

VISIT

Vehicle Internal Systems Investigative Team

RADIO-FREQUENCY RADIATION

BIOLOGICAL EFFECTS

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ELECTROMAGNETIC RADIATION SPECTRUM (BOUNDARIES ARBITRARY)

| | IONIZING RADIATION | | | | NONIONIZING RADIATION | | | | | |
|---------------------------------|--------------------|--------|--------------------------|--------|--------------------------|---------------|-------------------------------------|------------|-----------|---|
| Energy (eV) | 10^9 | 10^7 | 10^5 | 10^3 | 10^1 | 10^{-1} | 10^{-3} | 10^{-5} | 10^{-7} | 10^{-9} |
| | Gamma rays | | X-rays | | Ultraviolet | Visible light | | Microwaves | | Radio-frequencies |
| Wavelength (cm) | 10^{-12} | | 10^{-8} | | 10^{-4} | IR | 1.0 | | 10^2 | 10^4 |
| Type of interaction (prevalent) | Nuclear | | Internal orbit electrons | | External orbit electrons | | Intramolecular and intracrystalline | | | Nuclear moment and external magnetic fields |

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PREFACE

The purpose of this review is to provide information on the biological effects and health hazards of radio-frequency radiation (electromagnetic radiation in the radio- and microwave ranges, up through 300,000 megahertz).

Experts fail to agree on the biological effects for a number of reasons. Generally, however, the disagreement lies in the fact that many of the claims cannot be clearly replicated in the laboratory. From a purely scientific viewpoint this means the data must be disregarded. Unfortunately, this does little for the victims of exposure to radio-frequency radiation.

The purpose of this paper is to draw together a sampling of that data to serve as a base of information when examining claims of injury due to radio-frequency radiation.

SAFETY STANDARDS

The United States standard of safety for exposure to microwave radiation is set at a radiation dose of 10 milliwatts per square centimeter of body surface. The standard was based on the work of Dr. Herman Schwan, a research scientist working on the assumption that heat was to only effect caused by microwave radiation. The American Standards Institute has accepted this level as an occupational guideline.

The value accepted as safe in the United States is a thousand times greater than the microwave standard in the Soviet Union. They set the value at 0.01 milliwatts per square centimeter.

DOCUMENTATION

The remainder of this report will draw on the published results of researchers involved in determining the biological effects of radio-frequency radiation. Because the purpose of this paper is to examine why satisfactory answers have not been found in the quest for information about these effects, the material cited will concentrate on "non-textbook" type results.

1. DNA HELIX FOUND TO OSCILLATE IN RESONANCE WITH MICROWAVES
Science News, Vol. 125, p. 248, April 21, 1984

"For the first time, biophysicists have demonstrated that DNA - the molecular code of life - resonantly absorbs microwaves. This finding.....has prompted researchers to suggest that nonthermal genetic effects from low level microwaves are possible."

"Nonthermal means of absorption are far more obscure - and more controversial since they are thought to occur at relatively low power levels Moreover, at low power densities it is difficult to obtain statistically significant data from

laboratory experiments on animals; the results from such experiments as well as epidemiological studies on humans chronically exposed to low level microwaves have largely been inconsistent."

2. GENERATION AND DETECTION OF PULSED X-RAYS FROM MICROWAVE SOURCES. Anthony P. De Minco, Rome Air Development Center, N.Y., Biological Effects of Microwave Radiation, Vol. 1., New York Medical University, 16-18 August 1960. Plenum Press, 1961.

"In high power microwave generators, conditions and components exist wherein the production of soft X-radiation at levels as low as 15 kv, through the "intermediate" range and on up to "hard" X-radiation at 300 kv is possible."

3. BIOLOGICAL EFFECTS OF MICROWAVES. Z.V. Gordon, Foreign Science Bulletin, Vol. 3. No. 1, January 1967.

"The role of the central nervous system in the causation of microwave radiation damage has been the source of much controversy. While some researchers point to the central nervous system as being among the most UHF resistant portions of the body, most Soviet workers contend that it is the most sensitive to such radiation. The response to locally applied microwave radiation in the centimeter range was found to be nociceptive in nature and to include reflex withdrawal movements, elevation of blood pressure, and alterations in rate and depth of respiration. Reaction of the nervous system to microwave radiation is a function of radiation intensity, the range of microwaves, the functional condition of the nervous system, and the typological features of the animal. Intermittent exposure to low-intensity microwaves produced persistent functional shifts within the central nervous system which suggested the possibility of cumulative biological biological effect of microwaves."

4. RESPONSE OF THE NERVOUS SYSTEM TO MICROWAVE RADIATION.

Vladimir Mutschall, Foreign Science Bulletin, Vol. 5, No. 6, June 1969. P. 51.

"The nonthermal intensities applied to humans had produced symptoms primarily of an asthenic nature: increased fatigability, dullness, partial loss of memory and vision, insomnia, headache, excessive perspiration and chill, vertigo, reduced sexual potency, pain in the cardiac region, and dyspnea. Other symptoms indicating functional disorders of the nervous system included increased tendinous reflexes, occasional peritoneal emaciation, and vegetative disturbances such as vasomotor lability, hyperhydrosis, acrocyanosis, stable dermographism, and intensified pilomotor reflex: some individuals had developed trophic changes (nail fragility, trichorrhoea, etc.)"

5. THE MECHANISM OF ABSORPTION OF ULTRAHIGH FREQUENCY ELECTROMAGNETIC ENERGY IN TISSUES, AS RELATED TO THE PROBLEM OF TOLERANCE DOSAGE. H. P. Schwan and Kam Li, IEEE Transactions - Medical Electronics, 23-24 September 1955, Mayo Clinic. P.49.

"At frequencies lower than 400 mc and higher than 3,000 mc, the human body will absorb about 40 to 50 percent of airborne radiation. Between 1,000 and 3,000 mc the percentage of absorbed energy fluctuates between 20 and 100 percent, depending on frequency, thickness of skin, and thickness of subcutaneous fat. Conservative estimates of tolerable amounts of energy should be based, therefore, on a possible 100 percent absorption.

At frequencies lower than 1,000 mc most of the radiant energy is transformed into heat in the deep tissues. Frequencies higher than 3,000 mc cause predominant surface heating. Intolerable temperature rise due to exposure to high frequency electromagnetic waves is less likely, therefore, at high frequencies above 3,000 mc than at lower frequencies below 1,000 mc."

6. HUMAN PERCEPTION OF ILLUMINATION WITH PULSED ULTRAHIGH-FREQUENCY ELECTROMAGNETIC RADIATION. Allan H. Frey and Rodman Messenger, Jr., Science, Vol. 181, 27 July 1973. P. 356.

