Electromagnetic Fields (EMFs):
A Training Workbook for Working People

PRODUCED BY
The Labor Institute, NYC

Funded by a grant from the New York State Department of Labor,
Occupational Safety and Health Training and Education Program,
Contract Number: C006029

Table of Contents

A Training Program for Working People on Electromagnetic Fields

Why Is This Training Taking Place?

Evidence has emerged which raises questions about the health effects on workers of seemingly harmless electromagnetic fields (EMFs) emitted by power lines, electrical equipment and computer terminals. We now know that these fields are not harmless and that many workers and their families may be exposed to potentially dangerous electromagnetic fields.

Until now, no training program existed for working people on this issue. Although there are several good popular booklets on EMFs, there were no training materials for workers to educate each other on this very pressing matter.

The New York State Department of Labor Hazard Abatement Unit provided funding so that the Labor Institute could develop a training workbook and videotape on electromagnetic fields for working people around New York State.

What Is the Labor Institute?

The Labor Institute is a non-profit training and research organization, located in New York City, that provides innovative worker-oriented educational programs to unions and community groups around the United States. The six-person staff of the Labor Institute are members of OCAW (Oil, Chemical, and Atomic Workers) Local 8-149.

For more information about Institute programs and materials, and/or about this workbook, contact: The Labor Institute, 853 Broadway, Room 2014, New York, New York 10003; 212-674-3322.

How Was This Training Program Developed?

A group of 14 workers involved in safety and health issues in their local unions around New York were brought together to assist the Labor Institute in developing a training program on electromagnetic fields. These "worker-consultants" met with Labor Institute staff to listen to experts, to discuss and debate the results of different studies on the health effects of EMFs, and to develop plans of action and comment in detail on the many drafts of the curriculum. Some have tested this curriculum with their own members. Others have used segments of it in informational meetings with co-workers.

We thank the following worker-consultants for their help in the creation of this training curriculum:

Michael Arvanites, IBEW Local 503
Walter Birney, IBEW Local 589
Andrew Caputo, TWU Local 100
Steve Carney, CWA Local 1103
John Gentile, CWA Local 1103
Robert Karpf, IBEW Local 589
Ronald Lent, IBEW Local 503
Francis Leonard, IBEW Local 1049
Evelyn McDonnel, UAW District 65
Daniel Morales, IBEW Local 503
Jim O'Hare, CWA Local 1118
Debbie Rothman, UAW District 65
Floyd Thornton, IBEW Local 1049
Ralph Zoccolillo, CWA Local 1103

We also want to thank the following individuals for their contribution to the development of the curriculum:

Gary Cwitco, Communications & Electrical Workers of Canada
Roger Cook, WNYCOSH
Norm Danzig, NYCOSH
David Dembo, Council on International and Public Affairs
Marsha Love, CWA District 1
Dr. Steve Markowitz, Mt. Sinai School of Medicine
Mark Pinsky, *Microwave News* and Pagemark
Eric Scherzer, OCAW Local 8-149
Diane Stein, NYCOSH
Lisa Watson, NYCOSH

Additional thanks to Charles Barrett and Bob Kirkman at UAW District 65 for providing space for our curriculum development meetings.

The Labor Institute staff members who compiled this curriculum are: Cydney Pullman, Curriculum Director; Howard Saunders, Art Director; Cydney Wilkes, Desktop Publisher.

What Is the Small Group Activity Method?

This training package uses the Small Group Activity Method (SGAM)to teach about electromagnetic fields (EMFs). The Small Group Activity Method is a participatory, non-lecture training method which is worker-oriented. The Labor Institute uses this teaching approach to train workers to be trainers themselves and has shared this method with over 200 different unions and community groups in the United States and Canada.

The Small Group Activity Method puts the learner in the center of the workshop. Participants are put to work in the workshop solving real-life problems, building upon their own skills and experiences. Instead of learning-by-listening passively, **we learn by doing.**

Basic Structure
The Small Group Activity Method is based on **Activities**. An activity can take from 30 minutes to an hour. Each activity has a common basic structure: Small Group Tasks, Report-Back, and Summary.

1. Small Group Task: The workshop always operates with people working in groups at tables. Each activity has a task, or set of tasks, for the group to work on. The idea is to work together using each others' experiences to tackle problems and make judgements on key issues. Part of the task often involves looking at factsheets and reading short handouts to develop an opinion on an issue.

2. The Report-back: For each task, the group selects a **scribe** whose job it is to take notes on the small group discussion and report back to the workshop as a whole. The trainer records these reports on large pads of paper in front of the workshop so that all may refer to it. After the report-back the workshop is thrown open to general discussion about the problem at hand.

3. The Summary: Before the discussion drifts too far and wide, the trainer needs to bring it all together during the Summary. Here, the trainer highlights the key points, and brings up any problems and points that might have been overlooked in the Report-back.

How To Use This Workbook

This Workbook consists of four small group activities:

- Introduction to EMFs
- What Are EMFs?
- Can EMFs Hurt Us?
- What Can We Do About Them?

The introductory activity is brief, taking only about a half hour, but the other activities require one hour to work through the materials and discuss them adequately. And, if you show the videotape that accompanies this workbook at the start, the total time for the full EMF training program is four hours.

If you can arrange to train a group of workers over, say, four one-hour sessions or in one long four hour workshop, that is great. However, it is also possible to pick and choose among activities and factsheets to fit even a one hour informational session on EMFs.

No matter how long the training session, here are some suggestions for preparing yourself and the trainees:

- There are some articles about EMFs in Appendix 3 which you may want to copy and mail to participants ahead of time. Or, you may want to send the entire curriculum.
- No one knows all the answers on EMFs, so if you or others have any questions, take note of them and please contact the Labor Institute for assistance.
- Some room set-up suggestions: Arrange tables so groups are far enough apart that they do not disrupt each other; Remember large paper to write responses on, markers, tape, a VCR and monitor for videotaping; Name tags.
- Some trainer preparation suggestions: Spend a few hours preparing the day before the training session; Go over in detail what activities you are going to do and who is going to do what in each activity (for example, someone can write responses while another leads the discussion); Review the factsheets and charts, so you know which ones you want to emphasize in the summary.

- Introducing the activity: Introduce yourself; Have people introduce themselves; Briefly explain the training method; Read the purpose of the activity; Move people into small groups as soon as possible; Explain the role of the reporter or scribe and rotate this role with each activity.
- Small Group discussion: Be available to help, but don't interfere; Help a group that is stuck or lost; Cut off discussion before they are done, but not too soon.
- The Report-back: Decide how you'll get information from each group (one item from each group or what?); Record responses on tear off pad; Don't put words in people's mouths; Don't slip into being a lecturer; End discussion before it drags on too long.
- Summary: Remember to congratulate the group on all they were able to come up with on their own; Highlight a few main points people might have missed. Don't repeat the entire summary list; Summarize the main points you were trying to get across in the Activity.

Good Luck!

Activity 1: Introduction to Electromagnetic Fields (EMFs)

Purpose:

To share our concerns and questions about how electromagnetic fields (EMFs) might affect our members.

Task:

Take about 10 minutes to discuss the following question with the people sitting next to you. Jot down some notes on what you discuss. One of you should be prepared to present a brief summary of your discussion to the whole group.

What concerns you and your members about EMFs? Please list your concerns.

1.

2.

3.

4.

5.

Activity 2: What Are Electromagnetic Fields (EMFs)?

Purpose:

To understand some basic concepts about electromagnetic fields.

Task 1:

Please read the following statement. Then in your groups go over Factsheets 2-1 through 2-7 together. One person in each group should be selected to keep notes on your discussion. That person can also report back on your discussion for the workshop as a whole.

You are asked by your union's executive board to give a five-minute presentation on electromagnetic fields (EMFs) at your next union meeting. Specifically, they want to know what they are (not what they might do to you). Prepare a five minute "rap" for the union meeting on "what are EMFs?" referring to at least one factsheet.

What are the key ideas that your members need to know about EMFs?

Refer to at least one factsheet in preparing your presentation.

1.

2.

3.

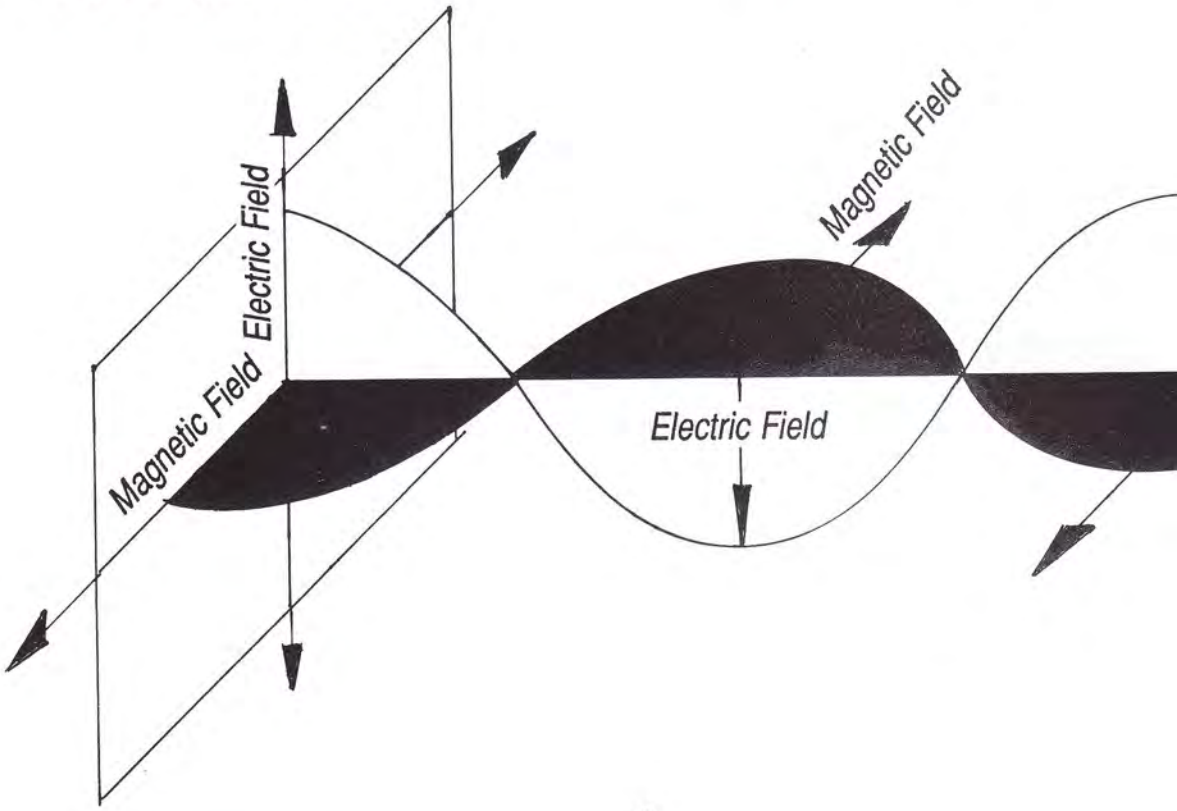
2-1. What Are Electromagnetic Fields (EMFs)?

Wherever electric current is flowing there are electric and magnetic fields. That means that there are fields created by large and small power lines, lighting fixtures and wiring in our homes and our workplaces, electrical equipment at work, and all electrical appliances.

Electric and magnetic fields exist in all living things. They occur naturally in the atmosphere. For example, powerful electric fields are produced when thunderclouds discharge electricity through lightning. And the earth itself is magnetically charged, making trav by compass readings possible.

We can think of EMFs as **invisible lines of force.** They are like waves created by a stone tossed in a pond. Electromagnetic waves radiate through space at the speed of light, which is 186,000 miles pe second.

EMFs consist of two fields, electric and magnetic, which move at right angles to each other.

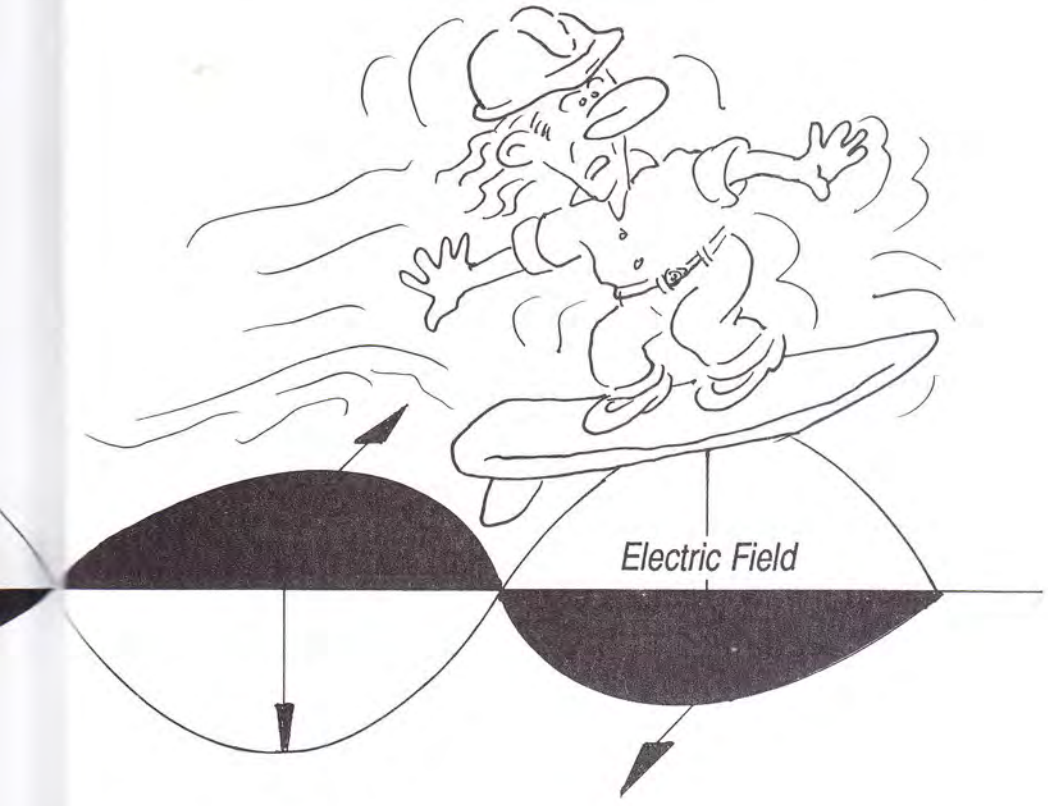


2-2. What Are Electric Fields?

Electric fields are invisible lines of force which result when two different electric charges come close to one another causing electric current to flow. An electric field loses intensity (strength) when you move away from it. The strength of an electric field depends on voltage and is measured in volts per meter (V/m). One thousand volts per meter is a kilovolt per meter (kV/m).

One of the strongest electric fields encountered by workers is under high voltage transmission lines. Workers, such as electronic switch technicians working for telephone companies, may also be exposed to strong fields.

Electric fields can be shielded or reduced in strength so that exposure is limited.



2-3. What Are Magnetic Fields?

Electric currents produce **magnetic fields.** A magnetic field is an invisible line of force which may be imagined as a set of loops encircling an electrical line. Magnetic field strength depends on th amount of the current (amperage) and is measured in milligauss (mG.) Sometimes they are measured in tesla (T).

Workers may be exposed to strong magnetic fields if they are arou high voltage transmission lines. Strong magnetic fields are also generated by processes that use high currents, such as arc-welding induction heating and some electric motors. And, magnetic fields have been measured around VDTs, video display terminals.

Although magnetic fields fall off as we move away from them, the cannot be shielded easily and are therefore potentially more dangerous.

2-4. Electromagnetic Fields Are NOT All the Same

Electromagnetic fields differ depending upon the frequency, wavelength, and intensity of the field.

Frequency is the number of waves passing a point in one second.

The length of a wave is its **wavelength.**

Intensity is the strength of the wave.

The number of times the waves of an EMF move back and forth (alternate) in one second is its frequency. The electric power used in North America alternates (it is AC or alternating current) 60 times each second. This is called 60 hertz (Hz) power. We are mostly concerned in this training program with the impact of this 60 Hz field on workers. **This is called ELF (extremely low frequency) EMFs (electromagnetic fields).**

There is also a form of EMF called **Pulsed Electromagnetic Fields.** These fields produce energy in the form of "packets" or "blips" in which the EMF is turned on and off over and over again. These pulsed fields are different from powerline fields which are constant. Pulsed EMFs are emitted from VDTs. The evidence shows that pulsed EMFs are more damaging biologically than constant electromagnetic radiation.[1]

---

[1] Bob DeMatteo, *Terminal Shock*, Toronto: New Canada Press, 1985.

2-5. The Different Kinds of Electromagnetic Fields

The electromagnetic spectrum is arranged according to frequency. Wavelength figures are given to show that frequency and wavelength are inversely related -- as one increases the other decreases.

The Electromagnetic Spectrum

Type of Radiation	Frequency (Hertz)*	Wavelength (Meters)	Workers Affected
Non-ionizing Radiation			
Extremely Low Frequency (ELF)	1	300,000,000**	Power line worker Electrical workers Office workers
	60	3,000,000	Electrical equipme workers
	100		Communications workers
Very Low Frequency (VLF)	10,000	30,000	Office workers
Short Wave AM Radio	1,000,000	300	Short wave and radio operators
Microwaves & TV FM Radio	100,000,000	3	Microwave, TV workers
Radar	10,000,000,000	.03 (one inch)	Radar operators
Infrared	1,000,000,000,000	.0003	
Visible Light	10^{14}(+ 14 zeros)	.000003	
Ionizing Radiation			
Ultraviolet***	10^{16}	.00000003	
X-rays	10^{18}	.0000000003	Medical technicia
	10^{20}	.00000000003	
Gamma rays	10^{22}	.000000000003	Atomic workers
Cosmic rays	10^{24}	.0000000000000003	

*Hertz = cycles per second.

** The speed of light (and electromagnetic waves) is 186,000 miles per second which is the basis our measurements of frequency and wavelength; 300,000,000 meters is equal to 186,000 miles.

