Combating the Effects

of

Electromagnetic Radiation

Naturally

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Foreword

The outcomes of recent research articles have revealed potential radio-protective substances, *those that protect us against biological damage from electromagnetic radiation sources*, such as cell phones, remote telephones, microwaves, satellite, and the many other sources we are all exposed to in modern society. These results show there are several substances, including vitamins, herbs and hormones, primarily antioxidants, which produce radio-protective, anti-carcinogenic effects. Many of these substances also have positive effects in other areas of disease prevention and protection, which have been shown in many well-cited studies over the last few decades. However, our *focus* here is to explore radio-protective aspects that offset the continually expanding bombardment of human bodies, especially in industrialized nations, by electromagnetic radiation in its many forms.

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ATP	Adenosine triphosphate
BEM	Bioelectromagnetics
CAPE	Caffeic Acid Phenethyl Ester
CNS	Central Nervous System
Co-Q10	Co-enzyme Q10
DNA	Deoxyribonucleic acid
eV	Electron Volt
EHF	Extremely high frequency
EHz	ExaHertz
ELF	Extremely low frequency
EMF	Electromagnetic Field
GaAlAs	Gallium-Aluminum-Arsenide
GHz	GigaHertz
Hz	Hertz
ICRW	Information Carrying Radio wave
J	Joule
LASER	Light Amplification by Stimulated Emission of Radiation
MASER	Microwave Amplification by Stimulated Emission of Radiation
LLT	Laser light therapy
MHz	MegaHertz
nm	Nanometer
RADAR	Radio Detection and Ranging
ROS	Reactive oxygen species
SHF	Super-high frequency
SOD	Superoxide Dismutase
THz	TeraHertz
UHF	Ultra-high frequency
VHF	Very high frequency
W	Watt
WHO	World Health Organization

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CHAPTER ONE

PROBLEMS WITH ELECTROMAGNETIC RADIATION

Overview

Many diseases or conditions, such as cancer, cardiovascular conditions, diabetes, autism, and infertility may be triggered or affected by exposure to electromagnetic radiation. These effects are due to destructive processes, such as oxidation of cells, which result from exposure to the energy produced by electromagnetic waves emanating from a vast array of sources. Electromagnetic radiation sources include cell phones, remote telephones, iPods, wireless networks, **global positioning systems** (GPS), satellite TV, satellite radio, standard FM and AM radio, and power lines, to name a few. In today's world of technology, it is virtually a given that we will be exposed to electromagnetic radiation in one form or another.

Many studies have explored the risks to the population associated with the ubiquitous power lines. For women who were living near high-voltage power lines a study performed in Norway found a 60 percent increase in the risk of contracting breast cancer *(Ref. 28).* Yet, the youngest population may be the most vulnerable to the negative effects of electromagnetic radiation. Many early and more recent studies of the effects of power lines on children have shown a causal relationship with leukemia *(Ref. 59)*.

The **World Health Organization (WHO)** refers to three important specialized workshops in its "2006 WHO Research Agenda for Radio Frequency Fields." The workshops focused on the effects of electromagnetic fields (EMF) and the sensitivity of children to the fields, general hypersensitivity to EMF, and health effects of exposure to base stations and wireless networks. The workshops were held in June and October, 2004, and June, 2005, and took place in Istanbul, Turkey, Prague, Czech Republic, and Geneva, Switzerland, respectively *(Ref. 61).*

The issue of EMF hypersensitivity was explored in both the Istanbul and Geneva workshops. The proceedings of the Geneva workshop addressed the difficulties inherent in research enlisting people with EMF hypersensitivity. They are "understandably reluctant to expose themselves to even low-level EMFs" and there is "a tendency to mistrust science among … support groups and many studies have been undermined by these groups." Additionally, "the most severely affected individuals … are unable to leave their homes and travel to the laboratory to be tested" *(Ref. 63).*

All of the workshops highlighted the effects of electromagnetic radiation on children as an important specific area of needed research, including endpoints such as cognitive changes

and brain tumors. The Istanbul WHO workshop focusing specifically on "The Sensitivity of Children to Electromagnetic Fields" was held in June, 2004 and its results were reported in the journal Pediatrics *(Ref. 26).* The article referenced the relationship between leukemia and EMF, highlighting "consistent epidemiologic evidence of an association between childhood leukemia and exposure to **extremely low frequency (ELF)** magnetic fields" *(Ref. 26)* Additionally, the article noted the poignant fact that "ionizing radiation given at large doses is one of the few known risk factors for leukemia" and "given in therapeutic doses is one of the few known risk factors for **central nervous system(CNS)** tumors" *(Ref. 26)*

The relationship between leukemia and the omnipresence of advanced technologies emitting electromagnetic radiation may be substantiated anecdotally by comparing developed and developing countries. Developed countries experience a sixty percent higher rate of leukemia in children under fifteen years of age than do developing countries, with the highest incidence of childhood leukemia occurring at around three years of age. In the range of one quarter to one third of all childhood cancers are leukemias, particularly acute lymphoblastic or acute myeloblastic leukemias, making these the most common malignancies in children.

Another category of cancer has been identified as one of the more common malignancies found in children of the same age group. The category of tumors found in or peripheral to a child's CNS is of importance, in particular brainstem gliomas. For the under fifteen population of children, approximately twenty percent of malignancy cases are tumors of the CNS, and the rate has been rising steadily in industrialized nations. Ratios of incidence for tumors of the CNS between developed and developing countries are similar to the proportions involved with leukemia.

Other concerns were raised by the workshop, including an increased potential for carcinogenic processes due to exposure of young and evolving neural pathways. Additional concerns were the elevated conductivity of young brain tissue and deeper penetration of radio frequency signals, particularly from cell phones, due to the relatively smaller head sizes. The duration of exposure of children to EMF due to their early access to recently developed technologies was identified as an important consideration as well. Some effects of exposure could include problems regarding immune and endocrine system response, development of sexual characteristics, and infertility *(Ref. 26)*.

Cognitive changes may be especially important in children since they have the potential to affect learning and early childhood development. Although neurons in parts of the spinal column continue to be produced throughout life, the maximum quantity of synapses occurs around age two and myelination slows after this age. The number of synapses drops to sixty percent of the top childhood number to provide the base capacity for adulthood. If damage occurs during the crucial early years of childhood, cognitive and other neural functions may be affected throughout the remainder of an individual's lifetime *(Ref. 47).*

The WHO research agenda specified many areas of concern for the general population as well. The many potential effects of electromagnetic radiation highlighted by the agenda, some of which reflected issues highlighted in the workshops, included brain cancer and other cancers, infertility, neurodegenerative diseases, sleep disturbances, headaches, thermo-physiological changes, and cognitive effects. Cognitive measures such as alertness, reaction times, and memorization performance were included, as well as related factors such as regional cerebral blood flow and blood-brain barrier permeability. Additional concerns included effects on the development of childhood CNS, hemopoiesis, immunity, and related organs and tissues, considered the body functions most likely to be vulnerable to the damaging effects of EMF *(Ref.61).*

The usage of wireless technologies may have various effects based upon adjacency to different body locations and the sizes and body shapes of the individuals. In the case of a young child, the entire brain may be encompassed by the circumference of a cell phone signal from a phone next to the head. Possibly amplifying the effects of a young brain enveloped by EMF is the higher brain tissue conductivity in children, due to a higher proportion of water and ions. A child's head tissues also absorb more of the electromagnetic radiation from cell phones than do the corresponding tissues of an adult *(Ref. 26)*

For a pregnant woman carrying a vulnerable fetus, a cell phone or iPod in a purse carried over the shoulder or on a belt around the waist, a cordless phone near a chair, or a laptop on the lap may directly radiate the developing embryo or fetus. The effects of such exposure may vary based upon the proximity of the EMF to the fetus or embryo. Proximity may be an important factor if a device induces significant thermal effects since such a temperature increase may cause physical deformations or death in a developing fetus *(Ref. 20).*

The effects of exposure to EMF may also vary based upon the particular phase of prenatal development, specifically the embryonic (preimplantation and organogenesis) or the fetal stage. During early embryonic development, if cells are damaged, recovery without malformation is more likely. Later embryonic damage may result in birth defects in the internal organs, CNS, appendages or face. Before the late fetal period, genitourinary and neurological development may be affected. Later negative effects to a fetus may be somewhat less prominent *(Ref. 26).*

In recent years, cellular telephones and microwave frequency wireless communication facilities have been implicated in the development of tumors. Women working in the telephone industry may be at higher risk for death due to development of breast cancer *(Ref. 13).* According to a study in Norway, female radio and telegraph operators showed an increase in the risk of breast cancer correlated with exposure to radio frequency and **extremely low frequency (ELF)** signals. The study found an increased risk of tumor development, specifically of the estrogen-receptor-positive type for pre-menopausal

women and estrogen-receptor-negative for post-menopausal women *(Ref. 27).* The risk of male breast cancer may also be increased significantly by exposure to EMF *(Ref. 33).*

At the higher frequency end of the electromagnetic spectrum, the effects of gamma radiation are well known from the dropping of atomic bombs on the Japanese during the Second World War. Additionally, nuclear power plant incidents have increased the exposures of populations to high frequency electromagnetic radiation and have heightened awareness of the inherent dangers of nuclear energy. Nuclear incidents producing gamma radiation and other high frequencies have occurred in Windscale, England, in 1957, in 1979 at Three Mile Island in Pennsylvania, and most infamously at the Chernobyl power plant in 1986, leaving hundreds of thousands ill and deformed. Despite these and other milestones, modern technology continues forward with a broadening range of electromagnetic frequencies and a wireless model of things to come. Wireless technologies abound, including wireless telephones, iPods, networks, monitors, keyboards, mice, toys, and remote controls for cars, garages, televisions, and even home entry and automation systems.