"A psychophysical study of the perception of "sound" induced by illumination with pulse-modulated, ultrahigh-frequency electromagnetic energy indicated that perception was primarily dependent upon peak power and secondarily dependent upon pulse width. The average power did not significantly affect perception. Perceived characteristics of pitch and timbre appeared to be functions of modulation."

7 HEARING SENSATIONS IN ELECTRIC FIELDS. H.C. Sommer and H.E. von Gierke, Aerospace Medicine, September 1964. P. 834.

"Electrical current of audio frequency passed through the human head by employing various types of electrodes gives rise to hearing sensations."

"In 1961, Frey reported that the human auditory system can directly detect radio frequency energy transmitted through air by electromagnetic waves. Several radio frequencies, transmitted by pulse modulated microwave transmitter, were used. Subjects, exposed to peak power densities of 200 to 300 milliwatts per square centimeter and electric field strengths in the order of 15 volts/cm, reported hearing these modulation pulses."

8. HOW DANGEROUS IS LOW-LEVEL RADIATION? Karl Z. Morgan, New Scientist, 5 April 1979. P. 18.

"It is also evident that all persons do not run the same risk of developing a malignancy from a given radiation exposure and that the risk of some types of cancer is greater for certain people than it is for others. The final onset of a malignancy or other disease may require a series of events. For example, a given type of leukaemia may require as many as three successive events (like throwing three electrical switches connected in series). Some of these switches may be thrown by viruses, bacteria, chemicals, mechanical damage or radiation."

"Studies by Irwin Bross, of the Roswell Park Memorial Institute in New York, support the hypothesis of a series of switches in disease processes and suggest that there may be interactions (synergisms) between the events in the series."

"Thus, because of a genitic inheritance, various diseases, age, sex, eating and smoking habits and, perhaps, many other individual characteristics, certain members of the general population have a higher risk of radiation-induced malignancies than others."

9. ELECTROMAGNETIC FIELDS AND THE LIFE ENVIRONMENT. K. Marha, J. Musil, and H. Tuha, San Francisco Press, 1971. Chapt. 4.

"The best know effect of rf energy absorption in biological material is its heating.... Brief irradiation produces maximum heating at the body surface (skin), often even leading to local superficial burns..... The temperature drops with increasing depth..... It is also possible for some organs to be seriously injured without the entire organism being overheated."

"Workers (in an rf field) complain of headaches and eyestrain, together with a flow tears, of fatigue derived from overall weakness, and dizziness..... At night their sleep is disturbed and they often feel sleepy in daytime.... Sometimes they perceive nervous tension or, on the contrary, mental depression combined with deterioration of intellectual functions (notably memory impairment)... Those affected complain of a pulling sensation in the scalp and on the brow, loss of hair, pain in muscles and in the heart region, and breathing difficulties.... A single irradiation may cause a drop in the resistance of the organism.... With regard to the dependence of the effect of rf field on sex, women are generally more sensitive to this factor than men."

"Soviet authors warn that chronic irradiation at intensities of the order of a few milliwatts per square centimeter are sufficient to produce opacities in the human eye. In such persons, a flow of tears and eye fatigue is observed first, combined with changes in vision, especially a decrease in sensitivity to colored light (especially blue) and defective observation of a white object.... A change in intraocular pressure was also observed to result from chronic exposure to centimetric waves."

"The reactivity of the entire nervous system of an animal is disturbed by an rf field. For example, sensitivity to touch and the threshold of pain are both reduced..... The decrease in the sensitivity of smell can serve as one of the earliest symptoms of the effect of centimetric waves on healthy subjects working with rf installations."

"Disturbances in blood circulation have been described, evidenced by a change in blood flow."

"A number of authors have studied the effects on the kidneys, the adrenal glands and the liver. They found decreased filtration in the renal tubules, perhaps caused by degeneration of the epithelial cells in the distal and proximal renal tubules.... Persons working in rf fields, particularly women, exhibited enlargement of the thyroid gland, though without an accompanying clinical picture of hyperthyroidism.... Rf radiation does not cause histological changes in bone marrow...."

"There is no uniform explanation for the resultant mechanism of the effects of electromagnetic waves. The reason is that there may be a whole series of independent primary mechanisms, several of which may be acting simultaneously for a given set of parameters."

"The group of "resonance theories" also includes the interesting idea of regarding the biological effect of electromagnetic waves as a nonthermal effect resulting from the cyclotron resonance of several notable varieties of molecules in the organism. It is actually a combination of the electromagnetic field with the earth's magnetic field."

10. QUANTITATION OF MICROWAVE BIOLOGICAL EFFECTS. Chung-Kwang Chou and A.W. Guy, U.S. Department of Health, Education and Welfare, July 1977. P.98.

"Although at the threshold of the microwave auditory effect the temperature rise in the tissue increases by only 5×10^{-6} degrees C, this minute but fast temperature rise can generate thermal expansion pressure in the head, resulting in a hearing sensation."

11. LIGHT AND ELECTRON MICROSCOPIC OBSERVATIONS ON THE BLOOD-BRAIN BARRIER AFTER MICROWAVE IRRADIATION. E. N. Albert, U.S. Department of Health, Education and Welfare, July 1977. P. 294.

"Microwaves have been reported to cause an assortment of physiological and morphological alterations in the central nervous system of experimental animals. These include tigrolysis and vacuolation of hypothalamic neurons, pyknosis of cerebral, deep cerebellar and brain stem neurons, nuclear eccentricity and karyolysis of spinal ganglia. The above mentioned alterations were reported after acute exposures (less than one hour) and at 20-100 mW/square centimeter power densities."

12. RADIO-FREQUENCY AND MICROWAVE ENERGIES, MAGNETIC AND ELECTRIC FIELDS. Sol M. Michaelson, Foundations of Space Biology and Medicine, NASA, 1975. P.419.

"Several investigators report that exposure of animals or man to electromagnetic radiation may result in direct or indirect effects on the cardiovascular system.... Disturbances of the blood circulation that have been described are evidenced by change in blood flow, usually an increase in flow which is

proportional to both the intensity and duration of exposure: a decrease observed only in denervated extremities."

"Clinical observations of humans exposed to microwave fields have suggested that motor effects may be accompanied by sleep disturbances, lower resistance to fatigue, increased irritability, and memory concentration deficits."

"Frey has reported that individuals can detect pulse-modulated electromagnetic energy at wavelengths of 10 to 70 cm and at average power densities of 0.4 to 2.1 mW/square cm. The reported sensations were usually auditory in nature..... Frey believes that modulation is necessary for perception of microwaves."

