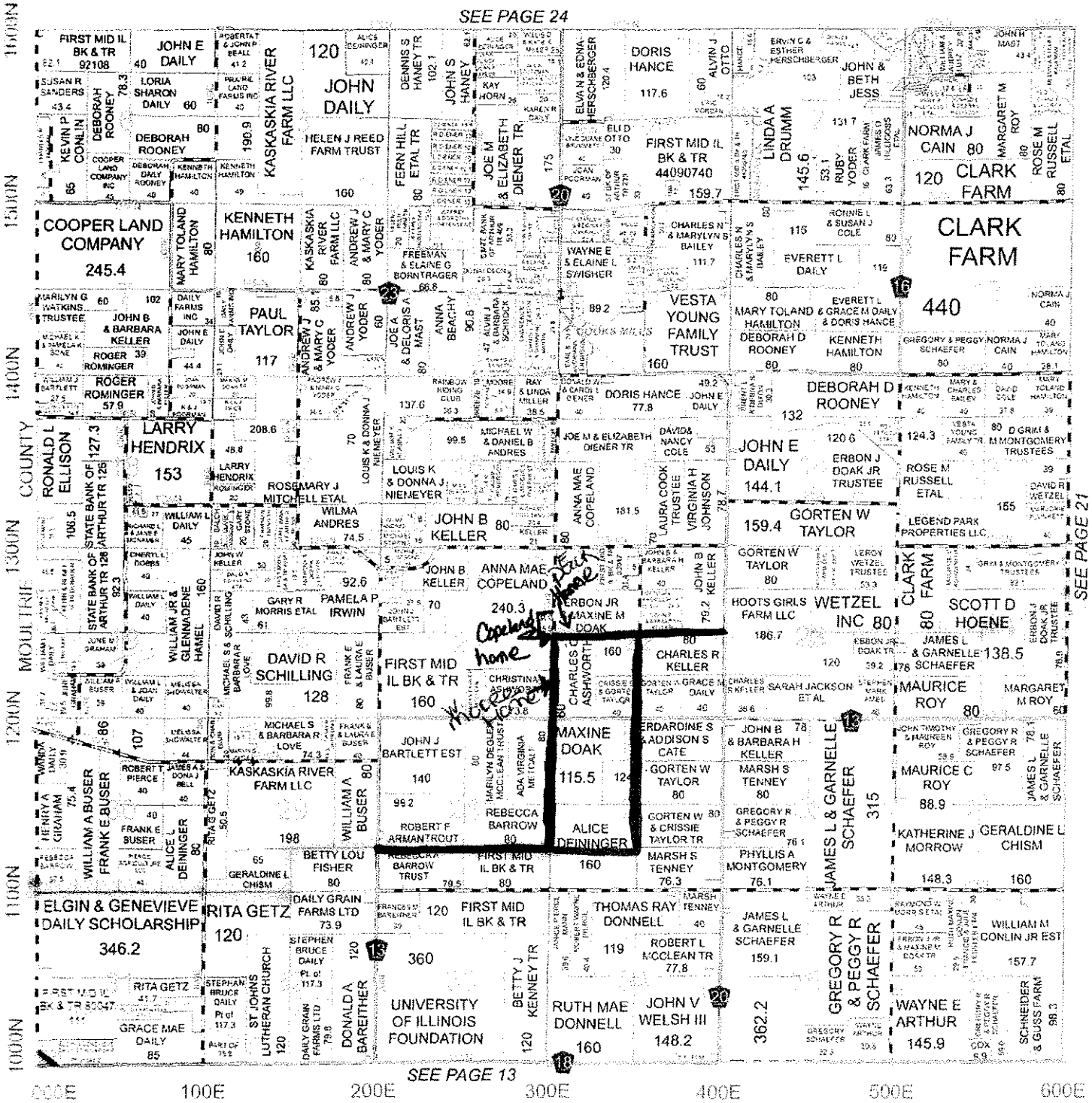
ALtRteScn.pdf



ATX1 Primary

Copeland's proposed Alternate route

AltRteScn.pdf

Principal Meridian, Moultrie County, Illinois;

THENCE Easterly, generally along or near the common lines of the following sections:

Said Sections 26 and 35, Township 13 North, Range 6 East of the Third Principal Meridian, Moultrie County, Illinois;

Sections 25 and 36, Township 13 North, Range 6 East of the Third Principal Meridian, Moultrie County, Illinois;

Sections 30 and 31, Township 13 North, Range 7 East of the Third Principal Meridian, Coles County, Illinois;

Sections 29 and 32, Township 13 North, Range 7 East of the Third Principal Meridian, Coles County, Illinois, to a point at or near the Northeast corner of the Northwest Quarter of said Section 32;

THENCE Northerly, over and across said Section 29, Township 13 North, Range 7 East, to a point at or near the Northwest corner of the Southwest Quarter of the Southeast Quarter of said Section 29;

THENCE Easterly, over and across the following sections:

Said Section 29, Township 13 North, Range 7 East;

Section 28, Township 13 North, Range 7 East of the Third Principal Meridian, Coles County, Illinois, to a point in or near the common line of said Section 28 and Section 27, Township 13 North, Range 7 East of the Third Principal Meridian, Coles County, Illinois;

*

THENCE Northerly, generally along or near the common lines of the following sections:

Said Sections 27 and 28, Township 13 North, Range 7 East of the Third Principal Meridian, Coles County, Illinois;

Sections 21 and 22, Township 13 North, Range 7 East of the Third Principal Meridian, Coles County, Illinois, to a point at or near the Northwest corner of the Southwest Quarter of said Section 22;

THENCE Easterly, over and across the following sections:

Said Section 22, Township 13 North, Range 7 East;

Section 23, Township 13 North, Range 7 East of the Third Principal Meridian, Coles County, Illinois;

Section 24, Township 13 North, Range 7 East of the Third Principal Meridian, Coles County, Illinois;

Section 19, Township 13 North, Range 8 East of the Third Principal Meridian, Coles County, Illinois;

Section 20, Township 13 North, Range 8 East of the Third Principal Meridian, Coles County, Illinois;

Section 21, Township 13 North, Range 8 East of the Third Principal Meridian, Coles County, Illinois;

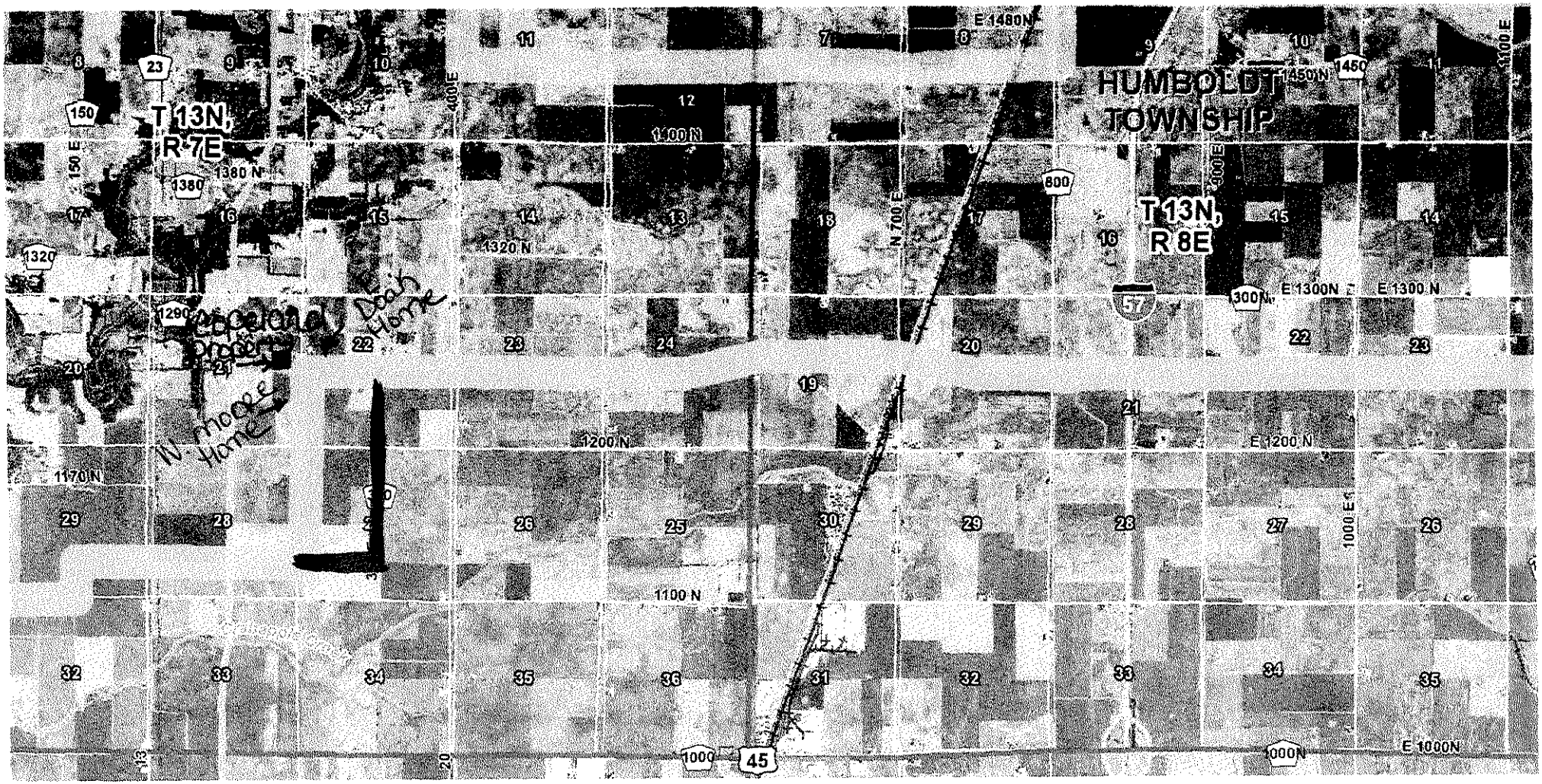
Section 22, Township 13 North, Range 8 East of the Third Principal Meridian, Coles County, Illinois;

Section 23, Township 13 North, Range 8 East of the Third Principal Meridian, Coles County, Illinois;

Insert txt.