Exposures to natural sources of EMF are more common as well, but under circumstances that are unnatural for human beings. Ultraviolet radiation exposure is stronger near the hole in the ozone layer resulting in the prevalence of cancers of the skin in those regions, such as Australia and Antarctica. Of course unnatural sources such as fluorescent lighting and tanning beds abound as well. Flight crews and frequent flyers are regularly exposed to both ends of the electromagnetic spectrum *(see Appendix)* and several frequency ranges in between. Exposures include gamma radiation at the higher altitudes of flight where there is little protection from solar emissions and those of other galactic objects. Passengers and crew are also exposed to man-made EMF due to wireless flight communication technologies and tracking technologies including Radar, at both flight and ground levels. Since it is highly unlikely that the direction of technology can or will be reversed, methods are needed to counter the negative bioelectromagnetic effects of all of this electropollution.

Terminology

What exactly is electromagnetic radiation? Electromagnetic radiation emanates from energized waves with electric and magnetic fields and it can penetrate cellular, molecular, and atomic structures. Electromagnetic radiation is categorized as ionizing or non-ionizing and by its location on the electromagnetic spectrum, specifically radio, microwave, infrared, visible (light), ultraviolet, x-ray, gamma and cosmic *(see Appendix).* The specific ranges are defined by their frequencies, measured in quantities of Hertz *named for 19th century scientist Heinrich Hertz* and symbolized as **Hz***. Each Hz is equal to one cycle per second*. Alternatively, electromagnetic radiation may be defined by wavelength represented by Greek letter **λ, pronounced as "lambda." The wavelength is usually measured in fractions of meters, su**ch as **nanometers (nm),** which are multiples of 10^{-9} meter or one billionth of a

meter. For example, visible light is roughly in the range of 700 nm (red) to 400 nm (violet). As indicated by the formula, $\mathbf{c = f \times \lambda}$, when the frequency f (in Hz) of electromagnetic radiation increases, its wavelength λ (in nm) decreases to maintain the constant velocity of the electromagnetic radiation known as the **speed of light** c where $c = 3.0 \times 10^8$ m/s *(Ref. 51)*

The energy level of electromagnetic radiation increases as the frequency increases, since energy is directly proportional to frequency based upon the formula, $\mathbf{E = h \times f = h \times c/\lambda}$. this formula, energy in Joules or electron volts is represented by E, the h indicates Planck's constant valued at 4.136×10^{-15} electron volt seconds or 6.626×10^{-34} Joule seconds, and the f represents frequency in Hz *(Ref. 51).* Thus, non-ionizing electromagnetic radiation is in the lower frequency range (longer wavelengths) and ionizing electromagnetic radiation is in the upper frequency range (shorter wavelengths).

All physical bodies contain electromagnetic radiation at some level. At the atomic and subatomic levels, the "shells" in which electrons move around an atomic nucleus contain energy. Some of the energy may be released when external forces act upon the electrons, causing the release of photons that are conceptualized as "particles" of light. Although, it should be noted that light itself is a form of electromagnetic radiation. The phenomenon described is what takes place with lasers, and based on this, the term laser was originally an acronym for **Light Amplification by the Stimulated Emission of Radiation (LASER).**

The stimulated emission occurs when lasers release infrared or visible light that is coherent after building light energy through amplification within a resonating chamber. The coherence of a laser beam has two aspects, which are temporal coherence (light of the same frequency) and spatial coherence (light that is highly directional or going in the same direction as a group emission). A similar effect occurs in the microwave frequency range with a maser, in this case an acronym for **Microwave Amplification by the Stimulated Emission of Radiation (MASER).** Microwave frequencies are also used in many forms of wireless communication with **information carrying radio waves (ICRW)** that are composed of modulated signals carried on microwave carriers. These ICRW are also temporally and spatially coherent, giving rise to problematic biological responses, as discussed in the following section.

Mechanisms of Damage

The potential for "action at a distance" exists with electromagnetic radiation due to associated electric and magnetic fields that surround an electromagnetic radiation source. When an electromagnetic field is propagating through space-time, it produces electric and magnetic fields at ninety degrees to each other surrounding the propagating field. As a result of these fields, electrical currents may be induced in living tissue creating thermal effects, as well as possible interference with naturally occurring electromagnetic signals produced in the body. Significant thermal effects may induce hyperthermia, which may lead to death of an embryo or fetus in a pregnant woman *(Ref. 20).* Other possible effects include developmental defects such as slowed growth or effects on the development of the CNS *(Ref. 26).*

The World Health Organization's "2006 WHO Research Agenda for Radio Frequency Fields" was limited in the area of mechanisms of damage. With a focus on radio frequency as a limited non-ionizing part of the electromagnetic spectrum, the WHO research agenda primarily recognized health consequences as resulting from thermal effects, induced currents and fields. However, it did mention on-going projects exploring possible effects on free radicals and protein formation, leaving the door open to these possibilities *(Ref. 61*).

As free radicals, **deoxyribonucleic acid (DNA)** mutations, intercellular communication breakdown and other mechanisms have become better understood, additional areas in which to expand on the WHO research agenda have also been brought to light. As stated by the Istanbul WHO workshop, "toxic agents with mutagenic and carcinogenic potential, such as ionizing radiation … risks for the induction or progression of cancer during embryonic and childhood development." The article goes on to state "cancer and genetic disease … result from agents that have either mutagenic properties or the ability to produce more subtle effects on carcinogenic processes, such as the stimulation of excessive cell proliferation or an influence on cell-to-cell communication, apoptosis, or DNA repair" *(Ref. 26*).

Ionization effects may occur in the area around electrical cables or other electromagnetic devices. Ionization affects solid objects and human beings by penetrating their molecular structures and charging a portion of the molecules present, thereby separating them into charged components. When unstable atoms with excess energy attempt to stabilize, they emit their excess energy in the form of radiation. This phenomenon, the stimulated emission of radiation, is applied to create the effect of lasers. In this case, a state of population inversion is achieved in which the population of atoms in the lasing medium is predominantly in a high energy (abnormal) state. The atoms of the laser medium return to a more stable state, but to do so they must release their excess energy. This results in their emission of electromagnetic radiation in the form of light (photons) or infrared radiation.

In addition to the ionization of the media within them (inside their resonating chambers), high power CO_2 lasers can ionize the local environments within a few feet of their resonating chambers. Any individuals or objects within this range may be ionized as a

result, including metallic objects that are not electrically connected in any way. If an individual touches such a charged object or even comes within a few feet of it, an arc of several thousand volts can be induced across to the body of that individual, in a fashion that is similar to the effect of a bolt of lightning, albeit on a smaller scale. People working around high power equipment of any type typically go through training to understand such effects. These technically-trained individuals are often equipped with sensing devices, sometimes at the end of long insulated poles. These tools allow them to detect any charges that may be present due to electromagnetic devices or their accompanying ionization effects.

The general public is not usually equipped with detection devices and may often ignore or be unaware of daily exposures to pervasive environmental electromagnetic radiation sources. These sources may be individually minimal in their effects, but may have pervasive and multiplying results. When compounded by the many electromagnetic technologies that are often present and active simultaneously, a larger threat to health and well-being becomes apparent. A household may have wireless routers, cell phones, portable phones, and iPods active simultaneously, unknowingly disturbing the peaceful calming environment that would otherwise be present. At the local coffee shop or restaurant hotspot, there may be dozens of electromagnetic radiation sources while customers use their cell phones, Bluetooth devices, iPods, and laptops. The users of iPods become part of a network of wireless beacons, the laptop users become exposed to direct wireless signaling, and the cell phone users expose their brains directly to microwave radiation, while the other customers wallow in the "mist" of wireless signals.