*** Ultraviolet radiation is actually on the dividing line between ionizing and non-ionizing rad

2-6. Ionizing Versus Non-Ionizing Radiation[2]

We need to know the difference between ionizing and non-ionizing radiation because it was always thought that only ionizing radiation could hurt us. Now, we know that non-ionizing radiation may cause health problems too.[3]

What is Ionizing Radiation?

Ionizing radiation includes high-frequency forms of radiation such as x-rays, gamma rays and cosmic rays. When something is "ionized" it becomes electrically charged.[4] When ionization occurs within a living cell, the chemical structure of the cell can be changed.

Exposure to ionizing radiation can damage our cells. It may damage DNA, the genetic material in our cells, causing severe illness and/or death.

---

[2] This factsheet draws on "A Worker's Guide to Electromagnetic Radiation" by Paul A. Landsbergis and Eric Scherzer, OCAW District 8 Resource Center.

[3] As a recent report by the U.S. Congress' Office of Technology Assessment (OTA) states: "Although as recently as a few years ago, scientists stated that available evidence showed no health risks from power frequency fields, emerging evidence no longer allows a categorical denial that risks exist."

[4] When an atom carries a positive or negative charge it is called an ion. If an atom is ionized it is no longer a part of the molecule it came from. Ionization produces a chemical change in a substance.

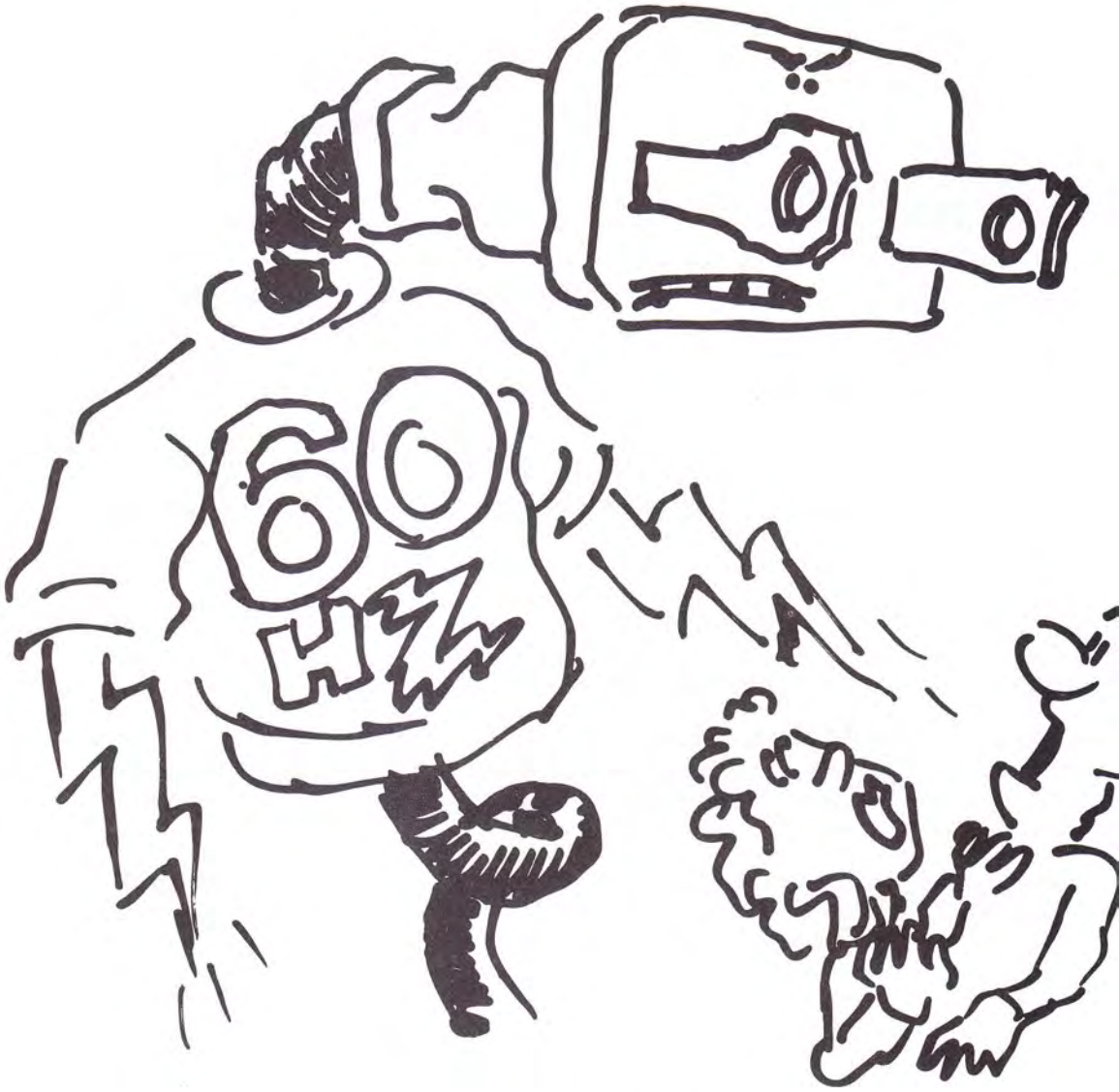
2-6. (continued)

What is Non-ionizing Radiation?

Non-ionizing radiation is the low-frequency form of radiation suc as visible light, infrared, microwave, radio frequency, very low frequency (VLF) and extremely low frequency (ELF) radiation.

Although these types of radiation do not alter the atoms they stri some, such as microwaves, can cause burns and possible damage the reproductive system.

ELF fields, such as those created by 60 Hz alternating electric curr (AC), **have subtle biological effects** as we shall see.



2-7. How Strong Are Electric and Magnetic Fields?

Fields around appliances like toasters, hair dryers, and refrigerators decrease rapidly at even short distances from the device. And users are only exposed briefly to these fields each day.

In contrast, power line fields from distribution lines and transmission lines are more pervasive. Both residents and workers are exposed for longer periods of time.

A recent study using a dosimeter (a new device which measures 60 Hz fields) found the following average and peak levels among a group of electric utility workers during work:[5]

	Electric Field (V/m)		Magnetic Field (mG)	
	Average	**Peak**	**Average**	**Peak**
Lineman (distribution)	62.5	416.2	14.5	54.0
Apparatus electrician (transmission)	181.7	1756.3	34.4	184.8
Lineman (transmission)	418.9	1430.0	13.1	35.1
Splicer (distribution)	6.7	15.7	20.8	171.2
Apparatus mechanic	4.7	6.7	11.8	51.7

Many studies suggest that these ranges of exposure may be unsafe. Although we do not have dosimeter readings for other workers exposed to EMFs we know that their exposure is significant also.

[5] J.E. Deadman, et al., "Occupational and residential 60 Hz electromagnetic fields and high-frequency electric transients: Exposure assessment using a new dosimeter," *American Journal of Industrial Hygiene,* vol. 49, no. 8, 1988, pp. 409-419; as excerpted in Paul Landsbergis and Eric Scherzer, "A Worker's Guide to Electromagnetic Radiation," OCAW District 8 Resource Center.

Activity 2: Summary

What are Electromagnetic Fields?

1. Electromagnetic fields are "invisible lines of force." Wherever there is electrical current, there are EMFs. They are made up o electric and magnetic fields.

2. Electric fields are created when one electric charge exerts a positive or negative force on another. They are measured in vo (V) and can be shielded.

3. Magnetic fields exist wherever there is electric current. They a measured in milligauss and can NOT be shielded easily.

4. Both magnetic and electric fields fall off rapidly with distance.

5. EMFs vary according to wavelength, frequency, and intensity.

6. The Electromagnetic Spectrum provides a perspective on the whole range of EMFs starting with ELF (extremely low frequer EMF and ending with very high frequency cosmic rays.

7. Ionizing radiation is higher frequency electromagnetic waves which can cause severe damage to cells. High doses can kill us.

8. Non-ionizing radiation is at the lower frequency end of the spectrum and although it was previously thought to present no risk to humans, it is now recognized to have biological effects.

9. Finally, the strengths of electric and magnetic fields vary widely. Appliances have strong fields, but we are not around them for a long time. However, power lines, for example, may expose workers over the course of their whole work day, which **may be unsafe.**

Activity 3: Can Electromagnetic Fields Hurt Us?

Purpose:

To review material about the potential biological effects of EMF on our bodies. To examine occupational and other studies on the effects of EMF exposure on our health.

Task 1:

The Biological Effects of EMFs

Read Factsheets 3-1, 3-2, 3-3 and 3-5.3 (Biological Studies). They contain excerpts taken from recent testimony before the U.S. Congress on the biological effects of EMF, excerpts from a comprehensive government study on EMF and a chart on biological studies on EMF.

In your small group, assign different factsheets to separate workers (they are lengthy) and then, as a group, develop a list of points you would make in a discussion with a co-worker about the **biological effects** of EMF. Select a person to take notes and reportback to the group as a whole.

List the key points you would make to a co-worker about the biological effects of electromagnetic fields on cells:

1.

2.

3.

3-1. Congress Is Being Told That EMFs Hav Biological Effects

The following is an edited transcript of Congressional Oversight Hearings on Electric Powerlines: Health and Public Policy Implications which were held on March 8, 1990:

Mr. Kostmayer:[6] Welcome Mr. Dodge, would you like to begin?

Mr. Dodge: Yes, thank you. I am Christopher Dodge and I with the Congressional Research Service, the Library of Congress. I have been tracking the biological and health eff of electromagnetic fields since 1962 and have continued to so over the last 4 or 5 years.

First, I think it is important to point out that the Soviet and European countries have been studying this issue for about years. The first paper I am aware of came out in 1933 and si then there has been a proliferation of research into the subje

I think it is fair to say that the Soviet and East European researchers are absolutely convinced that low level power frequencies are biologically active.

The issue of what the health implications of these effects ar remains a little bit vague. Ten years ago we were not [even] talking about health effects of low level power frequency electromagnetic fields. We were a silent minority. One of m colleagues said recently that we were sort of the "lunatic fringe," because some of us believed that there was someth going on.

Today, I think it is safe to say that **most of the bioelectro-magnetic research community believes that low level pow frequency electromagnetic fields are biologically active.**

---

[6] This is the Honorable Peter J. Kostmayer, chairperson of the subcommittee on General Oversight and Investigations of the House Committee of the Interior.

3-2. More Testimony on the Biological Effects of EMFs:

The following is based on the edited testimony of Dr. William Ross Adey[7] before Congress on July 25, 1990:

EMFs Can Affect Our Immune System.

The body's immune system is the fortress built by nature against infection and the creeping claws of cancer. Reduced immune competence is therefore followed by dire consequences for the individual, whether it results from aging, from the ravages of infection such as AIDS, or from environmental chemical pollution.

Lymphocytes (cells produced by the lymph system) of the immune system can be "targeted" against tumor cells, destroying them by breaking their covering membranes on contact.

In studies with cell cultures, fields simulating 60 Hz high voltage powerline fields can reduce the killing capacity (**cytotoxicity**) of lymphocytes targeted against cancer cells. These fields also disrupt activity of enzymes that act as internal messengers inside lymphocytes.

In terms of human exposures and epidemiological studies, these and related findings offer an important bridge to reports of reduced immunity, with increased risks of lymphomas and other malignancies.

---

[7] Dr. Adey is Associate Chief of Staff for research and development at Pettis Memorial V.A. Medical Center at Loma Linda, California. For the past 15 years, Dr. Adey has played a pioneering role in understanding how body cells "whisper" to one another and in so doing has discovered some of the keys to understanding how EMFs have biological effects.

3-2. (continued)

EMFs May Promote Cancer.

Available evidence indicates that electromagnetic fields (EMFs) d not function as classical **initiators** in tumor formation by causing damage to DNA and gene mutation in cell nuclei. However, they may function as **promoters,** by reason of their actions on cell membranes that form a closing envelope around all cells.

Research has established that the main site of action of electromagnetic fields is at cell membranes. Many chemical tumo promoters also act at cell membranes. They include insecticides (DDT), polychlorinatedbiphenyls (PCBs) formerly used as electric insulators and coolants, tobacco and certain other plant substance associated with human cancer.

Studies show that the joint actions of chemical cancer promoters a electromagnetic fields at cell membranes leads to uncontrolled growth. We know that chemical cancer promoters disrupt the "whispering together" between normal cells. Actions of these promoters are enhanced by weak EMFs, but there may be no effe of fields alone.

These findings imply that **electromagnetic fields may act jointly with chemical cancer initiators and/or promoters, including environmental pollutants, to disrupt normal communication between cells, leading to uncontrolled cancer cell growth.**[8]

---

[8] These findings offer an important bridge to other studies that have emphasized enhance cancer risk for those exposed to chemical carcinogens and electromagnetic fields, includ occurrence of brain tumors in microwave workers, brain tumors in children with fathers electrical occupations, lymphomas in workers in aluminum reduction plants, and a high cancer risk in telephone workers exposed to electromagnetic fields and chemical toxins. Please note that this section has been edited to simplify it.

3-3. A Major Government Agency Says There Are Biological Effects

The following information is from the Office of Technology Assessment's (OTA, a research arm of Congress) Report on Electromagnetic Fields.[9] Most of what we know today about the effects of exposure to power frequency (60 Hz EMF) fields comes from two types of experiments: cell-level and animal experiments.

Cell-Level Experiments Provide Evidence of Biological Effects

A considerable body of evidence has emerged that points to the cell membrane as the primary site of interaction between ELF (extremely low frequency) fields and the cell. The cell's membrane serves as the boundary and maintains the structure of the cell. It is also responsible for transmitting information arriving at its surface to the cell interior so that appropriate life processes can take place.

EMFs Affect Calcium Flow

Calcium flow regulates such processes as muscle contraction, egg fertilization and cell division. The quantity and the rate of calcium ion transport are important. Calcium flows also regulate certain enzymes which are found on the surface of nerve cells. The unusual behavior of calcium flow from cell membranes in brain tissue was the first clear effect of ELF fields observed in biological tissue.

---

[9] Excerpted from U.S. Congress, Office of Technology Assessment, *Electric Power Wheeling and Dealing: Technological Considerations for Increasing Competition*, OTA-E-409 (Washington, DC, U.S. Government Printing Office, May 1989).

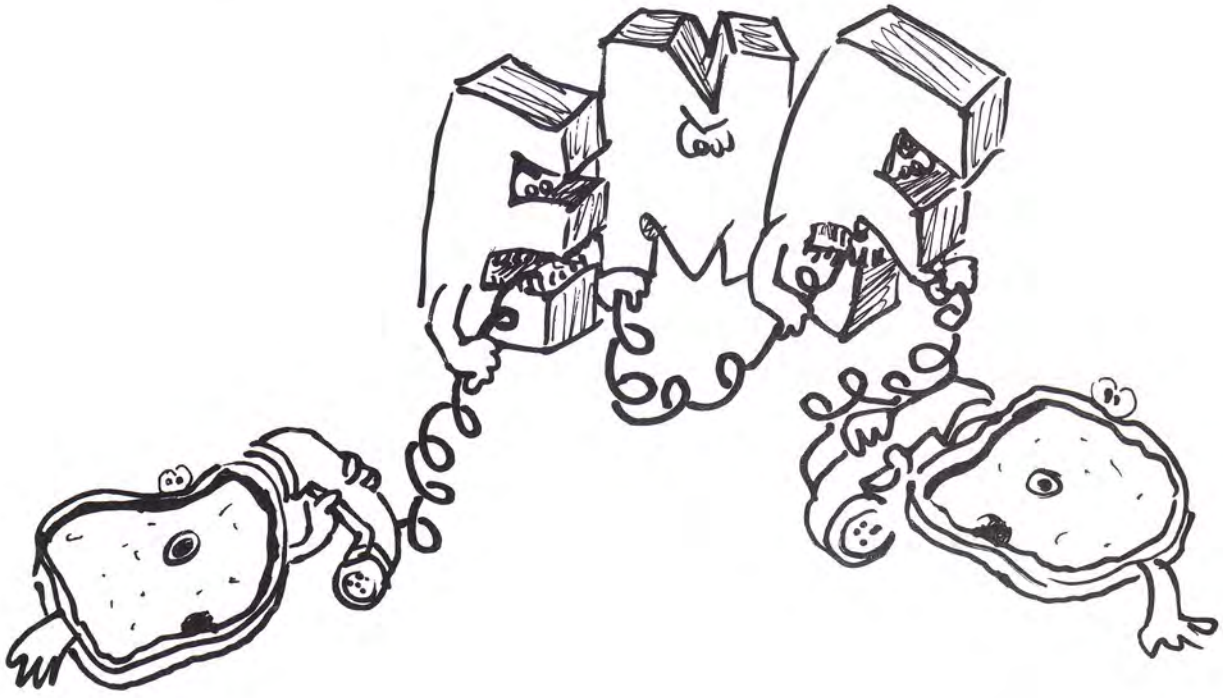
3-3. (continued)

EMFs Affect Communication Between Cells

Recent research has demonstrated unequivocally that under certain circumstances, the membranes of cells are sensitive to externally imposed low-frequency electromagnetic fields, even when the fields' intensity is much weaker than the cell membrane's natural fields. Consequently, processes that are governed by the cell membrane, such as the cell's capacity to recognize other cells, may be candidates for disruption by field exposure.

EMFs Can Interfere With Our Genes

Well-studied cancer-initiating agents, such as ionizing radiation and chemicals, cause direct damage to DNA by mutations. ELF fields do not have enough energy to disrupt the structure of DNA. However, research has shown that exposure to fields may interfere with RNA transcription (the RNA transcribes DNA command codes into proteins).



3-3. (continued)

Animal Experiments Show Biological Effects Too

Animal systems have been examined under a range of electric and magnetic field conditions. Animals such as rats, mice, swine, cows, guinea pigs and chicken eggs have been studied.

EMFs May Affect Reproduction

Most of the studies attempting to examine developmental effects of ELF field exposure have concluded that no overt defects and malformations resulted from the exposure. However, some studies have seen subtle effects and the possibility of the existence of an effect remains an open question.

