G. Prevention of mobile phone induced skin tissue changes by melatonin in rat: an experimental study. Toxicol Ind Health. Volume 20, Issue 6-10, pp. 133-139. Jul-Nov. 2004
59. Sanchez S, Milochau A, Ruffie G, Poulletier de Gannes F, Lagroye I, Haro E, Surleve-Bazeille JE, Billaudel B, Lassegues M, Veyret B. Human skin cell stress response to GSM-900 mobile phone signals. In vitro study on isolated primary cells and reconstructed epidermis. FEBS J. Volume 273, Issue 24, pp. 5491-5507. Dec. 2006
60. Brain. http://www.brain.com
61. Deepinder F, Makker K, Agarwal A. Cell phones and male infertility: dissecting the relationship. Reprod Biomed Online. Volume 15, Issue 3, pp. 266-270. June. 2007

[Downloaded from intjmi.com on 2026-11-17]

62. Arnetz BB, Berg MJ. Melatonin and adrenocorticotropic hormone levels in video display unit workers during work and leisure. Occup Environ Med. Volume 38, No 11, pp. 1108-1110. Nov. 1996
63. Rosenthal M, Obe G. Effects of 50-Hertz electromagnetic fields on proliferation and on chromosomal alterations in human peripheral lymphocytes untreated or pretreated with chemical mutagens. Mutation Research/ Fundamental and Molecular Mechanisms of Mutagenesis. Volume 210, Issue 2, pp. 329-335. Feb. 1989
64. Löscher W, Mevissen M. Animal studies on the role of 50/60-Hertz magnetic fields in carcinogenesis. Life sciences. Volume 54, Issue 21, pp. 1531-1543. Feb. 1994
65. Mccormick DL, Boorman GA, Findlay JC, Hailey JR, Johnson TR, Gauger JR, et al. Chronic toxicity/oncogenicity evaluation of 60 Hz (power frequency) magnetic fields in B6C3F1 mice. Toxicologic pathology. Volume 27, Issue 3, pp. 279-85. May. 1999
66. Van Den Heuvel R, Leppens H, Nemethova G, Verschaeve L. Haemopoietic cell proliferation in murine bone marrow cells exposed to extreme low frequency (ELF) electromagnetic fields. Toxicology in vitro. Volume 15, Issue 4-5, pp. 351-355. Aug- Oct. 2001
67. Kwee S, Raskmark P. Changes in cell proliferation due to environmental non-ionizing radiation 1. ELF electromagnetic fields. Bioelectrochemistry and bioenergetics.Volume 36, Issue 2, pp. 109-114. Mar. 1995
68. Landry PS, Sadasivan KK, Marino AA, Albright JA. Electromagnetic fields can affect osteogenesis by increasing the rate of differentiation. Clinical orthopaedics and related research. Volume 338, pp. 262-270. May. 1997
69. Ruiz GMJ, Pastor VJM, De La Pena L, Gil CL, Martínez MM. Growth modification of human colon adenocarcinoma cells exposed to a low-frequency electromagnetic field. Journal of physiology and biochemistry. Volume 55, Issue 2, pp. 79-84. Mar. 1999
70. Cain CD, Thomas DL, Adey WR. 60 Hz magnetic field acts as co-promoter in focus formation of C3H/10T1/2 cells. Carcinogenesis. Volume 14, Issue 5, pp. 955-960. May. 1993
71. The Control of Electromagnetic Fields at Work Regulations 2016, Health and Safety Executive 2016, Health andSafety Executive. No 588, May. 2016
72. Hardell L, Carlberg M, Söderqvist F, Mild KH, Morgan LL. Long-term use of cellular phones and brain tumours: increased risk associated with use for > or =10 years. Occup Environ Med. Volume 64, pp. 626-632. Mar. 2007
73. Kan P, Simonsen SE, Lyon JL, Kestle JR. Cellular phone use and brain tumor: a meta-analysis. J Neurooncol. Volume 86, pp. 76-78. Jul. 2007
74. Dasdag S, Ketani MA, Akdag Z, Ersay AR, Sari I, Demirtas OC, et al. Whole-body microwave exposure emitted by cellular phones and testicular functions of rats. Urol Res. Volume 27, pp. 219-223. June. 1999
75. Dariusz Leszczynski ,Sakari Joenväärä ,Jukka Reivinen ,Reetta Kuokka' Non-thermal activation of the hsp27/p38MAPK stress pathway by mobile phone radiation in human endothelial cells: Molecular mechanism for cancer- and blood-brain barrier-related effects' U. S. Copyright Clearance Center Code Statement: Volume 70, Issue 2-3, pp. 120-129. May. 2002
76. Vecchia P, Matthes R, Ziegelberger G, Lin J, Saunders R, Swerdlow A. Exposure to high frequency electromagnetic fields, biological effects and health consequences (100 kHz-300 GHz). International Commission on Non-Ionizing Radiation

