BIOLOGICAL EFFECTS OF NON-IONIZING RADIATIONS pdf

1: Ionizing Radiation

I was wondering how waves of the non-ionizing part of the electromagnetic spectrum differ from each other besides mere frequency and more specifically with respect to possible biological effects. How does exposure of a human or other organism to for example radiation from visible light differ to.

When ionizing radiation comes in contact with a cell any or all of the following may happen: It may pass directly through the cell without causing any damage. It may damage the cell but the cell will repair itself. It may kill the cell. The death of one cell is of no concern but if too many cells in one organ such as the liver die at once, the organism will die. Inside the nucleus of each cell are microscopic bodies called chromosomes. Different species of animals and plants may have a different number of chromosomes. Humans and potatoes have 46 chromosomes, while chickens have Chromosomes are made of two large molecules or strands of deoxyribonucleic acid DNA. These strands of DNA make up the genetic code, which in many ways acts much like a computer program. DNA is made up of four nucleic acids: How these nucleic acids are arranged in the DNA is the genetic code that determines everything from hair colour to how tall you grow and even susceptibility to certain diseases. If the cell reproduces instead of dying, a new mutated cell may be produced. In many cancers, the instructions that turn off cell growth are somehow damaged causing out of control cell reproduction, creating a tumour. Ionizing radiation, along with many other substances such as some chemicals, heavy metals and intense electromagnetic waves, can damage cells in this manner which can lead to diseases such as cancer. When talking about biological effects from ionizing radiation there are two categories of injury: Somatic injury is damage that occurs to the organism exposed to high levels of ionizing radiation and does not include reproductive cells. Effects like sickness, hair loss or internal bleeding are visible shortly after exposure. Other illness such as cancer may take a number of years to appear. Some potential illnesses could include birth abnormalities and cancer. Somatic and genetic injuries are not solely caused by ionizing radiation. Many chemical pollutants found in our environment such as cadmium, lead and mercury also can cause similar injuries. If a strand of DNA is damaged, the cell may repair the damage, die or kill itself through a process known as apoptosis. Sometimes the cell survives but incorrectly repairs itself and then passes the genetic abnormality on to other cells during reproduction. Genetic injury due to radiation exposure has not been observed in human populations e. Direct and Indirect Action of Ionizing Radiation on DNA Inside the nucleus of each human cell there are 46 chromosomes organized into two sets of 23 chromosomes. Packaged inside these chromosomes is our DNA, the genetic material we receive from our parents. These agents include ultraviolet light, natural and man made mutagenic chemicals and reactive oxygen species generated by ionizing radiation. When cells are exposed to ionizing radiation, radiochemical damage can occur either by direct action or indirect action. Direct action occurs when alpha particles, beta particles or x-rays create ions which physically break one or both of the sugar phosphate backbones or break the base pairs of the DNA. The base pairs adenine, thymine guanine and cytosine are held together by weak hydrogen bonds. Adenine always pairs with thymine except in RNA where thymine is substituted by uracil and guanine always pairs with cytosine. The bonding of these base pairs can also be affected by the direct action of ionizing radiation. Direct action of ionizing radiation on DNA. However, heavy charged particles such as alpha particles have a greater probability of causing direct damage compared to low charged particles such as X-rays which causes most of its damage by indirect effects. The DNA base pairs form sequences called nucleotides which in turn form genes. Genes tell the cell to make proteins which determine cell type and regulate cell function. When such breaks occur, DNA usually repairs itself through a process called excision. The excision process has three steps: These repair processes are highly efficient since we have evolved as a species in a sea of radiation. DNA repair takes place continuously, involving every cell in our bodies several times per year. Occasionally, however, damage to the base pair can occur when the DNA is incorrectly repaired and the wrong nucleotide is inserted which can lead to cell death or a mutation. Remember your DNA is the code which determines the type and function of the cell. There are two basic types of mutations: Substitutions â€” this is the replacement of one base by another. For example, if a DNA molecule usually contains guanine at a certain position, but adenine takes the place of the guanine, then a base substitution has occurred. There are two types of base substitutions: There are two types of frameshift mutations: The fat cat ate the hot dog. A base substitution might have an effect like this: The fat car ate the hot dog. The fat cat are the hot hog. In each case, the phrase still makes sense, but the meaning has been slightly changed. A mutation, on the other hand, would have a more profound effect: The fma tca tat eth eho tdo g. A deletion would have the same effect: The atc ata tet heh otd og. Two types of breaks in the sugar phosphate backbone can also be caused by ionizing radiation. A single strand break occurs when only one of the sugar phosphate backbones is broken. Single strand breaks are readily repaired using the opposite strand as a template. However, base pair substitutions and frameshift mutations can still occur. Double-strand breaks are believed to be the most detrimental lesions produced in chromosomes by ionizing radiation. Because such breaks are difficult to repair, they can cause mutations and cell death. Unrejoined double strand breaks are cytotoxic they kill cells. Double strand breaks can also result in the loss of DNA fragments which, during the repair process, can cause the joining of non-homologous chromosomes chromosomes not of the same pair leading to the loss or amplification of chromosomal material. Single strand and double strand breaks. These events can lead to tumorigenesis creation of tumour cells if, for example, the deleted chromosomal region encodes a tumour suppressor or if an amplified region encodes a protein with oncogenic potential cancer potential. If the genetic code is damaged and the cell does not undergo apoptosis cell suicide , the mutation may be passed on during cell division, perhaps leading to a cancer or other mutation. In some cases a mutation may remain dormant for years and perhaps forever. Ionizing radiation can also impair or damage cells indirectly by creating free radicals. Free radicals are molecules that are highly reactive due to the presence of unpaired electrons on the molecule. Free radicals may form compounds, such as hydrogen peroxide, which could initiate harmful chemical reactions within the cells. As a result of these chemical changes, cells may undergo a variety of structural changes which lead to altered function or cell death. Indirect action of ionizing radiation on DNA. NDT Resource Center, www.