* Continue East to the middle of Section 27, then North to the middle of Section 22; then continue east as planned.

ATXImap.pdf



= Copeland's proposed Alternate Route

AltStart.JPG

Alt2.JPG

ALT3.JPG

ALT4.JPG

ALT5.JPG

ALtEnd.JPG

ATTACHMENTS FOR ATXI-Copeland 1.04

I apologize if this is confusing to some. It is really very simple when you are looking at it in person. Basically what we are asking is ATXI move the section that comes to a point in front of our home over to the next country road to the east of were we live so it will be as far away from families and children as possible. If someone comes out to look at this suggestion they will see that it should be very simple and more importantly the safest solution.

AltRteScn.pdf - our submitted Alternate Route; also shows the Copeland home and land in relation to ATXI primary route

ATXImap.pdf - shows the Copeland home and land in relation to ATXI primary route

AltStart.JPG - VIEW ROM ACROSS THE ROAD FROM OUR HOME OF WHERE THE PRIMARY PROPOSED ROUTE WILL COME FROM THE SOUTH ON 300E AND TURN TO HEAD EAST AT THE NORTHWEST CORNER OF THE SOUTHWEST QUARTER OF SECTION 22.

Alt2.JPG - view facing east @ 300E. THIS IS WHERE ATXI PRIMARY ROUTE WILL BE COMING FROM THE EAST @ SECTION 28, COLES COUNTY.

Alt3.JPG - view facing south on 300E. THIS IS WHERE ATXI PRIMARY ROUTE WILL CROSS THE ROAD AT SECTION 28 INTO SECTION 27 AND BEFORE IT HEADS NORTH TO OUR HOME LESS THAN A MILE AWAY.

Alt4.JPG - view facing east @ 300E TOWARDS 350E. THIS IS WERE THE COPELAND FAMILY IS PROPOSING FOR THE ROUTE TO KEEP HEADING EAST THROUGH SECTION 27 TO THE MIDDLE OF SECTION 27, BEFORE HEADING NORTH @ 350E, INSTEAD OF TURNING AND HEADING NORTH ON 300E, AS IN ATXI'S PRIMARY ROUTE PROPOSAL. IT WILL ONLY BE GOING EAST THROUGH OPEN FIELDS INSTEAD OF HEADING NORTH, STRAIGHT TO HOMES WITH FAMILIES WITH CHILDREN.

Alt5.JPG - view facing north on 350E. THIS IS WHERE THE COPELAND FAMILY'S PROPOSED ALTERNATE ROUTE WILL TURN TO HEAD NORTH IN THE MIDDLE OF SECTION 28 ON 350E. THIS WILL END UP IN THE MIDDLE OF SECTION 22 WHERE IT WILL TURN TO HEAD EAST AND CONTINUE ON AS THE REST OF THE PROSED PRIMARY ATXI ROUTE.

AltEnd.JPG - view facing east standing on 350E. THIS VIEW IS SHOWING WHERE OUR HOME IS IN RELATION TO WHERE WE ARE ASKING ATXI TO MOVE THEIR PRIMARY ROUTE. IT IS CLEAR THAT OUR ROUTE IS A GREAT ALTERNATIVE TO THIS SEGMENT OF ATXI'S PRIMARY ROUTE.

Electromagnetic Radiation Health Effects

The EMF health effects listed below are just a sample from the mountain of research that has been reported in scientific literature.

Biological Effects of Electromagnetic Radiation

Here are some of the biological changes caused by electromagnetic radiation, as observed and reported in various studies (most recent first):

Protein Changes in Skin. Ten women volunteered to participate in a study in which radiation (900mH) from GSM cell phones was applied to them for one hour to simulate a phone call. Scientists then screened their skin cells for any stress reactions. They looked at 580 different proteins and found two which were substantially affected. (One was increased by 89% and the other decreased by 32%). New Scientist February 23, 2008

Excited Brain Cells. Researchers from Fatebenefratelli Hospital in IsolaTiberina,found that the electromagnetic field emitted by cell phones can cause some cells in the brain's cortex (adjacent to the side of phone use) to become excited for about an hour, while others become inhibited. Health24 - June 27, 2006

DNA Damage. German research group Verum studied the effect of radiation on human and animal cells. After being exposed to cell phone frequencies the cells showed increased breaks in their DNA. These DNA breaks could not always be repaired by the cells. The damage would therefore be passed on to future cells which could predispose them to becoming cancerous. USA Today December 21, 2004

Brain Cell Damage. A study of the effects of cell phone frequencies (applied at non-thermal intensity) on rat brains showed damage to the neurons (brain cells) in various brain parts, including the cortex, hippocampus and basal ganglia. June 2003 issue of Environmental Health Perspectives

Aggressive Growth in Leukemia Cells Researchers at the National Research Council in Bologna, Italy found that Leukemia cells exposed to cell phone frequencies (900mH) for 48 hours replicated more aggressively. New Scientist October 24, 2002

Increased Blood Pressure. Researchers in Germany found that one-time use of a cell phone for 35 minutes could cause an increase in resting blood pressure of between 5 and 10mm Hg. Lancet June 20, 1998

Harmful Effects of ElectroMagnetic Radiation

Here are some of the pathological (disease producing) effects attributed to electromagnetic radiation and reported in the media (most recent first):

Salivary Gland Cancer. An Israeli study reports that people who used cell phones for 22 hours a month or more were 50 percent more likely to develop parotid gland cancer than those who used cell phones infrequently or never. Health24 February 19, 2008

Brain Tumour. An analysis of several previous studies has concluded that cell phone use over 10 years causes an increased risk of acquiring certain types of brain tumour (2.4 times for acoustic neuroma and 2 times for gliomas). News24 October 3, 2007

Lymphatic Cancer and Bone Marrow Cancer. Researchers from the University of Tasmania and the University of Bristol studied records of 850 patients who had been diagnosed with lymphatic and bone marrow cancers. They concluded that people living within 300 metres of a high voltage power line for extended periods (particularly in childhood) were up to five times more likely to develop these diseases later in life. Internal Medicine Journal September 2007Physorg.com August 24, 2007

Miscarriage. Researchers in California found that EMFs from electrical appliances (such as domestic vacuum cleaners, hairdryers and food mixers) could significantly increase the risk of miscarriage. (Epidemiology January 2002)

Suicide. American researchers found that the rate of suicide among 5000 electricity utility workers who were exposed to extremely low frequency EMFs was double that of a control group of the same size. *The effect was particularly noticeable among young workers.*(Journal of Occupational and Environmental Medicine March 15, 2000)

Asthma. A study in California followed 626 children for 13 years. It found that magnetic fields greater than 0.3 mG (average) during pregnancy increased the child's risk of getting asthma by age 13. A clear dose-response was found. For every 1mG increase in EMF there was a 15% increased rate of asthma in the children. This means, for example, that children of mothers whose average exposure was 2mG during pregnancy were 3.5 times as likely to suffer from asthma during childhood. Archives of Pediatrics & Adolescent Medicine - August 2011.

These are known effects of EMF. What others are currently unknown, unconfirmed or unreported?

For further evidence, see our **EMF Articles** page.

Summary of Electromagnetic Health Effects

Life-threatening Diseases

Alzheimer'sDisease
Brain cancer (adult and child)
Breast cancer (male and female)
Depression (also leading to suicide)
Heart disease
Leukemia (adult and child)
Miscarriage

Other Conditions

Allergies
Asthma
Autism
Blood pressure (raised)
Electro sensitivity
Headaches
Hormone changes
Immune system damage
Nerve damage
Sleep disturbance
Sperm abnormalities

How does EMF Radiation Harm Us?