13. RF RADIATION: BIOLOGICAL EFFECTS. E. J. Lerner, IEEE Spectrum, December 1980. P. 51.

"Another area of possible importance is that of pulsed radiation with low average power density but relatively high peak power density. In the 1960s, Mr. Frey was the first to observe that humans and animals could "hear" microwave radiation pulsed at audio frequencies with average power as low as 30 mW/sq. cm. if the peak power was at least 60 mW/sq.cm. This phenomenon may be caused by acousto-thermal or electro-mechanical effects in the cochlea, rather than any direct coupling to the brain. Mr. Frey and other researchers have subsequently observed other effects of pulsed radiation at peak power even below 1 mW/Sq.cm."

14. THE EFFECT OF MICROWAVES ON THE FUNCTIONAL STATE OF NERVE. Y.I. Kamenskii, Dept. of the Navy, Washington, D.C., 1966.

"The irradiation of frog nerve with continuous microwaves in the course of 20-30 min. increased the conduction speed of excitation, shortened the refractory phases, changed the size of the APA, but did not affect the threshold of excitation of the nerve..... The irradiation of the nerve with pulsed microwaves in the course of 20-30 min. increased the conduction speed of excitation in the nerve and increased the excitability of the nerve.... There are grounds for regarding the effects of pulsed microwaves as non-thermal, while the changes observed with continuous irradiation can be attributed to the thermal effect of microwaves."

15. PATHOPHYSICAL ASPECTS OF EXPOSURE TO MICROWAVES. S.M. Michaelson, Agard Lecture Series N. 78 on Radiation Hazards, 1975

"Although a number of investigators state that the blood and blood forming system are not affected by acute or chronic microwave exposure, effects on hemotopoiesis have been reported. The time of onset and degree of hematopoietic change may be dependent on the wavelength, field intensity and duration of exposure."

"Presman and Levitina interpret their data as indicating an

effect on the parasympathetic nervous system (vagus nerve) during ventral irradiation and on the sympathetic nervous system during dorsal exposure. Levitina has suggested that the peripheral nervous system is the mediator between microwave radiation and its possible effects on heart rate."

"Functional damage to the cardiovascular system indicated by hypotonus, bradycardia, delayed auricular and ventricular conductivity, decreased blood pressure, and decreased height of EKG waves in workers in RF or microwave fields has been reported."

16. ENDOCRINE AND CENTRAL NERVOUS SYSTEM EFFECTS OF MICROWAVE EXPOSURE. S.M. Michaelson, AGARD Lecture Series No. 78 on Radiation Hazards, 1975.

"Functional alterations in the neuroendocrine system of both animals and man exposed to microwaves have been reported by several investigators. The findings include changes in the secretions of the pituitary gland, adrenal cortex, thyroid gland, and the gonads."

17. INTRODUCTION: EFFECTS OF ELECTROMAGNETIC RADIATION ON THE NERVOUS SYSTEM. W.R. Adey, Annals of the N.Y. Academy of Sciences, 1975. P. 16.

"These studies of the sensitivity of the brain as a whole to weak electric and electromagnetic fields lead to the striking conclusion that mammalian central nervous functions can be modified by electrical gradients in cerebral tissue substantially less than those known to occur in postsynaptic excitation and also substantially smaller than those presumed to occur with inward membrane currents at synaptic terminals during release of transmitter substances."

18. DO MICROWAVES ALTER NERVOUS SYSTEM STRUCTURE? E.N. Albert and M. DeSantis, Annals of the N.Y. Academy of Sciences, Vol. 247, 1975. P. 87.

"Electromagnetic radiation in the superhigh frequency or microwave range has been reported to alter central and peripheral nervous system structure. Structural modifications in both neurons and glia have been described. Vascular changes also noted include hemorrhage, congestion (hyperemia), and perivascular edema."

19. MICROWAVE-INDUCED ACOUSTIC EFFECTS IN MAMMALIAN AUDITORY SYSTEMS AND PHYSICAL MATERIALS. A.W. Guy, C.K. Chou, and J.C. Lin, Annals of the N. Y. Academy of Sciences, Vol. 247, 1975. p. 194.

"One of the most widely observed and accepted biologic effects of low average power electromagnetic (em) energy is the auditory sensation evoked in man exposed to pulsed microwaves. The effect appears as an audible clicking or buzzing sensation

that originates from within and near the back of the head and that corresponds in frequency to the recurrence rate of the microwave pulses. The effect is of great interest, because it can be elicited by average power levels far below those believed to be of thermal significance."

20. MICROWAVE EFFECTS ON THE BLOOD-FORMING SYSTEM WITH PARTICULAR REFERENCE TO THE LYMPHOCYTE. P. Czerski, Annals of the N. Y. Academy of Sciences, Vol. 247, 1975. P. 232.

"Long-term low-dose microwave exposure of experimental animals may induce peripheral blood lymphocytosis, an increase in the number of DNA-synthesizing cells in lymph nodes, and a slight decrease in the red blood cell count. Bone marrow counts did not reveal any significant changes, except slight alterations in the erythroblast maturation curve and in the mitotic index of these cells."

21. EFFECT OF MICROWAVES ON CELL FUNCTION AND VIRUS REPLICATION IN CELL CULTURES IRRADIATED IN VITRO. S. Szmigielski, M. Luczak, and M. Wiranowska, Annals of the N. Y. Academy of Sciences, Vol. 247, 1975. P. 263.

"Irradiation of cell suspensions in vitro with microwave energy results in functional disturbances at the cellular and subcellular level, which include inhibition of cell growth, chromosomal damage, increased cell membrane permeability, depression of phagocytosis, and formation of atypical cells. In certain instances, small nonthermal doses of microwave radiation in vitro may stimulate human lymphocytes to divide and transform."

22. ACUTE STAPHYLOCOCCAL INFECTIONS IN RABBITS IRRADIATED WITH 3-GHZ MICROWAVES. S. Szmigielski, J. Jeljaszewicz, and M. Wiranowska, Annals of the N. Y. Academy of Sciences, Vol. 247, 1975, P. 305.

"Long-term exposure of animals to thermal and nonthermal power densities of microwave radiation disturbs the hematopoietic system and alters peripheral blood cells. Displacement of white blood cells, which leads to changes in the number and composition of leukocytes in the peripheral blood, is the most commonly observed phenomenon.... The above observations all suggest that the granulocyte system may react in a different manner to acute bacterial infections in animals exposed for a long time to nonthermal power densities of microwave radiation, because granulopoiesis occurs rapidly after such infections."

23. EFFECTS OF ELECTROMAGNETIC RADIATION ON IMPLANTATION AND INTRAUTERINE DEVELOPMENT OF THE RAT. F. Dietzel, Annals of the N. Y. Academy of Sciences, Vol. 247, 1975. P. 367.

"We have demonstrated that vhf radiation adversely affects embryonic development."

24. EFFECTS OF PULSED MICROWAVES AT 1.28 AND 5.62 GHZ ON RHESUS MONKEYS PERFORMING AN EXERCISE TASK AT THREE LEVELS OF WORK. J. Knepton, J. DeLorge, and T. Griner, Naval Aerospace Research Lab., Pensacola. FL. 1983.