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2: Non-ionizing Radiation - WikiLectures

Non-Ionizing radiation (NIR) refers to radiative energy that, instead of producing charged ions when passing through matter, has sufficient energy only for excitation. Nevertheless it is known to cause biological effects. The NIR spectrum is divided into two main regions, optical radiations and electromagnetic fields.

Print this page What are the risks of non-ionising radiation? Non-ionising radiation does not penetrate deep into the tissues but increases the risk of damage to the skin and eyes. General risks Dependent on the energy and exposure time, non-ionising radiation can cause localised heating, or photochemical reactions can occur with possible permanent harm. Exposure should therefore be minimised. Inappropriate or incorrect use and a wrong design increase the chances of physical harm. Specific risks Risks with ultraviolet light UV â€” nm Ultraviolet light is emitted by hot light sources such as the sun, filament lamps, halogen lamps, sun beds, welding arcs electrical welding and gas discharge lamps e. Excessive exposure mainly poses a risk for the eyes and skin. Long-term effects are skin cancer, skin thickening, premature aging of the skin and clouding vision cataract. Read here which measures you can take. Risks for visible light and infrared light IR 0. The biggest risks are for the eyes and skin. In the infrared area the IR-A area poses the biggest risk retinal damage and ashen cataract. The eyes are also sensitive for excessive light. The greatest risk is in the nm range "blue light hazard". Here the skin can be burnt. Risks with radio wave and microwave fields 10 MHz â€” GHz Sources of radio wave and microwave radiation are high-frequency generators gyrotrons, klystrons etc. Base stations for cordless phones are weak sources. Exposure Exposure to electromagnetic fields in this frequency range can warm up exposed tissues because these absorb the radio wave and microwave energy and convert these into heat. The frequency level determines the depth of penetration into the body. Warming up by this radiation is the most dangerous for the brain, eyes, genitals, stomach, liver and kidneys. How deep the radiation penetrates depends on the frequency. If resonances occur in parts of the body then the damage can increase. Risks with low-frequency fields Hz â€” 10 MHz Up to kHz only the induced current density and the internal electric field strength are important. For exposure to fields with a frequency greater than kHz the specific energy absorbed is important. The energy is absorbed throughout the body but in differing degrees. Exposure No biological consequences of static fields have been observed. The most significant risk is electrical shock if an object is touched. Static magnetic fields cause slight electrical potential differences in blood vessels. The consequences of these are unknown. Low-frequency variable fields generate electric currents in the body of the same size as the body generates itself and these can directly activate nerves and muscles. No lasting detrimental effects are known. Short-term risks Artificial parts or aids for the human body such as pacemakers and ferromagnetic implants limit value 0. Long-term risks A lot of research has been done on this. The general picture is that there is no or a very weak relationship between health and ELF.

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3: Non-ionizing radiation & biological effects | Physics Forums

One characteristic of ionizing radiation on human body is that the energy absorbed is low but the biological effects are serious. For example after receiving a lethal dose of 10 Gy, the body temperature will only increase by o C but the dose may lead to death of all the exposed entities.

These recommendations were formulated according to the highest levels of radiation, above which the proven thermal effects of non-ionizing radiation are observed. However, there is general agreement that there may be additional health effects unrelated to heating of tissues non-thermal effects. Therefore, many countries have formulated more stringent recommendations. This stringency is in accordance with the precautionary principle. This principle advocates reducing exposure while striking a balance between the needs of evolving technology and protecting human health. Thermal effects heating The best-known proven effect of non-ionizing radiation is heating of tissues. This effect occurs mainly in the range of 30MHz to GHz radio frequency. Infrared thermography image showing the heat of Notebook and smartphone Biological tissues are composed mainly of water and electrically-charged particles. Each tissue has a specific capacity for absorbing energy, according to its characteristics. Energy from electromagnetic fields in the radiofrequency and microwave ranges, when absorbed by biological tissues, causes movement of the charged particles in the tissues leading to a local increase in the tissue temperature. The tissue can usually cope with a slight increase of its temperature, by increasing the blood flow to the area that absorbed the radiation. If the temperature increase is high the body cannot overcome and dispel the excess heat, and the tissue may be damaged e. For instance, exposure to a power of milliwatts mW for 50 minutes would raise brain temperature by 0. One study found that a mobile phone, with a power of mW would raise brain temperature by only 0. Induced voltage gradients and currents may also cause stimulation of biological tissues or a change in their electric or nervous conduction. This phenomenon may also occur at higher frequencies - within the radiofrequency range - under exposure to sources whose power is higher than the power that causes heating of tissues. Back Non-thermal effects Non-thermal effects of non-ionizing radiation are those not directly related to an increase in tissue temperature the thermal effect , but rather to other changes that occur in the tissue as a result of exposure to electric or magnetic fields. Such changes may be caused by a sequence of biological processes and may affect the living organism at different levels from the molecular to the cellular, the organ, and the whole living organism activating various mechanisms that affect health. To verify this hypothesis, the effects of different frequencies of non-ionizing radiation on intracellular processes in tissue cultures of various cell types were studied. Specific absorption rate and temperature increases in the head of a cellular-phone user. Calculation of change in brain temperatures due to exposure to a mobile phone.

4: What are the biological effects of ionizing radiation?

disciplines are related in the biological response to non-ionizing radiations is the cen- tral theme of my lecture. Shortly after I emigrated to the United States, I established contacts with Fricke and Cole. I profited much from frequent visits with both men, particularly those with Fricke.