Some scientists previously believed that the only way that EM radiation could produce damaging effects was if the radiation was sufficiently intense to cause a heating effect on the tissues. (It has been reported that talking on a cell phone for half an hour can raise the temperature of the brain on the affected side).

This theory has now been roundly discredited by many studies in which biological effects have been observed at intensities far too small to cause any measurable heating effect.

The mechanisms by which electromagnetic radiation may affect disease processes are not yet fully understood, but promising candidates include

DNA Damage. Our cells have mechanisms to repair DNA damage to a limited extent, but it appears that EMFs can overwhelm these mechanisms. Damaged DNA is implicated in several disease processes, including various types of cancer.

Interference with Melatonin production. Electromagnetic radiation appears to interfere with the production of melatonin, a hormone that is

normally produced in the body. Low melatonin levels have already been linked to several diseases, including cancers. (Recent research indicates that seratonin production can also be affected by EMFs).

Interference with Cellular Communication. Our body cells communicate internally and externally by means of electrical signals. These signals can be altered by EMF radiation (which generates electrical currents within the body) causing changes in both cellular activity and cellular structures.

How EMF characteristics may affect health

At this stage we don't have all the answers, but clues from various studies indicate that EMF health effects may depend on:

EMF Intensity. Exposure to strong EMFs may cause damage, even though the exposure is of short duration. In one study, researchers asked pregnant volunteers to wear a device which measured the highest intensity (peak) EMF in a 24 hour period. Results indicated that higher peak EMFs correlated with higher rates of damage (miscarriage).

Cumulative EMF Exposure. During a normal day a person will be exposed to EMFs of various frequencies. For example, these could arise from electric shavers and hairdryers, traveling by car, bus or train, domestic appliances such as heaters, ovens and microwaves, neon lights, household wiring, power lines, cell phone carrying and use, to name just a few of the more common sources. The combination of these exposures may overwhelm the body defenses and repair mechanisms.

EMF Exposure Duration. Many studies have indicated that various health effects are only noticed after many years of exposure to electromagnetic pollution, for example high voltage power lines, or cell phones.

EMF Transience. It could be more biologically stressful to be exposed to the fluctuating EMF which arises from an electrical appliance which cycles on and off (for example a photocopier or printer) than from a similar appliance that remains steadily on all day.

EMF Frequency. It is not yet known with certainty which electromagnetic frequencies cause which health effects, but it does appear that different frequencies cause different effects.

Superimposed Signals. An electromagnetic wave can be modulated in various ways to carry a signal, which might be digital or analogue. Where the wave is used for communication (e.g. radio, television, mobile telephony etc) it is normal to have a signal imposed on a carrier frequency. There is

evidence that, in some cases, the signal component can be more harmful than the carrier wave EMF itself.

EMF health danger is real

The danger to our health posed by current levels of man-made electromagnetic fields, is real. This is the consensus of a growing number of responsible scientists and professional healthcare workers.

Fortunately there are many ways to protect ourselves and our loved ones, before our health is affected. See our page **EMF Protection.**

The Dangers of High Tensile Power Lines

X

By Jeffery Keilholtz, eHow Contributor

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-
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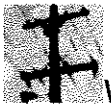
- Print this article

High tensile power lines provide electricity.

A number of dangers exist related to high tensile power lines. The majority of these dangers are related to cancer. Epidemiological studies show that exposure to static electricity and electromagnetic fields emitted by high power lines are putting neighborhoods and farms at risk. Specific dangers of high tensile power lines include adult onset cancer, childhood leukemia and cancer in animals.

Other People Are Reading

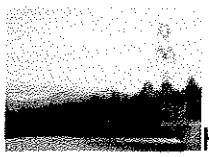
-
High-Tension Power Lines & Cancer
- 
What Are the Dangers of Power Lines by Homes?

1. Adult Onset Cancer

- Many high power lines overhang neighborhoods.

  Adult onset cancer is a critical concern in the medical community. Electromagnetic fields (EMFs) and static electricity are indiscriminate in the transmission of radiation, and adults are affected the same as animals or children. According to RoyalLife.com, epidemiological case studies have found static electricity in particular, "interferes with the nervous system and the bio-chemical life process of the human organism" often resulting in cancer.

2. Childhood Leukemia

-  High tension lines are designed to hang high off the ground.

  Childhood leukemia is an especial danger when it comes to high tensile power lines. Because of their developmental nature, children are more at risk to leukemia than adults. Some studies have even shown an increased risk of brain cancer. "Although the research does not prove cause and effect," states Time.com, it does show "an unmistakable correlation between the degree of exposure and the risk of childhood leukemia."

- Sponsored Links

  - 5 Signs You'll Get Cancer

    These 5 Signs Warn You That Cancer Is Starting Inside Your Body.

    www.newsmax.com

3. Animal Cancer

- Never touch high tensile power lines.

  Studies have found EMFs and static electricity are a dangerous contribution to livestock and other animals. Research has found a correlation between farms placed under high tensile power lines and animal disease. According to a study relayed on Demon.co.uk, "hens started to lay 'scrambled' eggs" on a farm found in close proximity to high tension lines.

4. Data Has Varied Results

- Preschools and child care centers located near power lines can cause a stir.

  Dangers of high tensile power lines strongly point to the causation of cancer although some studies say the evidence remains weak. According to PierceLaw.edu, while eerie correlations between EMFs and cancer are evident, "no plausible biological mechanism" in their scientific research, "is presented that would explain causality." Because of this, difficulties remain in determining what to do about the challenges posed by overexposure to EMFs and static electricity--a danger in itself.

References

- Royal Life: Power Lines, Static Electricty and Diseases
- Time: Danger Overhead
- Pierce Law: Coping With the Risk of Cancer From Power Lines

- Photo Credit powerlines image by JoLin from Fotolia.com High Voltage image by skyf from Fotolia.com powerlines pole image by PavolKmeto from Fotolia.com high tension image by paulocruz from Fotolia.com child image by Byron Moore from Fotolia.com

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- What Are the Dangers of Power Lines by Homes?
- What Are the Dangers of Living Near Power Lines?

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REVIEWS ON ENVIRONMENTAL HEALTH VOLUME 23, NO. 2,

Setting Prudent Public Health Policy for Electromagnetic Field Exposures

David O. Carpenter[1] and Cindy Sage[2]

[1] *Institute for Health and the Environment, University at Albany, Rensselaer, New York 12144;* [2] *Sage Associates Santa Barbara, California; USA*

Abstract: Electromagnetic fields (EMF) permeate our environment, coming both from such natural sources as the sun and from manmade sources like electricity, communication technologies and medical devices. Although life on earth would not be possible without sunlight, increasing evidence indicates that exposures to the magnetic fields associated with electricity and to communication frequencies associated with radio, television, WiFi technology, and mobile cellular phones pose significant hazards to human health. The evidence is strongest for leukemia from electricity-frequency fields and for brain tumors from communication-frequency fields, yet evidence is emerging for an association with other diseases as well, including neurodegenerative diseases. Some uncertainty remains as to the mechanism(s) responsible for these biological effects, and as to which components of the fields are of greatest importance. Nevertheless, regardless of whether the associations are causal, the strengths of the associations are sufficiently strong that in the opinion of the authors, taking action to reduce exposures is imperative, especially for the fetus and children. Inaction is not compatible with the Precautionary Principle, as enunciated by the Rio Declaration. Because of ubiquitous exposure, the rapidly expanding development of new EMF technologies and the long latency for the development of such serious diseases as brain cancers, the failure to take immediate action risks epidemics of potentially fatal diseases in the future.

Keywords: leukemia, brain cancer, electricity, radiofrequency, cell phones, neurodegenerative diseases

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Only a small number of children are affected
The risk is low
The evidence that adult diseases are secondary to 50/60 Hz EMF exposure is insufficient
There is little evidence that low-intensity RF fields pose human health hazards
There is no animal evidence
We do not know the mechanism
THE LEVELS OF PROOF AND STANDARDS OF EVIDENCE FOR DECISION-MAKING DIFFER AMONG PROFESSIONS
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INTRODUCTION AND BACKGROUND

Few issues have been as uncertain and divisive for so long a period as the question of whether exposure to electromagnetic fields (EMF) poses significant health hazards. The question of hazards from power line frequency EMF (50 Hz in much of the world, but 60 Hz in the United States (US), was first raised by the report of Wertheimer and Leeper /1/, who found elevated rates of childhood cancer in homes in Denver, Colorado that had elevated magnetic fields from neighborhood power lines. This initial report, greeted with significant skepticism, has been more-or-less replicated in most /2-4/ but not all /5-6/ succeeding studies. As everyone in the developed world is constantly exposed to electricity-derived EMFs, the question of whether such exposures constitute a significant health hazard is of critical public health relevance.