High-energy ionizing electromagnetic radiation can be especially damaging, even over brief exposure durations, since it can break carbon-hydrogen bonds or cause electrons to dislodge from atoms (by definition). Ions created from these effects may cause damage to cells. Despite the fact that DNA repair is a very efficient operation in cells, damage to the cellular genetic material of DNA molecules is likely if both strands of the double helix are broken by the ionizing radiation. If the cells are reproductive gamete cells (sperm or ova), damage to the cells may produce inherited mutations. If they are cells of a developing zygote, birth defects or miscarriage may result. Additionally, in the category of high energy ionizing radiation, x-ray exposure decreases the rate of DNA synthesis in cells, slowing cell reproduction *(Ref. 25).*

The portion of the electromagnetic spectrum that is considered ionizing radiation starts with weakly ionizing red visible light at a wavelength of 750 nm, at 400 **TeraHertz (THz)** or 400 x 10^{12} Hz, and ranges through visible, ultraviolet, x-ray, gamma and cosmic radiation above 100 **ExaHertz (EHz)** or 100 x 10^{18} Hz with a wavelength of 0.3 nm or less *(see Appendix).* Even short-term exposure to ionizing radiation, including the widespread use of medical x-ray technologies, can have carcinogenic effects. X-rays can cause many types of mutations including deletions of single nucleotides, chromosomal deletions in any position, and chromosomal re-arrangements. Non-lethal cell mutations can accumulate with each

additional medical x-ray exposure or exposures to other ionizing radiation. This situation can further exacerbate conditions that are present due to chromosomal abnormalities that already exist in the cells of smokers and other chromosomally compromised individuals. Such mechanisms of damage from electromagnetic radiation are indeed causal, based upon direct damage to DNA molecules.

Ionizing radiation produces damage at any level and many natural sources exist. Gamma and cosmic rays from the sun and galactic objects, usually filtered somewhat by the atmosphere of the earth, and radioactive trace elements such as radon in the air and uranium in the ground, all add to the exposure levels of human beings and other creatures to ionizing radiation. The higher the altitude at which one lives, the greater the exposure to ionizing radiation from extraterrestrial gamma and cosmic sources, since less protection is offered by the atmosphere at higher altitudes. Thus, the greatest exposures to these natural ionizing radiation sources are experienced by flight personnel and astronauts, as well as frequently flying business travelers. Although these sources of ionizing radiation are in essence natural, the circumstances of increased exposure levels at high altitudes are in fact unnatural for the human body. Several studies have found that flight attendants are at an increased risk of developing breast cancer *(Ref. 44, 30 & 45).*

The frequency range of non-ionizing radiation is from **0 Hz (direct current), through 50 - 60 Hz household power,** radio frequency, microwave and infrared, up to the **weakly ionizing red visible light wavelength of 750 nm at 400 THz.** Long-term exposure to non-ionizing radiation has been shown to decrease cellular protection mechanisms tending to make cells more susceptible to damage that may occur due to external pathogenic factors and internal disease processes *(Ref. 12).* Thus damaging effects may be produced by long-term exposure to either ionizing or non-ionizing electromagnetic radiation in various forms.

Additional mechanisms are somewhat indirect, such as induced damage due to increased production of **reactive oxygen species (ROS),** otherwise known as *free radicals.* Oxidation occurs when a molecule loses an electron, creating a very reactive molecule, which carries the damaging effects from cell to cell. Popping off more electrons along the way, these ROS yield more ROS, and so on. In this way, ROS can damage many molecules that are important to cellular structure and function, including lipids, proteins, DNA and even the DNA repair proteins normally used to repair the damage. Cellular mutation is also among the many damaging effects of the ROS resulting from exposure to electromagnetic radiation, often causing the formation of cancer cells or inducing cell death. Therefore, the damaging effects on cellular structure resulting from the ROS induced by exposure to electromagnetic radiation can be quite similar to the effects of direct DNA damage.

Some of the effects of ROS can be seen externally, including skin cancers such as basal cell carcinoma, squamous cell carcinoma and melanoma. These effects are believed to be responsible for the infamous 1904 death of Thomas Edison's research assistant, Clarence Dally, the first known death due to X-ray ionizing radiation. Other visible skin damage may

result from thermal effects, as with sunburn due to overexposure to ultraviolet and infrared radiation from sunlight or tanning beds, despite the increase in vitamin D production. Another common effect is skin aging due to epidermal atrophy, and loss of dermal collagen, blood vessels and fatty tissue *(Ref. 8).*

Another indirect effect may be present due to the onslaught of **information carrying radio waves (ICRW)** from wireless communication in the form of computer networks and routers, iPods, and both portable and cellular telephones. Despite the fact that carrier waves are in the microwave frequency range, modulated signals are packets of information comprising the ICRW and they resonate at very low frequencies of a few Hertz similar to those found in the range of human biological processes. These signals appear to cells as intrusions due to their man-made temporal and spatial coherence, a phenomenon that does not normally occur in nature. Due to a normal sympathetic cellular response, cell membranes become more densely packed when an intrusion is detected *(Ref. 4).*

Specifically, the intrusion of electromagnetic radiation is detected by cilia that act as vibrational receptors, located on the exterior walls of cell membranes. Due to the resultant increased density of affected cell membranes, the flow of nutrients into and waste out of the cells by active transport may be restricted, which may lead to diminished clearance of heavy metals. Thus, cells exposed to standing waves of electromagnetic radiation in the form of ICRW, which is incompatible with natural frequencies normally present in the human body, may become nutrient deficient and subsequently significant energy deficiency may result *(Ref. 5).* The same mechanism may be responsible for some cases of hypersensitivity seen in individuals around the world when they are using or within range of EMF sources *(Ref. 4).*

A study sponsored by the National Institute of Applied Science in France looked at the symptoms of people who lived relatively close to mobile phone base stations. The population was parsed among people living at a distance of three hundred meters or less, and those who lived further from the stations. Additionally, the variations in their symptoms were differentiated based on gender, surveying 270 men and 260 women. The study found that women had more frequent symptoms, including headache, nausea, disturbed sleep patterns, poor appetite, visual disturbances, and depression. In the population as a whole, tiredness was experienced at distances up to three hundred meters, headaches and sleep disturbances up to two hundred meters, and irritability, depression, memory loss, dizziness and decreased libido were experienced at distances up to one hundred meters from the stations *(Ref. 48).*

The workshop on EMF hypersensitivity in October, 2004, examined the issue directly and recommended further research to better understand the characteristics of related disorders. The proceedings mentioned a Swiss survey estimating that five percent of the country's population experienced EMF hypersensitivity. Several studies referenced by the proceedings further indicated a higher prevalence of EMF hypersensitivity among women.

Disorders highlighted by the proceedings included fatigue, sleep disturbances, dizziness, nausea, disorientation, diminished concentration, and memory loss. Additional problem areas included unusual headaches associated with mobile phone usage, possibly due to stimulatory effects on labyrinthine function, and stinging, itching and burning sensations on the skin. Excessive reactivity to visual and audio stimuli and irritability were linked to possible imbalances in the autonomic nervous systems and circadian rhythms of sensitive individuals *(Ref. 62).*

The workshop on the health effects of exposure to base stations and wireless networks in June, 2005, included a section on EMF hypersensitivity, with an emphasis on mobile phone base stations. Data were referenced in the proceedings that corroborated the assessment that women tended more toward EMF hypersensitivity than men, possibly due to lower EMF perception thresholds in women. Another possibility mentioned in the report was simply a "physiological predisposition to react to physical and environmental stress" *(Ref. 63).*

Dr. George Carlo, a public health scientist, attributes this hypersensitivity to ICRW used by cell phones and other wireless devices. The United States Congress tasked Dr. Carlo with oversight and supervision of research between 1993 and 1999 into the potential harmfulness of cell phones and other wireless communication technologies. Dr. Carlo reported in 1995 that digital cell phones interfered with cardiac pacemakers. His global team of hundreds of doctors and scientists also reported studies showing an increase in brain cancer occurrence in users of cell phones. The studies numbered in the fifties and each was reviewed by the Harvard School of Public Health.

Additionally, considering a potential correlation with the presence of heavy metals, an increase in the incidence of autism may be linked to the rapid increase in the density of wireless technology. Heavy metals such as mercury, cadmium and lead may be present in the bodies of infants due to compromised mother's milk, other foods, lead painted toys, or vaccinations. When the blood-brain barrier closes at a young age, these metals may be trapped in the brain. Also, the cell ion channels close down under ICRW exposure thereby trapping heavy metals *(Ref.4).*

Electric fields and currents are induced into the human body by exposure to ELF and other forms of EMF. A further assault on the younger population is experienced in regard to ELF fields, which are adjacent to most typical appliances. Power fields may be especially significant at the height level of a young child where most wall power outlets are placed. Some of the exposed body tissues of children have higher induced electric field intensities and currents than those of adults exposed to the same EMF. Relative variations occur due to the differences between the body topologies, although the adult tissues have higher average current and field values throughout their bodies.

The risk of acute lymphoblastic leukemia may be increased in children as a result of the effects of the induced electric fields. The fields may influence cellular clones that lead to leukemia and may have subsequent or concurrent effects on hematopoietic tissues. There

may also be a negative influence of ELF magnetic fields on the production of Melatonin, since EMF exposure has the effect of lowering the level of Melatonin in the human body (Stevens, Davis, Thomas, Anderson, & Wilson, 1992). This effect could increase the risk of leukemia in children, since normal Melatonin production enhances immune response and increases the cytotoxicity of killer lymphocytes *(Ref. 26).*

Another result of exposure to either ELF fields or ICRW may be a reduction in the efficiency of intercellular communication. Human bodies have adapted to naturally occurring magnetic fields to a limited extent. When high power drives a magnetic field that results from non-ionizing ELF radiation, the resultant magnetic field intensity may exceed the threshold beyond which human bodies can adapt and normalize. Disruption in gap junction communication between cells may result, especially in close range to the high power sources.