"These experiments demonstrate the microwaves will produce cardiovascular effects in addition to those produced by exercise alone and that body temperature induced by microwave energy does not seem to be further accelerated by exercise. The results also illustrate that monkeys working a physically arduous task are more likely to stop working when exposed to microwave than when working a less arduous task."

25. BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION (RADIOWAVES AND MICROWAVES) - EURASIAN COMMUNIST COUNTRIES, R.L. Adams and R. A. Williams, Defense Intelligence Agency, March 1975.

"The potential for the development of a number of antipersonnel applications is suggested by the research published in the USSR, East Europe and the West. Sounds and possibly even words which appear to be originating intracranially can be induced by signal modulation at very low average power densities."

"Combinations of frequencies and other signal characteristics to produce other neurological effects may be feasible in several years. The possibility of inducing metabolic diseases is also suggested. Animal experiments reported in the open literature have demonstrated the use of low-level microwave signals to produce death by heart seizure or by neurological pathologies resulting from breaching the blood-brain barrier."

"Effects of electromagnetic irradiation on the blood include biochemical variations, effects on erythrocytes, changes in coagulation, and alterations in the blood forming system."

"Long term ultrahigh frequency (UHF) exposure in rats reportedly reduced the iron and copper content in both the blood and muscle with a concomitant increase in iron content in the liver."

"Comparison of a group of engineers and administrative officials who were exposed to microwaves for a period of years and unexposed control group revealed a significantly higher incidence of coronary disease, hypertension, and disturbances of lipid metabolism among the exposed individuals.... Exposure may, therefore, promote an earlier onset of cardiovascular disease in susceptible individuals."

"Personnel exposed to microwave radiation below thermal levels experience more neurological, cardiovascular, and hemodynamic disturbances than do their unexposed counterparts. Some of the cardiac and circulatory effects attributed to

exposure include bradycardia, hypotension, and changes in EKG indices (sinus arrhythmia, extrasystole changes in intraventricular and intra-atrial conduction, diminished amplitude of EKG deflections, etc.)."

"Research on the effects of radiowaves and microwaves on the central nervous system of humans was relatively widespread.... Subjects exposed to microwave radiation exhibited a variety of neurasthenic disorders against a background of angiodystonia. The most common subjective complaints were headache, fatigue, perspiring, dizziness, menstrual disorders, irritability, agitation, tension, drowsiness, sleeplessness, depression, anxiety, forgetfulness, and lack of concentration."

"A number of alterations in the function of the gastrointestinal system were observed."

"Electromagnetic radiation exposure has been found to produce disturbances in carbohydrate energy and nitrogen metabolism in the brain, liver, and muscles."

"Soviet investigators have conducted studies on the effects of microwave frequencies in combination with ionizing radiation, magnetic fields, drugs, and nonionizing electromagnetic radiation of other wavelengths. Generally, synergistic effects have been observed."

"In an animal study, it was reported that oral administration of caffeine in doses of 20 mg per kg lowered the duration of resistance against hyperthermia caused by microwave irradiation. Caffeine did not influence the temperature at which the animals died, but it shortened the time to death."

"The Soviets have also studied the psychophysiological and metabolic changes and the alterations of brain function resulting from exposure to mixed frequencies of electromagnetic radiation. One physiological effect which has been demonstrated is heart seizure. This has been accomplished experimentally in frogs by synchronizing a pulsed ultrahigh frequency microwave signal of low average-power density with the depolarization of the myocardium and beaming the signal at the thoracic area."

26. RADIATION; ALL YOU NEED TO KNOW ABOUT. M.D. Ecker and N. J. Bramesco, Vintage Books, N.Y., 1981

"Another interesting point is that microwave radiation in "pulsed" or noncontinuous; such doses appear to produce more harmful biological and physical effects than radiation that pours out in a steady stream."

"As for genetic effects, the scientific literature contains numerous references to chromosome damage and abnormal cell reproduction brought about under certain conditions in certain cell types by nonionizing radiation."

"The effects of nonionizing radiation in humans have not been extensively studied. The subjective effects most often reported include headache, insomnia, irritability, loss of appetite, and faulty memory. Vague feelings of heaviness in the head, drowsiness, and chest pain may also occur. Physiological effects include easily irritated skin, excessive sweating, fluctuating blood pressure, and changes in various eye tissues such as the retina. In the area of emotional effects, anxiety has been reported, as well as hypochondria and the harboring of suicidal thoughts. Slow heartbeat (a pulse rate of 60 per minute or lower) has also occurred."

"....higher microwave exposures have been associated with increased production of red blood cells and lymphocytes, cells formed in lymph tissue. When white blood cells are exposed to low levels of radiation, their ability to neutralize cells that are harmful to the body declines. This would reduce the body's ability to resist disease,...."

"One of the most vital areas of concern is any possible link between nonionizing radiation and cancer. Apparently such links do exist. Scientists believe that low-frequency, non-ionizing radiation may be associated with disruption in the balance of body hormones. And such hormonal imbalances have been implicated in the development of cancers of the breast, cervix, and prostate."

DNA helix found to oscillate in resonance with microwaves

For the first time, biophysicists have demonstrated that DNA—the molecular code of life—resonantly absorbs microwaves. This finding, reported at the recent meeting of the American Physical Society in Detroit, has prompted researchers to suggest that nonthermal genetic effects from low level microwaves are possible.

Exactly how this and similar experiments might translate into effects on the health and genetics of humans and other living things, however, is far from understood and is speculative at best. The new data are sure to add to the already controversial debate about the bioeffects of "electronic smog" (SN: 4/22/78, p. 247) that is produced by a growing number of electromagnetic devices including microwave ovens, broadcast towers, radar installations and high voltage power lines.

Biophysicists classify the interaction of electromagnetic waves with biological matter in two categories: thermal and nonthermal. Microwaves (which range from 300 million hertz [MHz] to 300 billion hertz [GHz] in the electromagnetic spectrum) can be thermally absorbed by causing a dipolar molecule, such as water, to oscillate in a frictional media, thereby dissipating energy in the form of heat. This thermal absorption mechanism is relatively well understood and forms the basis, in fact, for the design of microwave ovens, diathermy medical instruments and industrial sealing devices.

Nonthermal means of absorption are far more obscure—and more controversial since they are thought to occur at relatively low power levels to which a larger segment of the population might be exposed. Moreover, at low power densities it is difficult to obtain statistically significant data from laboratory experiments on animals; the results from such experiments as well as epidemiological studies on humans chronically exposed to low level microwaves have been largely inconsistent.

