nice to know, he says, that research into its mysteries has alerted us to the existence of biochemical pathways that we share with the sponges, "creatures from which humans have been separated by a billion years of evolution."

The Human Machine

"A Chip You Can Talk To" by Rachel Nowak, in *Johns Hopkins Magazine* (Dec. 1990), 212 Whitehead Hall, Johns Hopkins Univ., 34th and Charles Streets, Baltimore, Md. 21218.

If scientists at the Johns Hopkins Applied Physics Laboratory have their way, it won't be long before telephones dial numbers on spoken request, tape recorders transcribe conversations directly onto paper, and cars drive themselves. Nowak, a writer for *Bio World*, reports that researchers at the lab are making their first breakthroughs on computer chips that will enable machines to hear and see.

Today's digital and serial computers are ill-equipped to understand language or interpret light signals, Nowak explains. Signals entering a microphone, for example, are "analog." That is, they are recorded in fluctuating voltage levels. But computers can't read analog signals. They must first be converted into a "digital" string of ones and zeros—a clumsy, time-consuming process.

To get around this problem, the team has developed a "basilar membrane" computer chip, which interprets analog signals directly by imitating the human ear and brain. Each of the chip's 30 microscopic filters responds to a particular frequency range and then works with the others to interpret the signals. The researchers hope that all 30 filters soon will be contained on an even smaller chip requiring only a minuscule battery. It will process sound instantly, in "real time." Conceivably, the chip could be connected to the auditory nerve in a deaf person's ear. The ultimate goal, however, is to create a chip that can change sounds into language a computer can understand.

There are many obstacles, Nowak writes. While humans are able to separate meaningful sounds from noise (a humming refrigerator, for example, or droning traffic), computers can't. But researcher Marc Cohen has developed a prototype of a microchip that may be the first step toward a solution. The chip separates blended signals by detecting distinctive frequency patterns and separating them.

Work on chips that "see" is slower going. So far the team has fabricated a three-layer "silicon retina," which, while not as complex as the human eye, can "detect edges, as well as automatically adjust . . . to different light intensities." One such chip, which is one centimeter square, will soon replace a refrigerator-sized computer in a solar observatory in Sacramento.

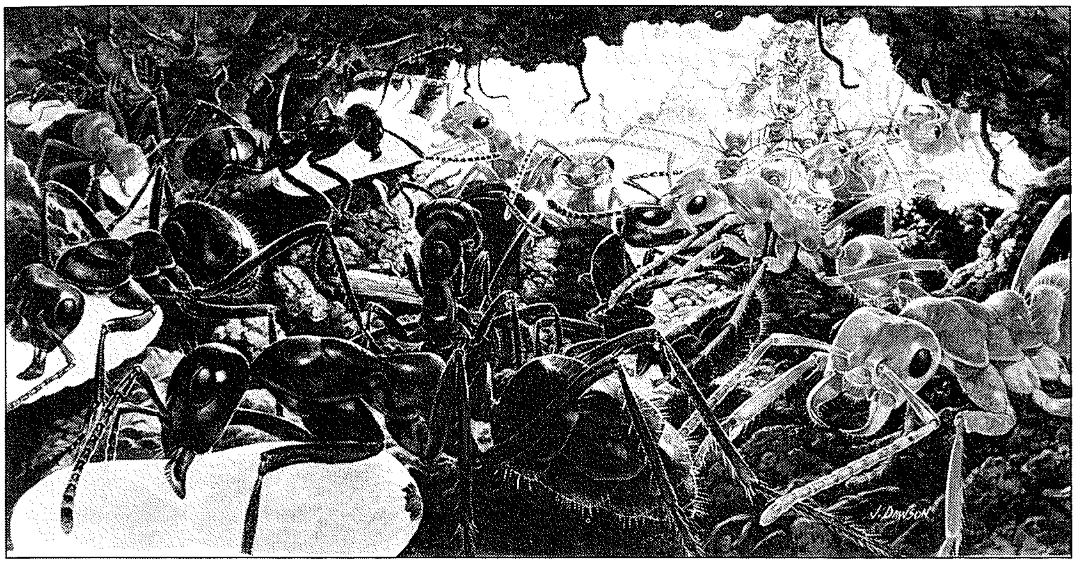
Eventually, the goal is to link the "seeing" and "hearing" chips through an "associative memory" chip, Nowak notes, so that "the *sight* of an object, say a cup sitting on a table, triggers the *name* of the object."

How long will it be before we can expect a "perceptive computer, obedient to our slightest utterance?" At least 10 years, the researchers predict. The deepest mysteries confronting them do not involve fabricating new microchips but understanding the human organ the chips are supposed to mimic—the brain.

Ants in Bondage

"Slave-making Ants" by Howard Topoff, in *American Scientist* (Nov.–Dec. 1990), P.O. Box 13975, Research Triangle Park, N.C. 27709.

For centuries scientists have been fascinated by the complex social structure of ant colonies. Charles Darwin made detailed studies of ant societies and noted their remarkably efficient division of labor. In recent years, writes Topoff, a psycholo-



Polyergus *ants, led by the scouts who discovered the site, invade a nest of* Formica *ants to capture and carry off hundreds of pupae. Some of them are eaten; the rest are enslaved.*

gist at Hunter College, entomologists have discovered more than 200 species of ants that do no work at all—they have slaves to do it for them.