Various types of radiation differ in penetrability based on LET, which expresses energy loss per unit distance traveled kiloelectron volts per micrometer. This value is high for alpha particles, lower for beta particles, and even less for gamma rays and X-rays. Thus, alpha particles penetrate a short distance but induce heavy damage, and beta particles travel a longer distance but much shorter than gamma rays. The radiation dose is obviously an important factor. In addition, a single dose of radiation causes more damage than the same dose being divided fractionated. Collectively these two factors are expressed as dose per fraction. Dose rate expresses the time for which dose is administered. The longer the duration for the same total dose, the better the chance of cellular repair and the smaller the damage. Although all cells can be affected by ionizing radiation, normal cells and their tumors vary in their sensitivity to radiation. Slowly and rapidly growing cells have different radiosensitivity in relation to their movement through the cell cycle. Radiosensitivity varies with the rate of mitosis and cellular maturity. Blood-forming cells are very sensitive to radiation, while neurons, muscles, and parathyroid cells are highly radioresistant. Within a given cell, the nucleus in general is relatively more radiosensitive than the cytoplasm. G2 synchronization produces a cluster of radiosensitive cells. A second hit within a time frame of 5â€”12 h leads to higher proportion of deleterious effects. Repair Capacity of Cells. Some cells are known to have a higher capacity than others to repair the damage caused by ionizing radiation; consequently, the biological effects of the same radiation dose are different. Significant repair is known to occur quickly, within 3 h. The life cycle of the cell includes several phases: All phases of the cell cycle can be affected by ionizing radiation. The radiosensitivity of a given cell varies from one cell-cycle phase to another. Overall, sensitivity appears to be greatest in G2 phase; irradiation during this phase retards the onset of cell division. Irradiation during mitosis induces chromosomal aberrations, i. The sensitivity of a given cell-cycle phase also differs from one cell type to another and by alteration of radiation injury [3]. For example, the reproductive cells are most sensitive during the M phase, while damage to DNA synthesis and chromosomes occurs mostly when the cell is in the G2 phase. Recovery from sublethal damage occurs in all phases of the cell cycle. However, this is most pronounced in the S phase, which is also the most radioresistant phase [3]. Degree of Tissue Oxygenation. Molecular oxygen is known to have the ability to potentiate the response to radiation; this is known as the oxygen effect. The amount of molecular oxygen rather than the rate of oxygen utilization by the cells is the most important factor for increasing the sensitivity of cells to radiation. The probable mechanism is the allowance of additional free radicals, which enhance the damage of cells [ ]. The nucleus is relatively more radiosensitive than the cytoplasmic structures. Nuclear changes after radiation include swelling of the nuclear membrane and disruption of chromatin materials. Cytoplasmic changes include swelling, vacuolization, disintegration of mitochondria and endoplasmic reticulum, and reduction in the number of polysomes [.

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5: Reported Health Effects From Non-Ionizing RF Radiation

[Biological effects of non-ionizing electromagnetic radiation]. [Article in Polish] Fedorowski A(1), Steciwko A. Author information: (1)ZakÅ‚adu Medycyny Rodzinnej, Akademii Medycznej we WrocÅ‚awiu.

They are the summaries of two high profile literature reviews with the summaries quoted word for word. There may be reasons that they are not appropriate, but it is certainly not the ones cited in the revision. Please do not remove again without discussing reasoning. Word for word too? Do the publishers not retain any kind of copyright? I know my University does. Thanks for pointing that out. Also, I agree that there are many reasons why it is inappropriate to put all this here, not least because it severely disrupts the flow of the article and makes it more about this sub-sub heading rather than the subject of the article. I am happy with removal under the basis that is extremely odd to have this level of detail for such a minor part of the article. I have left the link to the Health Concerns section of the Power Transmission page as it is well sourced, cited and documented. Again, thanks for approaching this with discussion: Even visible blue light is very very weakly ionizing. They all represent a non-zero risk promotion of cancer. Adam McMaster talk Cesium has the lowest ionization energy of all elements, and it still requires wavelengths below nm. Nightvid unregistered I have now removed wavelengths of radiation shorter than nm from the table, because they are not strictly non-ionizing that is, shorter wavelengths can ionize neutral atoms of at least one element. See Ionization energies of the elements for more information. Nightvid unregistered Non-ionizing radiation not mutagenic? UV light is capable of acting as a mutagen without the need for ionization. It can act on DNA and produce pyrimidine dimers leading to chromosomal lesions. Chemical bonds change the ionization potential, so the removal of UV and visible light only applies in a universe where there are electrons but no binding this is just silly for many cases like Hydrogen where the. Obviously, DNA is an important thing to think of when you are concerned about ionization, not sure why this article would exclude it from consideration. There are other causes of DNA damage such as free radicals that do not require ionizing radiation nice summary from the UK National Grid here: After all, excessive sun causes skin cancer, does it not? Maybe you can rewrite this section http: The internally consistent WP position has now been changed to reflect the subtle fact that non-ionizing EM radiation with enough energy to cause single-photon chemical bond changes and free radical formation, can act very much like ionizing radiation, without having enough energy quite to be technically ionizing. So nearly all UV is non-ionizing and yet is mutagenic and carcinogenic. Its effects are far beyond thermal. These without question produce free radicals and molecular damage by mechanisms which are not simply thermal. Visible light produces free radicals in plant leaves, which is why they are all full of carotenoids, for example. The debate on non-thermal effects of non-ionizing radiation has now shifted to microwwave and RF, simply because there is no debate anymore about UV and visible light. UV and visible light do have non-thermal radiation effects on molecules, so such quantum effects are not just a property of ionizing radiation. For reasons that are easy to see, when you think about it. S B H arris As far as I know, there are many sources of infrared radiation, such as black-body radiation from most objects, including the sun. I believe this should be changed. Feel free to add stuff. I do not have time to review the NTP study in full. However, WP advises using secondary references to the study rather than directly including, per WP: The edits by Cmt it critical of the current state of the page, but I do not think it bears removing the content entirely. Someone more knowledgeable on this please revise.