The concerns, however, go way beyond just those exposures from power line-frequency EMFs. Figure 1 shows the electromagnetic spectrum, which goes from DC fields such as the magnetic field of the earth and the extremely low frequency (ELF) fields characteristic of electric power, to the very high frequency cosmic, gamma and X-ray EMFs, which have sufficient energy to break chemical bonds and are therefore are "ionizing" radiation. What is in between includes ultraviolet radiation, known to have significant adverse health effects /7/, visible light, which is essential for life, and the wide range of communication frequencies that are usually referred to as 'microwaves' or 'radiofrequency' (RF) fields.

Fig. 1: The electromagnetic spectrum, showing the relation s between ELF and RF fields, wavelength and frequency, and the ionizing and non-ionizing portions of the spectrum. PRUDENT PUBLIC HEALTH POLICY FOR EMF EXPOSURES 93

Public exposure to RF fields is increasing at a rapid rate. AM and FM radio and television stations broadcast signals that can be received almost everywhere in most countries. Most members of society now have and use cordless phones, cellular phones, and pagers. In addition, most populations are also exposed to antennas in communities designed to transmit wireless RF signals. Some developing countries have even given up running land lines because of the expense and their vulnerability, and because of easy access to cell phones. Long-term and cumulative exposure to such massively increased RF has no precedent in human history. Furthermore, the most pronounced change is for children, many of whom now routinely spend hours each day on the cell phone chatting or sending or receiving text messages. Everyone is exposed to a greater or lesser extent. No one can avoid exposure because even if living on a mountain-top without electricity, exposure to communication-frequency RF is likely. Vulnerable populations (pregnant women, very young children, elderly persons, the poor) are exposed to the same degree as the general population.

The energy within the EMF spectrum increases with the frequency; therefore, on the reasonable assumption that the relative health hazards are proportional to the energy, one would expect comparable RF exposures to be more hazardous than power-line frequency exposures. Although very little scientific investigation has been carried out on the health effects of RF fields until quite recently, the rapid profusion of WiFi (trade name for a high-frequency wireless local area network technology used in home networks, mobile phones, video games, and more), cell-phone towers, and cell-phone use in all segments of the population, including young children, makes it essential that risks to health be considered as technology advances.

This review was triggered by several reports /8-12/ and actions by governments and courts /13/ that, in the opinion of the authors, unjustifiably imply and/or conclude that EMF exposure does not pose a significant health hazard to humans. These reviews and reports are important because they become the basis for regulatory standards. Each of these reports, however, presents evidence for the existence of human health hazards associated with EMFs, as well as discussions of the limitations in the overall understanding of the basis for such effects. The conservatism of their conclusions, in our view, fails to meet the standards of the European Commission Constitution Principle on Health (Section 3.1) /14/, European Union Treaties Article 174 /15/, the European Environmental Agency /16/, and other international statements on the "precautionary principle" as enunciated by the Rio Declaration of the United Nations /17/. The working definition used in the European Environ-mental Agency and that has been developed during the debates that followed the 2001 report, is explicit about specifying both uncertainty and ignorance as contexts for applying the principle, and in acknowledging that a case-specific sufficiency of scientific evidence is required to justify public policy action:

> *"The Precautionary Principle provides justification for public policy actions in situations of scientific complexity, uncertainty and ignorance, where there may be a need to act in order to avoid, or reduce, potentially serious or irreversible threats to health or the environment, using an appropriate level of scientific evidence, and taking into account the likely pros and cons of action and inaction" /16/.*

We find that current standards in most countries are not protective of human health, and provide our reasoning for this important conclusion along with recommendation for standards that we feel to be appropriate based on current scientific evidence plus a consideration of the need for precaution. The issues surrounding EMF exposure are particularly important because of the exposure encountered by everyone to a greater or lesser extent. More D.O. CARPENTER AND C. SAGE 94

difficult is determining the degree of risk when no population is unexposed. Furthermore, the sources of EMF in the environment are such that exposure for any one person varies greatly throughout the day, depending upon where they are at any particular time. Exposure occurs at home from power lines in the street, household wiring, appliances, and wireless devices. Exposure will vary depending upon where one is in the house and what appliances or devices one is using or near. Exposures occur when walking down the street, while going to school or work, and during recreational activities. Each exposure is different in both frequency and intensity. Therefore, deter-mining cumulative exposure over any significant period is exceptionally difficult. For all of these reasons it is likely that most studies, operating within these major limitations, have led to an underestimation of the true risk to human health. Therefore, considering ways in which to evaluate risk and reduce exposure is imperative. Good public health policy requires preventative action proportionate to the potential risk of harm and the public health consequence of taking no action.

KEY FALLACIES AND ANSWERS IN THE DEBATE OVER EMF EVIDENCE

Several arguments (false, in our view) have been presented by those who minimize the strength of the relation between exposure to both 50-60Hz ELF and RF EMFs. These arguments are as follows:

"Evidence for elevated risk of childhood leukemia from exposure to power line frequency EMF is weak and inconsistent"

The evidence reporting a relation between EMF exposure and childhood leukemia is neither weak nor inconsistent. The NRC (1997) report /8/ states,

> *"The link between wire-code rating and childhood leukemia is statistically significant (unlikely to have arisen from chance) and is robust in the sense that eliminating any single study from the groups does to alter the conclusion that the associations exists."*

In his introduction to the NIEHS EMF-RAPID program (1999) report /10/, Dr. Kenneth Olden, Director of the National Institute of Environmental Health Sciences, characterizes the state-of-the-art by the statement,

> *"The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults. While the support from individual studies is weak, the epidemiological studies demonstrate, for some methods of measuring exposure, a fairly consistent pattern of a small, increased risk with increasing exposure that is somewhat weaker for chronic lymphocytic leukemia than for childhood leukemia."*

Both reports then go on to minimize the observed relations based on the absence of knowledge about mechanisms explaining such relations. This is more directly stated in the 2007 WHO report /12/,

> *"Resolving the conflict between epidemiological data (which show an association between ELF magnetic field exposure and an increased risk of childhood leukemia) and experimental and mechanistic data (which do not support this association) is the highest research priority in this field."*

Leaving aside the issue of mechanisms, which will be discussed later, it becomes apparent that all three reports have accepted the demonstration of a statistically significant relation between exposure to elevated magnetic power line fields and child-

hood leukemia. This conclusion is supported by at least three meta-analyses of the relation between childhood leukemia and EMFs. Wartenberg /18/ reported on 16 epidemiologic studies, considering reports using the Wertheimer and Leeper /1/ wire codes as well as measured fields, and concluded that "*the observed results identify a consistent risk that cannot be explained by random variations*" Two more recent meta-analyses have been published. Greenland et al. /19/ reported a signifi-cantly elevated risk of 1.68 [95% Confidence Interval (CI) = 1.23-2.31] based on pooled results from 12 studies, using a time-weighted average of exposure greater than 3 mG (0.3 μT). Ahlbom et al. /20/ reported on nine studies, and found a elevated risk of 2.0 (95% CI = 1.27-3.13) for exposures equal or greater than 4 mG (0.4 μT) as compared with less than 1 mG (0.1 μT).

These reports are important in that they show consistency of a clearly elevated risk of leukemia in children having EMF exposure from power-line fields in homes. These meta-analyses lead to the conclusion reflected in the WHO report that an association exists between childhood leukemia and exposure to elevated magnetic fields in homes.

In addition, several recent studies add to the conclusion that the exposure-leukemia relation is strong. Draper et al /6/ studied rates of leukemia in children in relation to proximity of their home to high-voltage power lines. The investigators found a dose-dependent relation, with relative risk being 1.69 (95% CI = 1.13-2.53) when comparing rates in children living within 200 m to those living > 600 m from the line, and the relative risk being 1.23 (95% CI = 1.02-1.49) for children living 200-600 m as compared with > 600 m. A significant ($P < .01$) trend was found in relation to closeness to the power line. In children with Down's Syndrome, Mejia-Arangure et al. /21/ found an OR of 3.7 (95% CI = 1.05-13.1) between spot meas-urements of magnetic fields greater than or equal to 6 mG (0.6 μT) and leukemia. Foliart et al. /22/ examined the relation between magnetic field exposure and the survival of children with acute lymphoblastic leukemia in the US and found a hazard ratio of 4.5 (95% CI = 1.5-13.8) for child-ren exposed to greater than 3 mG (0.3 μT) as compared with those having exposure to less than 1 mG (0.1 μT). Svendsen et al. /23/ performed a similar study of German children with leukemia, and reported a hazard ratio of 2.6 (95% CI = 1.3-5.2) for the survival of children with acute lymphoblastic leukemia (ALL) exposed to 2 mG (0.2 μT) during recovery as compared with those exposed to less than 1 mG (0.1 μT).

