Man-made Electromagnetic Radiation:

What is it and What are the Health Effects

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Radiation And Biological Life

Biological systems on earth are electro-chemical in nature. The production and maintenance of life forms was most likely heavily influenced by environmental radiation. Life forms, undoubtedly evolved in harmony with the then existing electromagnetic radiations.

All matter vibrates and radiates. Science has been able to measure some of these emanations with instruments. Other radiations from all forms of matter, described as subtle energies, have proven difficult to quantify and measure and do not enjoy wide acceptance. However, Kirilian photograph can document radiations from living things.

In terms of the radiation types that have been quantified, the original natural environment has been drastically altered by the activities of human kind over the past 100 years. These alterations include the magnitude, frequencies, and wave patterns of the electromagnetic radiations to which humans are exposed. These changes have occurred in both the ambient environment and the environment within the buildings in which humans now spend 90% of their time.

Naturally occurring cosmic electromagnetic radiations include:

- Whistlers produced by lightening in the 10^3 Hertz (cycles/sec) frequency range (Becker, 1990).
- Cosmic *Noise* monitored by radio astronomers in the 10^6 to10^{11} Hertz range (Westinghouse, 1991).
- Visible Light from infrared to ultraviolet in the 10^{12} to 10^{17} Hertz range (Westinghouse, 1991).
- Gamma Rays produced by secondary cosmic rays in the 10^{20} and up range (Schneider, 1988).

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Naturally occurring Earth electromagnetic radiations include (Schneider, 1988):

- Radiations from water flows.
- Gamma radiation
- Neutron radiation
- Radiation from magnetic grid lines and their intersections
  - Hartmann north-south grid lines
  - Currie NE-SW and SE-NW Grid lines

Although not widely recognized in the United States, many of these Earth or Geo-radiations are considered to be 'geopathic' in that they can negatively affect human and animal health particularly during sleep time (Schneider, 1988).

Man-made Radiations

Since about 1900, human kind has superimposed man-made radiations on these naturally occurring radiations. That is the focus of this chapter.

Man-made radiations account for a large part of the electromagnetic spectrum. These radiations overlap and are today billions of times stronger than natural radiations. Our creations range from the lowest frequencies to frequencies of 10^{12} Hertz (Westinghouse, 1991).

These changes began with Thomas Edison and the inefficient generation and distribution of direct current (DC) electricity in large east coast cities, just before the turn of the century. The change accelerated with the invention, by Nikoli Tesla, of the alternating current (AC) form of electricity which could be transmitted long distances from large central generating facilities without uneconomical line losses. The first installations were running by 1894.

Tesla worked on the development of wireless transmission of electric power through the air. This work led him naturally to sending communication signals through the air, using specific frequencies. Although Marconi's name is associated with radio communications his early methods used a spark gap discharge which covered a large part of the communications frequency spectrum. This was an unworkable feature which prevented assigned transmission frequencies that we use today (Cheney, 1981).

This early development set the stage for the "electrification" of the world, and put into play economic and political forces that have become enormously powerful today. By the late 1920's commercial radio transmission was well established. All of this occurred before medical technology was sufficiently advanced to understand what subtle effects, if any, these changes would have on biological life. People did not drop dead from exposure- short of electrocution- so man-made electromagnetic radiation was declared safe by default.

What is EMF?

EMF stands for electromagnetic field. This field is an energetic radiation; hence it is also referred to as electromagnetic radiation (EMR).

Magnetism occurs naturally and is found in certain rocks. Such rocks have the ability to attract iron-based materials like iron filings. The motivating force- an energetic emanation- can be sensed in space away from the magnet and is described as a *magnetic* field. This field is measured in units of *Gauss* or *Tesla* (1 Gauss = 10,000 Tesla).

Similarly, when electrons (or current) flow in a wire, the wire develops a field around it, which has the same properties as the field around the permanent magnet, it attracts iron.

In order for a current to flow in a wire, there must be a difference in the potential between one end of the wire and the other. In other words, the wire must be energized to a potential called a voltage, that forces the current or electrons to flow. A water hose is a good analogy. The water pressure (voltage) determines how fast the water will flow (current). The more the pressure the more water can be moved in a given time.

When the wire is energized to a voltage another phenomenon can be measured around the wire- an *electric* field. This field is measured in *volts per meter*.

The *electric* field exists around the wire even when current is not flowing. However, the *magnetic* field exists only when current is flowing. These two fields- electric and magnetic- comprise the **electromagnetic field or EMF**.