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6: Non-ionizing radiation - Wikipedia

Non-ionizing (or non-ionising) radiation refers to any type of electromagnetic radiation that does not carry enough energy per quantum (photon energy) to ionize atoms or moleculesâ€"that is, to completely remove an electron from an atom or molecule.

Between three and four water molecules are ionized for every 1. Free radicals are extremely reactive. The radicals formed when ionizing radiation passes through water are among the strongest oxidizing agents that can exist in aqueous solution. At the molecular level, these oxidizing agents destroy biologically active molecules by either removing electrons or removing hydrogen atoms. This often leads to damage to the membrane, nucleus, chromosomes, or mitochondria of the cell that either inhibits cell division, results in cell death, or produces a malignant cell. Biological Effects of Ionizing Radiation From the time that radioactivity was discovered, it was obvious that it caused damage. As early as , Pierre Curie discovered that a sample of radium placed on his skin produced wounds that were very slow to heal. Radiation at the low-energy end of the electromagnetic spectrum, such as radio waves and microwaves, excites the movement of atoms and molecules, which is equivalent to heating the sample. Radiation in or near the visible portion of the spectrum excites electrons into higher-energy orbitals. When the electron eventually falls back to a lower-energy state, the excess energy is given off to neighboring molecules in the form of heat. The principal effect of non-ionizing radiation is therefore an increase in the temperature of the system. We experience the fact that biological systems are sensitive to heat each time we cook with a microwave oven, or spend too long in the sun. But it takes a great deal of non-ionizing radiation to reach dangerous levels. We can assume, for example, that absorption of enough radiation to produce an increase of about 6C in body temperature would be fatal. If this energy was carried by visible light with a frequency of 5 x s-1, it would correspond to absorption of about seven moles of photons. Ionizing radiation is much more dangerous. A dose of only joules of x-ray or -ray radiation is fatal for the average human, even though this radiation raises the temperature of the body by only 0. Whereas it takes seven moles of photons of visible light to produce a fatal dose of non-ionizing radiation, absorption of only 7 x moles of the -particles emitted by U is fatal. There are three ways of measuring ionizing radiation. Measure the activity of the source in units of disintegrations per second or curies, which is the easiest measurement to make. Measure the radiation to which an object is exposed in units of roentgens by measuring the amount of ionization produced when this radiation passes through a sample of air. Measure the radiation absorbed by the object in units of radiation absorbed doses or "rads. One radiation absorbed dose, or rad, corresponds to the absorption of joules of energy per gram of body weight. Because this is equivalent to 0. At first glance, the rad may seem to be a negligibly small unit of measurement. The destructive power of the radicals produced when water is ionized is so large, however, that cells are inactivated at a dose of rads, and a dose of to rads is fatal for the average human. Not all forms of radiation have the same efficiency for damaging biological organisms. The faster energy is lost as the radiation passes through the tissue, the more damage it does. To correct for the differences in radiation biological effectiveness RBE among various forms of radiation, a second unit of absorbed dose has been defined. The roentgen equivalent man, or rem, is the absorbed dose in rads times the biological effectiveness of the radiation.

7: What are the risks of non-ionising radiation? - NWO-I

Electromagnetic exposure of biological tissue â€¢ Electromagnetic fields are used for more than years to control cancer and for coagulation of hemorrhages.