Lowenthal et al. /24/ looked at adult lympho-proliferative and myeloproliferative diseases in relation to childhood residence within 300 m of a high-voltage power line during the first 15 years of life and found an OR of 3.23 (95% CI = 1.26-8.29). For those who lived within 300 m of a power line in the first 5 years of life, the increased risk was 4.74 (95% CI = 0.98-22.9), providing support for the hypothesis that younger children are more at risk, and that the resultant disease may occur many years later during adulthood. Infante-Rivard and Deadman /25/ showed that maternal exposure during pregnancy increased the risk of children 0-9 years of age developing leukemia (OR = 2.5, 95% CI = 1.2-3.0, for children of mothers in the highest 10% of exposure).

The observations of Lowenthal et al. /24/ and Infante-Rivard and Deadman /25/ are very important in that they demonstrate clearly that the fetus and young children are at greater risk than are adults, and that early life exposure may result in cancer many years later. This finding is consistent with a large body of information showing that the fetus and young child are more vulnerable than older persons are to chemicals /26/ and ionizing radiation /27/. This susceptibility may be why the evidence for the relation between magnetic field exposure and leukemia in children is stronger than that for adults. These considerations have led the US Environmental Protection Agency to propose a 10-fold risk adjustment for the first 2 years of life, and a 3-fold adjustment for years 3 to 5 /27/. Even these adjustments do not deal with fetal risk, which D.O.

is likely to be significantly greater because during this period of life, rapid organ development occurs.

In conclusion, the evidence for a relation between childhood exposures to magnetic fields, whether determined from residential wire codes or measured magnetic fields, and elevated rates of leukemia is consistent. Although the reported odds ratios are not particularly high, the limitations in the exposure assessment (consideration of only residential exposure from external power lines) are such that one would expect considerable under-estimations of the actual risk.

"Only a small number of children are affected"

This argument is not correct because we do not know precisely how many children are affected with leukemia resulting from of EMF exposure. In 1988, Carpenter and Ahlbom /28/ attempted to answer this question based on the results of the New York State Powerlines Project and the results of the study of Savitz et al. /2/, concluding that if the magnetic fields homes in the US were similar to those in Denver, Colorado (where both the Wertheimer and Leeper /1/ and Savitz et al. /2/ studies were done), fully 10% to 15% of US child-hood leukemia (about 1,000 cases) could be associated with residential magnetic field exposure from external power lines. The researchers then suggested that exposure to magnetic fields from non-residential sources (particularly appliances) must be at least equal in magnitude and that if so, then these two sources of exposure would account for 20% to 30% of all childhood leukemias. Other estimates are even higher /29/.

In the meta-analyses mentioned above, however, Greenland et al. /19/ calculated the attributable fraction of cases of childhood leukemia from residential magnetic field exposure in the US to be 3%. Kheifets et al. /30/ attempted to calculate the attributable fraction of worldwide childhood leukemia due to EMFs based on the meta-analyses of Ahlbom et al. /20/ and Greenland et al. /19/. The authors concluded that the attributable fraction of leukemia was between < 1% to 4%. The recent WHO Environmental Health Criteria ELF Mono-graph #238 /12/ states,

> *"(A)ssuming that the association is causal, the number of cases of childhood leukaemia worldwide that might be attributable to exposure can be estimated to range from 100 to 2,400 cases per year. However this represents 0.2 to 4.9% of the total annual incidence of leukaemia cases, estimated to be 49,000 worldwide in 2000. Thus, in a global context, the impact on public health, if any, would be limited and uncertain."*

We strongly disagree with the overall conclusion that these calculations indicate that the fraction of childhood leukemia attributable to EMFs is so small that it lacks serious public health implications. There are several reasons why the WHO ELF Environmental Health Criteria Mono-graph /12/ conclusions (as well as those of the earlier reports) are not justified. These studies all considered either only measured magnetic fields in homes or wire codes from power lines, ignoring exposure from appliances, wireless devices, and all exposures outside of the home. Thus, these metrics do not come close to accounting for any individual's cumulative exposure to EMFs. If residential magnetic fields cause cancer, then those from other sources will add to the risk, but only the Carpenter and Ahlbom /28/ analysis considered this factor. The failure to measure total EMF exposure would tend to obscure the relation and lead to significant underestimations of the true relation between exposure and disease.

A few reports have looked at childhood cancer specifically and solely in relation to appliance use. Savitz et al. /31/ reported weak associations between childhood leukemia and the use of both prenatal and postnatal electric blankets. Hatch et al. /32/ found statistically significant elevations in ALL in children whose mothers reported using an electric blanket or mattress pad during pregnancy

(OR = 1.59, 95% CI = 1.11-2.29). Children's use of electric blankets or mattress pads also showed a significant elevation in risk of ALL (OR = 2.75, 95% CI = 1.52-4.98). These reports clearly support the proposition that appliance use must be incorporated into the measurements of total exposure. None of the studies done to date has dealt with exposures at day care centers or schools, or at other places outside of the home where children spend time. Yet all such places are important in the consideration of cumulative exposure and risk.

Although the evidence for a relation between exposure and childhood leukemia may be considered to be definitive at exposure levels of 3 or 4 mG or higher; evidence from some (but not all) of the other studies indicates an elevated risk at levels not greater than 2 mG /2,33/. No evidence has been reported that exposures at lower levels are 'safe', as persons with such exposures usually serve as the 'control' group. Therefore, this WHO statement fails to acknowledge the true magnitude of the problem, even when considering only childhood leukemia. The global attributable risk of childhood leukemia resulting from exposure to EMFs must be significantly greater than that calculated from consideration of only residential 50/60 Hz magnetic fields in studies having no unexposed control.

"The risk is low"

This argument is incorrect because at present, determining the magnitude of the risk is not possible. Clearly as far as EMFs are concerned, no unexposed population exists. Therefore, one can only compare groups having different levels of exposure. We can perhaps say with confidence that the elevated risk of leukemia from residential exposure of children to magnetic fields is 'low' (meaning ORs in the range of 2-4), but this does not consider the child's exposure to appliances, exposure in automobiles and at daycare or school, exposures in playgrounds, and at all the other places that a child spends time. Even if the risk to one individual is low, the societal impact when everyone is exposed may be very significant.

In addition, the exposure assessment is grossly inadequate, even in the best of studies. Most reports deal only with either characterization of the fields within residences or with job titles in occupational settings. Some studies attempt to quantify other sources of exposure, such as the frequency of cell-phone usage or the use of other appliances, but these studies almost always do not consider residential exposure from power lines or living, working, or going to school in a WiFi building. In no investigation has it been possible to follow the exposures of a large number of people over a number of years with an accurate monitoring of total exposure to EMFs. Such a task would of course be almost impossible to do for the very good reason that as a person moves through his or her environment, the exposures vary from place to place and from moment to moment. To truly and objectively determine the risk of exposure to EMFs, however, considering residential, occu-pational (or school) and recreational exposures to the full range of the electromagnetic spectrum, including appliances and wireless devices is essential. This coverage has not been accomplished in any study, and without such information, determining the overall magnitude of the risk is not possible. What is possible, indeed likely, is that upon consideration of both childhood and adult diseases that the risk is not low.

"Evidence that adult to 50/60 Hz EMF exposure is insufficient"

The level of evidence definitively proving an association between exposure to EMFs and adult cancer is less strong than the relation with childhood leukemia. Multiple studies, however, show statistically significant relations between occupational exposure and leukemia in adults despite major limitations in exposure assessment. Significant elevations in the rates of leukemia

following occupational exposure to elevated EMF have been reported in review articles /34/ and in a meta-analysis /35/. Kheifets et al. /35/ report an OR of 1.18 (95% CI = 1.12-1.124) for all leukemias based on data from 38 studies, with significant elevations for both acute myelogenous (AML) and chronic lymphocytic (CLL), but with non-significant elevations in acute lymphocytic (ALL) and chronic myelogenous (CML) leukemia. Although the reported ORs are somewhat lower than those in most childhood studies, this difference may be not remarkable given the greater variety of settings in which most adults spend time with all of accompanying difficulties in evaluating total exposures. Most important, the strongest evidence for a cancer is that the same cancer (leukemia) is significantly elevated in children. Yet, considering only occupational exposure without attention to residential and recreational exposures is certain to lead to inadequate exposure assessment.

Some recent studies report similar elevations, whereas others do not. Savitz and Loomis /36/ did not find any elevation in risk of leukemia in a study of 138,905 electric utility workers. Minder and Pfluger /37/ report elevated leukemia mortality among Swiss railway employees exposed to magnetic fields (OR = 2.4, 95% CI = 1.0-6.1), whereas Harrington et al. /38/ reported no elevated rates of leukemia among UK electricity generation and transmission workers when compared with the rest of the UK population. The failure to find a relation could of course reflect the healthy-worker effect. In a 1997 review, Miller et al. /39/ reported that of 124 studies reporting odds ratios for leukemia in relation to occupations associated with electricity, 41 showed a significant elevation, and 4 showed a dose-response relation. The studies concluded that there is a reasonable relation with occupational exposure, but that occupational EMF exposure alone cannot account for the majority of leukemia cases among working men.