DC EMF

The permanent magnet's field is a constant or unvarying field. If the wire described above is energized by a voltage that always has the same polarity (the water pressure is always in the

same direction), the current in the wire (the water) always flows in the same direction and the magnetic and electric fields around the wire are constant or unvarying, so long as the voltage is unchanged.

This system is described as energized by a DC voltage, having a DC current and producing a DC magnetic and electric field. This is the situation with battery powered products, telephone systems and with Edison's original DC electric system.

AC EMF

If the polarity of the voltage alternates (the water pressure is applied first at one end of the hose and then at the other) then the direction of the current (water) will be first in one direction and then in the other. The *magnetic* field around the wire will not be constant, it will vary. The field will go from zero to a maximum north pole strength, then drop back to zero, increase to a maximum south pole strength and again return to the original zero point. The *electric* field around the wire will also vary. It will go from zero to a maximum positive voltage, drop through zero, increase to a maximum negative voltage and return to the original zero. This system is described as energized by an AC voltage, having an AC current and producing an AC magnetic and electric field.

Power System Frequency

This is the situation with electric power systems worldwide. In North America we have chosen to vary the voltage polarity 60 times per second (60 cycles per second or 60 Hertz). In Europe the frequency is 50 Hertz. For reasons beyond the scope of this chapter, world wide power systems also display harmonics which are even multiples of the base frequency. Here in North America these would be 120, 180 240 Hertz and so forth. Hence, people often are exposed to power system EMRs at multiple frequencies. The strength of the harmonic radiations is usually a fraction of the base, 60 Hertz EMF. These frequencies (0 to 300 Hertz) are classed as Extremely Low Frequency (ELF) EMR.

Specialized applications will use higher power frequencies. For example, the magnetic field produced by the TV (and video display terminals) picture tube fly-back transformers are 10,000 to 15,000 Hertz. Such frequencies (1000 to 25,000 Hertz) are classed as very low frequency (VLF) EMR.

Communications Signals

Communications signals also display variation. However, the frequency of the EME is considerably higher than for power systems and ranges from a few Kilohertz to 10^{12} Hertz. These frequencies (called air space) are assigned to specific uses such as navigation, AM and FM radio, TV, commercial and government radio, microwave, cellular phone, commercial and military radar, and satellite links. Demand for air space is so great that all of the usable frequencies have now been assigned (Becker, 1990).

Some of the more well known uses for this air space are: AM radio from 53 to 160 Kilohertz. Television occupies 54 to 800 Megahertz. Within this is the FM band from 88 to 108 Megahertz. Cellular telephones use 800 to 900 Megahertz. Beyond 900 MHz are microwave frequencies up to about to about 10^{12} Hertz.

Health Issues

The principal concern for the last twenty years has been the association between the magnetic field component of power system EMR and cancer. The EMR exposure source is most often from high voltage transmission lines or high current local distribution lines and transformer substations. However, conditions can exist inside homes which produce fields as high as found near these external sources. The author has personally found this to be true in 10% of homes evaluated. More recently attention has been focused on cellular telephone radiations and cancer. Overall, research has been mostly focused on EMR and various types of cancer.

Concerns were first generated by the results of epidemiological studies of cancer rates in children exposed to power system magnetic fields beginning in 1979. Other work has been directed towards animal studies, occupational epidemiological studies and basic research at the cellular level. A few studies have examined behavioral effects of EMR.

A great deal of anecdotal information has developed over the past 15 years in Germany and in the past five years in the U.S. on the effect of the power system AC *electric* field. Cooperative work between Baubiologists and doctors has shown the electric field can affect the ability of the body to heal itself during the sleep period and can affect every day wellness (Maes, 1990) (Gust, 1995).

Human Epidemiological Studies of ELF EMR

An Epidemiological study compares the rate of disease in a group of people (animals) exposed to a certain variable to a control group that was not exposed to the variable in question. The results will show if an association exist between the variable and the disease. This type of study can not determine cause and effect.

The results are usually reported in the form of an Odds Ratio (OR) or Risk Ratio (RR). This refers to ratio of incidence of disease found in the exposed group versus the incidence in an unexposed group. Such studies should be controlled for confounding variables. For example in a study of the increased risk of brain cancer from EMF exposure, the study would be controlled for risk factors such as smoking and exposure to cancer causing chemicals.