As an example he points to the ants of the *Polyergus* genus, which regularly raid nearby nests of *Formica* ants, secreting a toxic acid that scares off the adults and then carrying the *Formica* pupae back to their own nest. A typical raid yields 600 pupae. "Although a portion of the raided brood is eaten," Topoff writes, "some of the *Formica* pupae are reared to adulthood. The *Formica* workers then assume all responsibility for maintaining the permanent, mixed-species nest: foraging for food, feeding the colony members, removing wastes, and excavating new chambers as the population increases." When the colony becomes too large for the nest, the *Formica* slaves scout out a new nest and "carry all the *Polyergus* eggs . . . as well as every adult and even the *Polyergus* queen, to the new nest." *Polyergus* ants have become so dependent on their slaves that they have lost the ability to care for themselves.

Why don't the slave ants revolt or wander back to their colony? Topoff says that the young *Formica* ants "identify the smell of the parasitic *Polyergus* ants as their own; moreover, the *Formica* slaves do not recognize brood of their own species and will often destroy them." A *Polyergus* queen ant sometimes will take over an entire *Formica* nest, covering herself for several minutes with the dead *Formica* queen and fooling the workers. In as little as 15 minutes, Topoff says, the newly installed *Polyergus* queen is already being groomed by *Formica* workers.

Charles Darwin believed that slave-making species of ants evolved from predatory ancestors, Topoff writes. "Because the pupae could not always be entirely consumed, however, some individuals of the abducted species would emerge to adulthood." But Topoff contends that this theory fails to explain how the queen became dependent on slaves. He favors another theory, the "brood-transfer hypothesis." In simple terms, this hypothesis suggests that slave-making evolved out of much more common territorial contests between ant species. *Polyergus* queens at some point invaded *Formica* nests, took over, and both experienced "olfactory imprinting." The result: the two genera have difficulty distinguishing each other. Today's *Polyergus* raiders believe they are kidnapping *Polyergus* eggs.

Although a relatively new entomological subdiscipline devoted specifically to slave-making ants has produced many new theories, Topoff concedes that there is still much to be learned. And considering that there are hundreds of species of slave-making ants, he concludes, "it is conceivable that no one theory will be universally satisfactory."

RESOURCES & ENVIRONMENT

The Perils of Pesticides

"Cancer Prevention Strategies Greatly Exaggerate Risks" and "Natural Plant Pesticides Pose Greater Risks Than Synthetic Ones" by Bruce N. Ames and Lois Swirsky Gold, and "Exposure to Certain Pesticides May Pose Real Carcinogenic Risk" and "Arguments That Discredit Animal Studies Lack Scientific Support" by James E. Huff and Joseph K. Haseman, in *Chemical & Engineering News* (Jan. 7, 1991), American Chemical Society, 1155 16th St. N.W., Washington, D.C. 20036.

In her influential 1962 book *Silent Spring*, naturalist Rachel Carson warned of the dangers to the environment, and ultimately to human beings, from the widespread and indiscriminate use of DDT and other chemical pesticides. Nearly three decades later, the debate about the hazards pesticides present still goes on.

Chemical pesticides are employed extensively in American agriculture. In 1988, more than one billion pounds of pesticides and related chemicals were used—more than four pounds for every American. But Ames and Gold, of the National Institute of Environmental Health Sciences Center at the University of California, Berkeley, contend that the risks to consumers of developing cancer from pesticide residues on their food have been greatly exaggerated. Indeed, they say, by lowering the cost of fruit and vegetables and so increasing their consumption, the use of synthetic pesticides may even indirectly *reduce* the danger of cancer. After all, eating more fruits and vegetables and less fat may be the best way of lowering the risk of cancer, next to giving up smoking.

Pesticides that cause cancer in laboratory rats or mice when administered in extremely large doses don't necessarily do the same in humans when taken in much, much smaller amounts, Ames and Gold point out. Moreover, they say, the minuscule quantities of synthetic pesticides that Americans take in with their food are vastly outweighed by the "natural pesticides" they consume every day. These are the toxins plants produce to protect themselves against fungi, insects, and animal predators. Cabbage, for example, contains 49 natural pesticides. While relatively few such natural chemicals have been tested on rats and mice, about half of those that have been have caused cancer. Ames and Gold calculate that Americans eat about 1.5 grams of natural pesticides per person per day—about 10,000 times more than the amount of synthetic pesticide residues they ingest.

But such comparisons, because they don't take into account the pesticides' carcinogenic *potencies*, have little scientific value, argue Huff and Haseman, of the National Institute of Environmental Health Sciences. And the rodent studies of synthetic pesticides, they say, do have significant value in the eyes of most scientists. Such studies indicate "that exposure to certain pesticides may present real carcinogenic hazards to humans."

One point on which both sides seem to agree is that there is reason to be concerned when people are exposed to large amounts of certain pesticides. Haseman and Huff say that the potential risks to food consumers shouldn't be minimized, but