Scientific and policy developments regarding the health effects of electromagnetic radiation exposure from cell phones, cell towers, Wi-Fi, Smart Meters, and other wireless technology Monday, July 23, International Perspective on Health Effects of Low Intensity Non-Ionizing Radiation Thermal and non-thermal health effects of low intensity non-ionizing radiation: Thermal and non-thermal health effects of low intensity non-ionizing radiation: Abstract Exposure to low frequency and radiofrequency electromagnetic fields at low intensities poses a significant health hazard that has not been adequately addressed by national and international organizations such as the World Health Organization. There is strong evidence that excessive exposure to mobile phone-frequencies over long periods of time increases the risk of brain cancer both in humans and animals. The mechanism s responsible include induction of reactive oxygen species, gene expression alteration and DNA damage through both epigenetic and genetic processes. In vivo and in vitro studies demonstrate adverse effects on male and female reproduction, almost certainly due to generation of reactive oxygen species. There is increasing evidence the exposures can result in neurobehavioral decrements and that some individuals develop a syndrome of "electro-hypersensitivity" or "microwave illness", which is one of several syndromes commonly categorized as "idiopathic environmental intolerance". While the symptoms are non-specific, new biochemical indicators and imaging techniques allow diagnosis that excludes the symptoms as being only psychosomatic. Unfortunately standards set by most national and international bodies are not protective of human health. This is a particular concern in children, given the rapid expansion of use of wireless technologies, the greater susceptibility of the developing nervous system, the hyperconductivity of their brain tissue, the greater penetration of radiofrequency radiation relative to head size and their potential for a longer lifetime exposure. The US National Toxicology Program has released preliminary results of a study of long term exposure of rats to cell phone radiation which resulted in a statistically significant increase in brain gliomas, the same cancer found in people after long-term cell phone use, and schwannomas, a tumor similar to the acoustic neuroma also seen after intensive mobile phone use Wyde et al. Similar results in rats have been reported in an independent study at the Ramazzini Institute with exposures similar to those from a mobile phone base station Falcioni et al. This evidence, in conjunction with the human studies, demonstrates conclusively that excessive exposure to RF-EMF results in an increased risk of cancer. In this regard WHO has failed to provide an accurate and human health-protective analysis of the dangers posed to health, especially to the health of children, resulting from exposure to non-thermal levels of electromagnetic fields. In spite of recent efforts to control for conflicts of interest, ICNIRP has a long record of close associations with industry Maisch, Why this should exclude other scientific research groups and public health professionals is unclear, particularly since most members of ICNIRP are not active researchers in this field. We have definitive evidence that use of a mobile phone results in changes in brain metabolism Volkow et al. We do not know the mechanisms behind many known human carcinogens, dioxins and arsenic being two examples. Given the strength of the evidence for harm to humans it is imperative to reduce human exposure to EMFs. Similar results were found for cordless phones in the Hardell group studies, although such use was not reported by the other study groups. The findings are less consistent for meningioma although somewhat increased risk was seen in the meta-analysis of ipsilateral mobile phone use. A longer follow-up time is necessary for this type of slow growing tumor. This finding was confirmed in a second replicative study involving different participants Divan et al. A meta-analysis involving , children mean age These assumptions are not valid for two reasons. Not only do they fail to consider the specific morphological and bioclinical vulnerabilities of children, but also they ignore the effects known to occur at non-thermal intensitiesâ€¦. In summary it is the strong opinion of the authors that there is presently sufficient clinical, biological and radiological data emanating from different independent international scientific research groups for EHS, whatever its causal origin, to be acknowledged as a well-defined, objectively characterized pathological disorder. This is no longer the case. There are a number of well-documented effects of low intensity EMFs that are the mechanistic basis behind the biological effects documented above www. These include induction of oxidative stress, DNA damage, epigenetic changes, altered gene expression and induction including inhibition of DNA repair and changes in intracelluar calcium metabolism â€¦. Another example is the synergistic of exposure to lead and EMFs on cognitive function in children described above Choi et al. These co-exposure factors should be considered when assessment of detrimental effects, including carcinogenicity, is performed. Gliomas are increasing in the Netherlands Ho et al. The latency period between initial exposure and clinical occurrence of brain cancer is not known but is estimated to be long. While not all reports of brain cancer rates show an increase, some do. The continually increasing exposure to EMFs from all sources may contribute to these increases. Male fertility has been declining Geoffroy-Siraudin et al. EMFs increase the risk of each of these diseases and others. A recent meta-analysis Huss et al. Each of these diseases is associated with decrements in health and quality of life. Brain cancer patients often die is spite of some improvement in treatment, while EHS patients present with increased levels of distress, inability to work, and progressive social withdrawal. The ability for humans to reproduce is fundamental for the maintenance of our species. The scientific evidence for harm from EMFs is increasingly strong. We do not advocate going back to the age before electricity or wireless communication, but we deplore the present failure of public health international bodies to recognize the scientific data showing the adverse effects of EMFs on human health. It is encouraging that some governments are taking action. France has removed WiFi from pre-schools and ordered Wi-Fi to be shut off in elementary schools when not in use http: The State of California Department of Public Health has issued a warning on use of mobile phones and offered advice on how to reduce exposure State of California, There are many steps that are neither difficult nor expensive that can be taken to use modern technology but in a manner that significantly reduces threats to human health. It is urgent that national and international bodies, particularly the WHO, take this significant public health hazard seriously and make appropriate recommendations for protective measures to reduce exposures. This is especially urgently needed for children and adolescents. It is also important that all parts of society, especially the medical community, educators, and the general public, become informed about the hazards associated with exposure to EMFs and of the steps that can be easily taken to reduce exposure and risk of associated disease.

8: [Biological effects of non-ionizing electromagnetic radiation].

The various biological effects of ionizing radiation. The effects can be classified into early or deterministic, which have a threshold, and delayed or stochastic, with no threshold.

Summary of health effects What happens when you are exposed to electromagnetic fields? Exposure to electromagnetic fields is not a new phenomenon. However, during the 20th century, environmental exposure to man-made electromagnetic fields has been steadily increasing as growing electricity demand, ever-advancing technologies and changes in social behaviour have created more and more artificial sources. Everyone is exposed to a complex mix of weak electric and magnetic fields, both at home and at work, from the generation and transmission of electricity, domestic appliances and industrial equipment, to telecommunications and broadcasting. Tiny electrical currents exist in the human body due to the chemical reactions that occur as part of the normal bodily functions, even in the absence of external electric fields. For example, nerves relay signals by transmitting electric impulses. Most biochemical reactions from digestion to brain activities go along with the rearrangement of charged particles. Even the heart is electrically active - an activity that your doctor can trace with the help of an electrocardiogram. Low-frequency electric fields influence the human body just as they influence any other material made up of charged particles. When electric fields act on conductive materials, they influence the distribution of electric charges at their surface. They cause current to flow through the body to the ground. Low-frequency magnetic fields induce circulating currents within the human body. The strength of these currents depends on the intensity of the outside magnetic field. If sufficiently large, these currents could cause stimulation of nerves and muscles or affect other biological processes. Both electric and magnetic fields induce voltages and currents in the body but even directly beneath a high voltage transmission line, the induced currents are very small compared to thresholds for producing shock and other electrical effects. Heating is the main biological effect of the electromagnetic fields of radiofrequency fields. In microwave ovens this fact is employed to warm up food. The levels of radiofrequency fields to which people are normally exposed are very much lower than those needed to produce significant heating. The heating effect of radiowaves forms the underlying basis for current guidelines. Scientists are also investigating the possibility that effects below the threshold level for body heating occur as a result of long-term exposure. To date, no adverse health effects from low level, long-term exposure to radiofrequency or power frequency fields have been confirmed, but scientists are actively continuing to research this area. Biological effects or health effects? What is a health hazard? Biological effects are measurable responses to a stimulus or to a change in the environment. These changes are not necessarily harmful to your health. For example, listening to music, reading a book, eating an apple or playing tennis will produce a range of biological effects. Nevertheless, none of these activities is expected to cause health effects. The body has sophisticated mechanisms to adjust to the many and varied influences we encounter in our environment. Ongoing change forms a normal part of our lives. But, of course, the body does not possess adequate compensation mechanisms for all biological effects. Changes that are irreversible and stress the system for long periods of time may constitute a health hazard. An adverse health effect causes detectable impairment of the health of the exposed individual or of his or her offspring; a biological effect, on the other hand, may or may not result in an adverse health effect. It is not disputed that electromagnetic fields above certain levels can trigger biological effects. Experiments with healthy volunteers indicate that short-term exposure at the levels present in the environment or in the home do not cause any apparent detrimental effects. Exposures to higher levels that might be harmful are restricted by national and international guidelines. Widespread concerns for health A look at the news headlines of recent years allows some insight into the various areas of public concern. Over the course of the past decade, numerous electromagnetic field sources have become the focus of health concerns, including power lines, microwave ovens, computer and TV screens, security devices, radars and most recently mobile phones and their base stations. The International EMF Project In response to growing public health concerns over possible health effects from exposure to an ever increasing number and diversity of electromagnetic field sources, in the