Reduced efficiency in response to ICRW occurs due to interruption of microtubule formation and active transport processes. Microtubules play an important role in intercellular communication, during their short lives of approximately ten seconds, by facilitating the intercellular exchange of signals in the form of biophotons. Waste product build-up internal to each cell leads to formation of ROS. These ROS (*free radicals)* go to the mitochondria (*the cell energy factories*) disrupting energy production and DNA repair.

Improper DNA repair results in the formation of micronuclei, which are stray DNA strands enclosed in membranes. When a cell goes through apoptosis the immune system should respond to destroy the micronuclei that are released interstitially, but communication has been compromised, so the efficiency of immune response is also compromised. Concurrently, when cells become energy deficient due to ICRW-induced reduction in nutrient and waste transfer, cells are left to communicate via less efficient gap junctions. *(Ref. 5).*

Since communication via gap junctions is a fundamental type of intercellular communication, core processes may be affected at a deep level resulting in aberrations in cell and tissue formation, as well as negative effects on hormone signaling responsible for coordination and control of the endocrine system. A Swedish study noted a potential interaction between magnetic fields and the human endocrine and/or immune system. The study found an increased risk of testicular cancer in young males working in occupations with frequent exposure to magnetic fields, and an association with uterine cancer for similarly occupied women. The risk of contracting any form of cancer was increased significantly, by approximately 10%, for both men and women with medium to high levels of occupational exposure to magnetic fields *(Ref. 14).*

Bioenergetics

It has been shown that DNA may use electromagnetic frequencies to influence or control processes in the human body. According to studies by French scientist Jacques Benveniste, every molecule emits a unique frequency, which may be used for communication. During the 1990s, Benveniste recorded the frequencies of molecules and played them to other molecules. The signals subsequently imitated corresponding chemicals to influence biological processes, offering a possible explanation for some of the medicinal effects of homeopathic remedies diluted to negligible levels of solute *(Ref. 2).*

According to Benveniste, healthy individuals emit well-organized quantum light from their cells, which is electromagnetic radiation in the form of biophotons. Unhealthy individuals or cells, on the other hand, may emit disorganized electromagnetic radiation. This implies that cancer patients, for instance, may have lost the organization of this internal energy, such that the subatomic communication among various parts of the body has broken down. Some studies of carcinogenic compounds show that they take in the frequencies being emitted by the cells of human beings and change them. The implication here is that from an energy dynamic viewpoint, illness may result from or manifest through scrambling of electromagnetic radiation frequencies *(Ref. 2).* .

Electropollution

An artificially induced scrambling of natural frequencies in human beings may be an effect of the continually expanding range of frequencies of exposure. This serves as an example of technology advancing faster than the ability of research to assess the effects on the human population. The addition of technologies continues, taking advantage of the electromagnetic spectrum for communication and control purposes. Such technologies are expanding greatly beyond the early days of telegraph, basic 50 or 60 Hz electrical power, **amplitude modulation (AM)** radio, television, telephone land lines and Radar (adopted in the English language from the acronym **RADAR** for **Radio Detection and Ranging**). Despite their technologically more rudimentary forms, not even any of these earlier communication technologies may be deemed to be completely harmless.

Vast communication networks now add to the effects of radiation from these early sources. In addition to basic **frequency modulation (FM)** radio at 88 to 108 MegaHertz (MHz, where 1 MHz is 10^6 Hz), there is XM radio with satellites that broadcast signals back down to earth using the L band radio frequencies (950-1450 MHZ). There are also remote telephone signals flying through the air at frequencies of 900 MHz, 2.4 GigaHertz (GHz, where 1 GHz is 10^9 Hz), and beyond. Phones in the 900MHz range operate when in use, but the more recent remote telephone technologies at frequencies of 2.4 GHz and above operate continuously, irradiating human and animal tissues regardless of whether they are in use or not.

The array of electromagnetic technology continues its expansion with **global positioning systems (GPS)** operating at frequencies from 1 to 10 MHz, cellular telephone frequencies operating in the 800 to 900 MHz range, **PCS (personal communications service)** telephones operating in the 1.85 to 1.99 GHz range, wireless networks operating at 2.4 GHz, and so on. Virtually all people living in modern society are exposed to an array of these communication signals. Even a trip to the country does not totally remove the exposure due to the expanding geography of coverage included in cellular telephone provider service areas.

Many of the communication signals mentioned above are in the microwave range. Specifically, this range includes **ultra-high frequency (UHF)** from 300 MHz to 3 GHz, **super high frequency (SHF)** from 3 to 30 GHz, and **extremely high frequency (EHF)** from 30 to 300 GHz. In fact, even television long ago expanded from the original **very high frequency (VHF)** band of 30 to 300 MHz, which is in the radio frequency range of the electromagnetic spectrum (the upper radio band), to **UHF** frequencies (the low end microwave band).

In addition, many walkie-talkies used by department store employees are in the UHF range. These walkie-talkies are usually kept activated and are often stored on belts or in pockets at hip or genital level. Thus, these employees are regularly exposed to both transmitted and received UHF electromagnetic radiation at close range (walkie-talkies both transmit and receive these communication signals). In fact, customers of the stores are also exposed to these signals at a farther range in a somewhat less direct fashion.

Another signal type included in the microwave region, since World War II, is **Radar.** Radar signals are implemented to track speeders, weather systems, satellites, and airliner flights. Flights are tracked at all altitudes, from those taking place in the upper areas of the atmosphere, all the way down to planes on runways at ground level. At ground level, airport personnel work complete shifts without shielding from the tracking signals.

Radar signals encompass a very wide range that includes several of the frequency ranges commonly used for civilian communication. Hence, the need to request cessation of communication using wireless devices (including laptops and cellular phones) when a plane begins to taxi on the ground and while in flight. Radar has even been expanded to include millimeter wave frequencies (40 to 100 GHz or more) at the high end of the microwave range *(see Table 1).*

Table 1

Radar Frequency Bands

Band Designation	Frequency Range	Typical Usage
VHF	50-300 MHz	Very long-range surveillance
UHF	300MHz-1GHz	Very long-range surveillance
L	1-2 GHz	Long-range surveillance and traffic control
S	2-4 GHz	Moderate-range surveillance, terminal traffic control, and long-range weather
C	4-8 GHz	Long-range tracking and airborne weather
X	8-12 GHz	Short-range tracking, missile guidance, mapping, Marine Radar, and airborne intercept
K_u	12-18 GHz	High resolution mapping and satellite altimetry
K	18-27 GHz	Little used (due to H_20 absorption)
K_a	27-40 GHz	Very high resolution mapping and airport surveillance
mm	40-100+ GHz	Experimental

Note. Source is AIAA (American Institute of Aeronautics and Astronautics) –Modified.

Diagnostics and Therapy

The problems are not limited simply to communication and power systems. Even medical equipment electromagnetic radiation sources, such as x-ray machines and CT scanners, are well-known carcinogenic systems with government-regulated limits on the levels of exposure of patients. Unfortunately, these limits often fall victim to the priorities of urgent medical care and patients who go to multiple practitioners due to referral, switching of medical or dental insurers, or personal preference. Thus, many patients are exposed to far more radiation than is technically acceptable according to the limits set by United States government medical regulators *(limits that are set far higher than those of similar agencies of many other governments).*

Significant controversy exists regarding the application of x-ray based mammography, since the technology is inherently carcinogenic. A Swedish study questions the validity of mammography in breast cancer mortality reduction. A key paragraph in the conclusion states "screening for breast cancer with mammography causes more deaths than it saves … for every 1000 women screened throughout 12 years, one breast-cancer death is avoided but the total number of deaths is increased by six" *(Ref. 18)*

Some electromagnetic medical technologies have direct application as a concentrated form of energy medicine, similar to the practice of Reiki and the Oriental medical application of moxabustion. **Bioelectromagnetic (BEM)** therapy, exposing the body in whole or part to electromagnets and **laser light therapy (LLT),** applying low-power (up to 0.5 Watt) laser light in the visible and infrared range to specific body areas, have both been used for decades around the world. In the last few years, the United States **Food and Drug Administration (FDA)** has approved these therapies for certain applications, including carpal tunnel and musculoskeletal disorders. In BEM therapy, magnetic fields induce small electrical currents in the body that can energize cells and tissues, and enhance movement of electrolytes across cell membranes. LLT has recently been emerging as a non-surgical method for treatment and prevention of disease.

Two important effects of LLT are tissue regeneration and reduction of inflammation. Tissues regenerate due to increased cellular energy when photo-accepting surfaces on mitochondria increase energy levels and **adenosine triphosphate (ATP)** production. Inflammation reduces due to vasodilation, which results in increased blood and lymph flow, thereby reducing edema. Additionally, LLT has been shown to have anti-microbial effects *(Simunovic, 2000).* One technology that has become popular for therapeutic purposes is a **Gallium-Aluminum-Arsenide (GaAlAs)** solid-state diode laser operating in the near infrared range of 780 to 890 nm. Generally, the wavelength range of 1100 to 630 nm has been applied for LLT, corresponding to a frequency range of 273 to 476 THz.