A compendium of peer reviewed EMF epidemiological studies was compiled by National Library of Medicine, Bethesda, MD. for use in testimony to the Nebraska State legislature (National Library of Medicine, 1995).

The majority of these studies (8 out of 11) show that children living in homes near high voltage transmission lines and near high current carrying local distribution lines show a statistically significant risk of developing cancer. These cancers are mostly leukemia, brain cancer, and lymphoma. The RR in these studies were generally in the range of 1.3 to 4 (Brodeur, 1995). The results for adults in similar situations are less clear. Although it is not possible to review all of these studies there several are of interest

The pioneering study examined the effect on cancer rates from childhood exposure to high current local distribution lines that run through Denver neighborhoods (Wertheimer, 1979). Compared to controls, children exposed to 3 milliGauss (3/1000 Gauss) fields had an increased risk of contracting childhood cancers at a statistically significant level. The RR (OR) was 2.35 for leukemia and 2.22 for all other cancers (Kosta, 1995). At the time this finding was surprising as a 3 milliGauss AC field is many times weaker than the Earth's steady state (DC) magnetic field of about 500 milliGauss. Therefore, the study was met with much criticism on the grounds there was no *known* physical link between these extremely weak 60 Hertz fields and biological life.

In 1988 the Wertheimer study was duplicated (with resources enormously larger) as part of The New York State Power Lines project. This five-year project was expected to disprove the results of the Wertheimer study, instead it confirmed them. Additional evidence was reported that power frequency fields had significant behavioral and central nervous system effects (Savitz, 1988).

Although not part of the National Library of Medicine list, the next three studies are of interest from the behavioral standpoint: A British study found a statistically significant higher incidence of mental disturbance and suicide in patients living near electric power lines in a rural U.K. area (Reichmanis, 1979).

The US Navy in 1973, completed a study to assess the effects of the 45 or 70 Hertz magnetic fields which would be produced by the proposed buried communications antenna for the SANGUINE Project. This antenna was to be buried in Wisconsin and upper Michigan to communicate with submarines around the world.

Among the significant findings was evidence showing nine out of ten volunteer seamen exposed in a lab to the SANGUINE type radiation developed elevated serum triglycerides levels. A study of personnel at The Clam Lake, Wisconsin experimental SANGUINE facility showed similar elevated level in all personnel. Serum triglycerides level is elevated by stress (SANGUINE, 1973). The frequency of the 60 Hz US electric power system was right in the middle of the two possible SANGUINE frequencies. The magnetic field level of the SANGUINE signal was one million times *less* than the average 100 milliGauss field found at the edge of a 345,000 volt transmission line (0.1 milliGauss). SANGUINE was not built. Today, the Navy denies that the study ever took place (Becker, 1990).

Studies were done in U.K. with people housed in underground bunkers relatively free of EMR. Their wake-sleep cycles gradually shifted to 25-26 hours. When they were subjected to EMR they shifted to a 23 hour cycle showing a shift in the circadian rhythm. Other work showed a pulsating low intensity EMR (such as 60 Hertz EMR) will cause the release of noradrenaline in most people within 15 minutes (Jones, 1992).

Another epidemiological study on the National Library of Medicine list was conducted in Sweden. In the early 1980's 716 children who had died of cancer were compared with controls. The results showed that brain cancer occurred 3.7 (RR= 3.7) times as often as expected in children living within sight of a high voltage transmission line (Tomenius, 1986).

A landmark EMR epidemiological study was conducted by Ahlbom and Feychting. This study was significant because of the number of people involved (500,000), the efficiency of the Swedish Cancer Registry, and better knowledge about the magnetic fields levels produced by the 200 kilovolt and 400 kilovolt transmission lines in question (Microwave News, 1992).

This study found statistically significant RRs for leukemia in children as follows: For average 50 Hertz magnetic field exposures greater than 1 milliGauss the risk ration was 2. For exposures greater than 2 milliGauss the risk ration was 2.7. And for exposures over 3 milliGauss the risk ration was 3.8 (Feychting, 1993).

Residential epidemiological studies have produced less clear results for adults. However, the majority of peer reviewed, occupational epidemiological studies (24 out of 30) show that exposed occupations have a significantly higher risk of cancer. In these occupations workers develop leukemia, lymphoma and brain cancer far more readily than less exposed workers. These are occupations like Utility linemen, electricians, electrical engineers, Phone Company linemen, subway operators and so forth. The RR in these studies were generally in the range of 2 to 10 (Brodeur, 1995). Magnetic field level in occupational exposures is sometimes, but not always higher than that seen in homes (Gust, 1995).