EMFs Affect the Central Nervous System

Studies have found that developing nervous systems may be particularly susceptible and effects may be manifested only in specific situations or later in time.

EMFs Affect Circadian Systems of Animals and Humans

ELF experiments on the effects of electric and magnetic fields on circadian systems (biological clock) of humans, primates and other animals indicate a definite effect. It is not clear whether such effects are harmful or long-lasting. Disruption of the circadian systems can cause disorders such as altered sensitivity to drugs and toxins and chronic depression.

Task 2:

The Health Effects of EMFs

Read the following hypothetical statement by a worker on why he/she is skeptical about the health effects of EMFs.

> **"Okay, so I'll give you that EMFs can have some effect on a cell, but that's a long way from saying that it's gonna hurt me or kill me. What's the proof? Have they looked at workers like us and figured we'll be affected? And anyway, what are we talking about, one chance outta 10,000. Me and my buddies are on the line all day and we're okay."**

What would you say to this worker? Please look over Factsheet 3-4, which describes some basic concepts that will help you understand Charts 1, 2, and 3. Then see Factsheet 3-5 (3-5.1 and 3-5.2), which presents a summary of the critical residential and occupational studies for your information. Also, Factsheet 3-6 provides some answers to commonly asked questions about EMF.

What would you say to a co-worker about whether EMFs can hurt him/her? Refer to specific factsheets on the studies, and the graphs.

1.

2.

continued

3.

4.

3-4. Results of Epidemiologic Studies of Workers in Electrical Occupations

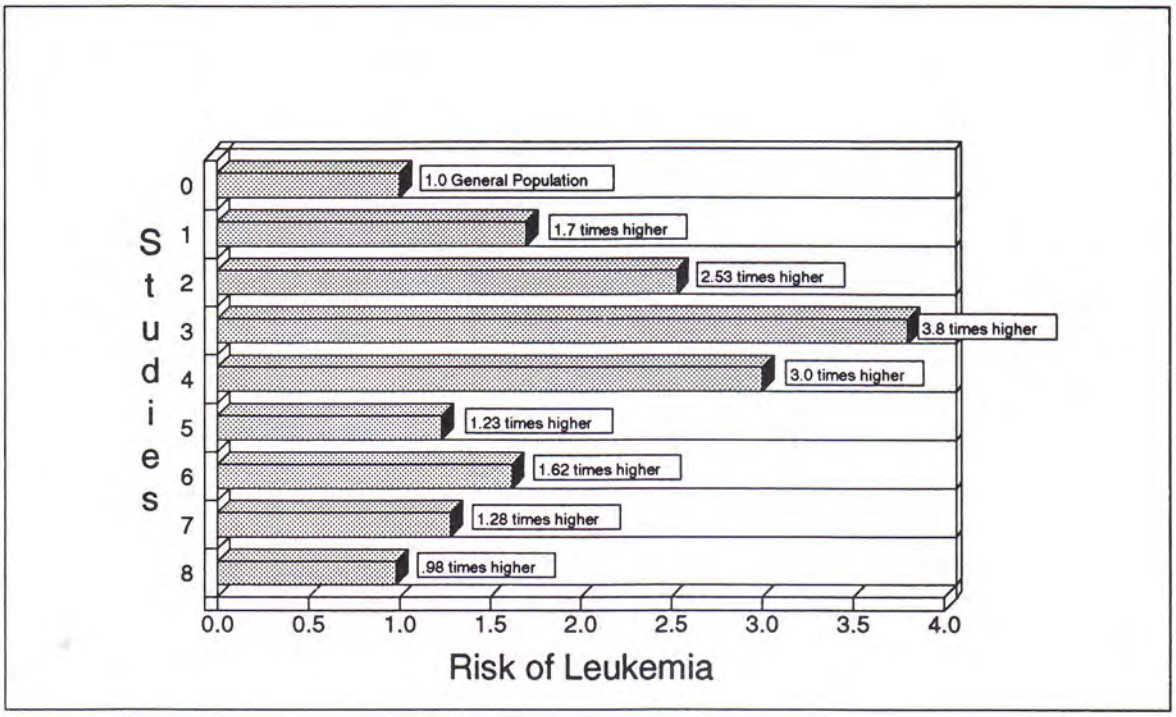
The following charts summarize some of the epidemiologic studies that have been conducted to date. They show the potential risk for workers in the occupations indicated compared to the general population. The following information may assist you in reading the charts:

Risk refers to the chances of developing a particular disease in your lifetime. Being at risk for a disease means that you have some exposure that makes the development of the disease more likely. So, for example, if a study shows that electrical workers' risk is 3.8 times higher than the general population that means that they are almost four times as likely to develop leukemia (Refer to #3 in Chart 1) than the general population.

General Population refers to that portion of the population assumed not to be at particular risk for the disease being studied. The general population is assumed to have relatively low exposure, if any. The rates of disease in the general population are used to predict how many people in a group of workers would be expected to get sick if they were not exposed.

Epidemiologic studies are scientific studies of who gets diseases and why. We examine exposures to toxins or other risk factors for disease among large groups of people in order to determine how important these exposures might be in causing disease.

Chart 1: Risk for All Types of Leukemias for "All Electrical Occupations:" Results of Eight Studies[10]



Studies:

1: Pearce (1985)
2: Gilman (1985)[11]
3: Flodin (1986)
4: Stern (1986)[12]
5: Juutilainen (1988)
6: Pearce (1989)
7: Wright (1982)
8: McDowall (1983)

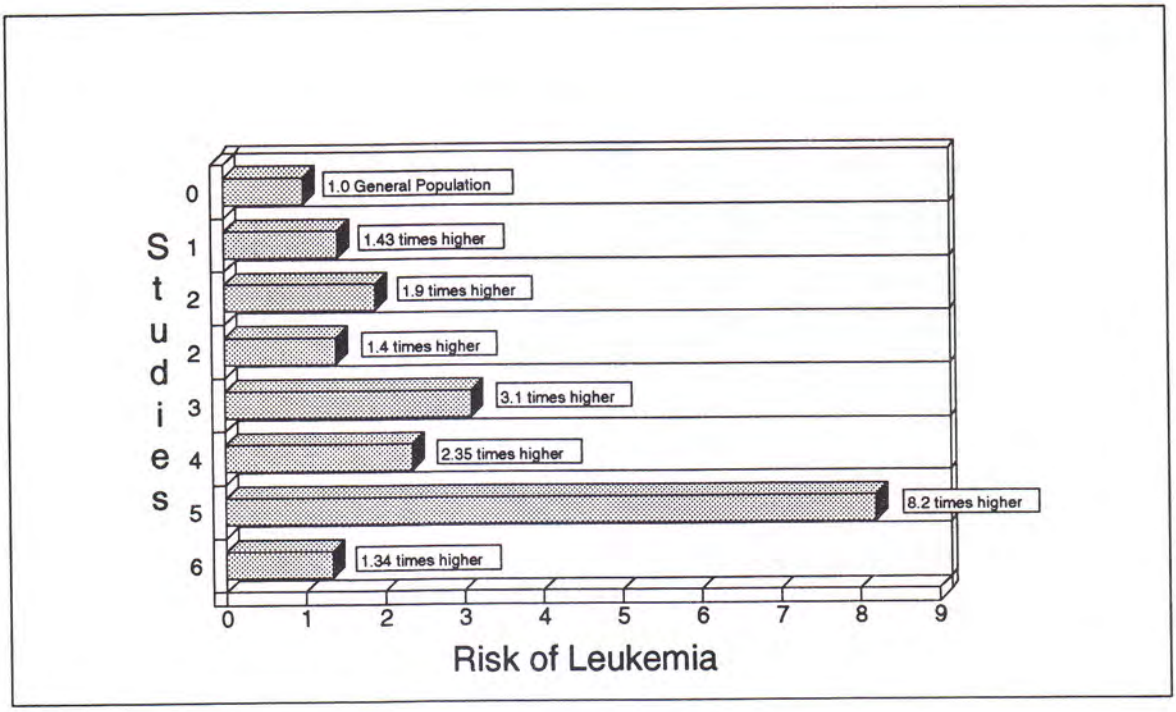
---

[10]Note that the following charts consist of measures of risk which have been transformed to allow expression of risk in units indicated. For more details on the individual studies, contact the Labor Institute or Dr. Steven Markowitz at Mt. Sinai School of Medicine.

[11]Miners, presumed EMF exposure only.

[12]Shipyard electricians only.

Chart 2: Risk of Leukemia for Line Technicians: Results of Six Studies



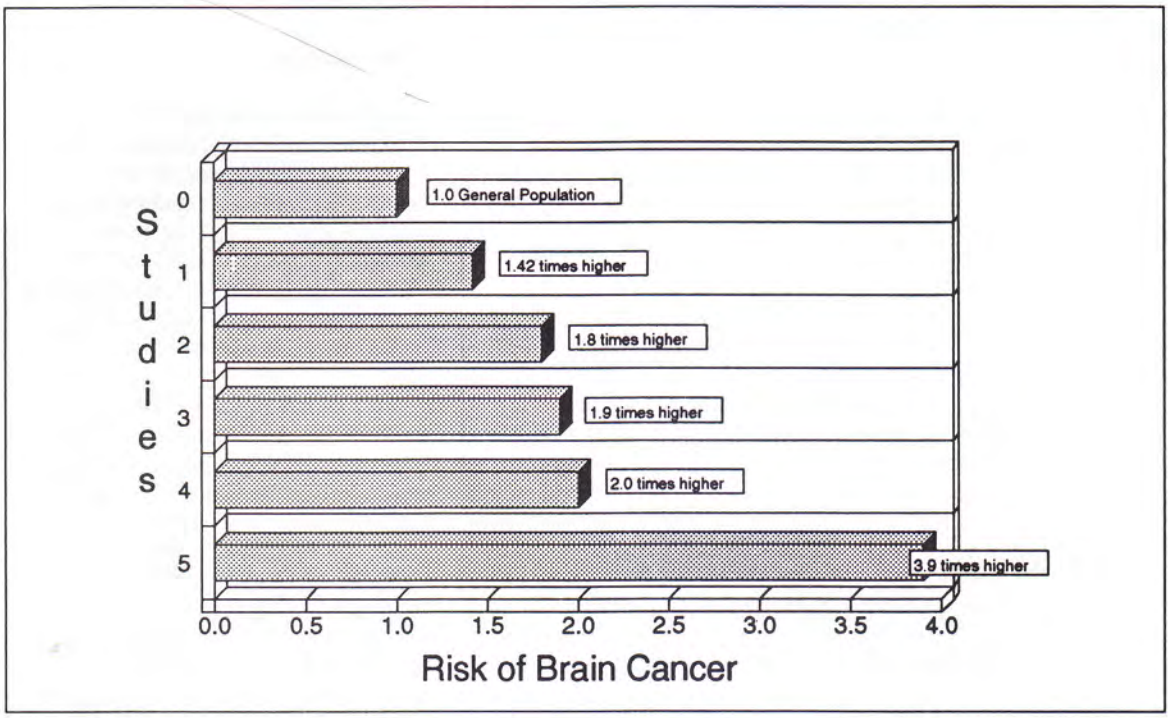
Studies:

1: Calle & Savitz (1985), acute leukemia.
2: Linet (1988), chronic lymphocyte leukemia.
3: Juutilainen (1988)[13], leukemia.
4: Pearce, et al. (1989), leukemia.
5: Wright (1982), acute myeloid leukemia.
6: McDowall (1983), acute myeloid leukemia.

---

[13]Linemen and cable joiners.

Chart 3: Risk of Brain Cancer Among Electricians: Results of Five Studies



Studies:

1: Preston-Martin, et al. (1982)
2: Loomis & Savitz (1989)
3: Rief (1989)
4: Thomas (1987)
5: Speers (1988)

3-5. What Do the Electromagnetic Field Studies Tell Us?[14]

3-5.1. The Residential Studies[15]

Year	Researchers	Subjects Studied	Conclusions
1979	Nancy Wertheimer Ed Leeper U. of Colorado	Study of EMF exposure of 344 children who died of cancer between 1950 and 1973.	Found correlation between childhood cancer and high EMF exposure from power lines as estimated by a wire coding index. Children from high exposure homes are 2-3 times as likely to develop leukemia, lymphoma and nervous system disorders as those from low exposure homes.
1980	David Savitz U. of Colorado Medical Center	Replication of above study. An analysis of 356 chilfood cancer cases in Denver between 1976 and 1983.	Found risk ratio of 1.5 which means that children with exposure to power line EMF were 1½ times as likely to develop cancer as children with low exposure to EMF.
1990	John Peters U. of Southern California	Study of 230 childhood cancers (leukemia victims) in Los Angeles area between 1980 and 1987.	Found that children living in homes near high current power lines had a 2½ fold increased risk of leukemia. Indicated a threshold of about 2 mG for increased childhood leukemia risk. (*Microwave News*, March/April 91) **The preliminary results of this study confirm the Wertheimer/Leeper and Savitz findings.**

[14] This factsheet is based on information contained in a three-part article: Robert Pool, "Is There an EMF-Cancer Connection?" *Science*, September 7, 21 and October 5, 1990. (See Appendix 2)

[15] Four other residential studies have looked for correlations between EMF and childhood cancer with mixed results: one found an increased risk of nervous system cancers; another found no risk; two other studies found higher risks for various cancers, but they were not statistically significant.

3-5.2. The Occupational Studies

Year	Researchers	Workers Studied	Conclusions
1985	Neal Pearce Wellington School of Med., New Zealand	Study of electrical workers	Found an increased risk of leukemia among electricians and radio and television repairers and assemblers in New Zealand.
1987	Terry Thomas National Cancer Institute	Study of electrical workers	Found an increased risk of brain cancer, but not as a result of their EMF exposure. When he removed those cases which had been exposed to lead, soldering fumes, and organic solvents, the risk for brain cancer among the remaining workers was much less than that for the general population.
1989	Genevieve Matanowski Johns Hopkins University	Studied dose response relationship for cancers in male New York telephone workers (cable splicers, central office workers, installation and repair) 1976-1980	Cable splicers were nearly twice as likely to contract all types of cancer as company workers who did not work on telephone lines. Risks for leukemia and lymphoma were particularly high. Central office workers exposed to peak fields from switching equipment were more than 3 times as likely to get prostate cancer and more than 2 times as likely to get oral cancer as coworkers who were less exposed. Found two cases of male breast cancer, a disease so rare that no cases were expected.
1990	Susan Preston-Martin Wendy Mack U. Southern Cal.	Study of workers in various electrical jobs	Found that men who worked for 10 years or more in a variety of electrical occupations had a 10 times greater chance of getting brain cancer.
1990	Joe Bowman U. Southern Cal.	Dose response analysis of Pearce study	Measured average magnetic field exposures for various occupations in Pearce study and found no dose response. Welders, for example, had the highest exposure to EMF but no leukemia cases. Low numbers limit this study's statistical power.
1990	David Thomas Hutchinson Cancer Research Institue, Seattle	Study of 250 male breast cancer patients	Found strong correlation with jobs that involved exposure to EMFs. Men whose jobs involved some exposure were nearly twice as likely to have breast cancer as men with no exposure. Men likely to have the highest exposure--electricians, utility linemen and power plant workers--had 6 times the risk of developing breast cancer as men who worked in occupations with no EMF exposure.

3-5.3. The Biological Studies

Year	Researchers	What Studied	Conclusions
1976	Suzanne Bawin Ross Adey Space Biology Lab	Chicks	Chick brain cells exposed to EMFs hold onto much more calcium than unexposed cells.
1990	Batelle Pacific Northwest Labs	Rats	Found that EMFs suppress levels of hormone melatonin. Female rats get breast tumors.
1990	Robert Liburdy Lawrence Berkeley Lab, UCLA	Rats	Altered calcium uptake in rat lymphocytes with magnetic fields comparable in intensity to some occupational exposures. Says that this could explain how cells could be altered by signals at the cell membrane.
1990	Richard Lubin, UC Riverside	Osteoblasts (cells that produce bone)	EMFs appear to be modifying a signal that passes across the membrane. The signal is triggered by the parathyroid hormone.
1990	Reba Goodman Ann Henderson Columbia Univ.	DNA/RNA	Found that pulsed EMF can alter DNA synthesis. Through applying 60 Hz magnetic and pulsed fields they modified RNA transcription and protein synthesis. Their cell cultures produced more than the normal amount of some proteins and less of others.

3-6. Ask Dr. M. About EMFs

The following questions were asked by workers in our training sessions. Answers are provided by Dr. Steve Markowitz, occupational medicine physician at Mt. Sinai School of Medicine.

Question: When EMF is absorbed into the body, what is being affected?

Answer: EMF would be absorbed by all cells in the body that would be reached. Just as EMF penetrates the walls of a house or building, it also penetrates the body and would reach all organs.

Question: Isn't it true that many new cells are constantly being created so that if EMF affects our cells, there are new ones to replace the affected ones?

Answer: New cells of many organs are, or can be, constantly made. For instance, cells of the skin, mucosa (inside the mouth and nose), all along the gastrointestinal system, and the bone marrow and blood are constantly being turned over. By contrast, nerve cells are largely irreplaceable since it is thought that there is little capacity for nerve cells to regenerate. Most other organs are capable of making new cells in response to specific stimuli.

The important issue, however, with reference to cancer induction, is not the ability of the body to produce new cells, but the capacity of the carcinogen to make normal cells go awry rather than actually killing the cells. The carcinogen transforms an existing cell, thereby causing it to become cancerous and grow in a disordered fashion without the proper control. The ability of certain body organs to make new cells cannot overcome this harmful effect of the carcinogen.

continued

3-6. (continued)

Question: What level of EMF exposure should cause concern among workers?

Answer: We do not currently know what level of EMF exposure causes the effects being studied.

Question: If a worker is exposed for "x" period of time, is it too late to bother doing anything?

Answer: While we do not have specific information about the length of exposure to EMF or other potential carcinogens which are required to lead to cancer, in general, we believe that the less the exposure, in terms of duration, the less likely that cancer will develop. In the absence of cancer, it is therefore never too late to reduce exposure. A risk of disease will decrease as the amount and duration of exposure decreases.