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World Health Organization WHO launched a large, multidisciplinary research effort. The International EMF Project brings together current knowledge and available resources of key international and national agencies and scientific institutions. Conclusions from scientific research In the area of biological effects and medical applications of non-ionizing radiation approximately 25, articles have been published over the past 30 years. Despite the feeling of some people that more research needs to be done, scientific knowledge in this area is now more extensive than for most chemicals. Based on a recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields. However, some gaps in knowledge about biological effects exist and need further research. Effects on general health Some members of the public have attributed a diffuse collection of symptoms to low levels of exposure to electromagnetic fields at home. Reported symptoms include headaches, anxiety, suicide and depression, nausea, fatigue and loss of libido. To date, scientific evidence does not support a link between these symptoms and exposure to electromagnetic fields. At least some of these health problems may be caused by noise or other factors in the environment, or by anxiety related to the presence of new technologies. Effects on pregnancy outcome Many different sources and exposures to electromagnetic fields in the living and working environment, including computer screens, water beds and electric blankets, radiofrequency welding machines, diathermy equipment and radar, have been evaluated by the WHO and other organizations. The overall weight of evidence shows that exposure to fields at typical environmental levels does not increase the risk of any adverse outcome such as spontaneous abortions, malformations, low birth weight, and congenital diseases. There have been occasional reports of associations between health problems and presumed exposure to electromagnetic fields, such as reports of prematurity and low birth weight in children of workers in the electronics industry, but these have not been regarded by the scientific community as being necessarily caused by the field exposures as opposed to factors such as exposure to solvents. Cataracts General eye irritation and cataracts have sometimes been reported in workers exposed to high levels of radiofrequency and microwave radiation, but animal studies do not support the idea that such forms of eye damage can be produced at levels that are not thermally hazardous. There is no evidence that these effects occur at levels experienced by the general public. Electromagnetic fields and cancer Despite many studies, the evidence for any effect remains highly controversial. However, it is clear that if electromagnetic fields do have an effect on cancer, then any increase in risk will be extremely small. The results to date contain many inconsistencies, but no large increases in risk have been found for any cancer in children or adults. A number of epidemiological studies suggest small increases in risk of childhood leukemia with exposure to low frequency magnetic fields in the home. However, scientists have not generally concluded that these results indicate a cause-effect relation between exposure to the fields and disease as opposed to artifacts in the study or effects unrelated to field exposure. In part, this conclusion has been reached because animal and laboratory studies fail to demonstrate any reproducible effects that are consistent with the hypothesis that fields cause or promote cancer. Large-scale studies are currently underway in several countries and may help resolve these issues. Electromagnetic hypersensitivity and depression Some individuals report "hypersensitivity" to electric or magnetic fields. They ask whether aches and pains, headaches, depression, lethargy, sleeping disorders, and even convulsions and epileptic seizures could be associated with electromagnetic field exposure. There is little scientific evidence to support the idea of electromagnetic hypersensitivity. Recent Scandinavian studies found that individuals do not show consistent reactions under properly controlled conditions of electromagnetic field exposure. Nor is there any accepted biological mechanism to explain hypersensitivity. Research on this subject is difficult because many other subjective responses may be involved, apart from direct effects of fields themselves. More studies are continuing on the subject. The focus of current and future research Much effort is currently being directed towards the study of electromagnetic fields in relation to cancer. The long-term health effects of mobile telephone use is another topic of much current research. No obvious adverse effect of exposure to low level radiofrequency fields has been discovered. However, given public concerns regarding the safety of cellular telephones, further research aims to determine whether any less obvious effects might occur at very low exposure levels. Key points A wide range of environmental influences causes biological effects. Special research is needed to identify and measure health hazards. At low frequencies, external electric and magnetic fields induce small circulating currents within the body. In virtually all ordinary environments, the levels of induced currents inside the body are too small to produce obvious effects. The main effect of radiofrequency electromagnetic fields is heating of body tissues. There is no doubt that short-term exposure to very high levels of electromagnetic fields can be harmful to health. Current public concern focuses on possible long-term health effects caused by exposure to electromagnetic fields at levels below those required to trigger acute biological responses. Despite extensive research, to date there is no evidence to conclude that exposure to low level electromagnetic fields is harmful to human health. The focus of international research is the investigation of possible links between cancer and electromagnetic fields, at power line and radiofrequencies.

9: Biological Effects of Electromagnetic Radiation - Engineering and Technology History Wiki

What some find surprising is the magnitude of the difference between the biological effects of non-ionizing radiation, such as light and microwaves, and ionizing radiation, such as high-energy ultraviolet radiation, x-rays, -rays, and - or /i>-particles.