Controversy Surrounding Human Epidemiological Studies

There is criticism of the results of such studies on the grounds that the risk ratios found are not sufficiently large. These people wish to see an RR of 5 or greater. (Kosta,, 1995). Others state that there are as many studies showing no association as showing an association. However, most of the studies which are presented as contradicting a positive association are not peer reviewed and tend to be funded and presented by vested interests such as utility industry or bodies funded by the utility industry (Brodeur, 1995).

Animal Studies with ELF EMR

John Reif, DVM, Colorado State University College of Veterinary Medicine and a team study the home magnetic field conditions of 93 cases of canine lymphoma and 137 controls over a four year period. The study showed dogs with lymphoma were six times more likely to have lived in homes with wire coded fields in excess of 2 milliGauss, and three times more likely to have lived in homes with moderately magnetic field levels of 0.5 to 2.0 milliGauss (Reif, 1995)

Phillips reported at a recent Washington, DC. seminar entitled *How Animals Perceive Weak Magnetic Fields*, sponsored by the EPA that "...birds, bees, newts, turtles and sharks have been shown to be exquisitely sensitive to such fields". Phillips also reported that recent research "suggests mechanisms based on radical pair formation which may also trigger melatonin changes observed in rodent exposed to magnetic fields". Weak EMR depresses output of melatonin which normally cycles lower during the day and higher at night (Litigation, 1996).

As Part of the New York State Power Lines Project Sulzman and Murrish studied the relationship between power line fields and behavioral changes associated with the circadian rhythms in monkeys. The monkeys were exposed to both electric and magnetic fields and observed for both acute and chronic changes. The circadian rhythms were altered by field exposure (Sulzman, 1987)

In the same project Wolpaw studied monkey brain function during exposure to a weak 60 Hertz magnetic field. He measure the neurohormones in the spinal fluid in monkeys exposed for three weeks. He found that the levels of serotonin and dopamine were significantly depressed immediately following exposure. Only dopamine returned to a normal level. Serotonin remained depressed for several months (Wolpaw, 1987).

Also as part of this project Salzinger exposed rats to 60 Hertz fields during gestation and for a few week after birth. These rats and controls were then trained in various routines. The exposed rats made more mistakes and learned the routines more slowly than the controls (Salzinger, 1987).

The Battelle Pacific Northwest Laboratories, in a study funded by the Electric Power Research Institute (a research arm of the electric utility industry), examined several generations of minipigs exposed to power line EMR (Battelle, 1987). The study focused on developmental abnormalities. Several month into the experiment an epidemic struck the pigs and the experiment had to be started again. All of the pigs in the exposed group died while significantly fewer in the control group died. Becker suggests that the exposed pigs' immune systems had been compromised by the exposure (Becker, 1990)..

The study was redone, but Battelle claimed no evidence of harm was found. However, the original director of the study, listed these findings: A marked reduction in night time melatonin production by the pineal gland after three weeks exposure. A significant loss in serum testosterone in males exposed for three months. Changes in the neuromuscular system after a one month exposure. An increased incidence of fetal malformations after chronic exposure for two generations (Phillips, 1988). These findings differ from the official Battelle version.

The effect of 'stray voltage' on dairy animals is also instructive. Dairy operators have been plagued over the last 50 years with problems associated with the electrification of farms. The problems encountered are spontaneous abortion, increased mastitis, lower milk production, extreme nervousness, sudden death, high somatic cell count, breeding problems, early peaking of milk production, swollen legs and joints (Dahlberg, 1995).

After 50 years of research and corrective measures the problem still exists. The term stray voltage exists because the problem was originally pinned on the difference in potential between metal barn components and the floor of the barn resulting in a shock to livestock when they connected these metal parts to the floor via their hooves. The voltage potential issue has been largely resolved and control measures proved beneficial on about 30% of the farms. For the

other 70% it was not, and in many cases made the situation worse.