Activity 3: Summary

Can Electromagnetic Fields Hurt Us?

1. There is almost total agreement that electromagnetic fields have biological effects, as cellular and animal studies have shown. These effects include changes in hormone levels, in calcium flows, in protein synthesis, in DNA/RNA transcription, and in ion flows across the cell membrane.

2. When we look at the epidemiologic studies of workers who might be exposed to EMFs (e.g. electrical occupations), we see many "positive" studies that show that the risk to electrical workers for various forms of cancer is higher than the risk to the general population, which is assumed to be unexposed to EMFs.

3. Residential studies on the impact of EMFs on children are strongly suggestive, showing a relationship between EMF exposure and cancer.

4. Researchers seem to have found over and over again that workers in various electrical jobs have higher risks for various types of cancer, particularly brain and nervous system cancers as well as leukemia.

Activity 4: What Do We Do About Electromagnetic Fields?

Purpose:

To debate the possible policy approaches to electromagnetic fields (Task 1). To develop a local plan of action focused on your workplace and your members (Task 2).

Task 1: Policy Debate

Please read the three policy options below. From what you have discussed in previous activities, which policy option would you choose? In your small group, discuss the pros and cons of all three positions. On the next page, list the reasons you would take a particular position.

Position 1: Do Nothing

There is simply not enough evidence that electromagnetic fields are harmful to our health. From the scientific research we've looked at there is just too much uncertainty. We have to wait for new research until we know that we are at risk. In the meantime, there is nothing to be done.

Position 2: "Prudent Avoidence"

Until more definite knowledge develops, we must take low-cost, low-effort steps to limit exposure to electromagnetic fields. This may mean routing new transmission lines so they avoid people and making "right of ways" (RoW) wider. New appliances should be redesigned to minimize EMFs. Workers should be metered so that at least we can gather data on exposure levels for the future. Workers should move away from EMF sources, when possible.

Position 3: Redo Everything

There is enough evidence to conclude that we have a real problem. Major resources and effort will need to be spent on rewiring, rerouting and reworking our electrical environment. An aggressive program must be begun to limit field exposures now.

Task 1 (continued)

What are the strengths and weaknesses of each position?

Position 1: Do Nothing
Strengths and Weaknesses

Position 2: Prudent Avoidance
Strengths and Weaknesses

Position 3: Redo Everything
Strengths and Weaknesses

Task 2: Local Plan of Action

Please look over the following examples of how workers, community groups and others are organizing around the EMF issue.

Your task, as a group, is to develop a local plan of action to begin tackling this problem. First, read the examples of what is being done (Factsheets 4-1 through 4-5), then discuss and list some possible approaches your union might take to the EMF issue.

Local Plan of Action:

1.

2.

3.

4.

5.

4-1. Are There Important EMF Court Cases?

A legal remedy for EMF-exposed workers.

Strom vs. Boeing:[16]
In the largest settlement for an electromagnetic field (EMF) injury ever recorded, the Boeing Co. of Seattle, Washington, agreed to pay more than $500,000 to Robert Strom, who claims that he developed leukemia from on-the-job exposures to electromagnetic pulse radiation (EMP).

Strom, a Boeing employee for 29 years, worked with EMP from 1983 through 1985, testing its effects on the electrical and electronic components of the MX "Peacekeeper" missile.[17]

The out-of-court agreement provides for a comprehensive medical program for 700 Boeing workers who have worked with EMP radiation.

The Boeing medical program will provide:

- Ten years of free medical examinations for the 700 Boeing EMP workers. Participation is voluntary.
- A $200,000 fund to cover expenses associated with medical exams.
- The appointment of a medical administrator, approved by both parties, to oversee the program.

---

[16]From *Microwave News*, September/October 1990.

[17]With at least $100,000 of the settlement money, the Stroms established the R.C. Strom Foundation to "ensure that the public continues to learn about the terrible hazards of electromagnetic radiation." The foundation will provide information to the general public through schools, unions and other organizations, sponsor symposia on EMFs and support legislation and EMF-related litigation.

4-1. (continued)

Trial Lawyers for Public Justice (TLPJ), a non-profit group based in Washington, DC, represented Robert Strom and his wife, Barbara. TLPJ filed a class action suit in June 1988 charging that Boeing had long known of the health risks associated with EMP exposure, yet never warned workers or took any precautions to protect them.

Unlike many other previous EMF settlements, the Boeing agreement is a matter of public record.[18]

[18]Because such cases are sealed, companies are never forced to go on record as setting a precedent that others might use against them.

4-2. What Is Business Doing About EMFs?

4-2.1. Some companies are changing their equipment.

IBM:
IBM has introduced a new line of computer terminals that are shielded to reduce magnetic fields. Previously, IBM sold low magnetic field terminals only in Denmark and Sweden. The terminals meet the Swedish standards for very low frequency (VLF) magnetic fields.

According to the IBM patent application, IBM can reduce VLF magnetic fields to a level of five to ten times less than that from an unshielded VDT. The shielding consists of a "magnetic shunt" -- a ring made of magnetically permeable material -- which is attached to the yoke of the Cathode Ray Tube (CRT).[19]

Sigma Designs, Inc.:
Sigma Designs is marketing high-resolution video display terminals that are shielded to reduce ELF fields -- the first U.S. company to make such a commitment for cathode ray tube monitors.

Following the lead of IBM, Sigma announced that it will sell VDTs shielded to meet Swedish guidelines for VLF fields. Sigma has been selling low VLF computer terminals in Sweden since 1988. They sell tens of thousands of VDTs each year.[20]

---

[19] From *Microwave News*, November/December 1989.

[20] From *Microwave News*, July/August 1990.

4-2.2. Companies are sponsoring "mitigation" research to make EMF exposure less severe.

Electric Power Research Institute[21]

EPRI has allocated $1 million to study ways of reducing electromagnetic field exposures. This will be done through "mitigation efforts" such as shielding and grounding systems. Other mitigation efforts are underway in Sweden and in at least three U.S. states. Among the mitigation techniques to be investigated by EPRI are:

- **Low-field transmission line configuration:** Tests have already shown that redesigning lines (reverse phase and split phase) can achieve some field cancellation.
- **Line burial:** Field cancellation can result when the three phase conductors of transmission lines are very closely spaced within an underground, oil-filled, steel pipe. Cancellation is less efficient for buried, residential, single-phase distribution lines.
- **Return current "roundup:"** Neutral return currents are often found on water pipes or other conductors in buildings and can cause current imbalances. This can contribute significantly to background EMF levels.
- **Ferromagnetic shielding:** Ferromagnetic materials can lessen magnetic fields. Use of this type of shielding would probably be limited to utility workers and others who spend significant periods of time exposed to high levels of EMFs at work.
- **Robotic equipment:** EPRI has already developed a robotic remote manipulator arm for working on overhead transmission lines and could develop similar equipment for other types of high exposure work.[22]

---

[21] EPRI is the research and public relations arm of the utility industry.

[22] From *Microwave News*, January/February 1991.

4-3. What Are Unions Doing About EMFs?

4-3.1. Unions are bargaining for contract language that may relate to EMF exposure.

There are several examples of labor responses to the potential hazards posed by electromagnetic fields. Several unions -- including the CWA, AFSCME, UAW, SEIU and the Newspaper Guild -- have contract language which allows VDT (video display terminal) workers who are pregnant to seek alternative work for the duration of their pregnancies if such work is available. Here are some examples of that contract language:

1. Unions are winning the right to reassign work for pregnant workers.

Boston University and District 65, United Auto Workers

Article 18, Section 1.H.: Although research to date has not proven that video display terminals are a health or safety hazard, in recognition of employee concern about the potential adverse effects involving pregnancy, the University agrees to the following:

Upon request, the University will attempt to reassign a pregnant employee to work which does not require the use of a video display terminal. If such reassignment is not practicable, the employee, upon request, may be granted a Personal Leave up to three (3) months.

Hennepin County, Minnesota, and AFSCME Council 14

Letter of Agreement: Available evidence concerning the effect of operating VDTs on the health of employees is of a limited nature and considered by some authorities to be inconclusive. It is hoped that research studies currently in progress will provide more complete and definitive information concerning this matter. In the interim, Hennepin County will address the following concerns in the manner indicated:

Pregnancy: Any pregnant employee assigned to operate a VDT may request reassignment to another position within the department which does not require use of such equipment. The Employer will attempt to accommodate such a request.

2. Unions are bargaining for radiation emissions testing.

Kamber Group and The Newspaper Guild (Washington/Baltimore)

Article IX: Safety, 2: The Employer will follow such safety procedures and inspection schedules as are prescribed by the manufacturer of the equipment...or as may be prescribed by government agency, in maintaining and inspecting such equipment. With respect to VDTs, CRTs or similar devices which may be utilized in the Employer's operations, the Employer will provide for and pay the cost of annual tests for radiation emissions. The results of such tests will be made available to the Guild or employee-users of the equipment upon request.

3. Unions are empowering their Health and Safety Committees.

University of New Haven and District 925, SEIU

Section 3. The Health and Safety Committee within 90 days from the signing of this agreement shall establish guidelines for VDT use in the following areas: radiation hazards, glare, lighting, workstation design, noise and eye exams. The University will implement no cost items immediately; other guidelines will be implemented in the order recommended by the Health and Safety Committee as soon as possible and in any case within two years.[23]

---

[23]Bureau of National Affairs, *VDTs in the Workplace: New Issues, New Answers*, 2nd ed., Washington, DC: BNA, 1987, pp. 188-196.

4-3.2. One union formed a joint working group.

The Communications and Electrical Workers of Canada (CWC), comprising some 40,000 telephone, telecommunications, electric and electronic manufacturing workers, lobbied the Canadian government to investigate the health effects of EMFs several years ago.

A Working Group on Electric and Magnetic ELF Fields was formed consisting of representatives from labor unions, utility companies, academia and federal and provincial governments. The group prepared a document to educate the Canadian public regarding health effects of exposure to electric and magnetic fields at 60 Hz.

The following recommendations were put forward:

- Additional research should be undertaken in Canada to resolve whether there is an association between exposure to 60 Hz electric and magnetic fields and an increased risk of cancer.
- An advisory committee should be established to advise on the research, which consists of all interested parties: industry, labor, academia and government.
- Workers and the general public need to be informed on current understanding of health effects of electric and magnetic fields. Thus, this report should be published.[24]

---

[24]See *Electric and Magnetic Fields and Your Health,* A report of the Working Group on Electric and Magnitic ELF Fields, Health and Welfare Canada, May 1989.

4-3.3. Unions are trying to get their workers monitored.

The CWC (Communications and Electrical Workers of Canada) also has begun to lobby for the EMF monitoring of its workforce. The union wants readings taken at telephone switching stations and areas where workers are constantly exposed to magnetic fields.

As Gary Cwitco, the national health and safety union representative says: "We would file those results. If someone down the road determines that X is a safe level, we have something to operate on. By the year 2000 we might be fighting for compensation."[25]

4-3.4. An arbitration board ruled for shielding the workforce.

In 1989 in Canada, an arbitration board in a labor/management case adopted a preventive precedent in ordering that an employer cooperate in the development of a prototype shielding mechanism for VDTs.

The board reasoned that although the evidence of harm from VDTs was merely suggestive and inconclusive, "there are simply too many incidents where the environment has been invaded by unknown factors which have come to light only after the harm has been done."[26]

---

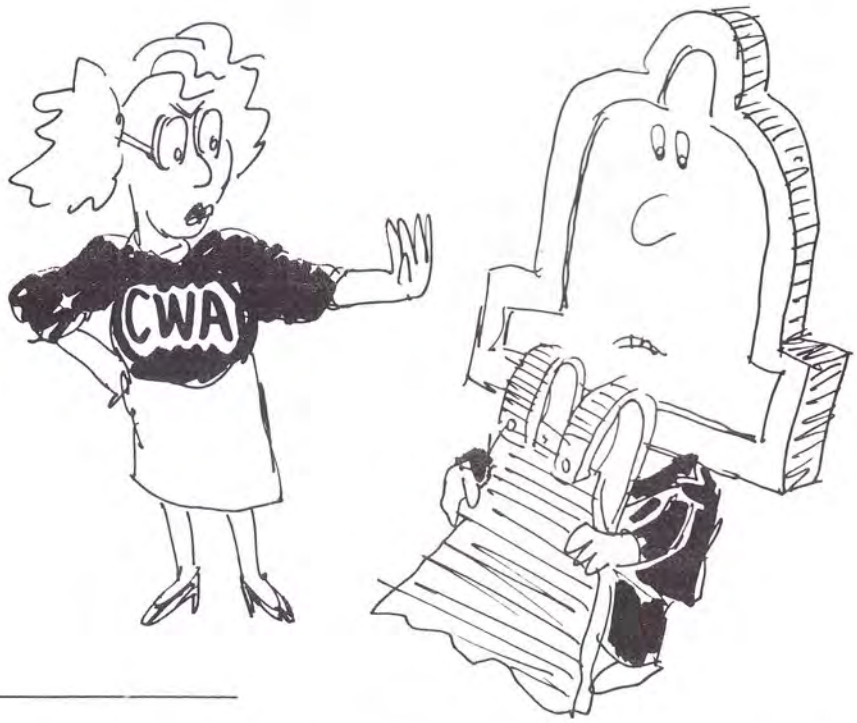
[25]See *Harrowsmith*, "The Killing Fields," No 95. Vol XV:5 Jan/Feb 1991.

[26]Quoted in William K. Stevens, "Scientists Debate Health Hazards of Electromagnetic Fields," *New York Times*, July 11, 1989.

4-3.5. Unions are educating their members about possible EMF control measures.

District 1 of the Communications Workers of America (CWA) developed an informational leaflet on electromagnetic fields for their members which suggests the following possible control measures:

- Labeling of all products and equipment which emit EMFs at levels exceeding a mutually determined level, as well as warning signs in work areas where EMF exposures are likely to occur.
- Periodic electromagnetic survey of working conditions.
- Regular medical monitoring of all workers exposed to EMFs.
- A right to alternative work during pregnancy that does not involve exposure to EMFs above background levels.
- Rejection of lead aprons and/or lead shields as protective equipment, since lead has no ability to block magnetic fields.[27]



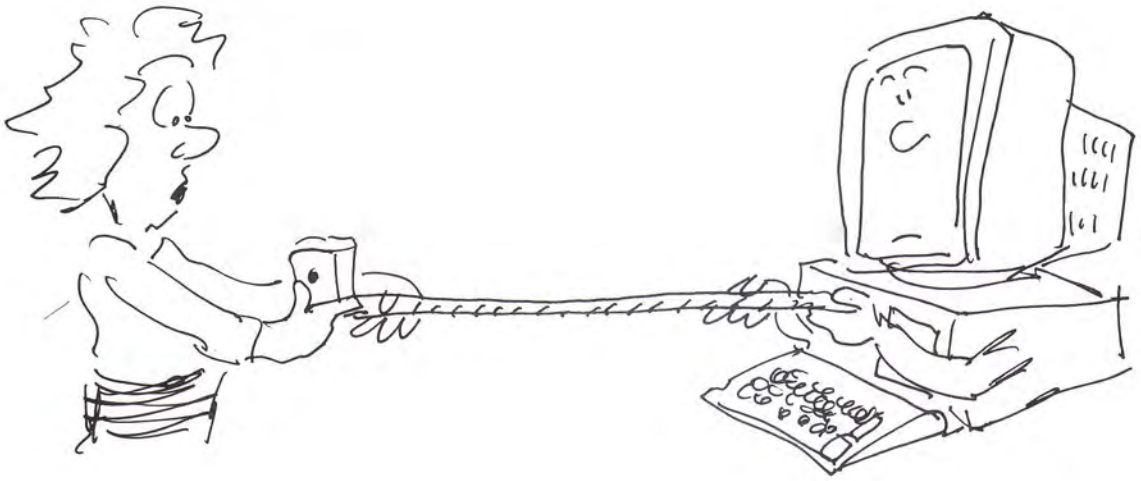
[27] "Electromagnetic Fields: What Are They? Are They Dangerous?" CWA, District 1, New York, New York (handout).

4-3.6. Municipal unions in NYC have won rules to limit EMF exposures.

New York City government workers now have ergonomic standards for new workstations and chairs -- and measures to reduce worker exposures to EMFs from neighboring VDTs.

The standards require that the backs and sides of VDTs be at least 40 inches from any employee, and that, "consideration should be given to purchasing equipment which provides for the reduction and or shielding of EMF emissions from VDTs, prior to the establishment of applicable radiation standards for VDTs."

The new standards resulted from a June 1990 agreement between the city and the two leading municipal unions: the Communications Workers of America (CWA) and District Council 37 of the American Federation of State, County and Municipal Employees (AFSCME).[28]



[28]From *VDT News*, March/April 1991.

4-3.7. Local unions can develop solid ideas about what to do about EMFs.[29]

Find out more about the problem.
Much of the information about EMFs has been gathered and publicized by Paul Brodeur in his new book *Currents of Death: Power Lines, Computer Terminals and the Attempt to Cover Up Their Threat to Your Health* (NY: Simon & Schuster, 1989, $19.95). The book is also summarized in articles in the June 12, 19, and 26, 1989 issues of *New Yorker* magazine.

In addition, the best source of current information on the potential health hazards of EMFs is *Microwave News*, (P.O. Box 1799, Grand Central Station, New York, New York 10163, 212-517-2800). Since a subscription is $250 per year, local unions can encourage their public library or their International Union to subscribe.

Argue for adequate government research funding.
We need to demand more government funding so that careful studies on a larger scale can be conducted. For example, in March 1990, Representative Peter Kostmayer (D-PA) convened a hearing of the House Interior Subcommittee on General Oversight and Investigation on federal power line research. He called for a "doubling or tripling" of the current federal power line EMF research budget of $3 million, and said that "we are not talking about a lot of money when tens of million of people may be protected as a result." For fiscal 1991, Representative George Brown of California got $750,000 appropriated to the Environmental Protection Agency for EMF research.