Both BEM and LLT are likely to become very important as implementations of electromagnetic technologies. BEM and LLT therapeutic implementations may prove effective as alternatives or complements to pharmaceuticals and conventional surgical techniques in applications such as heart disease, neurological disorders, arthritic conditions and various cancers. Generally, when operating in the non-ionizing range, such technologies may be relatively harmless in low doses, yet long-term exposure to non-ionizing radiation has been shown to produce cellular damage.

Another factor involved is the level of filtering of the signals getting to the body, since high frequency noise or spikes in the ionizing range can be produced even if the main frequencies are non-ionizing. Further studies of the long-term effects of BEM and LLT technologies appear to be needed to determine whether there may be hidden medical consequences of widespread implementation. Given the likely expansion of these technologies and their application to medical conditions, a protective supplementation regime may be of assistance to ensure a purely curative result without negative long-term consequences.

Key Issues

Voluminous studies show the negative effects of the various ranges of electromagnetic radiation on the human body, including generation of tumors, various forms of cancer, and many other disease-promoting effects. Most of the studies have only looked at specific limited frequency ranges. The cumulative effects of electromagnetic radiation from all of the ranges to which human beings are exposed have not been widely examined.

Such effects present an area for potential further research. Although further studies examining the cumulative effects would certainly be useful, it is quite clear that modern human bodies are under siege from the bombardment of these advanced technologies. Hence, there is a need for some sort of protection to defend against these widespread attacks. To address this prevalent, yet widely dismissed or omitted need, there are natural medicines that fall into a category called radioprotectants because they can offset or negate the destructive effects of electromagnetic radiation. These herbal, nutritional, and hormonal substances may prevent or delay the onset of diseases influenced by harmful exposures and work to protect biological structures.

CHAPTER TWO

A REVIEW OF RELATED RESEARCH AND LITERATURE

The importance of the issue of electromagnetic radiation and its damaging effects is evident in the research of increasingly voluminous studies that delve into herbal and nutritional components that may offset the damage. Studies have examined modulatory and radioprotective effects of such substances as Ginsan (a polysaccharide extracted from Panax ginseng), Melatonin (a potent antioxidant and natural hormone secreted by the pineal gland), Ginkgo Biloba (an antioxidant herb), Caffeic Acid Phenethyl Ester (CAPE) and Quercetin (antioxidant flavonoids), vitamin C (ascorbic acid), Co-enzyme Q10 (Co-Q10) and vitamin E (antioxidant vitamins). This avenue is appropriate due to the tie between cancer and oxidative cell damage, which leads to the possible prevention of detrimental effects through the use of dietary antioxidants.

Ultimately, the best protection may be offered by a combination of antioxidants corresponding to specific exposures and confounding environmental factors. Antioxidant vitamins A, C and E, beta-carotene, Co-enzyme Q10 (Co-Q10), Ginkgo Biloba, Ginsan, Melatonin, Caffeic Acid Phenethyl Ester (CAPE), Glutathione, and various bioflavonoids have been researched in the studies reviewed herein. Various factors may enhance the damaging nature of electromagnetic radiation, including hostile environments external and internal to the human body, from toxic pollutants to pesticide-laden foods and other carcinogens and mutagens. Additionally, variations in the intensity and transfer rate of electromagnetic radiation, as well as the density of exposed areas, may influence the resulting levels and types of damage *(Ref. 43).*

At the low end of the electromagnetic spectrum, an Italian study found a dose-dependent increase in DNA damage in cells exposed to 50 Hz extremely low frequency (non-ionizing) electromagnetic fields (Wolf et al., 2005). This is the frequency used for power in most of Europe and is at a lower energy level than the 60 Hz used in homes in North America. The study found that pre-treatment with Alpha Tocopherol (vitamin E) reduced proliferation of damaged cells and reduced the amount of DNA damage. The difference was found in both normal and tumor cells, and was attributed to the antioxidant properties of vitamin E.

Exposure to power lines has been associated with childhood leukemia. Cancer in children certainly provides motivation to find preventative measures addressing this disease. Results of a 2004 study documented in the journal *Die Pharmazie* showed that some amount of ROS is required for proliferation of human myeloid leukemia cells. The study indicated that Quercetin, an antioxidant that belongs to a group of plant pigments called

flavonoids, reduced proliferation and viability of leukemia cells, as well as reducing accumulation of ROS. Both the antioxidant and anticancer effects of Quercetin on the leukemia cells were further enhanced by the addition of water-soluble antioxidants, specifically vitamin C (ascorbic acid), N-Acetyl-Cysteine and Glutathione *(Ref.7).*

A study at Taipei Medical University in Taipei, Taiwan showed cytotoxic activity on leukemia cells using Cnidium monnieri fruit. According to traditional Chinese medicine, the actions of sun-dried ripe Cnidium monnieri fruit, which in Pin Yin is called She Chuang Zi, are to warm the kidneys, strengthen yang (male energy or vitality), disperse cold, expel wind, dry dampness, and expel worms and other parasites. Specific coumarins from Cnidium monnieri fruit were tested, including bergapten, osthol, imperatorin, isopimpinellin and xanthotoxin. Cytotoxic activity was found for human leukemia cells, particularly using osthol, as well as cervical and colorectal cells. Apoptosis of human leukemia cells could be induced by osthol or imperatorin *(Ref. 57).*

Egyptian researchers explored the protective effects of the amino acid L-Carnitine and the coenzyme (vitamin) Co-Q10 against damage from magnetic fields in a 2002 study, and subsequently electromagnetic fields in a 2003 study. In the first study, mice were exposed to high dose magnetic fields (20 milliTesla) for a half hour, three times per week and over a two-week period, or alternately to a single acute dose of three-hours duration. Interestingly, the testes of mice exposed to the intermittent dosages showed more damage than did those exposed to a single acute dose of the magnetic field. The resultant effects included significant reductions in sperm concentrations (sperm counts) and motilities. Mice pretreated with either L-Carnitine or Co-Q10 one hour before exposure showed a significant reversal of the counts and motilities, toward the baseline values established prior to magnetic field exposure *(Ref. 46).*

In the second study, mice were exposed to a 50 Hz electromagnetic field for a half hour, three times per week over a two-week period. Again, the mice were pretreated with either L-Carnitine or Co-Q10 one hour before each exposure. In this case immune factors were monitored, including white blood cell counts, splenocyte viability and lymphocyte proliferation. All of these factors were at decreased levels due to the exposure to ELF (in this case at a frequency of 50 Hz), but administration of L-Carnitine showed some reversal of the effects. No significant amelioration was demonstrated as a result of Co-Q10 administration in this particular study *(Ref. 1).*

Turkish scientists have explored the mechanisms for the biological effects of electromagnetic radiation due specifically to cellular systems, which are on the fringe of the microwave range of electromagnetic radiation. Various oxidant and antioxidant levels in rabbits were examined under 900 MHz mobile phone electromagnetic radiation. An increase was observed in serum Superoxide Dismutase (SOD), accompanied by a decrease in serum Nitric Oxide and no change in other levels. From these results, decreased Nitric

Oxide may be a factor in the biological effect and increased oxidative stress may be indicated as a pathological factor *(Ref. 24).*

Several Turkish studies have looked at various antioxidants as potential radioprotectants against mobile phone effects. One study found a reduction in oxidative damage due to 900 MHz mobile phones when Ginkgo Biloba was used (Ilhan et al., 2004). Evidence of the effects of ROS included reductions in the levels of SOD and Glutathione Peroxidase, as well as increases in Nitric Oxide levels. These levels were reversed by the Ginkgo Biloba treatment. Another Turkish study found that Melatonin had a similar effect, also reversing ROS damage due to the 900 MHz mobile phones *(Ref. 36).* Similar reversal was also found in yet another Turkish study using Caffeic Acid Phenethyl Ester (CAPE), a flavonoid found in honeybee propolis *(Ref. 38)*

Turkish scientists also explored the effects of these antioxidants on specific damaged organic structures. Reversal of skin tissue damage due to 900 MHz mobile phone effects was indicated as a result of Melatonin therapy *(Ref. 37).* Another study compared the radioprotective properties of both Melatonin and CAPE regarding renal tube damage due to 900 MHz mobile phone radiation. Both antioxidants were shown to protect the kidneys in general, and specifically to prevent oxidative damage to the renal tubules. Of the two, Melatonin appeared to have the greatest benefit *(Ref.38).*

One study indicates that higher Melatonin levels may also reduce the risk of contracting breast cancer *(Ref.50).* This study may be particularly applicable to ameliorate the increased development of breast cancer in flight attendants since there may be a hormonal link to abnormal nighttime lighting, gamma radiation exposure at high altitudes, and resultant lowered Melatonin production. In a broad sense, much of the potential benefit of Melatonin may be due to a reversal of the lowering of Melatonin levels in the human body that takes place under the influence of EMF *(Ref. 53).* Additionally, lowered Melatonin levels yield a reduction in the immune response thereby tending to enable cancerous growths to flourish *(Ref. 26).*