Current thinking has turned to the ambient magnetic field created by current flow in the ground. Approximately 65% of the current supplied by the utility returns to the generating station via the earth. This situation is true everywhere in the U.S. Current flow in the soil produces a magnetic field which appears to come from nowhere. It is higher in urban areas where power demand is concentrated, but it certainly exists in the suburbs as well. Soil conditions affect the density of current flow as do the number of points in an area where the utility has grounded the neutral. Normally this occurs at every power pole. In urban areas background 60 Hertz magnetic fields can be 0.5 to even 1.0 milliGauss. In suburban areas 0.2 to 0.5 milliGauss based on personal measurements.

You will recall that the study done for the Navy SANGUINE Project showed stress induced elevation in serum triglycerides levels for a magnetic field one millionth that by a 345 kilovolt power line right of way. This is approximately 0.1 milliGauss.

Smith, mentions that among the interesting research on animal effects was a US Navy study which found that a buried high voltage transmission line radically disturbed the earth worms in the area and affected the aeration of the soil. Bees subjected to ELF EMR stopped making honey and sealed their hives, thereby committing communal suicide. Other bees kept under a high voltage transmission line became savage and unproductive. When move, they resumed making honey. In another case, high voltage lines near a bird sanctuary disoriented the birds. The effect of a low level magnetic field on Escherichia coli bacteria was to cause changes at the cellular level (Jones, 1992).

Delgado, known for research on brain behavioral mechanisms and their control by electrical stimulation, exposed chick embryos to very weak (as low as 1 milliGauss) ELF EMR at 10, 100 and 1000 Hertz. Embryonic malformations resulted at all three frequencies with the largest number at 100 Hertz (Delgado, 1982).

In 1986 the US Navy set up Project Hen House in six different labs, all with the same equipment, in an effort to duplicate Degado's results. It was reported at a meeting of the Bioelectromagnetics Society that in five of the six labs "apparently very low level VLF, pulsed magnetic fields contribute to increased abnormality incidences in early embryonic chicks" (Navy, 1986).

Studies of the Effect of Radio and Microwave Radiation

So far we have dealt with the effect of very low frequency EMR. The other area of interest is the potential effects of high frequency EMR. There has been considerably less work in this area. Early studies were conducted in the radio wave range (megahertz frequencies) by the US Navy, in connection with WWII radar research.

Data reported in an old Navy study were reanalyzed by Marino. The original study was done to see what effect could be found in the blood of exposed workers at the Navy Research Laboratory. Marino found significant associations between increased white blood cell counts and months of EMR exposure, and average number of hours of exposure during the work day. The quality of the data may not support strong conclusions, but does beg for more study (Marino, 1995).

In a US Air Force School of Aerospace Medicine study, Guy exposed rats continuously to 2.45 Gegahertz (2.45×10^9 Hz) microwaves for 25 months. This was a well designed and expensive study that examined 155 different measures of health and behavior. "The results revealed few differences between controls and exposed animals. Any differences found were not statistically significant or came and went over the 25 months.

However, it was noted: "Primary malignant tumors developed in eighteen of the exposed animals, but in only five of the controls". Guy explained this by stating that the level of cancer in the exposed group was actually *lower* than normally expected for that strain of experimental rat. This study was widely publicized in the scientific press (Foster, 1986).

One factor was not reported except at a scientific meeting. All of the rats used were *gnotobiotic* or (germ and virus free) and housed in a totally germ free environment during the study. This seemed, according to Becker, not only unnecessary, but undesirable since the real world is far from septic. Studies show at least 20% of human cancers are viral and this is even higher in animals. The study results may then understate the incidence of cancer (Becker, 1990).

Other studies do shows that EMR stresses the system and prolonged exposure could depress immune function. Why use and maintain gnotobiotic animals at tremendous expense? Is it possible that the study was specifically designed to sharply reduce the incidence of cancer? The lower incidence of cancer, then, had to be totally expected. What was unexpected and highly important was that even with this environment, the exposed rats had four times the cancer incidence of the controls.

A Swedish group at Lund University studied the effect of 915 MHz EMR on the blood brain barrier (BBB) in rats (cellular phones use frequencies from 824 to 894 MHz). The BBB restricts the movement of medium and large size molecules from the blood to cerebrospinal fluid (EMF Health, 1995).

Rats were exposed to either continuous or the newer, pulse modulated EMR over a range of energy levels for two hours, then killed and the brain tissue studied. Two different size molecules were studied- fibrinogen, a large molecule and albumin, a smaller molecule. Albumin moved in to BBB-weak areas like surface membranes and pituitary area, but was also taken into BBB-strong areas when the rats were expose to either type of microwave at 2.5 watts/kg or more. This is significant since the widely accepted ANSI C95.1-1982 microwave radiation safety standard limits human exposure to less than 8 W/kg of tissue *based on the tissue heating effect only*. (This ANSI standard was revised in 1992, but, again, it only considers tissue heating effects) It is too early to project consequences, if any, for this BBB breaching phenomenon.