---

[29] Paul Landsbergis and Eric Scherzer, "A Worker's Guide to Electromagnetic Radiation," OCAW District 8 Resource Center, pp. 24-25.

4.3.7 (continued)

Measure exposure levels.
Just as we need to measure the concentration of chemicals in the air, we need to find out the strength (intensity) of the fields that workers are exposed to. Dosimeters can be used to measure workers' average daily exposure, and direct reading instruments can be used to find out what the strength of the electric or magnetic fields are right now. (See the January/February 1990 issue of *Microwave News* for a list of instruments on the market or send a self-addresed envelope and $1 to *MN*.) We can gain a better understanding of who faces higher exposure even though we are not yet sure what the health risks are of different levels of exposure.

Look at health records.
Does the company (or union) keep records of serious illnesses or deaths of members, including retirees? Are workers compensation records available? These could be valuable first steps in finding out if there are any unusual patterns or types of illnesses. OSHA regulations (29 CFR 1910.20) require employers to share the analysis of any medical surveillance data with workers and their unions.

Health surveys.
Collect information on employees' health symptoms, job titles, regular job activities, etc. Do workers (for example, welders, electroplaters) work near high voltages or current, or step-down transformers, causing potential exposure to electric and magnetic fields? Find out what other hazards workers may be exposed to that might be causing illness, for example, welding fumes or chemical solvents. It is possible that magnetic fields interact with some of these other hazards, increasing the risk of illness. These worker studies may point out the problem exposures and help to create pressure to fund large-scale scientific studies.

4-3.7. (continued)

Negotiate with management.
Possible hazards from electromagnetic fields can be dealt with through a union and/or labor-management safety and health committee, and through collective bargaining. For example in one o the first union contracts specifically addressing ELF or VLF fields, th Writers Guild of America (WGA) and CBS News just agreed to incorporate VDT safety measures in their new contract. The agreement requires CBS, among other features, to arrange workstations so that employees are not working near other VDTs, and to test for VDT emissions.

Reduce exposure.
Electric fields can be shielded, and high magnetic fields can sometimes be reduced by reconfiguring wiring. Since these may be major changes which may take a long time to put into effect, worker exposure can be reduced in the short term by "administrative controls." For example, the number of hours any one worker faces exposure may be reduced by rotating workers out of the area with the highest level of exposure on an hourly or daily basis.

It has already been 10-15 years since the first studies showed a link between ELF fields and cancer. It may take years longer to build an air tight case. Our workplace exposures are continuing, while the studies go on. Given the current evidence, local unions should take steps to reduce exposures now.

4-4. What Is Happening on the Residential Front?

4-4.1. Landowners are demanding that a utility buy their homes.

British Columbia, Canada:

Landowners who live along the site of a proposed British Columbia Hydro (Utility Company) 138 Kv power line are demanding that the Canadian utility buy their homes as it did some of the homes along another 230 Kv line on Vancouver Island. But BC Hydro has refused, citing the BC Utilities Commission's criticism that it acted "imprudently" in making its unprecedented offer.

A spokesperson for BC Hydro said: "It's reasonable to assume that anytime we build or propose a new line, we will have people questioning us. EMFs are an ongoing issue. We accept that." As of November 1989, BC Hydro had purchased 21 homes.

4-4.2. Teachers are wearing meters to monitor EMFs.

Florida:

Teachers at four schools have been ordered to wear meters to monitor EMF exposures from nearby high-voltage power lines. A judge also directed the Palm Beach County School Board to pay for the $48,000 measurement program.

The order followed a court ruling that children at the Sandpiper School in Boca Raton may not play in the school ground which borders on the high-voltage lines. The suit was filed by three parents who sought to close the school because of potential EMF health risks.

Over 100 teachers and teaching aides have offered to participate in the program. Volunteers will wear monitors one day a week and will record their whereabouts every 15 minutes.[30]

[30]Both of these reports are from *Microwave News*, November/December 1989.

4-4.3. Residents are proposing that electric companies investigate design changes and widen right of ways.

Maryland:

In late 1989, the Maryland Public Service Commission (PSC) gave the Potomac Electric Power Company (PEPCO) the go-ahead to complete the last segment of a 243 mile 500 Kv power line loop around Washington, DC. However, in early January 1990, one day before the order became final, the Office of People's Counsel (OPC) appealed the decision.

The OPC called for the PSC to adopt a strategy of "prudent avoidance." They want "the imposition of conditions which will reduce the magnetic field exposure levels in a reasonable and prudent manner."

The OPC proposed that the commission "take reasonable steps to minimize the consequences" -- including requiring PEPCO to "investigate the feasibility of design changes" or to widen the right of way to ensure levels of 10 Mg or less at its edge or to reroute the line through a less developed area. Failure to do so "subjects these residents to a long-term biological experiment, with potential short and long-term health consequences," according to the OPC.[31]

4-4.4. Voters approve *first* citizens' initiative restricting power lines.

Whatcom County, Washington:

Voters in Whatcom County, Washington, approved a citizens' initiative restricting power lines exceeding 115 Kv to industrial areas. Citizen's Initiative No. 4-90 marks the first successful power line siting referendum in the United States.[32]

---

[31]Quoted in *Microwave News*, January/February 1990.

[32]From *Microwave News*, November/December 1990.

4-4.5. Three states are studying ways to reduce EMFs from high-voltage power lines.

Washington, Florida and New York:

In Washington State, the Department of Health (DOH) is leading a task force charged with investigating EMF mitigation[33] techniques and their feasibility. The task force was mandated by a state law which appropriated $40,000 for the two-year project.

In Florida, the Environmental Regulatory Commission has appointed an independent EMF Task Force to lead a two-year, $1 million survey of magnetic field mitigation methods and costs. In New York, the Empire State Electric Energy Research Corporation, a consortium of New York utilities, is soliciting proposals for methods of reducing power line magnetic fields. The successful bidder will characterize significant sources of EMFs and estimate the economic, environmental and social impacts of potential mitigation approaches.

In April 1988, the New York State Public Service Commission ordered New York utilities to survey power line magnetic fields and investigate ways of minimizing exposures. As a result, in April 1990, the PSC proposed an interim magnetic field standard of 200 Mg for new high-voltage line right of ways. The Electric Power Research Institute reported in 1988 that magnetic fields can be reduced by as much as 50 percent by changing the phasing[34] of the lines.[35]

---

[33]The word mitigation means to make less severe or less intense.

[34]Phasing is the arrangement of power lines to minimize EMF emmissions by creating countervailing fields.

[35]From *Microwave News*, May/June 1990.

4-4.6. Town council is *first* in banning all new power lines above 60 Kv for three years.

Rhode Island:

In October 1990, the town council of East Greenwich, Rhode Island banned all new power lines above 60 Kv for three years. The ordinance came about in response to widespread citizen concern about EMFs from proposed 345 Kv and 115 Kv lines. **This is the first moratorium on power line construction in the United States.**

Rhode Islanders for Safe Power (RISP) pushed for the three year moratorium because of the need for further research on the health effects of EMFs and because it "was the least noxious formula and the most likely to be sustained by the Public Utility Commission (PUC)," according to a RISP spokesperson. If the moratorium is overturned, RISP may request the town council to order the more expensive alternative of burying the lines.[36]

---

[36]Quoted in *Microwave News*, November/December 1990.

4-5. Are There Electromagnetic Fields Standards?

4-5.1. Yes, but the residential standards are NOT health-based.

There are no federal government standards for either VLF or ELF radiation. And the standards that do exist are technologically achievable engineering standards or are simply a codification of existing levels.[37]

Some states have established standards for the strength of electric fields from high voltage transmission lines. No states have set standards for distribution lines. Only Florida and New York have set a magnetic field standard. Current state standards are summarized in the following table:

State Regulations that Limit Field Strengths on Transmission Line Right-of-Ways (RoW)[38]

State	Field Limit
Montana	1 kV/m at edge of RoW in residential areas
Minnesota	8 kV/m maximum in RoW
New Jersey	3 kV/m at edge of RoW
New York	1.6 kV/m at edge of RoW; 200 mG limit RoW
North Dakota	9 kV/m maximum in RoW
Oregon	9 kV/m maximum in RoW 10 kV/m maximum for 500kV lines 2 kV/m max for 500 kV lines edge of RoW 8 kV/m max for 230 kV & smaller lines RoW 2 kV/m max for 230 kV and smaller lines at edge of RoW
Florida	200 mG for 500 kV lines at edge of RoW 250 mG for double circuit 500 kV lines at edge of RoW 150 mG for 230 kV and smaller lines at edge of RoW

[37]From "The Powerline Controversy: Legal Responses to Potential EMF Health Hazards," *Columbia Journal of Environmental Law*, vol. 15, no. 2, 1990.

[38]From I. Nair, et al. "Power Frequency EMFs Exposure Effects: Research and Regulation," OTA contractor report, Carnegie Mellon University, January 16, 1989.

4-5.2. And, workplace standards do NOT protect us from low-level EMF exposure.

ELF guidelines in the US and in other countries do NOT take into consideration the potential for cancer promotion at low levels of exposure. The following chart shows some of the current standards designed to protect workers from *acute*[39] health effects from electric and magnetic fields in various countries:

Standards for Workplace Exposure (50 - 60 Hz EMFs)[40]

Source	Electric Field Limit (V/m)	Magnetic Field Limit (mG)
U.S. ACGIH* (proposed)	25,000	10,000
Germany	30,000	50,000
England (proposed)	30,000	17,000
USSR	25,000 (for 5 min.) 5,000	75,000 (1 hour) 18,000 (8 hours)
IRPA**	10,000	5,000

* American Conference of Governmental Industrial Hygienists, an industry group.

** International Radiation Protection Association.

---

[39] By acute we mean such effects as burns or shocks.

[40] This chart is taken from Paul Landisbergis and Eric Scherzer, "A Worker's Guide to EMF," OCAW District 8 Resource Center.

Activity 4: Summary

What Can We Do About EMFs?

1. There are a range of possible policy approaches to take to the problem of electromagnetic fields. We can "do nothing" and wait until more scientific evidence is available. We can adopt a "prudent avoidance" strategy and take certain limited steps in avoiding exposure to EMFs at home and at work. Or, we can "change everything" by reconfiguring our entire electrical environment.

2. There has been one very important EMF court case involving a group of workers who were exposed to pulsed EMF at a Boeing plant. A large monetary settlement was made to Robert Strom, a worker, and a medical program will be provided to all 700 Boeing employees who have worked with EMP radiation.

3. The business community, in general, isn't doing much about EMFs, however some companies like IBM are changing their equipment to shield VDT workers from magnetic radiation. And, the utility industry funds a research institute, EPRI, which is currently conducting work on "mitigation" techniques to reduce the strength of electromagnetic fields.

4. Most unions are just becoming aware of electromagnetic fields and their potential health effects on members. A Canadian union (Communications and Electrical Workers, CWC) is trying to have all its members monitored so that, over time, accurate measures will be available on EMF exposure. The CWC lobbied the Canadian government to investigate the health effects of EMFs.

5. Some unions representing VDT workers have bargained for contract language which calls for pregnant workers to be reassigned to non-VDT work. Others have bargained for radiation emissions testing and have empowered their health and safety committees to establish strong guidelines for VDT use.

continued

Summary (continued)

6. District 1 of the Communications Workers of America (CWA) has developed an informational leaflet on EMF for their members.

7. Community groups across the United States have been actively trying to limit EMF exposure for several years. They have succeeded in getting a utility to buy homes and have fought for teachers to wear meters in a school to measure EMF exposure. Community activists have pressured PUCs to adopt a "prudent avoidance" strategy and proposed that electrical companies redesign their lines.

8. Citizens groups have also voted to restrict power lines and several states are studying ways to reduce EMFs from high-voltage power lines. One town council was the first to ban all new power lines above 60kV for three years.

9. Electromagnetic field standards are almost non-existent. Although residential standards exist for electrical fields from high voltage lines, no states have set standards for distribution lines. And only one state, Florida, has a magnetic field standard.

10. Workplace standards are only for acute effects such as burns or shocks. They do not protect us from low level EMF exposures.

Appendices

Ten Things You Need To Know About EMFs

These ten points were developed for the Labor Institute by Gary Cwitco, National Representative for the Communications and Electrical Workers of Canada. They focus on the technical and medical points that workers should understand about EMFs.

1. Under normal working conditions, there is no immediate or acute risk from EMF exposure. It is impossible to sense the presence or strength of such fields without special meters.

2. Virtually everyone agrees that long-term or chronic exposures to these fields cause what the scientists term "biological effects." This means that something in the body -- everything from sleep/rest patterns to cell chemistry may be affected. The dispute is whether or not these changes are "health effects."

3. Epidemiology in humans shows increased rates of cancer in a number of studies conducted on both worker and community (primarily children) populations. The two major cancer types have been leukemia and brain cancer, although recently there have been indications that breast cancer rates may be increased. In epidemiological terms the increases are low to moderate. In everyday language this means the increase is two or three times greater than the level of disease found in the general population -- i.e. an unexposed group. (One may question the assumption that the general population is an unexposed group.)

4. One theory suggests that these fields do not cause cancer but rather promote its development. This is probably linked in some way to changes in the ability of the body's immune system to fight the growth of cancer cells.

5. There are also studies relating to the reproductive effects of these fields. The majority of studies seem to indicate no effect but there are others that raise questions. Also, it is important to note that some of the studies that have claimed to show no effect give a different result when analyzed by others.

Ten Things. . . (continued)

6. Don't trust the people who give you absolute answers. We don't know for sure what all the effects and hazards are but we do know enough to be very concerned. The absence of a final, complete answer does not mean we should do nothing; it means we don't know enough to do everything.

7. There are two parts to EMF, electric and magnetic. They are measured separately.

8. Electric, or E Field, is measured in volts per meter or kilovolts per meter (V/m or kV/m) and is present whenever two objects are at a different potential. Magnetic, or H field, (sometimes called B Field to avoid confusion) is measured in Tesla (T) or Gauss (G) or microtesla. Note: 1 Tesla = 10,000 Gauss. H Field is produced whenever there is a current flowing in a conductor.

9. More is not necessarily worse, although it might be. The science has suggested that there may be frequency and "intensity windows," time thresholds or "time windows." Also, some of the evidence suggests children may be at more risk than electrical utility line technicians working on transmission lines. (The difference between transmission and distribution, especially in relation to step down transformers, is important in understanding this apparent contradiction.)

10. In general terms, the easiest method for reducing unnecessary exposures to EMFs is to increase the distance from the source. Shielding for electric fields is relatively easy; any thin, grounded conductive material can be used. Shielding magnetic fields is more difficult. It requires special alloys with high magnetic permeability.

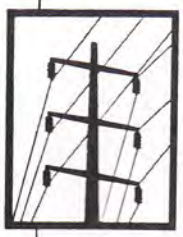
There is also one thing that we need to remember about all occupational and environmental health problems and their solutions -- while the definition of the problem has a scientific component, the solution is always political (this is not to suggest science is not political). When science clearly supports labor's perspective on an issue, it is easier, but by no means guaranteed that the problem will be satisfactorily resolved.

October 1990.

News & Comment

Is There an EMF-Cancer Connection?

The question of whether electromagnetic fields pose a health risk is being taken seriously by an increasing number of researchers, but don't throw out your electric hair dryer just yet



Are power lines and electric blankets hazardous to your health? There are scientists on both sides of the increasingly public debate over the biological effects of electromagnetic fields. Each camp can point to research supporting its position, but what does the evidence really say? Science *now begins a series of three articles examining that evidence. This first one looks at the epidemiological research that is searching for a link between electromagnetic fields and cancer; the second will deal with the cell and animal studies; and the third will consider policy questions and the politics behind the research.*

LIKE MOST SCIENTISTS 10 YEARS AGO, David Carpenter was skeptical of claims that exposure to electromagnetic radiation could promote cancer. But that was before he directed a $5-million project to test those claims with epidemiological and laboratory studies. Now Carpenter, who is the dean of the school of public health at the State University of New York in Albany, doesn't think it's such a crazy idea anymore. "I think there is sufficient evidence to really raise some red flags here," he says.

Although many of the researchers who study this controversial field disagree with Carpenter about the red flags, there has been an undeniable shift in attitude toward electromagnetic fields (EMFs) and their purported health effects. In the 1970s, it seemed absurd that EMFs—which are generated by anything electric, from power lines to household appliances—could be hazardous, even in the tiniest degree. Now it's a legitimate open question.

Much of the rethinking has been prompted by a series of epidemiological studies. Over the past 11 years, a number of researchers have found increased risk of cancer among children who live close to power lines or among men whose jobs expose them to unusually high levels of EMFs. This epidemiological work, which has been highly publicized, has created a great deal of public concern about EMFs.

In Alexandria, Virginia, for instance, the city council has tried to force the local electric company to remove aboveground power lines that run very close to homes in the city's densely packed historic district. Hillsborough County in Florida is fighting the construction of a high-power transmission line on the grounds that the magnetic fields it generates are too intense to be considered safe. In Seattle, a Boeing Company employee sued to be compensated for leukemia that he claimed was caused by on-the-job exposure to EMFs; the claim was denied, but lawyers see many more such lawsuits in the future.

A widely read magazine—*The New Yorker*—has published several sensationalistic articles by a journalist who has made the EMF issue into a personal crusade. And newspapers, television newscasts, and radio talk shows have gotten into the act, worrying their audience members. Meanwhile, a report from the Environmental Protection Agency assessing the possible health effects of EMFs is due out in final form in a few weeks; the draft version of the report labeled EMFs as "a possible, but not proven, cause of cancer." And a bill that would set federal standards for EMF exposures has been introduced in Congress.

How good is the evidence that is generating all this concern? It is, in a word, inconclusive. The half dozen childhood leukemia studies are somewhat contradictory, for instance, and researchers have generally found no increased risk at all among adults living close to power lines. The data do seem to imply that men working in electrical jobs, such as electricians and telephone linemen, are at higher risk of brain tumors and other cancers, but EMFs may not be to blame. Many of these workers have been exposed to chemical carcinogens, such as benzene, that could explain the extra risk.