[Downloaded from intjmi.com on 2026-11-17]

Protection. ISBN 978-3-934994-10-2, ICNRIP 16/2009

77. A S Bugaev, P A Eroshkin, V A Romanko, E P Sheshin' Low-power X-ray tubes (the current state)' Uspekhi Fizicheskikh Nauk Volume 56, Issue 7, pp. 691- 703. Mar. 2013

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Tables& Figures

Table 1: Sources and limits of the wavelength of the spectrum of electromagnetic waves.

Wave	About the wavelength	Source
gamma ray (γ)	10^{-12}m	The nucleus of radioactive materials and cosmic rays
X-ray	10^{-10}m	X-ray lamp
Ultraviolet(UV)	10^{-8}m	The sun, the electric spark and the mercury vapor lamp
light	6×10^{-7}m	The sun, hot bodies and lasers
Infrared(IR)	10^{-4}m	Sun, hot things
Very High Frequency(VHF)	3m	Microwave oven, radio and television antennas, etc

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Table 2: The effect of electromagnetic field on different tissues in animal and humans

Tissue	Effect	Reference
brain	The skin of the upper level of the skull is affected by these waves.	Dehghan b, et al.[41]
lymphatic system	Increasing the amount of micronucleus formation and sister chromatid exchanges in the culture medium	Cho YH, et al.[43]
fertility	Decreased fertility, decreased chance of conception, change in shape and function of sperm	Bernaben N,et al.[44] Zare S, et al.[47]
bone	Increasing the rate of bone formation in rat calvarial defects	Takahito SATO,et al.[48]
eye	Damage to the cornea of the eye	Xu S,et al.[49] Lai H,et al.[50]
ear	Acustic neurinoma	Salahaldin, Bener,[52] Balcı et al.,[53]
Neurological system	Cancer	Brain,2009[60]
testis	Oligospermia	Deepinder F,et al.[61]
kidney	Tubular epithelium damage	Oktem et al.,[56] Kang et al.,[54] Ozguner et al.,[57] Pyrpasopoulou et al.,[55]
skin	Harmful changes	Sanchez et al.,[59] Ozguner et al.,[58]
Hormones	Melatonin ↓ ACTH ↑	Arnetz, Berg,[62]
blood	Leukemia	Hardell et al.,[72] Kan et al.,[73]

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Table 3: Principles of protection against ionizing and non-ionizing radiation

Wave / Number	Ionizing rays	Non-ionizing rays
1	reduction of radiation time	Not sending non-ionizing radiation in unnecessary cases
2	increasing the distance from the radioactive source	Reducing the level of radiation to the minimum possible in all cases
3	Use proper protection	Paying attention to the protection regulations against non-ionizing radiation
4	installing physical barriers	Familiarity of all employees with non-ionizing radiation and their possible dangers
5	Installation of alarm equipment	Using appropriate danger signs on devices that produce or use non-ionizing radiation