Exposure to ultraviolet radiation may result in cumulative damage, including cutaneous malignancies such as basal or squamous cell carcinomas and melanoma, partly due to generation of reactive oxygen species (ROS). Addressing the destructive ROS mechanism through antioxidant supplementation may help defend the body against such pathogenic damage. Although studies performed at the University of Manchester have shown mixed results *(Swindells & Rhodes, 2004),* other studies have shown vitamin A derivatives to be effective for prevention of malignant skin cell damage. Some retinoids derived from vitamin A, the most effective of which may be Tretinoin used topically, have been shown to promote disintegration through programmed cell death (apoptosis) and impede the proliferation of new basal and squamous cell carcinomas *(Ref. 6).* Additionally, black and green tea polyphenols may inhibit carcinogenic processes resulting from ultraviolet radiation exposure *(Ref. 55).*

A Norwegian study examined the effects of antioxidants on mutations induced by ultraviolet radiation through unstable processes, including ROS from ultraviolet A radiation and damage to DNA by ultraviolet B radiation. According to the study, the antioxidant reduced Glutathione had a significant effect on mutations from ultraviolet A radiation and decreased the early mutation rate from ultraviolet B radiation by 24%. Reportedly, the antioxidants Catalase, Superoxide Dismutase (SOD), and reduced Glutathione significantly inhibited mutations evolving from ultraviolet B radiation exposure *(Ref. 9).*

A study at Duke University in North Carolina showed ultraviolet protective properties using topical vitamins C (L-ascorbic acid) and E (alpha-tocopherol). The antioxidants were shown to be protective against erythema and sunburn, especially when combined. An implication of the result was that topical application of vitamins C and E might be protective against ultraviolet-induced DNA damage, aging and skin cancer, since these have similar etiologies *(Lin et al., 2003).* A German study also showed that antioxidant vitamins C and E provided significant protection against ultraviolet B-induced erythema. In this case human subjects were administered vitamin C (one gram, twice daily of ascorbic acid) and vitamin E (500 IU, twice daily of d-?-tocopherol) for a three month period, although the combination took only one month to show significant ultraviolet protection *(Ref. 41).*

Two interesting studies looked at the ameliorative effects of antioxidants on lipid peroxidation (oxidative degradation of lipids) under x-ray exposure. A study regarding such x-ray induced cell damage found that supplementation with antioxidant vitamins C and E had a probable protective effect. The same study indicated that supplementation with a group of minerals, specifically manganese, zinc and copper, had a similar protective effect against x-ray induced lipid peroxidation *(Ref. 10).* Another study indicated that through administration of the antioxidant N-Acetyl-Cysteine, either before or after exposure, the prevalence of x-ray induced DNA damage and cell apoptosis was reduced. The study results also indicated that by reducing lipid peroxidation, the administration of N-Acetyl-Cysteine resulted in a reduction in x-ray induced liver damage *(Ref. 31).* A couple of studies performed in the United States provided results that may be of interest regarding radioprotectants. One study performed by the National Cancer Institute looked at nitroxides as protectants against the effects of ionizing radiation. The nitroxides proved effective against oxidation and DNA damage *(Ref. 35).* Another study, this one funded by NASA, looked at space radiation-induced oxidative stress from gamma radiation, protons and other high-energy particles. The study demonstrated a significant decrease in plasma antioxidant levels four hours after exposure to gamma radiation. Supplementation with either L-Selenomethionine or an antioxidant blend resulted in partial through complete reversal; an increase in plasma antioxidant levels to at least the prior values *(Ref. 17).*

Exposures of flight personnel range from ELF in flight power circuits, through radar and microwave wireless communication frequencies, to the highest end of the electromagnetic spectrum, including gamma and cosmic radiation. In part, the high frequency exposures are due to the minimal atmospheric protection offered at the high flight altitudes of modern

aircraft. This exposure is somewhat similar to the space radiation experienced by NASA astronauts, although it is not as continuous since flight altitudes vary. The result is a corresponding variation in the amount of protection offered by the atmosphere during individual flights.

Theoretically, since the energy level of electromagnetic radiation increases as the frequency increases, damage to DNA would most likely increase in correspondence with the higher energy levels of gamma and cosmic radiation. An Italian study examined DNA damage in flight personnel exposed to cosmic, extremely high frequency ionizing radiation, and other forms of electromagnetic radiation. In the study, it was found that DNA damage did increase with the higher frequency levels. Potential corrective action for this situation was explored for the purposes of the study, and the application of antioxidants was found to be associated with a corresponding reduction in the level of DNA damage *(Ref. 5).*

Radiation therapy is widely used in medical applications such as treatment of various types of tumors and thyroid problems. One undesirable result of high dose radiotherapy is likely to be the atrophy of body fibers, possibly even necrosis, largely due to the development of ROS evolving from the radiation exposure. The negative effects can result from high dose radiotherapy-induced ROS damaging molecules that are important to cellular structure and function. Damage to lipids, DNA, proteins, and specifically DNA repair proteins, can lead to cellular mutations and possibly formation of tumors, various cancer cells or cell death, in addition to skin and tissue aging *(Ref. 8).*

According to a French study, the fibroatrophic process may be reversible, at least partially. In theory, atrophy may be reversed due to the repair activity of antioxidants, which may allow cellular structures to rebuild, and cellular functions to subsequently normalize. Reversibility has been shown in both clinical practice and animal experiments, through the application of antioxidants. The French study included SOD and the combination of tocopherol (vitamin E) with Pentoxifylline (Trental), which is a pharmaceutical that is chemically refined for improving blood flow throughout the human body *(Ref. 11)*

Another study examined combined treatment with tocopherol and Pentoxifylline, a hemorrheologic agent that is chemically similar to caffeine . Pentoxifylline is used for the treatment of cerebrovascular and peripheral vascular diseases, often indicated by intermittent claudication, which may result from impaired microcirculation. The drug acts primarily by reducing blood viscosity and oxygenating tissues *(Ref. 40).* The study found that the combination of Pentoxifylline and tocopherol might alter the pathogenesis of proctitis/enteritis, a common and typically chronic complication of pelvic irradiation. Results included significant improvement in seventy-one percent of the radiation-induced proctitis/enteritis patients studied *(Ref.21).*

Herbs such as Garlic, Hawthorn, Feverfew, Red Sage and Ginkgo Biloba all improve blood flow and may have similar therapeutic effects to the drug Pentoxifylline. Since xanthines like caffeine and Pentoxifylline may be catalyzed by the enzyme xanthine oxidase to convert

to uric acid, thereby exacerbating conditions such as gout and rheumatoid arthritis, the drug may not be the most desirable option. Perhaps a suitable natural alternative to the drug Pentoxifylline could be used, especially given its side effects, which include cardiac arrhythmia, hypotension, central nervous system disorders, seizures, unconsciousness, and *fever* *(Ref. 40).*

A relevant article explored radiation-induced disturbances of antioxidant defense systems as documentation of collaborative research on specific protective effects. The research explored the exact mechanisms of the radioprotective effects of Ginsan *(Ref. 19).* The model for the research was primarily quantitative. Specific dosing schedules and tight controls with control groups were used.

The research question asked whether the known radioprotective effect of Ginsan (with reference to prior research) could be tied directly to the activation of antioxidant defense systems. Logically following this question, the effects of Ginsan on several antioxidants were examined in the course of the research. Resultant data on the effects of Ginsan on antioxidant levels were analyzed statistically, using a one-**way analysis of variance (ANOVA)** for data found to be significant. The antioxidants that were examined included various forms of Superoxide Dismutase, Catalase, Glutathione Peroxidase, Heme Oxygenase, and non-protein thiol Glutathione.

A Ginsan dosage of 100 mg per kg of body weight was administered 24 hours before exposure of the animals to a controlled dosage of gamma radiation. In vivo antioxidant systems did not appear to be altered directly by Ginsan (through direct free radical scavenging). Rather, the repairing effect appeared to be induced by Ginsan through its modulation of antioxidant enzymes, which then acted upon free radicals. Additionally, hematopoietic cells were rapidly regenerated under the influence of Ginsan, adding to speed of recovery from oxidative damage. It should be noted that there was a small amount of scavenging of free radicals by Ginsan, but that this was relatively insignificant when compared to the enzyme modulation and hematopoietic cell regenerative effects.

Another study that took place in India, and was reported in an Iranian journal, suggested the possible radioprotective ability of Aloe vera leaf extract under gamma radiation exposure. These results suggest healing properties for conditions such as chronic ulcerations that may result from radiation treatment or other intense exposures to gamma radiation from various sources. Pre-treatment of gamma irradiated animals with Aloe vera leaf extracts resulted in a significant reduction in lipid peroxidation and an increase in Glutathione activity. The Aloe vera leaf extract was administered orally to albino mice for a two-week period at a dosage of 1000 mg per kg of body weight *(Ref. 15).*

A common side effect of radiation therapy, often used for cancer treatment, is a skin reaction. One study found Calendula officinalis (Marigold) helpful in treating skin reactions related to irradiation, particularly for acute dermatitis due to breast cancer radiotherapy. The study also showed fewer treatment interruptions and significant improvement in pain

associated with radiation treatments when patients were given topical Calendula treatments *(Ref. 42).* Another study found that the triterpene and flavonol glycosides in Calendula exhibited anti-inflammatory activity, antiviral traits (tested against the Epstein-Barr virus), and cytotoxic activity against human cancer cells in vitro, in particular colon cancer, leukemia, and melanoma cells *(Ref. 56).*

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CHAPTER THREE

TYING IT ALL TOGETHER

Overview

The research involved in the following studies delves into herbal and nutritional components that may offset damage due to electromagnetic radiation and its effects. These studies focus on modulatory and radioprotective effects of dietary antioxidants due to the tie between cancer and oxidative cell damage. Antioxidant vitamins A, C and E, beta-carotene, Coenzyme Q10 (Co-Q10), Ginkgo Biloba, Ginsan, Melatonin, Caffeic Acid Phenethyl Ester (CAPE), Glutathione, bioflavonoids and polyphenols are examined.