"It needs to be resolved," says Patricia Buffler, director of the Epidemiological Research Unit at the University of Texas Medical Center in Houston. Buffler, who says she is not persuaded that EMFs are a health hazard, nevertheless believes that epidemiologists need to do another round of studies to resolve the ambiguities in the data.

One of the complications facing epidemiologists is that nearly everyone in the industrialized world is exposed to electromagnetic radiation in one form or another. Created by moving electric charges, electromagnetic radiation propagates outward from any object that carries an electrical current and contains two components that behave quite differently: an electric field and a magnetic field. The electric component pushes or pulls charged particles, such as ions, in the direction of the field; the magnetic component acts on moving charged particles and pushes them perpendicular to their direction of motion.

In terms of possible health effects, the two components have an even more important distinction. An electric field is easily screened—only a tiny part makes it through the walls of a house or even through skin—but magnetic fields travel right through most matter without losing strength.

The EMFs that most people come in contact with are quite weak. The magnetic field generated by an overhead power line or a video terminal, for instance, is normally only a few milligauss, or about 1% of the earth's magnetic field. And although the electric field directly below a high-tension power line can be as much as 10 kilovolts per meter, the corresponding field induced inside the body will be only about 1 millivolt per meter—no bigger than the electric fields naturally generated by some cells.

These facts, more than any other, initially persuaded scientists that EMFs must be safe. How could such seemingly insignificant magnetic and electric fields be dangerous?

So in 1979 when Nancy Wertheimer and Ed Leeper first reported a correlation between childhood cancer and high EMF exposure from power lines, almost no one believed it. Wertheimer and Leeper had performed a case-control study in which they compared the EMF exposures of 344 children in Colorado who died of cancer from 1950 to 1973 with those of an approximately equal number of controls—children born at the same time as the cancer victims but who did not get cancer. The researchers concluded that children from high-exposure homes were two to three times as likely as those from low-exposure homes to develop cancer, particularly leukemia, lymphomas, and nervous system tumors.

It was a nearly unbelievable result, and other researchers didn't have to look too hard to find reasons to doubt it. The study's major weakness was that Wertheimer and Leeper had not actually measured the EMFs that the children were exposed to. They had merely estimated them according to what types of electric power lines ran near the homes. (Such lines carry anywhere from 115 volts to several hundred kilovolts, depending on their function in the distribution system; most lines near homes are no more than 35 kilovolts.) Moreover, this "wire coding" was not even done blind: The two researchers knew which homes had the cancer cases and which had the controls. "Everyone expected that the Wertheimer study's flaws were fatal," Carpenter recalls.

That certainly was Carpenter's expectation. He first got involved in EMF research in 1980 when he was asked to direct a series of EMF studies paid for by New York power companies and administered by the state health department. Carpenter asked David Savitz at the University of Colorado Medical School to try to replicate the Denver study, expecting that the new research would come up negative.

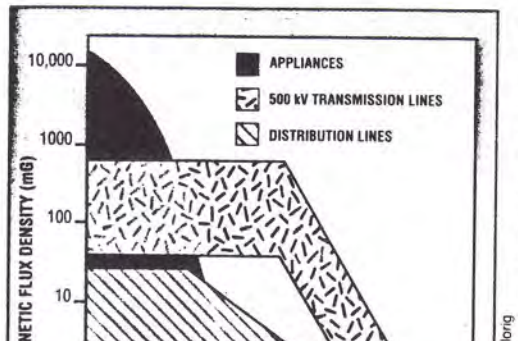
Instead, Savitz essentially replicated the Wertheimer-Leeper results. From a case-control analysis of 356 childhood cancer cases in the Denver area between 1976 and 1983, he calculated a risk ratio of about 1.5—that is, children with high exposure to power line EMFs were about 1½ times as likely to develop cancer as children with very low exposure. Although Savitz's calculated risks were lower than those of Wertheimer and Leeper, his thoroughness gave the results greater weight. For example, Savitz performed statistical analyses to make sure his results were not skewed by such possible confounding factors as socioeconomic class or mothers smoking during pregnancy. "It was that study," Carpenter remembers, "that caused me and most of the panel members [overseeing the New York State studies] to change our position."

In addition to the Wertheimer-Leeper and the Savitz work, four other studies have looked for correlations between EMFs and childhood cancer—with mixed results. One found no increased risks at all for children living close to power lines; another found increased risks of nervous system cancers and lymphomas, but a decreased risk for leukemia; two others found higher risks for various cancers, but the numbers were not statistically significant.

Each of these reports has a variety of flaws. All, for instance, included relatively small numbers of children, and therefore the statistical power of the results is low. But the major shortcoming is that no one has found a consistent dose-response relationship between cancer rates and EMF exposures. If a little electromagnetic radiation is bad, then more should be worse, but that doesn't emerge from the data. One study, for instance, found a higher cancer risk in homes where the average magnetic field was lower.

A related problem is finding a correlation between cancer risk and measured—as opposed to estimated—EMF exposures. Even the well-regarded study by Savitz, for instance, found an increased risk in high-exposure homes as rated by wire coding, but a weaker or absent relationship between cancer rates and EMF exposures as determined by spot measurements in the home.

This is not a fatal flaw, Savitz says. He argues that because electrical usage varies widely from day to day and even hour to hour, long-term EMF exposure may be more accurately estimated by looking at the types of power lines near a home than by taking a one-time measure of the EMFs in or near that house. Still, he says, the question won't be settled until the data show a better correlation between dose and effect.



Y. Rook/adapted from Keith Florig

Magnetic field exposure *varies according to distance and type of equipment.*

That information could soon be provided by John Peters at the University of Southern California, who is putting the finishing touches on a case-control study of 230 childhood leukemia victims in the Los Angeles area between 1980 and 1987. In it he will compare cancer rates with 24-hour records of actual EMF exposures in the homes as well as with exposures obtained by spot measurements and those estimated by wire coding. In addition to the EMF measurements, Peters says he has collected information on "everything else we can thi
that might cause or promote cancer
effort to rule out other possible cause
increased risk appears. He plans to
the results at an October meeting spo
by his funding agent, the Electric
Research Institute. Meanwhile, he is
ing his findings under wraps.

Although a majority of the stud
childhood cancer and EMF exposure
found at least some correlation, those
ing at adults living close to power line
generally been negative. In 1982,
heimer and Leeper claimed to have
increased cancer rates among adults liv
various parts of Colorado who were ex
to higher than average doses of EMF
several other studies since then have
little or nothing. And that's hard to ex
Why should EMFs increase the risk of
hood cancer while having little or no
on adult cancer? One possible explanat
that it is much more difficult to separa
EMFs from other risk factors for adults
for children, but no one really knows.

In contrast to the uncertainty about
dential EMF exposures, the pictur
emerges from occupational stud
sharp. Again and again, epidem
gists have found that workers in va
electrical jobs have higher risks for
ous types of cancer, particularly
and nervous system cancers as w
leukemias. In a recently finished
control study in the Los Angeles
for instance, Susan Preston-Martin
Wendy Mack at the Universit
Southern California found that
who had worked for 10 years or
in a variety of electrical occupation
a ten times greater chance of ge
brain cancer than men in the co
group. "Employment in these occ
tions is definitely conferring some
of risk," Mack says, but "we don't k
whether EMFs are to blame."

The problem, she explains, is
electrical workers may be expose
things besides electric and magn
fields that could be causing the
creased cancer risk. In the past, electric
have worked with organic solvents, suc
benzene, that are known to cause cancer
it's premature to single out EMFs as
culprit.

And proving a dose-response relation
here has been just as tough as in the cas
EMFs and childhood cancer. One wi
noted study, performed by Genevieve
tanoski of Johns Hopkins University,
find a dose-response relationship for can
in male New York Telephone emplo
from 1976 to 1980. Matanoski measu
the average magnetic field exposure am

different types of employees and found that cable splicers had by far the largest doses, followed by central office employees and then installation and repair workers.

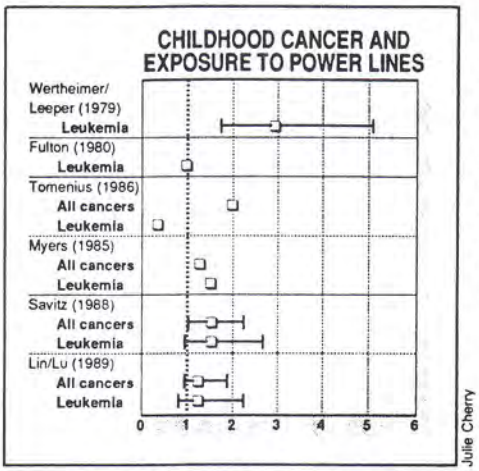
When she compared cancer rates among the various types of employees, she found an ominous result: Cable splicers were nearly twice as likely to contract all types of cancer as company employees who did not work on telephone lines, with the risks for leukemia and lymphomas being particularly high. Among central office workers, who are exposed to short, intense fields from telephone switching machinery, the rates of several cancers were unusually high, although not as high as for the cable splicers. The central office workers were more than three times as likely to get prostate cancer and more than twice as likely to get oral cancer as co-workers who were less exposed. And there were two cases of male breast cancer, a disease so rare that no cases at all would be expected among a group as small as the one Matanoski studied.

That suggestive finding by Matanoski was supported by a study announced in June by David Thomas of the Hutchinson Cancer Research Institute in Seattle, Washington. In a case-control study of 250 male breast cancer patients, Thomas found a strong correlation with jobs that involved exposure to EMFs. He calculated that men whose jobs involved some exposure to EMFs were nearly twice as likely to have breast cancer as those men with no exposure, and men likely to have the highest exposures—electricians, utility linemen, and power plant workers—had six times the risk of developing breast cancer as men who worked in occupations with no EMF exposure.

But other studies have found no evidence of a dose response for EMF exposure. A 1987 report by Terry Thomas at the National Cancer Institute found an increased risk of brain cancer among electrical workers, but apparently not as a result of their EMF exposure. When Thomas removed those cases who had been exposed to lead, soldering fumes, and organic solvents, the risk for brain cancer among the remaining workers was much less than that for the general population.

More recently, Joe Bowman at the University of Southern California finished a dose-response analysis of a 1985 study in which Neal Pearce of the Wellington School of Medicine in New Zealand found an increased risk for leukemia among electricians and radio and television repairers and assemblers in New Zealand. Bowman measured the average magnetic field exposures for the various occupations and found no dose response. Welders, for example, had the highest exposure to electromagnetic fields but no leukemia cases. Although the low numbers of cases limit the study's statistical power, it is "a strike against the hypothesis that all EMFs cause cancer," Bowman says.

Individually, the various epidemiological studies can each be challenged on one ground or another, but as a group they have a rough consistency that is harder to ignore. The cancers linked with EMF exposure are usually leukemia, lymphomas, and nervous system cancers, and the risk rates comparing exposed with unexposed persons are usually on the order of two or three.



Increased risk? *Most studies find risk ratios between 1 and 2 for childhood cancer.*

Savitz, who is now at the University of North Carolina, has performed a meta-analysis on leukemia among electrical workers in which he combined and analzyed the data from 11 occupational studies, some negative and some positive. He found that as a group the studies imply a small but unmistakable effect. For a wide range of occupations that involve some EMF exposure, the risk for developing leukemia was 1.2 times that of the general population.

If the increased risk is real, Savitz says, the calculated risk ratios almost certainly understate the size of the effect. The occupational studies, for instance, usually judge how much EMF exposure a person had over his career by relying on job titles. This imprecise approach must certainly lead to a great deal of misclassification, which will tend to bias the results toward a lower risk.

On the other hand, some researchers suspect that better studies, particularly those looking at childhood cancer, might find little or no risk from EMFs. Buffler at the University of Texas Medical Center points out that as the studies have improved, the risk ratios have tended to get smaller. This is particularly evident when comparing the Wertheimer-Leeper work with the Savtiz results. This pattern argues against the existence of a much larger risk that is waiting to be identified, she says.

And even if the effect is real, EMFs are clearly not as dangerous to the general population as smoking, for instance. Electricity usage has doubled several times in the last 40 years—and with it, probably, the average exposure to EMFs—but there has been no corresponding giant upsurge in childhood leukemia, or any of the other cancers suggested by the epidemiological work. If the implications of the Savitz study are true, then roughly 15% of childhood cancers are due to power line exposure, and Carpenter thinks it's reasonable to guess that another 15 to 25% could be caused by appliances. But if 30 to 40% of childhood cancers are caused by EMFs, there should have been a big jump in these cancers over the last 40 years. Epidemiologists don't agree on exactly how much cancer rates have changed over time, but it would be hard for them to miss something this large.

Scientists would also like to understand the biological processes by which EMF exposure might lead to cancer. Laboratory investigations have shown that EMFs can indeed elicit some effects in cells, including changes in hormone levels, in protein synthesis, and in ion flow across cell membranes. But so far this research has not produced a "smoking gun"—there is no clear laboratory evidence that EMFs either cause or promote cancer. Without such evidence, most researchers are reluctant to pin the carcinogen label on EMFs based on the somewhat ambiguous epidemiology studies.

What is needed, researchers say, is more research, and that is coming. Two or three epidemiological studies, including Peters', are scheduled to be released in the next couple of months, and several large projects are under way which won't be finished for 2 or 3 years. This next generation of research will include several improvements over its predecessors. The studies will in general be much larger—large enough to provide some real statistical power—and they will take into account what researchers have learned in the past few years about measuring EMF exposures. "If the next wave of studies doesn't answer the question," says Bowman at the USC, where several of the studies are being done, "it probably won't be decided by epidemiological means."

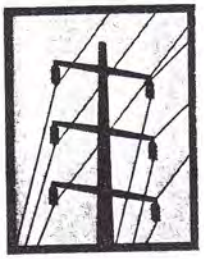
■ ROBERT POOL

ADDITIONAL READING

I. Nair, G. Morgan, H. K. Florig, *Biological Effects of Power Frequency Electric and Magnetic Fields* (Office of Technology Assessment, Washington, DC, 1989).

Electromagnetic Fields: The Biological Evidence

Researchers now accept that even relatively weak EMFs have biological effects, but the evidence for health effects remains "iffy"



The second in a series.

OVER THE PAST FEW YEARS, epidemiological studies that seem to show links between exposure to electromagnetic fields (EMFs) and cancer—especially leukemias, lymphomas, and brain cancer—have generated headlines and prompted public concern about the hazards of living near power lines and operating electrical equipment. But while these studies are suggestive, they are sometimes contradictory and often lack statistical significance, and that has led most scientists to decide that the epidemiological data by themselves are inconclusive (see *Science*, 7 September, p. 1096). A recent draft report on EMFs and cancer, prepared by the Environmental Protection Agency, concludes, for example, that there is not enough evidence to classify the fields as "probable human carcinogens."

So researchers are studying how the body reacts to EMFs at the cellular level, in the hope that this will shed some light on the epidemiological findings. After more than a decade of laboratory experimentation, there is still no direct evidence that EMFs cause or promote cancer in lab animals. But during that time scientists have discovered a number of ways EMFs can affect biological functions, including changes in hormone levels, alterations in the binding of ions to cell membranes, and the modification of biochemical processes inside the cell, such as RNA transcription and protein synthesis.

Could any of these biological effects explain how EMFs might increase the risk of cancer? Some scientists think it's possible. Calcium ion concentrations in the cell, for instance, plays a major role in cell division, which in turn has an important part in cancer promotion. And recently, researchers at Battelle Pacific Northwest Laboratory in Richland, Washington, have come close to showing a direct EMF-cancer link in rats. They have found that EMFs suppress levels of the hormone melatonin, something that other researchers have shown makes female rats more susceptible to chemically induced breast tumors.

Despite these possible connections, "it's still not clear whether these biological effects translate into health effects," says Imre Gyuk, who manages the EMF research program at the Department of Energy. The Battelle work, for instance, hints at an EMF–breast cancer connection, but the epidemiological evidence pointing toward breast cancer is weaker than for leukemias, lymphomas, and brain cancers. Many of the laboratory experiments have been done at EMF intensities thousands of times higher than those people normally encounter at home or at work. And little of the data has been independently replicated by researchers in separate labs. As a result, Gyuk says, many of the results are still "iffy."

To some researchers, it is amazing that the

Battelle Pacific Northwest Laboratory

Breast cancer connection? *Bary Wilson's melatonin work is suggestive.*

EMFs produced by power lines and electric appliances have any effect on the body at all. In the early and mid-1970s, most scientists thought that because these fields have low frequencies—and thus low energies—they would be far too weak to have biological effects. The energy carried by photons of 60-hertz electromagnetic radiation is too meager to break chemical bonds, as x-rays do, or even heat up things in their path, as microwaves do. So how could EMFs have any biological effects?

The answer to that question, it now seems, may lie in the fact that low-frequency EMFs induce weak electric fields inside the body. Low-frequency EMFs—such as those produced by the 50- and 60-hertz electric currents in power distribution systems—behave as if they consist of independent electric and magnetic fields, each of which interacts with the body in its own way. An external electric field induces a much smaller electric field inside the body—usually about one ten-millionth the size of the applied field—and this induced field accelerates ions, creating electrical currents in and around cells. An oscillating magnetic field, such as from a 60-hertz power line, also creates an induced electric field and currents.

If these oscillating fields do affect cells, "the cell membrane is where the interaction is likely to be," says Jim Weaver, a physicist at the Massachusetts Institute of Technology who studies the effects of physical stimuli on biological systems. The EMFs may alter something on the membrane, perhaps the conformation of receptors on its surface; these changes in turn appear to modify signals that are sent through the membrane into the interior of the cell; and the final result is a change in some aspect of the cell's biochemistry, such as protein synthesis.

The problem with this model, though, is

Face to Face with EMFs

Standing in the grasp of an intense electric field is a spooky experience. You see nothing and hear nothing, but suddenly the hairs on the back of your neck are standing on end. As the field increases, the sensation spreads across your body. "You can feel a pulsing," says Charles Graham, who runs an electric field exposure test facility at Midwest Research Institute in Kansas City, Missouri. "It's a creepy, crawly feeling, like bugs crawling across your skin."