This is why biophysicists such as Mays L. Swicord of the National Center for Devices and Radiological Health at the Food and Drug Administration (FDA) in Rockville, Md., look for fundamental absorption mechanisms at the molecular level. One motivation for looking at DNA molecules in particular, says Swicord, is that genetic aberrations in laboratory animals have been observed in the microwave range that are not easily explained by thermal effects.

Swicord and co-workers recently demonstrated that DNA molecules can nonthermally absorb energy from microwaves partially because the DNA chains exhibit a phenomenon known as

resonance. All physical systems have some sort of resonance or natural frequency. A violin string, for example, has a resonance frequency that is directly related to its length, mass and tension; if plucked and left alone, the string will vibrate happily at that frequency. If the string is made to vibrate at another frequency by an external force, it will do so, but without much enthusiasm. When the driving frequency approaches the resonance frequency, however, the amplitude of the vibrations will increase manyfold and the string will resonate in harmony with the driving force.

And so it is, apparently with DNA molecules. Swicord's group extracted and uncoiled DNA chains from the bacteria *Escherichia coli*. From a saline solution containing DNA chains of two specific lengths, the researchers obtained a resonance absorption curve (one for each length type) as the frequency of the applied microwaves was varied in the neighborhood of 3 GHz.

According to Swicord, theorists such as Earl W. Prohofsky at Purdue University in West Lafayette, Ind., and others had predicted that microwaves could resonantly drive a longitudinal vibration mode in DNA chains by electrically coupling with the ions residing on the backbone of the DNA helix. But most biophysicists had also thought that the oscillations of the helix would be damped by the surrounding aqueous solution, so that energy from the microwaves would be dissipated instead of transferred to the DNA chain.

The surprise in the recent experiments was that damping does not occur to a significant degree. In fact, in one experiment with a solution containing a mixture of DNA chain lengths, Swicord recorded an absorption coefficient for the DNA molecules that was 400 times greater than that for the solvent alone at 11 GHz. "This is the really interesting phenomenon," says Swicord. "If you've got a soup containing water and DNA, the DNA is more strongly absorbing than the water."

The demonstration of resonant absorption with little damping is scientifically interesting, but it also troubles researchers. "Resonance absorption means you're packing an awful lot of energy into a very small number of modes and usually at a fairly small region of space," says Prohofsky. "That's worrisome because that's about the worst place in the body you'd want resonant absorption—right in the DNA." The localization of energy and the large oscillations of the DNA helix induced at resonance, speculates Prohofsky, could conceivably result in a number of adverse ef-

fects such as knocking off a repressor molecule that normally inhibits a certain transcription process.

Both Prohofsky and Swicord note that the recent experiments involved isolated elongated DNA. However, DNA molecules are naturally found coiled up and tightly packaged in proteins, and in humans and other high life forms especially, DNA chains form very complex structures. So, while resonant modes can be induced in unraveled DNA, the question of other resonant modes existing for the coiled DNA in chromosomes remains. According to Prohofsky, calculations indicate that nucleosomes—the beads of coiled DNA and proteins that make up part of the chromosome—should resonate at 40 GHz. Whether this would actually happen with all the proteins around remains to be seen, but if there is one experiment that is important to do, he says, it is one that explores the possible resonance effects in nucleosomes.

Adding to the suggestion that microwaves can interact with DNA in nonlinear, complex structures, is some very preliminary data that Swicord says indicates that resonance also occurs in whole plasmids—small rings of DNA that are found outside the chromosome. In addition, he notes that two other research groups have observed that microwaves can disrupt chromosome-associated proteins and cause chromosomes to uncoil.

Swicord, who has started experiments on the bundled-up packages of DNA found in viruses, believes that it will take at least five years before researchers collect enough evidence to judge theories about resonance in chromosomal structures. Even if resonance is confirmed, the implications for real chromosomes in the biological environment of the body or in the external electromagnetic environment presents yet another long research chapter to be pursued.

The new findings, stresses Swicord, do not say what is happening in people, but coupled with the observed genetic effects, the potential biophysical mechanisms "imply some degree of caution for people who might purposefully expose themselves (to microwaves). It's not simply something to be passed over lightly."

This kind of research, he says, is leading up to a basis for making decisions about safety and perhaps using our understanding for potential beneficial uses. "The excitement is that there is a path pointing in a given direction that hadn't been there before. ... It says to those people who think all the information is in that it is not."
—S. Weisburd

Health



Medical Update

Electromagnetic energy linked to stress, disease

By BEN ZINSER

Stress increased — New evidence suggests that ever-increasing use of electromagnetic energy for power and communications "may be producing stress, disease and other harmful effects all over the world by interfering with the most basic levels of brain functioning."

That's the view of Dr. Robert O. Becker, a research professor at Upstate Medical Center in Syracuse, N.Y.

In laboratory tests, mice were exposed to electromagnetic fields with strengths approximating those found near high-voltage transmission lines. After 30 days the mice underwent a pattern of change in hormones, body

weight and blood chemistries similar to those found in animals under chronic stress.

In mice or humans, such chronic stress can be expected to produce an increase in such conditions as high blood pressure and behavioral abnormalities, Becker says in a report in *Psychology Today*.

Genetics overlooked — Both the public and the medical profession have overrated the influence of lifestyle on health and disease, a doctor says.

Exercise, diet and prudent living are appropriate but have only a limited ability to modify the health of the population, says Dr. Charles R. Scriver, professor of pediatrics at McGill University in Montreal, Canada. Scriver also is a professor of biology there.

Medical science, in overestimating an individual's power to prevent natural illness by improving his lifestyle, tends to label disease with "the taint of sin."

Scriver thinks there should be a broader view of disease that would recognize medical genetics, which concerns itself with an individual's intrinsic risk for disease.

He says he often sees patients who have suffered long and unnecessarily because physicians have failed to look for the genetic factors associated with their disease.

Source: *Internal Medicine News*, a newspaper for doctors. Scriver also has addressed the American Academy of Pediatrics on the topic. ■

GUANONG

Effect of long-term microwave exposure unclear

BY BRENT STAPLES
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It generally is agreed that at current recommended exposure levels, microwave radiation presents no health hazard for the public at large. However, there is concern about the effects of long-term exposure for workers who maintain the nation's 25,000 microwave installations.

Zory Glaser, a senior researcher at the Food and Drug Administration's Center for Medical Devices and Radiological Health, warns against complacency about the effects of long-term exposure to even low levels of microwaves. "In our understanding of non-ionizing radiation (microwaves, radar, emanations from high-voltage power lines), we are about where we

were with ionizing (nuclear) radiation 40 years ago," Glaser said. "We now know the effects of nuclear radiation to be far more serious than we imagined."