The best protection may be offered by a combination of antioxidants, since corrective responses to **reactive oxygen species (ROS)** resulting from electromagnetic radiation are largely due to free radical scavenging and antioxidant modulation. Combinations of antioxidants have been shown to address damage from electromagnetic radiation in various ranges. Since much of the damage caused by toxins, carcinogens and mutagens is similar in nature to that caused by electromagnetic radiation, antioxidant treatment can simultaneously address several types of damage and pathogenesis.

To clarify the study results, radioprotectants have been grouped by the frequency ranges that they help to address any specific indications or methodologies for treatment (such as pre-treatment) are indicated. The grouped results of the studies examined herein have been summarized in **Table 2.**

High Dose Magnetic Fields

Egyptian studies show protective effects from pre-treatment with L-Carnitine or Co-Q10 one hour before exposure, protecting against damage from high dose magnetic fields (20 milliTesla as studied) with exposures of a half hour, three times per week over a two-week period compared with a single acute dose of three-hour duration *(Ref. 46).* Intermittent doses of such magnetic fields appear to produce more damage than do single acute doses. Effects may include significant reductions in sperm counts and motilities. There may be some relevance herein with regard to the experiences of modern life,considering that all modern human beings are intermittently exposed to various ranges of electromagnetic radiation in everyday life.

Table 2

Radioprotectants Listed by Electromagnetic Frequency Range

Frequency Range	***Radioprotectants***
High Dose Magnetic Fields	1. L-Carnitine (use as pre-treatment) 2. Co-enzyme Q10 (use as pre-treatment)
50/60 Hz	1. Quercetin (+vitamin C, N-Acetyl-Cysteine, Glutathione) 2. Vitamin E (use as pre-treatment) 3. L-Carnitine (use as pre-treatment) 4. Cnidium monnieri (coumarins osthol and imperatorin)
High Dose Radiotherapy	1. Vitamin E 2. Superoxide Dismutase (SOD)
900 MHz	1. Ginkgo Biloba 2. Melatonin (related skin tissue or kidney damage) 3. Caffeic Acid Phenethyl Ester (CAPE) (kidney issues)
Ultraviolet	1. Retinoids (vitamin A derivative), vitamins C and E 2. Polyphenols (black/green tea derivative) 3. Catalase 4. Superoxide Dismutase (SOD) 5. Glutathione
X-ray	1. Vitamins C and E 2. Minerals manganese, zinc and copper 3. N-Acetyl-Cysteine
Gamma	1. Nitroxides 2. L-Selenomethionine 3. Ginsan (Siberian Ginseng derivative – pre-treatment)
Cosmic	1. Nitroxides 2. L-Selenomethionine

50/60 Hz Power Frequencies

To address the link between exposure to power lines with 50 Hz or 60 Hz frequencies and childhood leukemia, Quercetin, an antioxidant flavonoid, targets proliferation and viability of leukemia cells, and reduces accumulation of ROS. Combining Quercetin with water-soluble antioxidants, specifically vitamin C (ascorbic acid), N-Acetyl-Cysteine and Glutathione enhances the antioxidant and anticancer effects of Quercetin on the leukemia cells *(Ref. 7).* Additional treatment with Cnidium monnieri may be helpful *(Ref.57).*

Dose-dependent DNA damage in cells exposed to 50 Hz electromagnetic fields may be ameliorated through pre-treatment with vitamin E (alpha tocopherol). Vitamin E has been shown to reduce proliferation of damaged cells and to reduce the amount of DNA damage, especially since the difference was found in both normal and tumor cells *(Ref. 60).* Egyptian studies demonstrated that pre-treatment with L-Carnitine one hour before each exposure to 50 Hz electromagnetic fields somewhat reverses changes in white blood cell counts, splenocyte viability and lymphocyte proliferation, otherwise decreased due to exposure. *(Ref. 1*).

High Dose Radiotherapy

French studies show that fibroatrophic processes can be somewhat reversed, as evidenced by both clinical practice and animal experiments, using Superoxide Dismutase and Pentoxifylline with tocopherol *(Ref. 11).* Combined treatment with Pentoxifylline and tocopherol (vitamin E) may alter the pathogenesis of proctitis/enteritis as a complication of pelvic irradiation *(ref. 21),* with significant improvement (71 percent in this study).

900 MHz Mobile Phone Frequencies

Turkish scientists demonstrated the appropriateness of antioxidant treatment to address pathogenic responses to electromagnetic radiation by showing that plasma antioxidant levels change with exposure to 900 MHz mobile phone electromagnetic radiation. Specifically, serum Superoxide Dismutase increases and serum Nitric Oxide decreases (Irmak et al., 2002). Ginkgo Biloba *(Ref.22), Melatonin (Ref. 36) and CAPE (Ref. 39)* reverse these levels. Melatonin therapy specifically addresses skin tissue damage due to 900 MHz mobile phone frequencies *(Ref. 37).* Melatonin and CAPE both protect the kidneys and prevent oxidative damage to the renal tubules, with most benefit shown from Melatonin (Ref. 38).

Ultraviolet Radiation

Preventative and radioprotective measures addressing ultraviolet radiation include the use of vitamin A derivatives called retinoids, particularly Trentinoin (Retin-A), vitamins C and E applied topically, and polyphenols from green and black teas *(Ref. 6, 41 & 55).* The antioxidant reduced Glutathione may significantly reduce the number of mutations from ultraviolet A radiation and decrease the early mutation rate from ultraviolet B radiation. Antioxidants Catalase, reduced Glutathione and **Superoxide Dismutase (SOD)** may also inhibit mutations from ultraviolet B radiation exposure *(Ref. 9).*

X-ray Radiation

Either supplementation with antioxidant vitamins C and E or supplementation with the minerals manganese, zinc and copper had a protective effect against x-ray induced lipid peroxidation. *(Ref. 10).* Administration of the antioxidant N-Acetyl-Cysteine, either before or after exposure, improved x-ray induced DNA damage and cell apoptosis. N-Acetyl-Cysteine also yielded a reduction in x-ray induced liver damage *(Ref. 31*).

Gamma and Cosmic Radiation

The effects of cosmic and gamma radiation can be addressed by antioxidants, which are shown to reduce DNA damage *(Ref.3).* Nitroxides are effective against oxidation and DNA damage due to space radiation-induced oxidative stress from gamma radiation, protons and other high-energy particles, such as cosmic radiation. Additionally, supplementation with either an antioxidant blend or L-Selenomethionine can result in partial through complete reversal *(Ref. 17).* Pre-treatment with Aloe vera leaf extracts may also be preventative against the effects of gamma radiation. The studied dosage of 1000 mg per kg of body weight produced a significant lipid peroxidation reduction and greater Glutathione activity *(Ref. 15).*

Pre-treatment with Ginsan 24 hours before exposure can also offset the effects of gamma radiation. The studied dosage for such an effect was 100 mg per kg of body weight. Although there will likely be a small amount of free radical scavenging, the repairing effect of Ginsan appears to be primarily due to its modulation of antioxidant enzymes such as Superoxide Dismutase and Glutathione Peroxidase, which then act upon free radicals. Additionally, acceleration of hematopoietic cell regeneration may speed recovery from oxidative damage *(Ref. 19).*

Radar

Some of the frequency ranges already discussed are included in the span of frequencies used by Radar. It is quite likely that the radioprotectants corresponding to the individual frequency ranges will continue to have applicability to those particular ranges when used for Radar as well. The Radar bands range from 50MHz to more than 100 GHZ, overlapping most of the radio and microwave bands. Therefore, the likely radioprotectants for Radar are those corresponding to these bands, as shown in the studies reviewed herein.

The 50 to 300 MHz frequency range used for Radar is in the upper part of the radio band, so the radioprotectants corresponding to high dose radiotherapy would seem appropriate. Specifically, these are Vitamin E and Superoxide Dismutase (SOD). The 300 MHz to 100 GHz frequency range is also used in Radar. This range overlaps the UHF, SHF and EHF bands of the microwave range. Ginkgo Biloba, Melatonin and Caffeic Acid Phenethyl Ester (CAPE) have been shown to work well as radio-protectants in the lower end of this range (900 MHz). This protection may extend to the upper end of this range as well.

In summary, Table 3 lists the Radar frequencies and their likely corresponding radioprotectants.