Yet, the first use of electric-field heating for control of cancer occurred only four decades after Volta , in , described the electric pile []. In fact, the practice became so widespread in the following few years that Pichard [], in , called attention to its over use. There was considerable competition in the mid19th century between these early researchers for recognition of being first to apply electricity for heating tissue. Becquerel [14] credited Fabre-Paloprat [44] for first burning tissue with an electrified platinum needle in , but Petrequin claimed to be the first to come up with the idea based on his reading a book on electropuncture published in []. The early application of electricity to medicine named Galvanocautery, after Luigi Galvani , in 18th century obstetrician and surgeon in Bologna"for his work on chemical effects of electric current, involved dc currents applied directly to the tissue through needle, wire, or knife-type electrodes. The technique was reported to destroy tumors, aneuryisms, and fungoid growths, as well as to close fistulas and to stop bleeding. It was actually the caustic effect of the electricity in coagulating blood, rather than to heating effect, to which these early physicians attributed the beneficial effects. Oscillatory sources soon became available through the work of Helmholtz, Kelvin, and Hertz. Joubert, in the year , demonstrated that when the frequency of current applied to frog muscle was raised to a certain level, it would not cause the muscle to contract. Physiologist and pioneer in medical applications and biological effects of radiofrequency energy. In measuring the intensity of muscle excitation as a function of frequency, he noticed that the excitation decreased until it was barely noticeable at 10 kHz, the maximum attainable frequency of his source. He was able to apply the high-frequency current to himself at a high level without sensing anything but a warmth. Though the immediate sensation of the currents passing through his hands from large electrodes were nil, he found that after a period of time the skin was flushed with increased sweating. He attributed this to vasodilation rather than a heating reaction and wrote that the high-frequency currents would be a great service to therapeutics, thinking in terms of direct effects on blood pressure and kidney output, rather than the indirect effect of heat. The recorder of the commission wrote in July Marey and myself of the principle results recorded in the previous note. We were particularly struck by an experiment in which 6 lamps volts X0. We have not experienced the best sensation by the passage of the current flow to which we were submitted, while one could not doubt the enormous amount of energy which passed our bodies volts X 0. It manifested itself either by the luminousness of the lamps or by lively and numerous sparks which were produced when the circuit was broken. The same amount of energy would have sufficed to destroy us like lightening, but under the above given conditions it produced no appreciable sensation. After using a better oscillator that he devised which came to be widely used for medical purposes Fig. Up until , all medical applications of high-frequency currents were made by direct electrical contact with the tissues or conduction. At first, he experimentally placed animals and then humans in induction coils. The human-size solenoidal coils were huge with big gaps between the turns Figs. Autocondensation, the forerunner of diathermy, remained popular for many years, especially with many optimistic reports being made. Each was exposed for min daily in the induction coil for a total of treatments. He found that most types of hysteria and certain forms of local neuralgia received no benefit, while on the other hand there was marked improvement in the health of patients suffering from arthritic, rheumatic, and gouty conditions. The patient reclined on a large, shaped, metal plate with insulating dielectric cushions Fig. Other patients were treated by having conduction currents pass from the feet in a footbath to the hands in contact with electrodes. A current of mA was used for daily treatments of 6 min. At that same time, Tesla was also conducting similar experiments in America, showing that kHz oscillations not perceived by the human body could light up nearby glow tubes or heat metal objects. Tesla conducted a number of experiments on himself and noted that the physiological effects, depending on voltage, current, and waveshape, were not only heated tissue, but were also changes in perspiration, blood circulation, and fatigue bordering on somnolescence. Tesla lectured on both sides of the Atlantic, and electrotherapy became very popular with an entire professional society: Tesla reported his work at a meeting of that Society in Typical of today, newspapers in published a sensational report that Tesla had cured pulmonary tuberculosis with high-frequency current, following a suggestion by Tesla of that possibility, based on his findings that high frequency current passing directly through bacilli killed them. Freund [50] wrote, in , that clinical trials fell far short of what had been expected, "Consequently in some quarters the whole method received unqualified condemnation. He coined the word diathermy to describe the procedure, and published the first textbook on the subject in By , diathermy machines were beginning to make their appearance in supply houses. Prior to this time, a physical therapy clinic would have been a noisy place with minor thunderclaps from spinning static wheels and the humming and singing of spark gaps Fig. Though Lee de Forest constructed the first radio tube high-frequency medical apparatus in the "Cold" cautery for electrosurgery-American surgeons refused to use it for many years. It was being used effectively by physicians in Paris and Vienna. The frequency of the current used in long-wave diathermy up to was approximately 1 MHz. Though these early generators were spark-gap oscillators, they were in vogue from to In , shortwave diathermy was introduced when Esau, a physicist in Jena, constructed for Schliephake at Giessen a machine which was capable of delivering W at MHz []. Schliephake [], [] was the first to use the higher frequency shortwave diathermy clinically, by first using it on himself to cure a furuncle on the nose. He believed that shortwave diathermy had a selective or specific , bactericidal effect. He did much basic work on the heating of animal tissues. Schereschewsky [] placed small animals in a condensor field of a m apparatus capable of delivering 7. With his ability to kill flies with the apparatus, the press responded by calling it the new death ray. In , manufacturers large and small began to produce and sell increasing quantities of machines and made many exorbitant claims about the cure of tuberculosis and cancer. Neon glow tubes were used to prove the presence of electromagnetic radiation, in addition to sometimes impressing patients with the marvellous properties of shortwaves that could light the tube without contact. With over-enthusiasm and lack of precaution, moderate and occasionally severe burns resulted until the circuit and electrode designs were improved. The first electrodes were bare capacitive plates, and later became coated with thick glass shoes with considerable air spacing. Riviere was the first to