Feychting et al. /40/ conducted an investigation of adult leukemia in relation to exposure to magnetic fields with consideration of combined residential and occupational exposures. The investigators found no relation between residential exposure alone with either total leukemias or any of three specific types of leukemia, and only a non-significant elevation of risk of leukemia with occupational exposure alone. Nevertheless, when both residential and occupational exposures were considered, the authors reported a significant elevation of risk of all leukemias with an OR = 3.7 (95% CI = 1.5-9.4), and significant elevations in both AML and CML, but a non-significant elevation in CLL. This study convincingly demon-strates the importance of considering exposures in multiple settings, especially both residential and occupational.

In adults, some evidence has been found for a relation between magnetic field exposure and other kinds of cancer, which is strongest for brain cancer. Kheifets et al. /41/ performed a meta-analysis of 29 reports of brain cancer and EMFs and found an OR = 1.21 (95% CI = 1.11-1.33) for all electrical workers. The authors found signifi-cant elevations for electrical engineers, welders, and power station workers. Rodvall et al. /42/ investigated glioma and meningioma in central Sweden in relation to job title, and reported only non-significant elevations of both neoplasms in relation to measured magnetic fields. Villeneuve et al. /43/ also reported only non-significant elevations in rates of all brain cancers in relation to residential exposure to magnetic fields, but found a highly significant relation among men diagnosed with glioblastoma multiforme (OR = 5.36, 95% CI = 1.16-24.78).

The evidence for a relation between EMF exposure and breast cancer is relatively strong in men /44/, and some /45-46/ but by no means all /47-49/ studies show female breast cancer also to be significantly elevated with increased exposure. Peplonska et al. /50/ recently found increased risk of breast cancer in women occupationally exposed to elevated magnetic fields. Less evidence has been published on other cancers, but Charles et al. /51/ PRUDENT PUBLIC HEALTH POLICY FOR EMF EXPOSURES 99

reported that workers in the highest 10% category for EMF exposure were twice as likely to die of prostate cancer as those exposed at lower levels (OR = 2.02, 95% CI = 1.34-3.04). Villeneuve et al. /52/ report statistically significant elevations of non-Hodgkin's lymphoma in electric utility workers in relation to EMF exposure, whereas Tynes et al. /53/ report elevated rates of malignant melanoma in persons living near to high voltage power lines. Although these observations need replication, they suggest a possible relation between exposure and cancer beyond leukemia and brain cancer in adults.

The evidence for an association between ELF-EMF exposure and the neurodegenerative diseases Alzheimer's and amyotrophic lateral sclerosis (ALS) is strong. For Alzheimer's disease, Qio et al. /54/ found ORs of 2.3 (95% CI = 1.0-5.1), Feychting et al. /55/ reported ORs of 2.3 (95% CI = 1.6-3.3), and Hakansson et al. /56/ found ORs of 4.0 (95% CI = 1.4-11.7). For ALS, Savitz et al. /57/ reported ORs of 3.1 (95% CI = 1.0-9.8) and Hakansson et al. /56/ found an OR of 2.2 (95% CI = 1.0-4.7). Roosli et al. /58/ looked at neuro-degenerative diseases among Swiss railway employees and reported an elevated risk for train drivers as compared with a risk of 3.15 (95% CI = 0.90-11.04) for Alzheimer's disease in station masters. For every 10 μT years of cumulative exposure the authors found Alzheimer's disease risk to increase by 9.4% (95% CI = 2.7-16.4). No elevated risk was found for Parkinson's disease or multiple sclerosis. Garcia et al. /59/ reported a meta-analysis of EMF exposure and Alzheimer's disease. From 14 different studies they found an OR of 2.03 (95% CI = 1.38-3.00 for case-control studies, and 1.62 (95% CI = 1.16-2.80) for cohort studies. These reports show a consistent pattern of elevated risk that cannot be ignored.

In total, the scientific evidence for adult disease, especially leukemia, brain cancer, Alzheimer's disease and ALS, associated with ELF-EMF exposure is sufficiently strong that preventive steps are not only appropriate but also called for. This conclusion is despite all the difficulties with exposure assessment. Although many possible sources of false-positive results can be found in epidemiologic studies, even more possible reasons exist for false-negative results, depending on the sample size, exposure assessment, and a variety of other confounders. Discounting the positive studies just because not every investigation shows a positive result is inappropriate. Although further research is needed with better exposure assessment and control of confounders, the evidence for a relation between ELF-EMF exposure and adult cancers/neurodegenerative diseases is sufficiently strong at present to merit preventive actions to reduce EMF exposure.

"There is little evidence that low-intensity RF fields pose human health hazards"

The thermal effects of radiofrequency radiation, including microwaves, have been studied for many years (see review by Elder /60/), and are well known to cause serious harm if exposures result in tissue heating. The important question, however, is whether adverse health effects occur at RF intensities that do not cause heating. Present international standards for exposure to RF fields are based on limited information and the questionable assumption that there are no non-thermal hazardous effects of RF radiation. That non-thermal effects occur in biological systems is clear, but the degree to which these constitute a hazard is less clear /61/.

Current thermally based RF standards are designed only to protect against acute (not chronic) exposures and protect only against thermal damage based on a six-foot man model. Because size and shape are important determinants of RF exposure, the existing public safety standards are deficient in providing protection to children and smaller adults.

The literature for health hazards from RF fields is not as extensive as that for power lines frequencies. Yet, a large body of evidence reports elevations in cancer in relation to exposure. D.O. CARPENTER AND C. SAGE 100

Szmigielski /62/ investigated cancer morbidity in Polish military personnel and found that persons occupationally exposed to RF/microwave radiation had a greater than two-fold risk of any cancer than unexposed personnel. The relations were strongest for hematopoetic cancers, which were elevated between 5.8 and 13.9 fold. Grayson /63/ reported a significant 1.39-fold elevation (95% CI = 1.01-1.90) in brain tumors in US Air Force personnel exposed to RF radiation.

Several studies have reported elevated risk of leukemia resulting from exposure to RF fields from AM and FM radio communication frequencies. Dolk et al. /64/ reported a 1.3-fold elevation in leukemia among individuals living near an FM radio transmitter in England. Michelozzi et al. /65/ found a significant dose-dependent elevation in adult and childhood leukemia among residents living near to a high-powered radio station in Rome. Park et al. /66/ investigated cancer rates in Korea in individuals living near AM radio broadcasting towers, and found significant elevations in leukemia, especially in the young (standardized mortality ratio (MMR) = 2.29, 95% CI 1.05-5.98 for 0-14 years and MMR = 2.44, 95% CI = 1.07-5.24 for 15-29 years).

Ha et al. /67/ reported on an expanded cohort of 1,928 Korean children with leukemia, 956 children with brain cancer, and 3,082 age-matched controls with respiratory illnesses. The investigators found a significant elevation in risk of leukemia for children residing within 2 km of the nearest AM radio transmitter as compared with those residing more than 20 km away (OR = 2.15, 95% CI = 1.00-4.67), but no significant relation with brain cancer. This study is consistent with the hypothesis that radiofrequency EMFs increase risks of the same diseases reported for 50/60 Hz EMFs. Because radiofrequency EMFs have higher energy than do power line frequencies, one might expect that radiofrequency EMFs would be even more likely to cause disease.

Evidence is rapidly mounting that brain tumor risk is elevated with long-term cell-phone use.Hardell et al. /68/ first reported that on multivariate analysis, the OR for ipsilateral temporal, occipital, or temporoparietal lobe brain tumors was 2.62 (95% CI = 1.02-6.71), whereas no elevation in risk was found for the contralateral brain (OR = 0.97, 95% CI = 0.36-2.59). Later, Hardell et al. /69/ found that individuals using analog cell phones had a greater than eightfold increased risk of developing brain tumors, and with cordless phone usage, the increased risk was more than fourfold. Additionally, Lonn et al. /70/ found an increased risk of acoustic neuroma (a form of brain cancer) among persons in Sweden who had been using a cell phone for 10 years or more.

Results are beginning to appear from the European INTERPHONE study, and although not complete as yet, both the German /71-72/ and the French /73/ preliminary reports present at least a suggestion of an elevation in rates of some forms of brain cancer and acoustic tumors among indi-viduals who are the heaviest and longest duration users of cell phones. Schoemaker et al. /74/ reported on mobile phone use in a case-control study in five North European countries, and found that risk of acoustic neuroma on the same side of the head as reported phone use was raised for use for 10 years or longer (OR = 1.8, 95% CI = 1.1-3.1). Lahkola et al. /75/ reported on a similar study but focused on glioma. The authors report an OR of 1.39 (95% CI = 1.01-1.92, p for trend 0.04) for mobile phone use on the same side of the head, but no significant elevation in the contralateral hemisphere. In neither the Schoemaker /74/ nor the Lahkola /75/ studies was there a significant increase in overall risk of acoustic neuroma or glioma based simply on the use of a mobile phone. An Israeli component of the INTERPHONE study has reported a significant and dose-dependent elevation in the development of parotid gland tumors on the ipsilateral side (OR 1.58, 95% CI = 1.11-2.24), but no relation with contralateral tumors /76/. Other large studies, however, have not detected any relation between either brain cancer /77-78/ or acoustic neuroma and mobile phone use PRUDENT PUBLIC HEALTH POLICY FOR EMF EXPOSURES 101

/77/. Some researchers who did not find a relation have noted that cell-phone usage is sufficiently recent such that concluding that long-term exposure is without hazard is not possible (cf. /77/).