A magnetic field is harder to detect, but one that is 200 times as strong as the earth's magnetic field and oscillating at 20 times a second does the trick. Under those conditions, the magnetic field interacts directly with the retina and becomes palpable as waves of faint light that ripple across the visual field.

The fields that produce these dramatic sensations are stronger than anything a person normally encounters, even standing directly under a high-tension power line. In fact, most electromagnetic fields (EMFs) outside the laboratory are imperceptible. But imperceptibility does not imply the lack of an effect, and researchers who study how humans and other primates respond to EMFs have found that physically undetectable fields can produce physiological and behavioral changes. So far, however, none of these whole-body changes have been linked to specific health effects.

In the mid-1960s, Russians scientists reported that workers in a high-voltage power switchyard were suffering from headaches, fatigue, and decreased libido, and there have been anecdotal reports of various physiological effects of EMFs since then, but most of the observations have been poorly characterized. MRI's Graham is trying to change that. He has exposed human volunteers to 60-hertz EMFs of slightly higher intensities than those directly under a high-voltage transmission line: electric fields of up to 12 kilovolts per meter and a magnetic flux of as much as 300 milligauss. At these levels, the subject cannot sense the EMFs, Graham says, but the fields are strong enough to produce consistent changes in both heart rate and test performance.

"The heart rate slows within 3 or 4 minutes after you turn the field on or off," Graham reports, each time returning to its normal rate within a few minutes. The average drop in heart rate is about three beats per minute. Graham has also found subtle changes in brain activity, as well as a slight slowing of reaction time and a minor deterioration in performance on time-related tests, such as estimating the passage of time. All of the changes disappear after the field is turned off.

At the molecular level, Graham says, "We checked out umpteen different biochemical tests, and we haven't found anything"—no changes in hormone levels and no differences in the blood cell counts. That may be because the 24- and 36-hour periods over which the tests were done were too short, he notes. It might take weeks or even years for some effects to appear, but no one wants to try that on humans.

Baboons are a different matter, however, and Walter Rogers at the Southwest Research Institute in San Antonio has exposed these animals to intense electric fields for weeks at a time. The apes can sense fields as low as about 12 kV/m—approximately the same as the perception threshold in humans—and they accept fields up to 66 kV/m without pain. In one experiment, Rogers exposed the baboons to a 30-kV/m field for 12 hours a day, and looked for effects on learning activities and social behavior. "On the first day of exposure, the monkeys don't do anything—they look slightly sedated," Rogers reports. But by the beginning of the third day, they're all performing tasks just like the baboons in the control group, who get no EMF exposure. "There is something interesting [to the baboons] about the first exposure," Rogers says. "Maybe the apes are just responding to a new sensation, getting used to it, and then deciding to act as normal." Social behavior among the exposed baboons is noticeably different at first, too, he says. During the first week, there is more passiveness, more tension, and more grooming and scratching than in the control group, but after another week, their behavior returns to normal.

Like Graham, Rogers ran a battery of biochemical tests on his subjects and found nothing. Nor is there evidence that the baboons' exposures led to the simian equivalent of headaches or fatigue. Although he couldn't ask the apes how they felt, Rogers says that because there was no noticeable difference between the controls and exposed group, it seems unlikely that the fields made the baboons feel worse. The combination of human and ape data seems to imply that whatever effects EMFs may have over periods of years, they do little or nothing obvious over the short run. ■ **R.P.**

that no one knows how the rather weak fields and currents induced by EMFs could make their presence felt in the midst of the electrical activity that naturally takes place inside the body all the time. Cells maintain electric fields across their outer membranes, for instance, that are billions of times larger than the electric fields induced by EMFs from power lines. And the electric signals of the heart induce currents in the tissue surrounding the heart that are as high as 10 to 100 milliamperes per square meter—100 to 1000 times as intense as the currents induced by EMFs from power lines.

Several researchers, including Weaver, have suggested ways in which the small signals from EMFs could be detected by cells, but they are all rather speculative. At this point, the only thing that appears certain is that cells do manage somehow to respond to EMFs no larger than those commonly found in the environment.

One such response that has been replicated many times is a modification of melatonin production by the pineal gland. Melatonin is a regulatory hormone whose levels have been linked to various cancers, especially breast and prostate, as well as to the functioning of the immune system. At Battelle Pacific Northwest Laboratory, a series of studies has shown that 60-hertz electric fields of about 2 kilovolts per meter reduce the amount of melatonin in the rats' pineal glands at night, when melatonin levels are normally at their peak. And at the University of Texas Health Science Center in San Antonio, Russel Reiter has found that by quickly turning on and off magnetic fields of 0.8 gauss—twice the strength of the earth's field—he can reduce rats' nighttime melatonin levels by 30 to 50%.

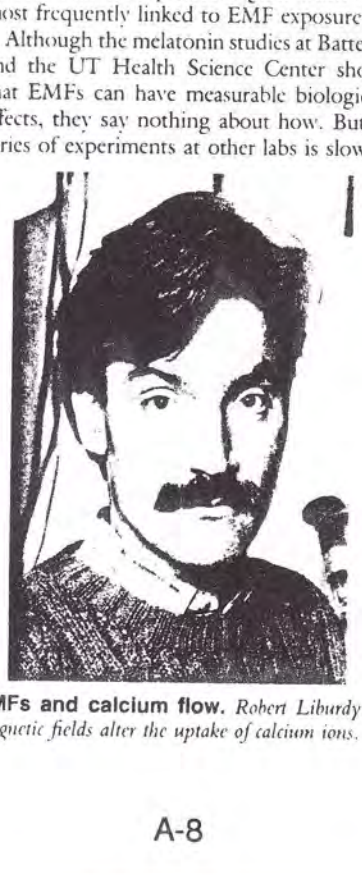
The melatonin studies may be one experiment away from finding a direct link between EMFs and cancer. Bary Wilson at Battelle notes that other researchers have found that lower melatonin levels leave the rats vulnerable to chemically induced mammary tumors. Rats whose pineal glands have been surgically removed are more likely to develop tumors, and will develop more tumors on average, than rats with intact pineal glands; on the other hand, rats whose pineal glands have been removed but that are given melatonin injections are no more likely to develop tumors than the controls.

Battelle scientists plan to attempt to reproduce the results with EMF exposure in place of the pinealectomy. They hypothesize that the EMFs will lower melatonin levels, leaving the rats more prone to developing tumors. Preliminary, unpublished data do show an effect, Wilson says, but it was necessary to put together data from two groups of animals to get statistical significance, weakening the overall results. He now plans to perform the experiment on a larger group of animals in hopes of getting statistical significance from a single data set.

The melatonin work has also received support from a recent epidemiological study. In 1987, Richard Stevens at Battelle reasoned from the laboratory evidence to suggest that EMFs might promote breast cancer, although at the time there was no epidemiological evidence of that. He pointed out that since melatonin suppresses sex hormones, lower levels of melatonin would lead to higher levels of estrogen and prolactin, which are known to be associated with increased risk of breast cancer.

In June, epidemiologist Paul Demers at the Hutchinson Cancer Research Center in Seattle released a report that seems to have borne out Stevens' prediction. The study found that male electricians, utility linemen, and power plant workers had six times as great a chance of developing breast cancer as males who worked in jobs with no EMF exposure. Now Stevens and workers from the Hutchinson Center are putting together a proposal to look for a link between female breast cancer and EMF exposure. Two earlier studies have looked for such a link with conflicting results, Stevens notes. One saw a correlation between EMF exposure and female breast cancer, and the other didn't, but neither result had a high statistical significance. No laboratory data, however, yet bears on the childhood leukemias and brain cancers that the epidemiological work has most frequently linked to EMF exposure.

Although the melatonin studies at Battelle and the UT Health Science Center show that EMFs can have measurable biological effects, they say nothing about how. But a series of experiments at other labs is slowly assembling a picture of the ways in EMFs interact with individual cells.



EMFs and calcium flow. *Robert Liburdy's magnetic fields alter the uptake of calcium ions.*

The first clear, reproducible evide EMFs affecting biological tissue wa observation of a change in how ca atoms leave the cell membrane. In Suzanne Bawin and Ross Adey at the Biology Laboratory at the Universi California, Los Angeles, took the b from freshly killed chicks, cut them in put them in solution, and exposed on to an electric field and used the other h a control. They found that the brain exposed to the electric field held onto more calcium than the unexposed cells. Blackman, a researcher at the Environm Protection Agency and current preside the Bioelectromagnetics Society, has seen a modification in the binding of um to the membrane, although he u different type of EMF exposure and results generally show less calcium bin in the exposed cells rather than more. B man is one of the few researchers reports seeing effects at EMF levels co rable to normal background in homes.

At Lawrence Berkeley Laboratory, ert Liburdy has recently completed a s of experiments in which he altered calc uptake in rat lymphocytes with magn fields comparable in intensity to some o pational exposures. He found that, in un turbed cells, EMF exposure did not a how much calcium the cells took in fro surrounding solution, but when he dosed the cells with a mitogen—a substa that triggers cell division—the EMFs' e sure did increase calcium uptake. The crease varied from 20% to 200%, he sa

"This could explain how cell proliferat and division could be altered by signal the cell membrane," Liburdy says. Once mitogen binds to the cell membrane sends a signal to the interior of the cell eventually triggers cell division. Calci flow through the membrane is an import part of this signal, and the increased calci uptake is an indication that the mitoge signal is somehow being amplified by EMFs, Liburdy says. Since cancer growt dependent on cell proliferation, these fi ings might offer a way that EMFs co promote cancer, Liburdy adds, but the c nection is rather tenuous.

At the University of California, Riversi biochemist Richard Lubin is also trying trace the path of EMF-induced effects on cell membrane and into the cell. He wo with osteoblasts, the specialized cells t produce bone. For more than 15 yea orthopedic surgeons have used strong, p sating magnetic fields to speed the heali of fractures that have not joined by the selves, but no one understands why t

fields trigger the bone healing. Lubin now thinks he is close to an answer.

Once again, the EMFs appear to be modifying a signal that passes across the membrane—this time a signal triggered by parathyroid hormone, a substance that stimulates the breakdown of bone and inhibits bone growth. Magnetic fields, Lubin says, seem to block the action of this hormone. To test the effects of high-intensity magnetic fields on the receptor for parathyroid hormone, he did a series of experiments using monoclonal antibodies designed to recognize various parts of the receptor. Turning on a magnetic field doesn't alter the binding of monoclonal antibodies designed to mimic the hormone, Lubin says, "but the monoclonal antibodies that recognize the signal transduction region are being affected." His conclusion: "The induced electric fields are changing the pattern of charges on the surface [of the membrane] so that the receptor is not in the best configuration to transmit its signal."

Inside the cell, the result is a decrease of up to 80% in the amount of cyclic adenosine monophosphate (cAMP) , an important regulator of cell metabolism. The decrease in cAMP somehow causes an increase in bone synthesis, but that part of the picture is still out of focus.

Researchers have identified several other functions inside the cell modified by EMF exposure. Some have reported that pulsed magnetic fields can alter DNA synthesis. And in a series of experiments at Columbia University in New York City, Reba Goodman and Ann Henderson have modified RNA transcription—the process of making molecules of messenger RNA from the DNA template—and protein synthesis. Working with both 60-hertz magnetic fields and the complicated pulsed fields used to facilitate bone healing, they found that their cell cultures produced more than the normal amount of some proteins and less of others.

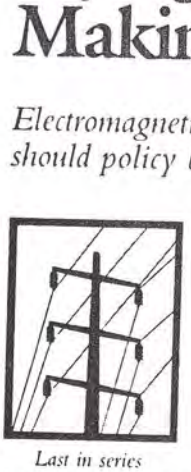
On the other hand, a number of experiments have shown that low-frequency EMFs apparently do not cause mutations in the cellular DNA. This is consistent with theory. Since low-frequency EMFs have too little energy to damage molecules.

So does any of the laboratory evidence point toward a connection between EMFs and cancer in humans? As with the epidemiological data, the laboratory data remains maddeningly inconclusive. The most suggestive evidence—the melatonin work—points toward breast cancer, which is not one of the types of cancer with the most epidemiological data behind it. For now, says Gyuk at DOE, what is known about the biological effects of EMFs makes it at least possible that the fields could promote cancer. But whether "possible" ever turns into "probable" depends on the results of further research. ■ **Robert Pool**

Science, vol. 249, September 21, 1990, © AAAS

Flying Blind: The Making of EMF Policy

Electromagnetic fields may be dangerous—or they may not. How should policy be formulated in this state of confusion?



Last in series

WHEN THE BOEING Company agreed in August to pay $500,000 to ex-employee Robert Strom, who claimed that on-the-job exposure to electromagnetic radiation had given him cancer, it dramatized how high the stakes have become in the controversy surrounding electromagnetic fields (EMFs). Strom, who for 3 years had tested how MX missiles withstood electromagnetic pulses, later developed leukemia and blamed the company, citing scientific evidence that EMF exposure may be linked to different types of cancer. Although Strom had lost an earlier case for worker's compensation, Boeing decided to settle this one out of court, and observers say the decision could open the door to a rash of personal injury cases where cancer victims try to pin the blame on EMF exposure.

But whether Strom *vs.* Boeing is the beginning of a trend or just a one-time accommodation, one thing is clear: EMFs pose a dilemma. On the one hand, there is no solid proof that EMFs are dangerous. Several epidemiological studies have found links between EMF exposure and certain types of cancer, especially leukemias, lymphomas, and brain cancers, but the data are inconclusive (*Science*, 7 September, p. 1096). And lab experiments have shown that low-frequency EMFs like those produced by power lines and electrical appliances can have biological effects, but there is no direct evidence that these effects lead to cancer or other health problems (*Science*, 21 September, p. 1378).

On the other hand, there is an increasing consensus that EMFs may pose some type of health hazard for humans, and many scientists believe this possibility cannot be ignored. "The researchers I speak to put the chances at between 10% and 60% that EMFs will turn out to have some health effects," says Granger Morgan, head of the Department of Engineering and Public Policy at Carnegie Mellon University in Pittsburgh. And, as Strom's case suggests, EMFs have already proven to be threatening to one kind of health: the financial health of corporations. The number of personal injury cases involving EMFs is small but growing, says Thomas Watson, a Washington, D.C., attorney who represents utilities and appliance manufacturers on EMF-related matters. There have also been dozens of attempts by citizens' groups and local governments to block construction of transmission lines and electric substations. "The increasing legal and regulatory proceedings," Morgan says, "indicate that there is a growing social cost of doing nothing."

The EMF quandary is typical of the problems that face policy-makers any time they tackle an issue that depends on scientific information, but on which the scientific data are far from conclusive. Morgan, who has done an extensive study of policy-making in such data-poor settings, says it is possible to formulate a reasonable course of action for the next few years until more is known about EMFs, and he identifies three issues that need to be addressed: regulation of EMF exposure without complete knowledge of the fields' biological effects, funding of further research, and preparation for the possibility that there is a real problem.

Each of these issues offers its own challenges. Regulation is potentially the most contentious issue since it could be quite expensive to industry, but so far there are few limits on EMF levels. The federal government has no guidelines on EMF exposure, although Representative Frank L (D–NJ) has said he plans to introduce lation to set national exposure stan Seven states limit the maximum electr near high-voltage transmission lines two of those also have limits on the m ic fields, but those limits are mostly eff make sure that new lines generate no fields than existing ones. And no currently limit the fields from distrib lines, which carry electricity to indi buildings.

Carnegie Mellon University

Prudent avoider. *Granger Morgan advises doing the easy things to lessen EMF exposure.*

Even if EMFs should prove dange there is a major stumbling block to dec what to regulate: "We don't know e what the concept of dose should be," Thomas Tenforde at Battelle Pacific N west Laboratory in Richland, Washin Laboratory studies have shown that biological effects of EMFs can vary in usual ways as the intensity of the changes—sometimes a field of one inte will have an effect, while intensities e higher or lower have none. This m setting an EMF intensity standard prob atic, to say the least. "The guidelines we for chemical carcinogens are [probably] appropriate for this agent," says Re McGaughy, who is overseeing a repor EMFs and cancer for the Environme Protection Agency.

In the face of such uncertainty, gov ments have a number of options, Mor says. The most common approach so far been the similarity-based approach, wh simply means: "Don't do anything to m the situation worse than it is." New Yo for example, is preparing to adopt codes will limit magnetic fields from new transm sion lines to 200 milligauss on the edge the right-of-way, a limit that was det mined by measuring the magnetic fields n existing transmission lines.

Some observers argue, however, that su standards are meaningless and could dama industry. "You're trying to pick a numb because someone says to pick a number, b there's no real basis for it," says Bill Fee president of the consulting firm Elect Research and Management in Pittsburg The danger here, he says, is that once t precedent exists for setting limits, agenc or legislatures may well set limits that a quite expensive to meet without any pa back in terms of a healthier environment.

Morgan suggests it should be possible avoid such problems by using "prude avoidance"—doing the relatively easy thing to sidestep a risk. "In our private lives," says, "we make these judgments all th time." As an example, he tells how he rea ranged the furniture in his son's bedroom s that the bed was no longer adjacent to th point where the electric power cable can

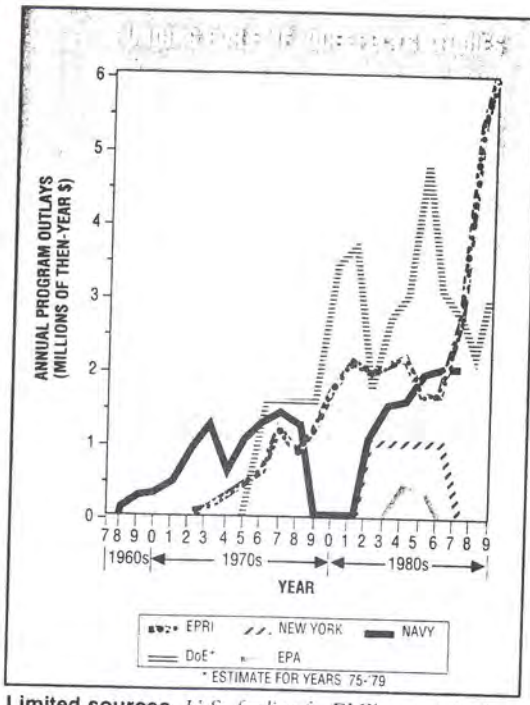
into the house. "I would not spend large amounts of money to redesign my house," Morgan says, "but if it's something simple, why not?"