Glaser's concern is based on recent findings that show that ionizing radiation is considerably more dangerous than had been thought. An unusually high incidence of cancer has been reported among American and British veterans who were exposed to ionizing radiation from nuclear test blasts during the late 1950s. The National Academy of Sciences has confirmed such findings in American veterans who participated in the "Shot Smokey" test blast of 1957. The Energy and Defense departments have undertaken a mortality study of 50,000 other veterans to determine whether these findings ap-

ply to all those who participated in nuclear tests.

In light of these and other developments, the National Academy of Sciences has been asked to oversee the rewriting of dosage standards for ionizing radiation. NAS senior researcher Seymour Jablon says the risk of cancer from ionizing radiation may be at least four times greater than previously thought. Others place estimates as high as 10 to 20 times greater. And cancer risk among Hiroshima and Nagasaki atomic bomb survivors now exceeds official estimates.

Servicemen who received massive doses of microwave radiation before it was known to be harmful suffered a variety of effects, including cataracts, neurological disorders and immunological disorders, Glaser said.

"There can be no disputing the effects of high-level microwave exposure on human beings," he said. "But on what differentiates a high dose from a low dose, we know nothing. Are there cumulative effects? What if you get a sub-threshold effect today and another sub-threshold effect tomorrow? These questions will be particularly important for people who install, repair and calibrate this equipment."

"There aren't nearly enough studies that have looked at the effects of low-dose exposure over long periods of time and, more importantly, over an animal's life-span. And there are even fewer studies that combine the two. We can't say that there are no demonstrable effects, because we have not performed studies to look for those effects."

Microwave exposure lawsuits expected

WASHINGTON (AP) — A State Department medical consultant says the U.S. government may face class-action lawsuits that seek damages totaling about \$200 million in connection with Soviet microwave bombardment of the American embassy in Moscow.

The disclosure by Dr. Herbert Pollack, who has served since 1976 as a consultant to the State Department on medical aspects of the embassy affair, came at a joint meeting of two federal scientific advisory panels dealing with non-ionizing radiation.

U.S. officials have said the existence of the mysterious Soviet microwave beams was technically verified in late 1962 and that the radiation may have been present at the Moscow post as early as 1953.

For years, however, information about the radiation problem was kept se-

cret from most American diplomats and other personnel serving in Moscow. Briefings for the overall embassy staff did not begin until February 1976.

Irradiation of the embassy ceased during the summer of 1979, according to U.S. officials.

The purpose of the beams remains unclear.

Pollack told the meeting Friday that after the radiation affair broke into headlines in 1976, the State Department initially had to deal with about \$30 million in legal claims brought by employees who alleged injuries related to microwave exposure.

"Basically, they were congenital defects and breast cancers in women," he said. "The bulk of those (legal cases) have disappeared. However, there's a whole new rash coming along."

Pollack said the new round of litiga-

tion was expected to involve "some \$200-odd million of class-action suits against the Department of State and the U.S. government, based on occupation in the (embassy) chancery in Moscow during the period of time from '53 to '77."

He voiced the comments at a joint meeting of the Electromagnetic Radiation Management Advisory Council, known as ERMAC, and the Frequency Management Advisory Council. The panels advise the government on matters including biological effects of non-ionizing radiation and federal use of the electromagnetic frequency spectrum. Pollack is one of ERMAC's 13 members.

The medical consultant, a professor emeritus from George Washington University's School of Medicine and Health Sciences, did not give any details on how the initial round of legal cases had been disposed of.

One Moscow case that has been publicly reported involves a former Marine security guard, George W. Watson Jr., of Tustin, Calif., who fathered a child suffering from hydrocephalus, a birth defect. The boy, now 8 years old, is blind, severely retarded and institutionalized at a 24-hour care facility.

Watson's \$1.75 million suit, which also alleges medical malpractice at a Navy hospital, is pending in U.S. District Court in Los Angeles.

A Johns Hopkins University epidemiological study, funded by the State Department, said in late 1978 that "no convincing evidence was discovered that would directly implicate the exposure to microwave radiation . . . in the causation of any adverse health effects."

But critics of the study have raised questions over its thoroughness and scientific validity.

Moscow embassy blood ills noted

MOSCOW (AP) — Medical tests show that one of every 29 adults at the U.S. Embassy in Moscow suffers from a mysterious blood condition resulting in abnormally high levels of white blood cells, embassy sources said Tuesday.

Some scientists dispute previous official embassy claims that Soviet microwave radiation of the embassy building has nothing to do with the blood counts.

Comparative figures for the frequency of the same high levels of white cells in the United States do not exist, but the sources said there was no question that an abnormality has been found in Moscow.

The cause of the blood condition remains unknown, the sources said, despite a stepped-up program of special tests and detailed analysis of the health histories of Moscow embassy personnel and their families.

For the past year, Moscow has been officially designated as an "unhealthy post," entitling Americans serving here to a higher hardship pay differential or increased retirement credit.

U.S. officials have said privately they believe the microwaves — first detected at least as far back as 1962 — are intended to foil American electronic intelligence-gathering operations at the embassy.

The State Department claims that no outward disease symptoms have been brought on by the high white cell levels, and that a variety of environmental factors, including viruses and intestinal parasites, might be behind the situation.

The department has flatly ruled out any connection between the elevated blood counts and microwave radiation still being beamed at the embassy by the Soviets.

But some scientists concerned with the possible effects of low-level microwaves have questioned this assertion, pointing to links between microwaves and blood abnormality found in Soviet clinical studies and U.S. laboratory experiments.

Embassy officials have said that in recent months the Soviet microwaves have been running at power levels of 1 to 2 microwatts per square centimeter and that screens mounted over the embassy's windows reduce the intensity to a fraction of a microwatt inside.

This is well below the Soviet safety standard of a maximum 10 microwatts per square centimeter for occupational exposure to microwaves. The U.S. standard is 1,000 times higher — 10 milliwatts.

A source closely familiar with the microwave situation reported that about a week after the Aug. 26 fire which seriously damaged upper floors of the embassy, the radiation levels suddenly rose as high as 4.5 microwatts. Another week later, the levels jumped again, to a peak of 8.5 microwatts.

The source noted that U.S. personnel monitoring the radiation were puzzled because the higher levels seemed to occur in random bursts during both day and night. Previously, the Soviet signals had been found to operate for an 8- to 10-hour period every day, roughly coinciding with the main working hours of the embassy staff.

Dr. Kris Murawski of the American National Red Cross blood program said in Washington that "having a higher count doesn't necessarily mean it's abnormal." But he also said interpretation of counts was different if considering a group instead of an individual. "Then, even relatively small increases appearing regularly across an entire group would mean something," he said.

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Russians stop embassy rays

By BARTON REPERT
Associated Press Writer

MOSCOW — After more than a decade of U.S. diplomatic protests, the Soviet Union has ceased bombarding the American Embassy here with microwave radiation, an embassy spokesman said Tuesday.

Western diplomats viewed the move as an attempt to help sweeten the overall tone of relations prior to next month's Vienna summit and signing of the new SALT II treaty limiting strategic nuclear weapons.