Kundi et al. /79/ summarized the results of nine different human epidemiologic studies made in another recent review by ICNIPT et al. /80/, which points out that not all human studies are consistent, and that so many deficiencies are present in the studies conducted to date that one cannot rule out an association between exposure and cancer.

Recently a meta-analysis was published that focused on cell phone use and cancer. Hardell et al. /81/ examined 2 cohort and 16 case-control studies. Nine of the case-control studies were of cases with a latency period of greater than 10 years, but most of these included few cases. The risk of glioma was estimated to be 1.2 (95% CI = 0.8-1.9), and increased to 2.1 (95% CI = 1.2-3.4) for ipsilateral use. Acoustic neuroma risk was estimated to be 1.3 (95% CI = 0.6-2.8), increasing to 2.4 (95% CI = 1.1-5.3) for ipsilateral use. The enormous and very recent increase in the use of cell phones by children is particularly worrisome. Inadequate information is available at present concerning the long-term consequences of cell phone use, especially by children, but the reports cited above suggest that the risk of brain tumors and acoustic neurons is significant. Should further study confirm these relations, we may be facing an epidemic of disease resulting from cell-phone usage. Because the latency for developing such diseases is long, this situation is of particular concern, especially for children.

A number of human studies of biological effects other than cancer associated with RF fields have been reported, as well as a number of studies not finding such effects. Huber et al. /82/ showed that human exposure to digital radiotelephone handsets affects brain physiology in young healthy male subjects, modifying their electroencephalo-gram during subsequent sleep. Koivisto et al. /83/ reported that exposure to 902 MHz fields actuallyaccelerates simple reaction times in human participants. A number of other biological effects that are not believed to be secondary to thermal changes have been reported. Such effects include increase spontaneous abortion, shifts in red and white blood cell counts, increased mutations in lymphocytes (see /84/), and changes in brainwave activity /85-86/. Seitz et al. /87/ reviewed studies of electromagnetic hypersensitivity and subjective health complaints associated with EMF exposure and concluded that such effects are not proven, but that at present, long-term effects of impaired well-being also cannot be excluded. Three recent reports suggest a relation between cell-phone use and reduced male fertility /88-90/. Further studies are needed to determine whether significant effects of RF fields affect both nervous system function and fertility, but with careful exposure assessment and adequate concern for confounders.

Divan et al. /91/ reported that prenatal and postnatal exposure of children to cell-phone frequencies was associated with a significant increase in behavioral problems of emotion and hyperactivity around the age of school entry (OR = 1.80, 95% CI = 1.45-2.23). Although the results need replication, they point to an elevated susceptibility of the fetus and young children and suggest a variety of adverse effects of cell-phone frequencies beyond just cancer.

Although these studies do not provide the same level of proof found in the studies of power line frequencies, they most certainly **do not** allow one to conclude that RF exposures are safe.

"There is no animal evidence"

It is correct to say that no adequate animal model system is available that reproducibly demonstrates the development of cancer in response to exposure to EMFs at the various frequencies of concern. McCann et al. /92/ reviewed the animal studies, and whereas the authors found most studies to be negative, several

showed suggestive positive results. The investiga-tors also clearly identified issues that must be improved in further animal carcinogenesis research. Kheifets et al. /93/, however, in a policy review noted that,

> *"... even consistent negative toxicological data cannot completely overcome consistent epi-demiological studies. First, a good animal model for childhood leukemia has been lacking. Second, particularly for ELF, the complex exposures that humans encounter on a daily basis and a lack of understanding of the biologically relevant exposure calls into question the relevance of exposures applied in toxicology. Another limitation of toxicologic studies is that animals cannot be exposed to fields that are orders of magnitude more powerful than those encountered by humans, decreasing their power to detect small risks."*

Further, they conclude that,

> *"(A)lthough the body of evidence is always considered as a whole, based on the weight of evidence approach and incorporating different lines of scientific enquiry, epidemi-ologic evidence, as most relevant, is given the greatest weight."*

More striking is the report from Denver, Colorado, using the wire-code characterization originally developed by Wertheimer and Leeper /1/ showing that pet dogs living in homes that are characterized as having high or very high wire codes, as compared with those with low or very low wire codes or buried power lines, showed a OR of 1.8 (95% CI = 0.9-3.4) for developing lymphoma after adjustment for potential con-founders, whereas dogs that lived in homes with very high wire codes had an OR of 6.8 (95% CI = 1.6-28.5) /94/. This study is impressive because the exposure of the dogs reflects the environment in which exposure has been associated with elevated risk of human cancer in two independent investi-gations /1,2/.

One positive animal study is that by Rapacholi et al. /95/, who demonstrated that lymphoma-prone transgenic mice developed significantly more lymphomas after exposure to 900 MHz fields (lymphoma being the animal equivalent of human leukemia) than did unexposed animals. Utteridege et al. /96/, however, were not able to replicate this observation, although their exposures were not identical.

Salford et al. /97/ reported that low power RF fields, below that which caused thermal effects, increase the leakage of protein from the blood-brain barrier, and they later found that this resulted in direct damage to nerve cells from microwaves from a GSM mobile phone /98/. Tattersall et al. /99/ found that RF field applications below the level that causes heating resulted in changes in the electrical activity of brain slices, suggesting that such fields can alter nervous system function. Wang and Lai /100/ reported altered performance of rats in learning tasks exposed to 2450-MHz microwaves.

Curiously, in many legal situations the courts are reluctant to accept evidence that a chemical substance causes cancer in animals without corresponding evidence in humans. In the case of EMFs, we have strong evidence that magnetic fields cause cancer in humans, but much less evidence from animal models. The US Supreme Court /101/, in the case of Daubert vs. Merrell Dow Pharmaceuticals, effectively ruled that animal studies were not relevant to human health, and that the only admissible evidence must be from human epidemiologic studies! Although this is certainly not a justifiable conclusion, the situation with regard to EMF health effects is that we have strong evidence for human cancer from epidemiologic studies but do not have good evidence for cancer in experimental animals. Yet, humans are what we should be concerned about, not laboratory rats! PRUDENT PUBLIC HEALTH POLICY FOR EMF EXPOSURES 103

"We do not know a mechanism"

We do not know the mechanism of cancer in general, although we do know a lot about cancer. It came as a major surprise to most scientists when Lichtenstein et al. /102/ reported that genetic factors play a minor role in causing most types of cancer because it had been commonly assumed that genetics was the major cause. Yet, Lichten-stein et al. concluded from their study of identical twins that environmental factors were the initiating event in the majority of cancers. This finding does not of course mean that genetic susceptibility to environmental contaminants is unimportant, but rather that genetic factors alone do not result in cancer in most cases. We know the mechanisms of action for certain carcinogenic substances, but for most cancers, we know neither the environmental trigger nor the mechanism of action. Thus, there is no reason to negate the evidence that EMFs cause cancer just because we do not know a single mechanism to explain it's mode of action. Whether magnetic fields actually cause childhood leukemia, or whether some other component in the electromagnetic environment is responsible for the association, is a subject of debate within the scientific community, but from a public health point of view, this controversy does not matter.

We do not know the mechanism or cause for the development of Alzheimer's disease or ALS. We do know that both are more common in individuals in certain occupations and that exposure to certain metals is associated with increased risk /103-104/. In the case of Alzheimer's disease, abnormalities of amyloidβ and the tau protein have been found /105/, but the understanding of why or how they form is very limited. Neither the association with metals nor the presence of abnormal proteins constitutes a mechanism for the cause of these diseases. So, rather than discounting the relation between EMF exposure and neurodegenerative diseases, we should be using this information as a tool to better understand the etiology of these diseases.

Clear evidence has emerged from animal and cell culture studies that ELF and RFR have biological effects. Furthermore, such effects occur at intensities commonly experienced by humans. We know a number of ways in which EMFs alter cell physiology and function. Electromagnetic fields affect gene transcription /106-110/, induce the synthesis of stress proteins /111/, and cause breakage of DNA /112/, probably through the generation of reactive oxygen species /113-114/. Changes in the blood-brain-barrier and in calcium metabolism have been demonstrated for various RF frequencies (see review by Lai /115/), and such effects occur at exposures that do not cause significant heating. Any one of these actions might be responsible for the carcinogenic and/or neuro-degenerative actions of EMFs. As with many environmental agents, however, assuming that only one target or mechanism of action exists would be a mistake. For example, it is unlikely that the mechanisms causing effects on the nervous system and behavior are secondary to the same as those leading to cancer. More likely is that multiple mechanisms of action are in force leading to disease. Yet, the lack of complete understanding of basic mechanisms does not alter the importance of the relations.