In 1983 Manikowska-Czerska, et. al., from the FDA Center for Devices and Radiological Health studied mice exposed to microwaves. They found that sperm production fell with a thirty minute a day exposure to so called non-thermal microwave levels (i.e. below the 1982 ANSI standard). And there were significant abnormal changes in the chromosome structure of sperm. When exposed males were mated with unexposed females significant fetal death occurred. The chromosome damage occurred far below microwave levels that produce heating in tissue (Manikowska, 1985).

On the anecdotal side, tiny Vernon, New Jersey, a town of 25,000, is fourth ranked for number of microwave transmitters behind major cities. The incidence of Down's syndrome there is 1000% above the national average (Becker, 1990)

Cellular telephone EMR research began only a few years ago based on public demand. The General Accounting Office recently gave a research status report to the chairman, Subcommittee on Tele-communications and Finance, Committee on Energy and Commerce, House of Representatives[1]. A number of laboratory studies show that biological effects can occur when animals and cells have been exposed to low level radio frequency radiation. For example, Lai and Singh found that low level microwave radiation similar to that emitted by cell phones can cause DNA breaks in the brains of experimental animals (GAO, 1994)

Motorola has recommended that its customers "control the duration of your calls and operate

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[1] General Accounting Office Document # RCED 95-32, available at 202-512-6000.

your phone in the most power efficient manner". The most power efficient manner is to hold the phone away from the head. Other studies have shown that up to 50% of the radiated power is absorbed by the head. The smaller heads of women and children absorb more power, more deeply in the brain than do larger male heads. Motorola has recently confirmed that use of a cellular telephone causes biological effects within the user. At this time it has not proven that these effects cause cancer. Research is continuing (Network News, Spring 1995)

The typical hand held cell phone emits about 40 microwatts/cm^2 EMR. The 1992 ANSI standard covering cell phone is 533-600 microwatts/cm^2. By comparison, the typical EMR from a cordless phone used at home is around 4 microwatts. At the other end of the cell phone air link is the antenna. Measurement of cellular tower EMR shows it to be around .01 to 0.1 microwatt/cm^2. The maximum measured at ground level 800 feet from the tower was 1 microwatt (Hatfield, 1995).

Cellular Studies

Addey investigating the effect of EMR on cancer cell growth rates in petri dishes showed cancer cell growth rates increased (Maes, 1990). Winters confirmed the finding. Cancer cells increased their growth rate several hundred percent with 24 hours exposure. After exposure ended, the accelerated growth continued. This study was replicated later by Winters and Phillips and reported in a peer review journal. This study found 60 Hz magnetic fields cause human cancer cells to permanently increase their growth rate by as much as 1600 percent and to develop more malignant characteristics in that they resisted destruction by the body's killer-type cells (Phillips, 1986).

Cell level investigation accelerated when funding was authorized by Congress in the National Energy Policy Act of 1992. The funding for this program was split 50-50 with private business and set at $65 million. The program got underway in 1994, and is overseen by the ten person National Electric and Magnetic Field Advisory Committee appointed by the secretaries of Health and Human Services and the Department of Energy.

Recent work has focused on activity at the cell membrane, and activity within cells as affected by membrane action. Nutrient and information transport involves ion movement through the membrane via channels, as well as molecular interactions at the membrane level. Ions such as Ca, Cl, Na. and K are involved here. Only recent advances in microscopy have provided the ability study these phenomena and results are incomplete. Early work shows that calcium ion membrane transfer could be affected by EMR. Higher than normal concentrations of Ca ions were found in the cells.

The area has proven to be exceedingly intricate and complex. Reports are voluminous[2]. Replication of results has proven difficult. Reasons suggested are differences in location, EMR characteristics (including frequency and duration), use or non-use of chemical initiators and difference in the cells themselves.