THE MYSTERIOUS Soviet beams, first detected in the early 1960s, aroused concern about possible health hazards for embassy personnel and proved a long-standing irritant in U.S.-Soviet relations.

The specific purpose of the Soviet radiation was never disclosed.

U.S. officials theorized the microwaves could be intended either to jam American electronic intelligence-gathering equipment on the embassy's upper floors and roof, or to trigger Soviet surveillance devices planted within the building.

SOURCES SAID there was no hard evidence that the Soviets had dismantled electronic installations used to beam the low-intensity microwaves at the embassy.

This left open the possibility the bombardment might be resumed if Soviet-American relations should worsen significantly in the future.

During the last 3½ years the Soviet beams had been aimed at the embassy's upper floors from transmitters located east and south of the 10-story structure on Tchaikovsky Street.

An embassy spokesman said Tuesday: "Neither the east nor the south signal has operated since the end of April. Hence we have detected no radiation since that time from these sources."

"Occasionally we have picked up brief, very low-level emanations from more distant signals at unknown locations in various directions for brief periods," the U.S. spokesman added.

The statement indicated these other microwave sources were not considered comparable to the high directional, searchlight-like beams that had been clearly aimed at the embassy.

action against the culprits, he added.

Watch on waste: Congress gave the Department of Energy \$600 million to set up a program of grants to local governments and public institutions that want to find ways to conserve energy. But the applicants may wind up paying more than half that amount just to fill out the Department of Energy forms.

The form worked out by Department of Energy bureaucrats is so complicated that even the agency admits it will take about 84 hours to complete. Grant applications are routinely filed out by specialists in the arcane art of grantsmanship, and the going rate for these experts is about \$30 an hour.

Multiplying this by the 125,000 applications DOE expects to get gives an impressive \$315 million for the 10.7 million man-hours of work filling out the forms.

GURNEY

Wray Herbert reports from Atlanta at the Ninth Congress of the International Primatological Society

The evolution of kin support

A basic principle of evolutionary biology is that animals internalize behavioral "strategies" in order to maximize reproductive success and improve the fitness of the family lineage. The theory explains apparently self-sacrificial behavior as a "kin selection" strategy—individual sacrifice made in exchange for genetic representation in the future family line. The theory has generated considerable controversy over the past two decades, and in the wake of that controversy scientists have begun to test the theory's usefulness in predicting actual social behavior. According to Susan M. Essock-Vitale and Michael T. McGuire of the University of California at Los Angeles, sociobiological theory predicts that individuals will be more altruistic toward close kin than toward distant kin because close kin carry more of the individual's genetic legacy. In addition, kin support should be directed so as to increase relatives' reproductive success. Essock-Vitale and McGuire interviewed 300 women and found "strong support" for the sociobiological predictions. In relationships with friends, the subjects reported far more reciprocal exchanges—receiving support in exchange for giving support—than they did in relationships with kin, where helping was more often unrequited. The subjects were much more apt to help close kin than more distant kin, regardless of geographical proximity, and investment was most apt to flow from older to younger kin. In addition, subjects were more apt to help siblings whom they rated as likely to have children, and they received more help from siblings whose own children were grown. "Our perceived motives notwithstanding," the researchers conclude, "rather than having the best interests of others at heart, our patterns of helping suggest that we appear to help in ways that will maximize our own inclusive fitness."

...and grandparenting

Sociobiology also predicts, because paternity is always less certain than maternity, that grandparents will tend to invest more in the survival of their daughters' children than their sons' children. In order to test this principle, Martin S. Smith, a psychologist at Simon Fraser University in British Columbia, surveyed almost 600 grandparents in North America concerning their relationships with their grandchildren. He found that the subjects spent about 40 percent more time with their daughters' children than with their sons' children. Smith also found that grandparents—and especially grandfathers—tend to spend more time with granddaughters—"a better reproductive bet," Smith suggests—than with grandsons. And in contrast to parenting patterns, grandfathers reported spending only slightly less time than grandmothers in grandparenting. When males are young, Smith speculates, they have other more profitable options for maximizing genetic fitness; as these options decrease, males turn to kin investment. "In the fitness game," Smith suggests, "a poor bet is better than no bet at all."

...and senescence

Do the behaviors that typify old age have an evolutionary component? UCLA anthropologist Marc D. Hauser compared the behaviors of old and young stump-tail macaques, and found that the old subjects were not only less active but that they voluntarily restricted their social network, ignoring and avoiding engagement with other group members—especially non-kin. Although the pattern could be explained by the physical depletion that accompanies aging, Hauser concedes, it is also possible that senior group members, with depleted investment potential, become more discriminating in social interaction, wasting less energy on activity with no potential for genetic payoff.

Leukemia and magnetic or electric fields

While updating a study of 438,000 deaths among working men in the state of Washington during 1950 and 1979, Samuel Milham Jr. noticed a higher than expected incidence of leukemia among those whose jobs required them to work around high electrical or magnetic fields. What first caught his attention were statistics associated with aluminum workers. This group experienced roughly twice the number of deaths from leukemia as would have been expected. Looking at only acute forms of leukemia, the rate was elevated 150 percent above the norm.

The prevailing wisdom, says Milham, is that any leukemia excess in this group is probably due "to inhaling coal-tar-pitch volatiles that come off as part of the [aluminum] reduction process." But, points out the epidemiologist with Washington's Department of Social and Health Services, "coke-oven workers are exposed to the same thing—at much higher levels—and they don't show any leukemia excess."

Since strong magnetic fields are induced by high (75,000 ampere) direct currents used in the aluminum-reduction process, Milham's attention turned to electric- and magnetic-field exposures. He broke out data for 10 other occupational groups in which workers might be expected to encounter high fields: electronic technicians, radio and telegraph operators, electricians, power and telephone linemen, radio and television repairmen, motion-picture projectionists, electrical engineers, streetcar/subway motormen and welders/flame cutters. As Milham reports in the July 22 *NEW ENGLAND JOURNAL OF MEDICINE*, only welders and flame cutters show no leukemia excess. Together these groups exhibit a proportionate mortality ratio (ratio of observed deaths to expected deaths, multiplied by 100) of 137 for all leukemias and a PMR of 163 for acute forms. Highest PMRs occur among power-station operators (259 for all leukemias, 282 for acute forms) and television and radio repairmen (291 for acute leukemias).

"I'm hoping to follow up union or factory groups that are exposed to [high fields] and see whether those with highest exposures are the ones with the mortality excess," Milham says. Right now, he is examining death records for men in this apparent high-risk group to see whether all forms of leukemias are represented, or whether there appears to be selective preference.

