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 in'uced at resonance, speculates Prohofsky, could conceivably result in a number of adverse effects 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*