Goodman, et. al. showed that insect salivary gland cells demonstrated marked increase in heat shock protein production when exposed to weak EMR under 300 Hz. This is the same stress response that occurs with elevated temperature and with other environmental insults. This result was extended to Human HL60 leukemia cells in a 60 Hz field under a variety of EMF conditions. "The experimental conditions used suggest that cells are exquisitely sensitive to subtle stress provided by EMFs." Other groups have failed to duplicate the results despite efforts to duplicate all conditions. One apparent difference is in the HL60 cells used which differed in growth rates by a factor of 2:1. The theoretical linkage to health risk comes when "under intermittent EMR exposure, escape of cells from feedback control could lead to aberrant heat shock protein production. This could prove to be a critical step in the progression of stressed cells to tumor

[2] Interested readers are advised to obtain a subscription to *Bioelectromagnetics*, a peer review journal of The Bioelectromagnetics Society at 301-663-4252.

cells" (Smith, 1996).

Major ELF EMR Study Reviews by Scientific Panels

The EPA charged its Office of Health and Environmental Assessment to review all research on the cancer-EMF link. A 1992 draft report concluded: "With our current understanding, we can identify 60 Hertz (cycle) magnetic fields from power lines and perhaps other sources in the home as a possible, but not proven, cause of cancer in people." (EPA, 1990). This report was sent back to the EPA by the Bush administration and has been under 'revision' ever since.

In 1986 the EPA created The National Council on Radiation Protection & Measurement (NCRP) to evaluate EMF health effects. In an 800 page draft report, the Council endorsed a 2 milliGauss magnetic field exposure level for day care centers, schools, and playgrounds. It asked regulatory agencies to pay "serious attention" to EMFs (Microwave News, 1995).

The Council said: "Epidemiological studies in the USA and Europe... indicate a positive association between childhood cancers and exposure to magnetic fields... generated by electric power transmission and distribution systems. Evidence has accumulated in other studies ...implicating exposure to (60 Hertz) EMFs as a factor common to an increased incidence of leukemia and brain cancer in occupationally exposed adults." This study is expected to be formally published in 1996 after undergoing a review process.

1995 American Physical Society Statement

The NCRP findings were given little play in the media compared to the enormous coverage in May 1995 when The American Physical Society released a statement that there exists "no consistent, significant link between cancer and power line fields". This statement was based on a literature review done by David Hafemeister, a physicist at California Polytechnic State University. By his own admission, Hafemeiser has not published one peer review paper examining either the biological, epidemiological or medical implications of exposure to EMF. The report as submitted to the society was described by Hafemeister as incomplete- to be "periodically updated."

Liboff summarized the opposing view: "Right thinking individuals must believe that the American Physical Society is not in a position to intelligently judge the important questions in surgery, neurobiology, molecular biology, genetics, or microbilogy. Is bio-electromagnetics somehow different? Its tenuous link to physics lies in the present inability to formulate a reasonable physical mechanism to explain experimental results." (EMR Alliance, 1995)

"The last time the society involved itself in a public health issue", said Paul Brodeur author of Electromagnetic Man, "was to assure the public that fall out from atomic bomb tests in Nevada were completely harmless" (EMR Alliance, 1995).

The Society's position that no action be taken on a public health risk until it is proven is at odds with the view among public health professionals. Precautionary measures need not, and should not, wait for definite proof of hazard. This position is termed "prudent avoidance" and is the recommended strategy for the home and office.

Electric Field EMR and Every Day Health

Nearly all of the concern and publicity about EMF is focused on cancer. However, the relationship between EMF, human stress and every day functioning seems clearer and important.

The magnetic field can be elevated in some homes either from proximity to transmission or distribution lines or because of wiring errors or faults within the building. All of the canine cancers reported by Reif occurred in homes that were irradiated from outside the dwelling (Reif, 1995). Apparently most animals can sense magnetic fields, while most humans can not. Consequently, for animals, the author suggests that exposure to magnetic fields occurs when the animal has no field free place to go.

While the danger of the magnetic component of EMR is not to be discounted, the electric field is a problem far more often. Bau-biological investigations of homes find that 90% of the time, the environmental problems are in the sleeping area In the sleeping area 90% of the time the problem is high electric fields (Maes, 1990), (Gust, 1995).

High electric fields in the sleeping area appear to interfere with rest quality and healing ability. Excessive fields have been found to increase allergy response, cause muscle cramping and nerve pain and reduce the rejuvenation potential of sleep time leading to day time tiredness and irritability (Maes, 1990), (Gust, 1995).

Amazingly, high electric fields are found in 99% of all sleep areas (Gust, 1995). The electric fields can be shut down at night by turning off appropriate circuits. Shutting off the sleeping area circuit can usually reduce the fields to some degree, but not far enough to meet the standards for sleeping areas developed in Germany.