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6	Reducing the risk of human error	Determining the areas to which entry is prohibited for the general public
7	development of instructions	Paying attention to the instructions related to how to use devices and equipment
8	training, motivating and supervising personnel	Repair or service of non-ionizing radiation generating devices by responsible persons
9	Accepting residual risks	See a doctor in case of radiation

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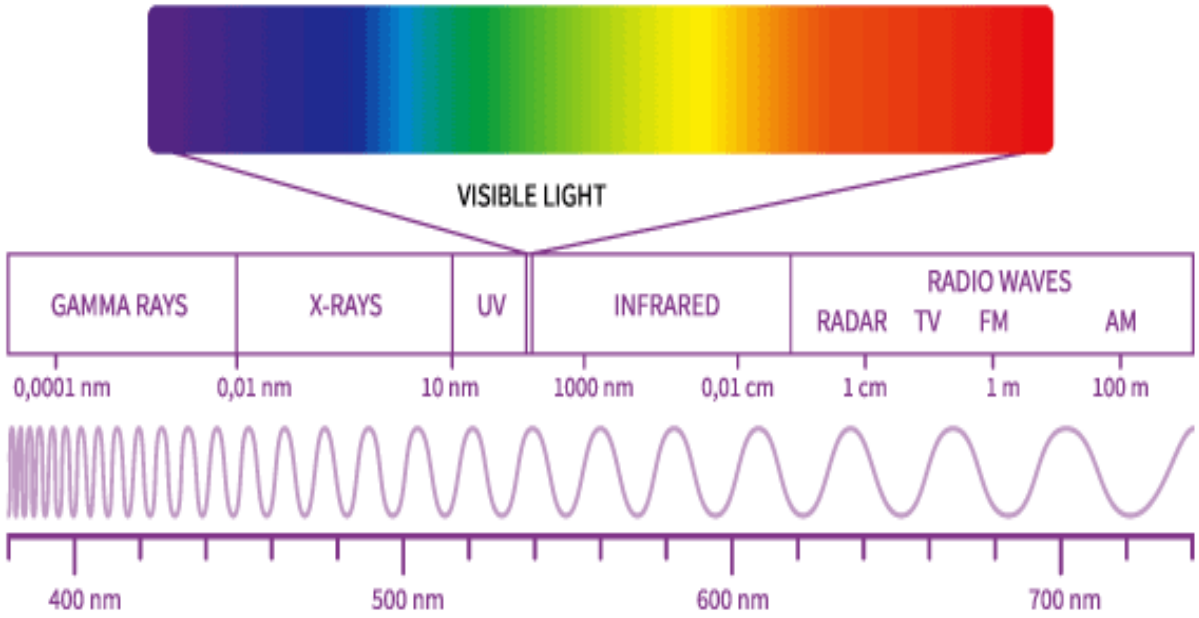


Figure 1: Spectrum of electromagnetic waves.