Radiation-induced reproductive changes

Healthy 10-year-old rhesus monkeys developed testicular changes after long-term chronic irradiation with cobalt-60 gamma rays, according to a report in the April *SCIENTIA SINICA* by Wu Cheng and colleagues at the Institute of Biophysics of the Academia Sinica in Beijing, China. With 0.8 rad per day exposures, the researchers were able to shut down the animals' sperm production when the accumulated dose reached 100 to 212 rads—half that necessary to achieve the same effect using a single dose. And "repair after acute exposure... appeared more rapidly than that after chronic irradiation," the Beijing team reports.

The Chinese study involved 36 animals: an unspecified number in group A received 0.15 rad/day, the 17 animals in group B got 0.8 rad/day, others received no radiation. Even after 3 years of continuous irradiation, sperm count and testis volume remained normal in group A, although occurrence of sperm shape and chromosome abnormalities did increase. In group B, however, testis atrophy appeared within only 2 months. As the cumulative dose reached 40 rads, sperm count fell. After 5 to 11 months of irradiation (100-212.8 rads), sperm production moved toward complete shutdown. Recovery of sperm production began in some group B animals a year after exposures ended, but even three years after irradiation not all animals had recovered.

Radiofrequency radiation: Deciding what is a safe exposure

It's hard to escape exposure to radiofrequency (RF) radiation. After all, if your radio or television can pick up a clear broadcast signal, your body can too. The Environmental Protection Agency (EPA) has just completed a critical review of more than 5,000 health-effects studies involving RF radiation, including the microwave band. And according to radiation biologist Daniel F. Cahill, one of the review's editors, the data are now strong enough to allow — and in fact to justify — federally enforced protection of the public from hazardous levels of RF radiation.

RF radiation represents the nonionizing portion of the electromagnetic spectrum. Its frequencies include those used for AM, FM and short-wave radio; for ultra-high frequency (UHF) and very-high frequency (VHF) television; for radar; for satellite communications; and for microwave relay links. The human-resonance frequencies, for which the body serves most effectively as an antenna, are 30 megahertz (MHz) to 300 MHz — primarily the FM and VHF bands.

Growing electronics use has increased the ambient RF environment to which the general public is exposed. Health effects — most notably body heating and effects one might associate with fever (including brain damage, miscarriage and death) — have been observed in many species, including humans, after prolonged or high-level RF exposures. It was concern that there might be related hazards posed by low-level exposures — omnipresent in modern, industrialized society — that prompted Canada, Czechoslovakia, Great Britain, Poland and the Soviet Union to set their RF-exposure standards.

The United States has no comparable standard for limiting human exposures to RF radiation. However, EPA's new survey of RF's biological effects, publicly unveiled in draft form this week, is a first step toward development of such a standard. Explains David E. Janes, who directs analysis and support for EPA's Office of Radiation Pro-

grams, "This report is the biological basis from which we're moving."

That report was also the basis for the public-exposure limit — of 0.04 watts per kilogram of body tissue — which Cahill, recently retired from EPA, proposes in the July HEALTH PHYSICS. Cahill's figure translates into a power density of roughly 200 microwatts per square centimeter ($\mu\text{W}/\text{cm}^2$) for the human resonance frequencies. At frequencies outside that range, higher power densities are required to deposit the same energy into body tissue.

Based on his reading of the data just surveyed by EPA, Cahill believes that the exposure limit he is proposing would not cause any observable health effects. His figure is 50-fold lower than the Occupational Safety and Health Administration's former "advisory" ceiling (a limit which OSHA stopped enforcing last year). A new OSHA standard for workers should be forthcoming, though not immediately. If it mirrored the 1,000 $\mu\text{W}/\text{cm}^2$ limit for human-resonance frequencies being recommended by the American National Standards Institute, it would still be five times higher than Cahill's.

Perhaps as early as September, EPA intends to issue a proposed limit for public exposures. Though EPA would have no direct authority to enforce these guidelines, Janes said they would be binding on federal agencies. He noted that the Federal Communications Commission has indicated it would enforce the standard in its regulation of commercial-broadcast signals. And the National Telecommunications and Information Administration — which regulates federally owned radio transmitters — has also agreed to adopt the EPA guidelines, Janes said. As such, the major sources of RF exposures to the public would be controlled.

Cahill notes that the agency will have more than just health effects to consider when deciding on its public-exposure limit, most notably economics and politics. Even so, he believes EPA's final figure

will resemble his own.

Intellectual satisfaction was one factor that motivated Cahill to derive the RF-exposure limit he advocates in HEALTH PHYSICS, but not the only one. "Having been with the federal government for 20-some years, I know that they have a propensity for dragging their feet before taking a stand," he said. Moreover, he felt that by putting a "reasonable" number in the scientific domain, the public and courts — in the absence of a federal standard — would still have some scientific basis for making decisions on siting RF sources (such as satellite relay stations) and on health compensation. —J. Raloff

Divesting a hormone of its secrets

It has been 20 years since scientists reported the identification of the hormone that switches on the production of white blood cells called granulocytes. The purported hormone is called granulopoietin. The maddening thing about human granulopoietin extracts that have been tested, though, is that while they have stimulated granulocyte production in tissue culture with great gusto, they have done it only half-heartedly, if at all, in experimental animals. This discrepancy has raised the dark possibility that granulopoietin isn't the hormone that induces granulocyte production.

Now granulopoietin's reputation appears to have been exonerated by a team of blood cell scientists at Wright State University School of Medicine in Dayton, Ohio. They report that they have found the reason why past extracts have been active in the test-tube milieu, yet not in animals: The extracts (from human urine) probably haven't contained a compound — naturally active in humans — that the hormone needs to be active in animals.

As Martin J. Murphy Jr. and co-workers at Wright State report in the PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES (Vol. 80, No. 12), they first managed to isolate an extract of granulopoietin from a group of persons with a rare blood disease that was much more active than any tested before. They found out that this extract was so active because it contained sialic acid. They thus suspect that previous extracts haven't been very active in animals because they had lost their sialic acid, perhaps via the extraction process.

The challenge now, says John D. Lutton, an experimental hematologist doing related research at New York Medical College in Valhalla, N.Y., is to see whether granulopoietin extracts containing sialic acid also induce granulocyte production in humans. Murphy agrees.

—J.A. Treichel

Claw leads to discovery of 'new' dinosaur



Wide World

Bill Walker, a 55-year-old plumber who hunts for fossils in his spare time, unearthed this foot-long dinosaur claw last January in Surrey, Great Britain. The finding is reported by the British Museum of Natural History, which in May dispatched workers to the site to complete the excavation. The claw belonged to a new species of dinosaur that stood 10 to 15 feet tall, and lived 125 million years ago. The animal no doubt used its claws, nearly twice the size of those wielded by Tyrannosaurus Rex, in procuring its meals — the plant-eating dinosaurs that also lived then in southern England.