Table 3

Potential Radar Radioprotectant Radar Frequency Bands

Band Designation	Frequency Range	Radioprotectant
VHF	50-300 MHz	1. Vitamin E 2. Superoxide Dismutase (SOD)
UHF, SHF, EHF (includes L, S, C, X, K_u, K, K_a, and mm)	300 MHz-100+ GHz	1. Ginkgo Biloba 2. Melatonin (also for skin or kidney damage) 3. Caffeic Acid Phenethyl Ester (CAPE) (also for kidney issues)

Several radioprotectants offer protection in more than one frequency range. At the bottom of the electromagnetic spectrum, individuals expecting to be exposed to 50 Hz or 60 Hz ELF *(Arafa et al., 2003*) or High Dose Magnetic Fields *(Ramadan et al., 2002)* may benefit from the protective effects of L-Carnitine pre-treatment. N-Acetyl-Cysteine has been found effective in 50/60 Hz ELF environments when combined with vitamin C, Quercetin and Glutathione *(Ref.7).* Additionally, vitamin E may be useful for pre-treatment in 50/60 Hz ELF exposure cases *(Ref. 60).*

Moving further up the electromagnetic spectrum, the combination of **Superoxide Dismutase (SOD)** and Pentoxifylline, or Pentoxyfylline alone, with vitamin E (tocopherol) may provide protection against High Dose Radiotherapy *(Ref. 11 & 21).* Beyond the radio range, SOD may also be helpful for exposure to ultraviolet radiation when combined with Glutathione and Catalase *(Ref. 9).* Common ultraviolet exposure environments include sunbathing, tanning machines, and fluorescent lighting.

At higher levels on the electromagnetic spectrum radiation crosses over from the non-ionizing range, which includes radio, microwave, infrared, visible and ultraviolet, to the ionizing range including x-ray, alpha, beta, positron, gamma, and cosmic radiation. All of these are used in various diagnostic medical applications. N-Acetyl-Cysteine may be effective protection against ionizing radiation. The protective nature of N-Acetyl-Cysteine has been shown for cases of x-ray exposure *(Ref. 31).* Vitamin C is also potentially helpful for x-ray cases when combined with vitamin E *(Ref. 10).*

At the extreme upper end of the electromagnetic spectrum, L-Selenomethionine and nitroxides have been indicated for protective applications in the gamma and cosmic radiation ranges. Additionally, Ginsan has been identified specifically for the gamma range *(Ref. 19).*

Table 4 summarizes the radioprotectants with multiple demonstrated applications, as well as those shown to be individually effective, and the frequency ranges for which they have shown protective benefits.

Table 4

Frequency Ranges Corresponding to Radioprotectants

Radioprotectants	Frequency Range
Caffeic Acid Phenethyl Ester	900 MHz
Co-enzyme Q10 (as pre-treatment if possible)	High Dose Magnetic Fields
Ginkgo Biloba	900 MHz
Ginsan (from Siberian Ginseng; pre-treatment)	Gamma
Glutathione (with vitamin C, N-Acetyl-Cysteine and Quercetin for 50/60 Hz)	50/60 Hz Ultraviolet
L-Carnitine (as pre-treatment if possible)	High Dose Magnetic Fields 50/60 Hz
L-Selenomethionine	Gamma; Cosmic
Manganese, zinc and copper (taken together)	X-ray
Melatonin	900 MHz
N-Acetyl-Cysteine	X-ray
Nitroxides	Gamma; Cosmic
Polyphenols (black/green tea derivative)	Ultraviolet
Quercetin {Combine with vitamin C, N-Acetyl-Cysteine and Glutathione}	50/60 Hz
Retinoids (vitamin A derivative)	Ultraviolet
Superoxide Dismutase (SOD) (with Catalase and Glutathione for ultraviolet)	High Dose Radiotherapy Ultraviolet
Vitamin C & E (taken together)	Ultraviolet and X-ray
Vitamin E (as pre-treatment if possible)	50/60 Hz High Dose Radiotherapy

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CHAPTER FOUR

What it all means

Compelling evidence shows that supplementation with antioxidants can assist the body in preventing or reversing damaging effects of a range of frequencies and amplitudes of electromagnetic radiation. Studies presently reviewed showed the efficacy of antioxidants in damage prevention and reversal for specific types and at specific levels of electromagnetic radiation. Targeted research with all antioxidants in individual trials could further delineate which specific antioxidants would be most effective in each specific frequency range.

Additional research with combined exposures to various frequency ranges of electromagnetic radiation could provide further valuable information regarding the efficacy of antioxidant supplementation in specific applications. In order to achieve thorough results, studies could include various types and levels of electromagnetic radiation. Multiple frequency and phase variations could be examined simultaneously, in coherent and dispersed modes.

The ubiquitous nature of 50/60 Hz ELF in the walls of buildings and in power cables makes vitamin E, L-Carnitine, and the combination of N-Acetyl-Cysteine with vitamin C, Quercetin and Glutathione, protectants for the 50/60 Hz range of exposure, of particular common interest for the population as a whole. Due to studies linking the 50/60 Hz ELF range with leukemia, these protectants may be of special interest for protection of children in particular.

The ozone hole and the practice of sunbathing both present possible applications for the ultraviolet radiation protectants. These protectants include polyphenols (black/green tea derivatives), retinoids (vitamin A derivatives), vitamins C and E, and the combination of Glutathione with SOD and Catalase, all of which could be combined in a sunscreen cream.

The common application of x-rays for medical diagnostics makes protectants for the x-ray range of potential interest for individuals in the medical radiological community. These protectants may also be of interest as pre-treatments for patients scheduled for x-rays, CT scans or mammograms. Radioprotectants identified for the x-ray frequency range include N-Acetyl-Cysteine, the combination of vitamins C and E, and the combination of manganese, zinc and copper.

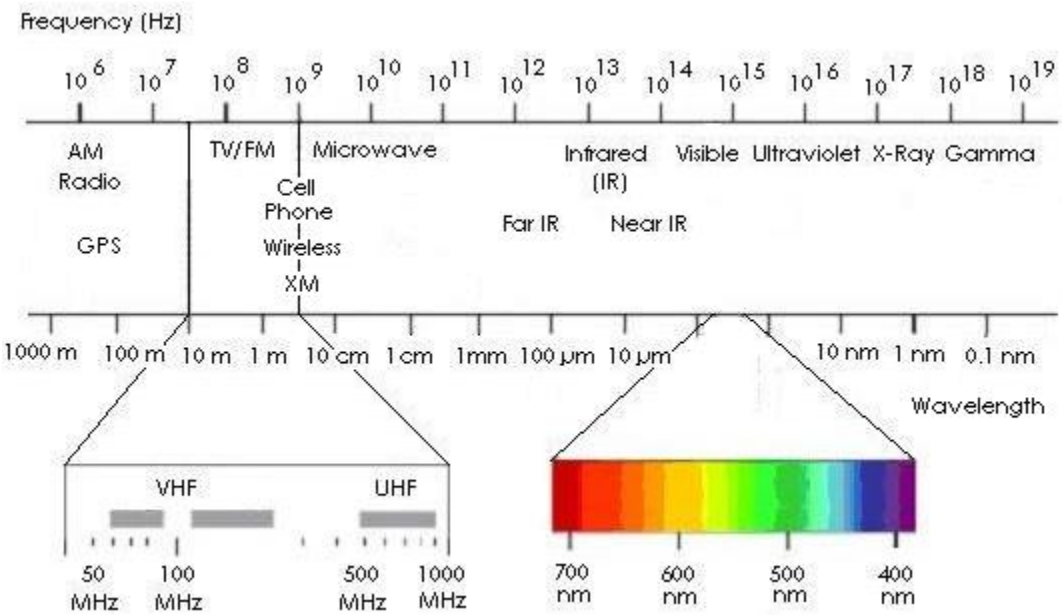
A similar medical application is the use of targeted radiation therapy for treatment of cancers, particularly breast cancer. The cytotoxic activity of Calendula combined with its protective qualities against radiation may make this a powerful radioprotectant capable of addressing the effects of radiation both before and after exposure. Perhaps Calendula administration could also help to prevent the development of angiosarcoma, a fast-spreading cancer resulting as an occasional complication of breast irradiation. Further research into this and similar applications of Calendula is recommended.

Another interesting application has been identified that may be of some importance, particularly in this time of international travel, national security issues, and potential threats of dirty bombs. Studies indicate that the component Ginsan from Siberian Ginseng may be useful as a preventative pretreatment for exposure to gamma radiation. Pretreatment with Aloe vera leaf extracts may also significantly improve outcome. Two additional protectants, L-Selenomethionine and nitroxides, have been identified for both the gamma and cosmic ranges. Many gamma and cosmic radiation emanations originate from space and may expose flight personnel and passengers, especially frequent business and retired flyers, to undesirable ionizing radiation dosage levels.

Additionally, gamma radiation is emitted by nuclear materials, including explosive devices and some radioactive medical dyes used in Positron Emission Tomography. These may result in long and short-term ionization of exposed areas and individuals. Therefore, more research into the protective effects of Siberian Ginseng and the derivative Ginsan may show benefits for flight personnel, nuclear workers, national security personnel, and even the general populations of potential target cities.

APPENDIX

Figure 1: Electromagnetic Spectrum



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