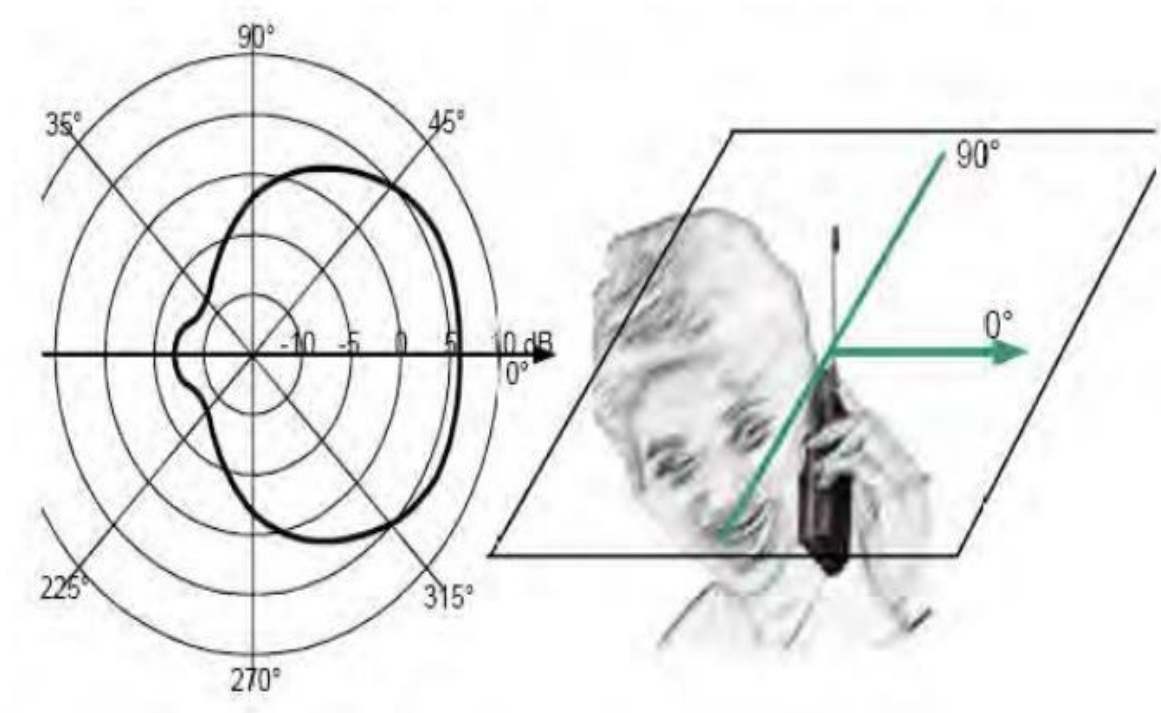


Figure 2: Penetration of mobile waves in the brain (76)

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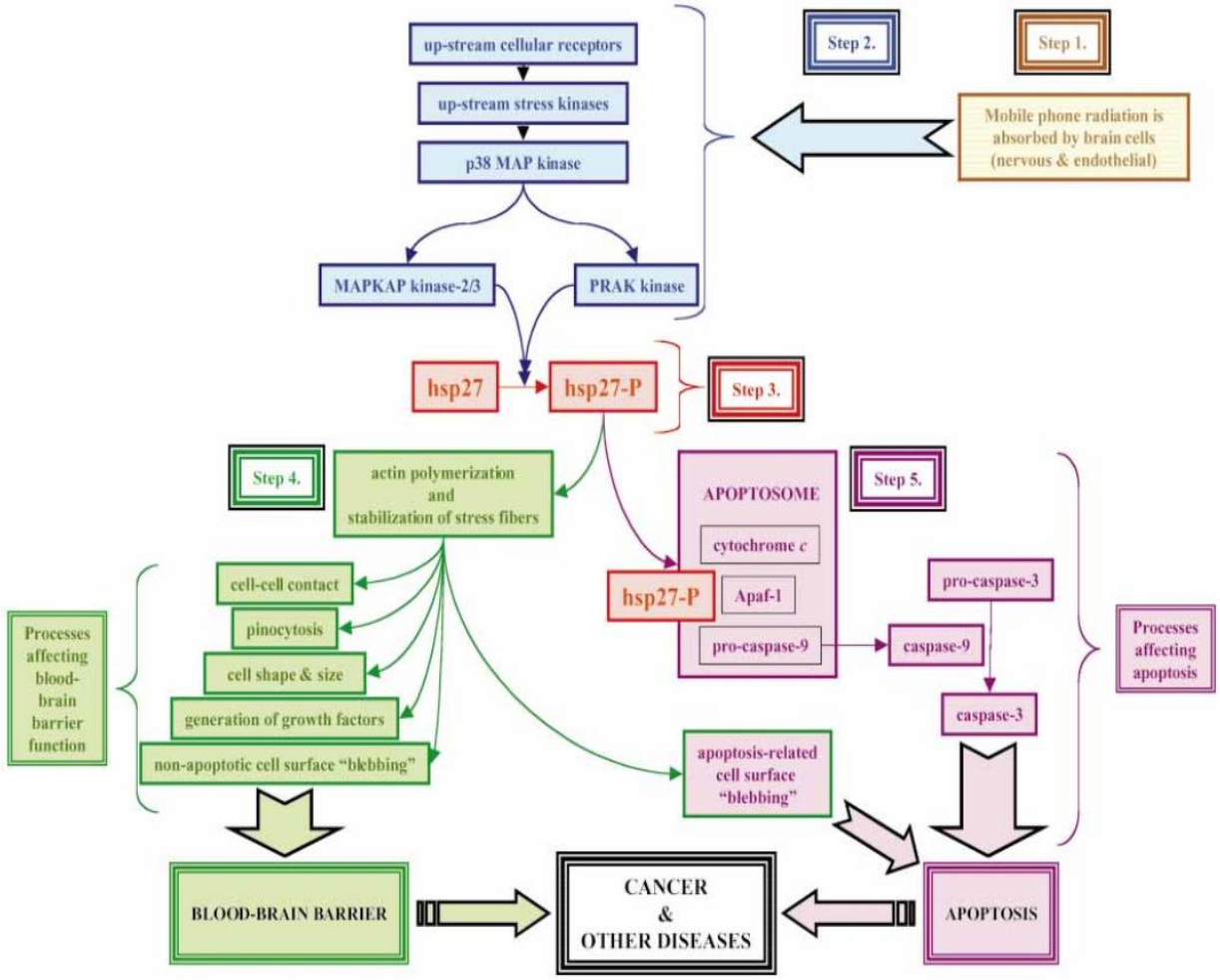