Indeed, the idea of prudent avoidance has already been used in at least one regulatory case, says attorney Watson. Last year, the Public Service Company of Colorado applied for an upgrade of an existing transmission line. During the hearings, Watson says, "we showed why the utility's work in designing and routing was consistent with prudent avoidance." The upgrade was approved.

It won't be easy to legislate prudent avoidance, Morgan says, since the U.S. legal system tends to classify things as either safe or hazardous. "I can envision the tort system shoving you into a position where you have to spend unlimited money to avoid the fields." Nonetheless, Morgan thinks laws and regulations could be written in such a way to keep the money and effort spent on limiting EMF exposure to a reasonable level. "You could probably justify spending up to a few thousand dollars per person-exposure avoided," he says, based on how much is spent to avoid other hazards and on the current evidence concerning EMFs.

The long-term solution, however, is obviously to understand the biological effects of EMFs well enough to know whether a problem exists, how bad it is, and what to do to avoid it, and this means more research. But research takes money, and there's the rub. Over the past decade, federal and private funding of EMF research has been spread so thin that there has rarely been enough even for replications of positive experiments. "Everybody's working on a different project," says biologist Reba Goodman at Columbia University, who studies how magnetic fields affect RNA transcription. "It's crazy. It's the money."

And that seems unlikely to change any time soon, given the federal budget constraints that Congress is wrestling with. New Jersey's Pallone introduced a bill this summer that called for a 5-year, $34-million research program, but it didn't make it out of committee. And George Brown (D–CA) offered an amendment to an Environmental Protection Agency authorization bill to give the agency $5 million for EMF research from 1991 to 1993, but it, too, went nowhere. That leaves the Department of Energy as the main federal sponsor of EMF research, with $3 million in 1990 and a still-to-be-determined amount for 1991. It could be anywhere between $1.7 million and $4 million, says Imre Gyuk, DOE's program manager for EMF research.



Office of Technology Assessment

Limited sources. *U.S. funding for EMF research has been mostly through the Electric Power Research Institute and DOE.*

Some scientists say that the source of the funds for EMF research is just as important as the amount: "Who controls the funds? That's the only question as I see it," says Allan Frey, an independent consultant and long-time researcher into the biological effects of electromagnetic radiation. To date, most of the funding for EMF research has come from agencies that have a real or perceived tie to the electric power industry.

The Electric Power Research Institute (EPRI), a private organization funded by utility companies, has consistently been the major funding source for EMF experiments; this year it will spend $6 million on the research. In the federal government, most of the low-frequency EMF work has been paid for by DOE, which many scientists perceive as having a pro-energy bias. "Each [of the major funding agencies] has very decided views," Frey says. "Scientists are concerned about losing funding if they upset their sponsors. It's a real fear."

For their part, the funding agencies deny they put any pressure on researchers. "We all want to know the truth," says Leeka Kheifets, an EPRI program manager in charge of epidemiological studies. And some scientists agree. "We've been totally left alone to do this study," says Michael Bracken, a Yale epidemiologist overseeing an EPRI-funded project on the effects of electric blankets on pregnant women. "The people we deal with [at EPRI] are scientists just like we are." If it were any other way, Bracken says, he would quit.

But other researchers say they can't be oblivious to the source of their money. "These are expensive experiments and we can't afford to lose the funding," says one scientist who has been in the field for several years. That researcher adds that while the funding concerns do not affect how the research is conducted, they do make a difference, for instance, in how the results are reported to the media. "I don't want to come across as some nut who scares the whole population," the researcher says.

As a result, some researchers are calling for other federal agencies to play a role in funding EMF research. One candidate is the Environmental Protection Agency, which had a small low-frequency EMF program in the mid-1980s until budget cuts killed it. The agency is interested in getting back into the field, says the EPA's McGaughy. But that agency too is subject to political influences that may play a role in determining its posture toward EMFs. The report on EMFs now under revision at EPA provides a case in point.

In a preliminary draft of the report, the authors had concluded that electromagnetic fields were a "probable human carcinogen," a classification that would have made them subject to a variety of regulations. But "probable" was weakened to "possible" by higher-ups in the EPA, and several media reports suggested White House pressure was behind the switch. The White House did see the preliminary draft, McGaughy acknowledges, but he says the decision to make the change "came from our own in-house discussions."

Conversely, observers familiar with the workings of EPA suggest that politics may have had a role in the original "probable carcinogen" classification. "In the last 1½ to 2 years, [some people at the EPA] have decided that EMFs are a way to get their budget jacked up," says one university scientist close to the field. An official in another government agency analyzes the report this way: "The original bias was, 'Go find the dirt—there is a causal connection [between EMFs and cancer].' Then a bias was put on top of that saying, 'It's not all that serious.'"

Perhaps the best candidate for new EMF funding, many researchers say, would be one with no previous connection with EMFs and with a solid track record in funding basic biological research. These criteria seem to point naturally to the National Institute of Environmental Health Sciences,

one of the National Institutes of Health. In the past, NIH has had a reputation among researchers as not being very receptive to proposals to study EMFs, but that seems to be changing. "We do have an interest [in funding EMF work]," says Anne Sassaman, director of extramural research and training at NIEHS, which is located at Research Triangle Park, North Carolina. Two weeks ago, Sassaman met with representatives from several other funding agencies, including the EPA and the National Institute of Neurological Disorders and Stroke, as a "first step" toward funding EMF research, including a possible "targeted program."

Whoever funds the basic biological research, there is one other funding issue that must be considered. "If EMFs do pose a risk, the persuasive evidence could emerge rather quickly—within 5 to 8 years," Morgan says. "There will then be fairly rapid pressure to start doing things to avoid EMF exposure." So if we are to avoid "lots of dumb, cost-ineffective measures" 5 years from now, research on lessening EMF exposure needs to start immediately.

Some simple steps have already been worked out. Last year, IBM announced it had found a way to reduce electromagnetic radiation from its video display terminals. Northern Electric, manufacturer of Sunbeam electric blankets, now makes a blanket with greatly reduced field strengths. And most utility companies are arranging the wires in their high-voltage transmission lines to reduce the magnetic fields, Feero says. However, EMFs from local distribution systems, which have been implicated in some epidemiological studies as being linked with childhood leukemia, will be much harder to reduce, says Frank Young at EPRI. One major problem is that the grounding of home electrical systems to water pipes or the earth creates a return circuit independent of the utility wires, and the current through this grounding system creates EMFs in a complicated fashion.

The utility industry is already beginning to study how it might solve these problems, however, and that decision—undertaken even before the fields are proven to be a hazard—seems to sum up the entire dilemma over EMFs. This research policy, as obvious as it seems, could end up costing power companies a lot of money, Feero says. "The trouble is, as soon as the industry comes up with a technique to lower exposure by an order of magnitude, somebody will force them to do it, even without the facts [about risks]. Nonetheless, Feero says the cost of not doing it could prove to be a lot greater if EMF's do indeed turn out to be a human carcinogen. "It's a gamble the industry has to take." ■ **ROBERT POOL**

Science, vol. 250, October 5, 1990, © AAAS

Volume 7, Issue 6
University of California at Berkeley Wellness Letter
The newsletter of nutrition, fitness, and stress management
March 1991
Published in association with the School of Public Health

Computers at arm's length

While computer technology has sped forward, our knowledge about its health effects on humans has not kept pace. One potential hazard in particular worries scientists and the people who work at computers: the risk posed by the electromagnetic radiation emitted from computer screens—also called video display terminals, or VDTs. The debate about this risk heated up last year when *Macworld*, an independently owned magazine for the users of Apple Macintosh computers, reported that cathode-ray-tube VDTs, the most common type, emit relatively high levels of electromagnetic fields, which some researchers have associated with an increased incidence of certain cancers, miscarriages, and birth defects. Since millions of workers and entire industries depend on computers, any changes in the way they are used could entail enormous economic and social costs.

What are electromagnetic fields?

Wherever there's electricity—be it overhead power lines, home appliances, or computers—there are low-frequency electromagnetic fields (EMFs). These imperceptible energy emissions, located at the low end of the electromagnetic spectrum, are produced by alternating current as it surges in electric wires. As the term "electromagnetic" suggests, EMFs have two components, an electric charge and a magnetic attraction. Low-frequency EMFs are less blatantly damaging to living cells than higher-frequency forms of radiation such as X-rays, microwaves, or ultraviolet rays, which contain more energy.

It is very difficult to determine what subtle effects, if any, low-frequency fields may have on living tissue over long periods. It is known that the body's cells have their own electric fields, and some laboratory studies have shown that these internal fields can be disrupted by exposure to even low-energy EMFs. Some scientists hypothesize that subsequent cell changes—notably in cell membranes, genetic material, immune function, and/or hormonal and enzyme activity—may lead to an increased risk of cancer. However, it's hard to extrapolate from test-tube studies on isolated cells to human beings living in the real world.

Why single out computers?

Most electric appliances emit EMFs, but exposure to them tends to be brief (as with hair dryers or toasters) and/or at a distance (at least several feet away, as with TVs). In contrast, millions of people, year after year, spend most of their working hours within a foot or two of VDTs, which have relatively strong fields.

The mechanism by which a VDT displays images on its screen generates electric and magnetic fields in what are called the very-low-frequency (VLF) and extremely-low-frequency (ELF) range, which pass right through the machine's case. It's the magnetic fields that scientists are most concerned about and that are hardest to shield. Various appliances produce similar energy fields, but the distinctive type from VDTs is emitted in sharp bursts—in what's called a pulsed "sawtooth" pattern—which, some researchers hypothesize, may allow them to have a greater effect on tissue.

A number of studies have looked at the potential health hazard posed by the long-term exposure of both animals and humans to low-frequency electromagnetic radiation. Although some studies have found, for instance, a link between EMFs and increased birth defects in animals, or an increased risk of cancer (especially leukemia, lymphomas, and brain cancer) in electrical workers or even in children living near high-voltage power lines, other studies have found no clear link. Earlier this year the Environmental Protection Agency concluded that EMFs are "a possible, but not proven, cause of cancer in people." *At this time, it is impossible to say whether EMFs pose any risk, and if they do, at what dose.*

Concern specifically about VDTs began in the late 1970s, when reports appeared about computer operators having high rates of headaches, miscarriages, and other health problems. Yet over the years, studies on VDTs have yielded contradictory or inconsistent results. And those that have found an increased incidence of cancers and birth disorders, for instance, generally suggest that the risk is statistically small. In Sweden, meanwhile, the government and labor organizations have set up stringent low-radiation standards for VDTs. There are no such standards on low-frequency VDT emissions in the U.S., though some researchers are now advocating such guidelines.

The only consensus among scientists is that more research needs to be done. A number of long-term studies are currently underway (including ones at the University of California at Berkeley and the Mt. Sinai School of Medicine in New York) and may help clarify matters.

Volume 7, Issue 6
University of California at Berkeley Wellness Letter
The newsletter of nutrition, fitness, and stress management
March 1991
Published in association with the School of Public Health

What to do

Until we know more, it's probably prudent to minimize your exposure if your work involves heavy computer use. Though the evidence about birth defects and miscarriages remains inconclusive, pregnant women in particular should take these steps:

Sit farther from the screen—in most cases this is all you have to do. A few inches can make a significant difference. Electromagnetic radiation falls off rapidly with distance from the source. Try to work at least 28 inches (about arm's length) from the screen. The fields are almost always considerably stronger at the sides and rear of the machines, so sit at least four feet from your colleagues' monitors. (Magnetic-field emissions pass through partitions, walls, and even lead barriers.) In some offices, it may be necessary to rearrange work stations.

An adjustable computer desk with a shelf that pulls out to hold the keyboard will let you sit farther from the screen. If you have trouble reading the screen at that distance, enlarge the type size. If your computer program can't do this, you can buy a special large-type program, a magnifying screen, or a pair of eyeglasses that will let you focus at a distance of 28 inches or more from the screen (regular reading glasses focus at about 18 inches).

Turn off the VDT when you're not using it but sitting nearby. Dimming the screen won't reduce the emissions.

Don't fall for the ads for anti-glare screens that claim to block "radiation." Though these costly devices can block low-frequency electric fields, a *Macworld* study found that they don't block the magnetic fields, which worry scientists most.

Don't trust a bargain-basement EMF meter to give you an accurate reading on your computer's emissions. In any case, if you sit far enough from your VDT, you needn't worry. If you or your employer nevertheless wants to test your monitors, be prepared to spend at least several hundred dollars.

When shopping for a new computer

If you're thinking of buying a new VDT, look for one with lower electromagnetic emissions, such as the following:

• *Models that meet the "Swedish standards."* Several American manufacturers are now marketing "low-radiation" VDTs originally designed for sale in Sweden, where there are strict specifications for VDT emissions. Ask the salesperson about them. Thanks to consumer demand, more such models will undoubtedly be available soon in the U.S.—apparently at little or no added cost.

• *Liquid crystal display (LCD) monitors.* Nonbacklit LCDs, which contain no cathode ray tube, generate extremely low magnetic fields. They are generally employed in laptop models, but are also becoming available in some larger models.

• *Monochromatic screens.* These generally give off less radiation than color monitors. A small monitor, however, doesn't necessarily emit a weaker field than a large one; an undamaged old VDT isn't necessarily worse than a new one.

For an information packet and other data about VDTs, contact the Labor Occupational Health Program at the University of California at Berkeley (2521 Channing Way, Berkeley, CA 94720; telephone 415-642-5507).

COSH Groups*

(No health and safety activist should be without one.)

Alaska

Alaska Health Project
1818 W. Northern Lights Blvd., Ste. 103
Anchorage, AK 99517
(907) 276-2864
Director: Lawrence D. Weiss

California

LACOSH (Los Angeles COSH)
2501 S. Hill Street
Los Angeles, CA 90007
(213) 749-6161
Directors: Bob Villalobos, Chair
Judith Linfield, Staff Coordinator

SACOSH (Sacramento COSH)
c/o Fire Fighters Local 522,
3101 Stockton Boulevard
Sacramento, CA 95820
(916) 444-8134 or 924-8060
Secretary: Chris Weinstein

SCCOSH (Santa Clara COSH)
760 North 1st Street
San Jose, CA 95112
(408) 998-4050
Director: Meta Mendel-Reyes

Connecticut

ConnectiCOSH (Connecticut COSH)
P.O. Box 31107
Hartford, CT 06103
(203) 549-1877
Director: Rick Melita

District of Columbia

Alice Hamilton Occupational Health Center
410 Seventh Street, S.E.
Washington, DC 20003
(202) 543-0005
Director: Brian Christopher

Illinois

CACOSH (Chicago COSH)
37 South Ashland
Chicago, IL 60607
(312) 666-1611
Directors: Donald Hank, Chairman
Michael Ross, Staff

Maine

Maine Labor Group on Health, Inc.
Box V
Augusta, ME 04330
(207) 622-7823
Director: Diana White

Massachusetts

MassCOSH (Massachusetts COSH)
555 Amory Street
Boston, MA 02130
(617) 524-6686
Director: Nancy Lessin

Western MassCOSH
458 Bridge Street
Springfield, MA 01103
(413) 247-9413

Michigan

SEMCOSH (Southeast Michigan COSH)
2727 Second Street
Detroit, MI 48206
(313) 961-3345
Director: Barbara Boylan

New Hampshire

NHCOSH
c/o NH AFL-CIO
110 Sheep Davis Road
Concord, NH 03101
(603) 224-4789

New York

ALCOSH (Allegheny COSH)
100 E. Second Street
Jamestown, NY 14701
(716) 488-0720
Chairperson: Arthur L. Thorstenson
Project Director: Linda A. Berlin

CNYCOSH (Central New York COSH)
615 W. Genessee Street
Syracuse, NY 13204
(315) 471-6187
Director: Gordon Darrow

* As of November 1990

COSH Groups

New York (continued)

ENYCOSH (Eastern New York COSH)
c/o Larry Rafferty
121 Erie Blvd.
Schenectady, NY 12305
(518) 393-1386

NYCOSH (New York COSH)
275 Seventh Avenue, 8th Floor
New York, NY 10001
(212) 627-3900
(914) 939-5612 (Westchester)
(516) 755-2400 (Long Island)
Director: Joel Shufro

ROCOSH (Rochester COSH)
797 Elmwood Avenue, #4
Rochester, NY 14620
(716) 244--0420
Director: Ronald G. Ball

WYNCOSH (Western New York COSH)
450 Grider Street
Buffalo, NY 14215
(716) 897-2110
Director: Roger Cook

North Carolina

NCOSH (North Carolina COSH)
P.O. Box 2514
Durham, NC 27715
(919) 286-9249
Director: Tobi Lippin
Staff: Susan Lupton, Susan Pollitt

Pennsylvania

PhilaPOSH (Philadelphia Project OSH)
3001 Walnut Street, 5th Floor
Philadelphia, PA 19104
(215) 386-7000
Directors: Jim Moran
Joan Gibson

Rhode Island

RICOSH (Rhode Island COSH)
340 Lockwood Street
Providence, RI 02907
(401) 751-2015
Director: James Celenza

Tennessee

TNCOSH (Tennessee COSH)
1515 E. Magnolia, Suite 406
Knoxville, TN 37917
(615) 525-3147
Director: Jim Tramel

Texas

TexCOSH (Texas COSH)
c/o Karyl Dunson
5735 Regina
Beaumont, TX 77706
(409) 898-1427

Wisconsin

WisCOSH (Wisconsin COSH)
1334 S. 11th Street
Milwaukee, WI 53204
(414) 643-0928
Director: Mark Schulz

Canada

WOSH (Windsor OSH)
1731 Wyandotte Street, East
Windsor, Ontario N8Y 1C9
CANADA
(519) 254-4192
Director: Jim Brophy