use high-frequency current to treat skin cancer in , but the voltage was too low to destroy the cells. De Keating-Hart was the first to apply the spark to destroy tumor tissue, during his demonstration at the International Congress of Electrology in Milan, in While a great battle for recognition for the discovery of the destruction of tumor tissue by high-frequency currents took place between Riviere and de Keating-Hart, R. Cook, in New York, accidentally short-circuited the current from a static electricity machine through his fingers. The resultant tissue destruction gave him the idea of treating small tumors with a spark of static electricity, and he published his findings unaware that similar work had begun in France []. Doyen [37] felt that deeper penetration than that obtained by the electric spark used by de Keating-Hart was needed in order to produce deeper tissue destruction. He also believed that if he could increase the current frequency from kHz to 1 MHz, he would be able to raise tissue temperature to the proper levels and with greater accuracy. He had a manufacturer build such a generator with a small condensor, a resonating coil, and a rotating spark gap. One electrode from the generator was applied to the patient through a moist pad while the other electrode was used for contact with the tissue to be destroyed, resulting in coagulation at a depth of 5 to 8 mm after only two minutes of contact. A survey of work prior to on treatment of tumors by radio frequency energy was summarized by Rohdenburg and Prime [], whose own work involved the treatment of spontaneous tumors in mice by X-rays alone, diathermy alone, and a combination of the two. Their work showed that compared with controls, tumors treated with diathermy or X-ray radiation alone showed inhibition, or aggression of growth, while growth was significantly retarded, when the tumors were treated by the combined agents. With MHz shortwave diathermy, the clinical applications of diathermy as an adjunctive treatment of cancer continued with the use of high-frequency generators. Although Rohdenburg and Prime [] contended that combined diathermy and X-ray treatments are required for satisfactory results, Liebesny [] was able to eradicate carcinoma in mice by using diathermy alone. With the introduction of shortwave and ultra-shortwave radio-frequency apparatus, Schereschewsky [] was often able to inhibit the growth of transplanted carcinomas in mice, and in some cases to completely eradicate tumors by treating mice with ultra-shortwaves of 3-m wavelength. Pflomm [] was able to inhibit the growth of Jenson-rat sarcoma by shortwave treatments at 4. Some researchers, for example Reiter [], after experimenting with shortwaves varying from 3 to 15 m in wavelength, stated that there is a specific biological effect associated with wavelength. He reported that diathermy at 3. He excluded elevated temperature as a possible factor in his interpretation of specific biologic action. Roffo [] demonstrated that waves ranging from 0. Hill [75] showed that exposure to ultra-shortwave elevation of temperature was insufficient by itself to be tumoricidal, but Mortimer and Osborne [] believed that heating alone is responsible for evidence that the growth of Ehrlich mouse sarcoma in vitro was retarded when exposed to 3. Eidinow [39] held that there is no specific action of ultra-shortwaves of m wavelength, and stated that they act the same way as diathermy currents of longer wavelengths by simply heating the tissues. Schliephake [] treated carcinoma of the uterus by a combination of shortwaves and X-rays ; he observed after several treatments a marked disintegration of the carcinomatous tissue, but, after suspending treatment for a period of several weeks, malignant growth recurred. Fuchs [58] reported retardation of tumor growth after low-power shortwave exposures, in which heating was negligible, as an adjunct to X-ray therapy. They used shortwaves of 6-m wavelength in combination with X-rays to treat 30 cases of human malignancy, including carcinoma of the oral cavity, the larynx, the epigastrium, the uterus, and the rectum. At the time of their report, they could not form definite conclusions concerning the increase of radiosensitivity of the tumors treated by the shortwaves. They stated, however, that the method was qf value in that there was no aggravation or stimulated growth of neoplastic tissue in any of their cases, and that there was a lessening of skin injury by the X-rays. They also reported other benefits of the treatment: Johnson [87], using more precise qualitative methods than those employed by other investigators, reported on the action of shortwaves on transplanted tumors in vivo and in vitro. Johnson found that the exposure durations required to produce a percent regression of the Walker-rat Carcinoma at 47,45, and Exposure durations for percent regressions of the Jenson-rat sarcoma at the same set of temperatures were 25 min, 1 h, and 3 h. Johnson measured temperatures via thermocouples embedded in hypodermic needles; he tried to eliminate coupling of high-frequency currents by using a tuning process. Considerable problems were encountered with wave trapping by thermocouples under certain conditions, but he was able to obtain reliable temperature measurements. Despite the early reports of successful use of shortwaves to control malignancies in the laboratory and in the clinic, the methodology was never widely adopted in practice until recently, as discussed in Section III. Williams [] reported that waves of a few centimeters could be focused, and Southworth [] pointed out that such waves can be directed through hollow conducting tubes waveguides. The proposal to use microwaves for therapeutic purposes originated in Germany when Hollman [79] in discussed the possibility of therapeutic applications of 25cm waves; he predicted that the waves could be focused to produce heating of the deep tissues without excessive heating of the skin. Similar predictions were made shortly afterward by Hemingway and Stenstrom [74] in the United States. In , the magnetron tube was developed at Bell Laboratories , but the available power it generated was only W. Later that year, RCA developed a magnetron capable of generating 20 Wand promised that W could be produced. In , the klystron tube was developed at Stanford University, and promises were made that the tube could soon be used for therapeutic purposes. Suddenly, at this time when tubes of sufficient power for therapeutic application were known to exist, they all became mysteriously unavailable. It was not until the secret of radar was finally revealed that the medical community realized all such tubes had become frozen for military use during World War II. After the war, a magnetron tube developed at M. With the new equipment, therapeutic application of microwaves began at the Mayo Clinic in [96], [97]. This application involved exposure of laboratory animals to MHz fields at an output power of 65 W. Temperature distributions in thighs of experimental dogs were measured by thermocouples before and after irradiation. In this work thermocouples were removed during periods of irradiation , it was demonstrated that deep tissues could be heated, resulting in a number of physiological responses, including an increased blood flow to the treated area.

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