Figure 3: Hypothetical flow of events that may occur in brain cells (nervous and endothelial) in response to mobile phone radiation (75)

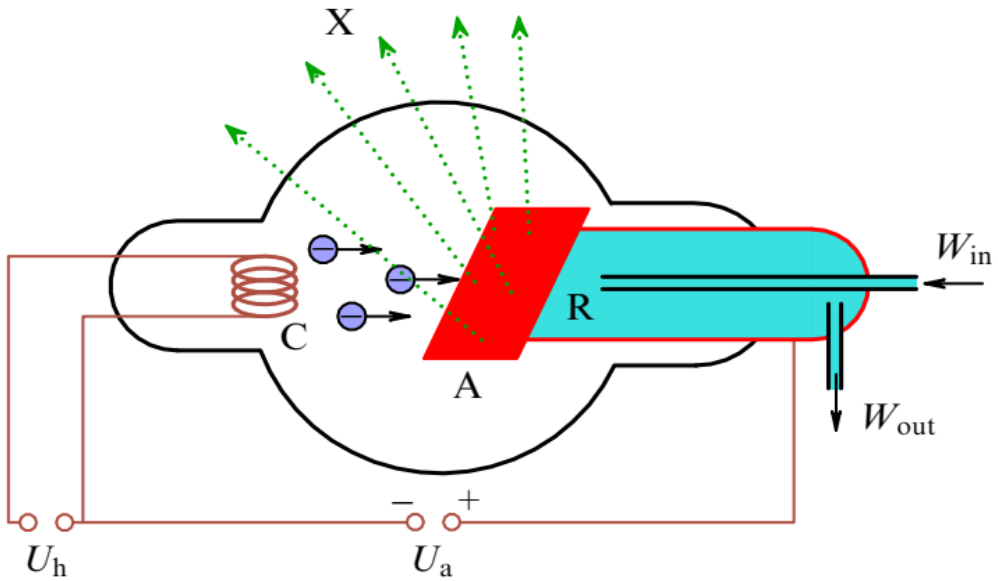


Figure 4: Schematic of an X-ray tube (77)

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