LEVELS OF PROOF AND STANDARDS OF EVIDENCE FOR DECISION-MAKING DIFFER AMONG PROFESSIONS

The levels of proof that are required for general acceptance vary among the disciplines. The level of proof that should trigger a public health response does not, and should not, require the same level of proof as that required for proof of a mathematical theorem or a basic principle in biology. The principal reason that the levels of proof are different in these situations is that in the case of public health, an enormous cost, in terms of human life lost, in doing nothing could be involved. D.O. CARPENTER AND C. SAGE 104

Fig. 2: Standards of evidence for decision-making, as used in mathematical proof, scientific investigations, legal and public health. Standards for ActionIncreasing Evidence100%50%0%100%95-99%50+%10-40%Absolute ProofStrong evidencefrom animal, cell and humanstudies Evidence for more likely than not Significant potentialimpactPRECAUTIONrequires LAWrequiresSCIENCE requiresMATHEMATICS requires

Evaluating the strengths of scientific evidence on public health and environmental hazards requires that these differences are recognized and transparent. Decision-makers and the public will be best served by a clear recognition that differing standards of evidence and levels of proof are expected and justified, and making them explicit in review processes is essential.

These differing standards reflect both the standards of the different professions and the training given to students of different disciplines. The consequences of these differences are of paramount importance in understanding why different 'experts' can arrive at apparently opposite conclusions when reviewing the same body of evidence. Such experts will differ in their judg-ments about when the evidence justifies drawing conclusions, what degree of evidentiary proof is sufficient to do so, and what actions might be justified at any point on that information continuum. This approach, however, creates reviewing the same body of evidence may well come to diametrically opposed opinions about whether sufficient information is available at a point in time to reasonably link cause to effect. Figure 2 shows that at least four standards

dence are accepted as levels of proof or requirements for action in different professions. The following discussion is presented to highlight several of the main differences in the professional approach and traditional ways of viewing and interpreting scientific evidence. The most rigorous is mathematical proof, which constitutes proof at 100% confidence. This level is the standard in mathematics, physics, and chemistry but is a level of proof that in almost every situation cannot be achieved in biology and medicine. The level of proof used by t

dical scientific community is that the associa-tions from experimental animal and cell studies and from human epidemiologic studies are established such that no more than a 5% possibility PRUDENT PUBLIC HEALTH POLICY FOR EMF EXPOSURES 105

This possibility is called the 95% confidence inter-val, or even better the 99% confidence interval, at which no more than a 1% possibility remains that the results are due to chance. This level is the accepted standard of proof of association (not necessarily of causation) in laboratory and epidemiologic studies, and when achieved, the results are concluded to be 'statistically significant'. We expect that all possible evidence (animal, cell, and epidemiologic studies, with replications) will show a high degree of consistency. In human epidemiologic studies, the Hill Criteria are important factors for

ese Criteria were suggested by Sir Bradford Hill in a lecture in 1965 /116/. The Hill Criteria are important when one attempts to go beyond 'association' to 'causation'. Although some insist that each of the 'criteria' must be met to assign causation, understanding how Hill introduced these considerations is important. The Hill Criteria are listed in the sidebar, together with quotes from his article. Clearly, Hill did not believe that each consideration had to be met before concluding that a relation exists between exposure and disease. Rather, he meant these considerations to be the factors that are considered in determining the 'weight of evidence'. The concept of weight of evidence is very important, and is basically what the Hill Criteria are about—dealing with the strength of association, how similar the findings are from different studies, how strong the evidence is that more is worse, and how well the studies in different model systems provide consistent results. The Hill Criteria provide a framework for taking action when the weight of evidence indicates a relation between exposure and disease, even when some unknowns remain. When evaluating the findings of statistically significant relations betw

ease in relation to the considerations outlined by Hill, the evidence for leukemia in children is sufficiently strong to meet the criteria. The associations of disease with adult leukemia and brain tumors and for the neurodegenerative diseases Alzheimer's disease and ALS is certainly less extensive, but still sufficient to meet most of the criteria. The evidence for the adverse effects of RF exposure, although growing rapidly, is not as complete but is still strongly suggestive. Thus, the question remains of how to deal with evidence that is incomplete, but for which the public health impact is potentially great. The legal profession looks at the burden of proof and standards for jud

different way. The level of proof that is the standard applied in civil legal proceedings is 'more likely than not'. In other words, if there is a 50%+ likelihood of harm, then this level is taken as evidence for a relation, as shown in Figure 2. It is not necessary that the evidence of harm be conclusive, neither is some uncertainty of causation a reason to conclude that no relation exists between exposure and harm. In fact, a certain amount of uncertainty is allowable, even under the more stringent (criminal) standard of evidence, namely "beyond a reasonable doubt". No legal standard requires complete certainty of effect to make a defensible judgment on the evidence at hand. The level of certainty about an effect that is sufficient to take action (in this case to decide the admissibility of evidence or the outcome of a court trial) can be lower than a strictly scientific determination on causality. Important social issues must often be decided based on uncertain scientific evidence. This level of evidence has been more than reached for the association between prolonged and frequent use of cell phones and increased risk of ipsilateral brain tumors, acoustic neuromas, and parotid gland tumors. Prudent public health policy requires yet a different approach to st

precaution (far right bar in Figure 2). A large difference can be seen between what constitutes causal evidence for purposes of achieving scientific consensus, what constitutes "a more likely than not" case under the law, and what constitutes sufficient evidence for purposes of interim public health policy. The demonstration of a low level of proof of D.O. CARPENTER AND C. SAGE 106

The Hill Criteria, as presented by Sir Bradford Hill:

1. *Strength of the Association:* He indicates that a strong
"In thus putting emphasis upon the strength of an association we must, nevertheless, look at the obverse of the coin. We must not be too ready to dismiss a cause-and-effect hypothesis merely on the grounds that the observed association appears to be slight. There are many occasions in medicine when this is in truth so. Relatively few persons harboring the meningococcus fall sick of meningococcal meningitis. Relatively few persons occupationally exposed to rat's urine contract Weil's disease." Thus while strength of the association is an important consideration, it must be placed in context. With regard to health hazards from EMF it is true that in most studies the odd ratios are relatively low, often in the range of 1.5-3.0. But the consistency with which elevated and statistically significant ORs are found is the important consideration, particularly in light of the inadequacy of exposure assessment. 2. *Consistency*: This means that diffe
put a good deal of weight upon similar results reached in quite different ways, e.g., prospectively and retrospectively. Once again looking at the obverse of the coin there will be occasions when repetition is absent or impossible and yet we should not hesitate to draw conclusions." Thus, one does not need to demonstrate a statistically significant relation in every study, especially given the problem with exposure assessment. 3. *Specificity*: Specificity is to say that the effect is due to the specific exposure. He concludes, "We
keep in mind that diseases may have more than one cause. It has always been possible to acquire a cancer of the scrotum without sweeping chimneys or taking to mule-spinning in Lancashire. One-to-one relations are not frequent. Indeed I believe that multi-causation is generally more likely than single causation though possibly if we knew all the answers we might get back to a single factor. In short, if specificity exists we may be able to draw conclusions without hesitation; if it is not apparent, we are not thereby necessarily left sitting irresolutely on the fence." 4. *Temporality*:
determine. Hill states, "This is a question which might be particularly relevant with diseases of slow development. Does a particular diet lead to disease or do the early stages of the disease lead to those peculiar dietetic habits?" The issue of brain tumors and acoustic neurons from cell phone use is a perfect example of the problem with diseases with a long latency. 5. *Dose-Response Relation* (which Hill ca
considered a key factor in any toxicologic investigation. But Hill cautions, "Often the difficulty is to secure some satisfactory quantitative measure of the environment which will permit us to explore this dose-response. But we should invariably seek it." Thus, lack of a dose-response relation does not destroy a causal connection. 6. *Plausibility*: Hill notes, "It will be helpful if the causation we suspect is biologically plausible. But
feature I am convinced we cannot demand. What is biologically plausible depends upon the biological knowledge of the day." This consideration is particularly relevant to EMF considerations. 7. *Coherence*: Coherence means that there should not be serious conflict between know
under consideration. Hill discusses coherence in relation to smoking and lung cancer and says "Personally, I regard as greatly contributing to coherence the histopathological evidence from the bronchial epithelium of smokers and the isolation from cigarette smoke of factors carcinogenic for the skin of laboratory animals. Nevertheless, while such laboratory evidence can enormously strengthen the hypothesis and, indeed, may determine the actual causative agent, the lack of such evidence cannot nullify the epidemiological observations in man. Arsenic can undoubtedly cause cancer of the skin in man but it has never been possible to demonstrate such an effect on any other animal." Again, this consideration is directly relevant to the issue of a lack of an animal model for EMF-induced leukemia.