Practical Consideration in Creating a Low Stress Environment

These German standards define specific sleeping area conditions (figure 1) for four biological concern levels: *None, Slight, Severe* and *Extreme*. These standards were originally developed as the result of ten years effort by Wolfgang Maes of Baubiologie Maes, Neuss, Germany, in conjunction with practicing German medical doctors.

Sleeping Room Standards

Figure 1

	Level of Concern			
PARAMETER	**EXTREME**	**SEVERE**	**SLIGHT**	**NONE**
ELECTRIC FIELD				
a) Body Voltage in millivolts (mV)	> 1000	100-1000	10- 100	<10 mV
b) Field Strength in volts/meter[3] (V/m)	>10	1.5- 10	0.3-1.5	< 0.3 V/m
MAGNETIC FIELD				
Field in MilliGauss (mG)	> 5	1-5	0.2- 1.0	< 0.2 mG
MICROWAVES				
MicroWatts per square meter ($\mu W/m^2$)	> 1000	10-1000	0.1-10	< 0.1
IONIZING RADIATION				
% Increase In Build'g Vs Outside	>100	70-100	50-70	< 50 %

Definition of Concern Levels

None- Provides the highest degree of precaution. It reflects the unexposed natural conditions or the common and nearly inevitable background level of our modern living environment.

Slight- As a precaution and especially with regard to sensitive and ill people, remediation should be carried out whenever it is possible.

Severe- Values in this category are not acceptable from a building biology point of view, they call for action. Remediation should be carried out soon. In addition to numerous case histories, scientific studies indicate biological effects and health problems within this reference range.

[3] *Potential Free* measurement method

Extreme- These values call for immediate and rigorous action. In this category international guidelines and recommendations for public and occupational exposures may be reached or even exceeded.

If several sources of risk are identified within a single subcategory or for different subcategories, the larger one should be more critical in the final assessment.

The *Ideal* electrical condition for sleeping areas is for the electric field to be less than 0.3 volt/meter potential free measurement method and the magnetic field to be less than 0.2 milliGauss. Composite microwave radiation should be less than 0.1 microwatt/cm2. This is the preferred environment for people with compromised immune systems. In the author's opinion it is a good starting point for animals as well.

Prudent avoidance is the recommended strategy for EMR. This means people need to scan their home and work place for areas of higher magnetic fields and their sleeping areas for electric fields and take measures to avoid these areas or reduce these radiations.

Purchase of an inexpensive gauss meter will allow anyone to check for magnetic fields. Awareness of potential magnetic field hot spots is also helpful:

- The front, **back** and sides of the TV and the computer VDT.
- Within four feet of the refrigerator.
- Within three feet of little black box transformers that plug into wall outlets.
- Over operating ceiling fans and fluorescent lights.
- Near the electric service panel, and electric meter.
- In proximity to local electrical distribution line (on poles).
- In proximity to transmission lines (on big steel towers).
- Within three feet of appliances with digital clocks.
- Within three feet of any electric (120 volt) alarm clock.
- Within one foot of an electric heating pad or electric blanket.

Checking for electric fields in sleeping places is more complex. Electric fields are difficult to measure so body voltage is used as a surrogate. Body voltage in bed is compare to earth ground (zero volts) using a sensitive digital multimeter[4] The electrical system is manipulated to find the offending circuits- usually four to six- and by installation of shielding materials. Which circuits will be turned off during sleep time is specific to the layout of the house wiring.

Electricity in Medicine

The controlled use of electricity can be beneficial. Information compiled in 1990 highlighted the following: Very small DC current applied across a bone fracture speeds the growth of bone. Pulsed DC current has been used in treatment of drug addiction. In U.K., six weeks of treatment resulted in patients experiencing a personality change and remaining drug free. For those interested in slash, burn and poison cancer treatment, pulsed magnetic fields have increased the response to chemotherapy. Healing of wounds has been speeded by electrically generated silver ions being injected into the wound. Of course, the use of pace makers is now wide spread. These devices pulse the heart muscle with a 1 millivolt signal. And finally MRI- magnetic resonance imaging is now widely used. For further information the reader is referred to Becker, 1990.

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[4] You may obtain equipment for measuring electric and magnetic fields from the Safe Living Technologies, www.safelivingtechniologies.co .

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