
OMNI
HUMAN HIBERNATION:
CURE FOR AGING AND OBESITY?
KILLER ROBOT
INTELLIGENT CELLS
PLUS: FRANK HERBERT'S
NEW DUNE NOVEL

OMNI®

VOL 6 NO 6 MARCH 1984

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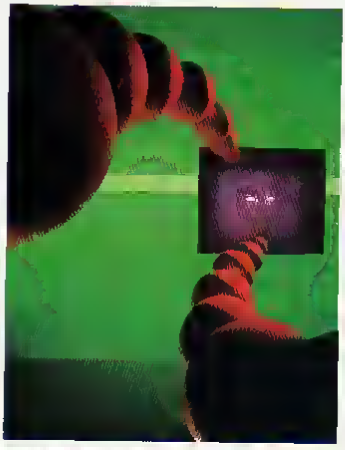

Michel Tcherevkoff conceived this photograph for a corporate client and then redesigned it for a forthcoming book on his work. He is an advertising photographer known for his creative use of special effects and his continual experimentation with new techniques

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FIRST WORD

By Dick Teresi

"We have given eight world-class scientists a singular mission: Uncover the unsung heroes of science, those who are secretly shaping our future."

Science, one of America's leading academic journals, recently began an article with this bold statement: "If all goes well, researchers will soon be startled to read an account of the first X-ray holography experiments."

It was a courageous prediction—except for one detail: The first X-ray holograms had already been made—by three Japanese scientists in 1972, a decade before the *Science* article appeared. It represented another step backward for science publishing.

About three years ago I received a call from a major university inviting me to a press conference at which an important advance in prostheses was to be announced. It was an artificial arm that "could actually be controlled by human thoughts." Imagine. Well, I didn't have to imagine. I had written a story about such an arm developed by the University of Utah several years earlier. I declined the invitation, but when I turned on the TV news that evening, there was my favorite anchorman extolling the virtues of this alleged innovation. Another step forward for press conferences.

For the past five-and-a-half years, we at *Omni* have been trying to tell people about the future. But it's difficult to convince the public of the reality of upcoming technological advances if it can't accept the present—or even the immediate past. It's especially scary when the group responsible for enlightening the public—the science press itself—shares this technomyopia.

Why does the press resist acknowledging progress? One reason is that journalists gravitate toward big science, by which I mean big-*budget* science. In the case of the X-ray holography story, *Science* magazine neglected the work of three published but relatively unfamiliar Japanese researchers in favor of an experiment by Lawrence Livermore Laboratory, a well-funded weapons factory with a public-relations staff of 27. As for the case of the redundant artificial arm, it simply reinforces the time-honored power of the press conference.

We have entered the Age of Quantum Science Reporting. By this I refer to quantum mechanics, which holds, among other things, that an electron does not occupy a specific position until it is observed to do so. In quantum science reporting, a scientific breakthrough does not take place until a press conference is held. Add an open bar and you have a potential paradigm shift.

Before you think this is just a diatribe against academic journals and the TV networks, I should add that we at *Omni* have also blundered. Two years ago our London bureau discovered an English inventor who claimed he had reinvented the wheel. *His* wheel had spokes of elastic spring steel to allow its rim to fold around obstacles. In March 1982 we devoted a short item to the "invention," in which we reiterated the inventor's belief that the wheel might be appropriate for lunar-exploration vehicles. Shortly thereafter we received a polite letter from the Grumman Aerospace Corporation, which pointed out that, yes, this was a reinvented wheel. One of its scientists, Edward G. Markow, had proposed such a metal-elastic wheel system back in 1963. And yes, it would be appropriate for lunar exploration, considering that a similar design from Boeing was employed on the lunar rover driven by Apollo astronauts a decade ago.

Embarrassing as these episodes may be, the press should not shoulder the entire blame for technological staleness. The scientific community is doing more than its share. The scientific process, for example, places so much importance on the replicability of an experiment that an unoriginal but competent researcher can quite legitimately make a career out of simply replicating other people's work. Then there's the government's peer-review system of awarding grants. Ultimately, what this means is that any scientist on the cutting edge—that is, a researcher without peers—finds difficulty in getting financial backing through established scientific channels.

We'd like to do something about this. While we can't do much about the government (at the moment), we are going to make a concerted effort to find those scientists whose work is shaping our future, but who do not have 27 public-relations people singing their glories. We are going to beat the bushes for the unsung heroes of science.

But we're going to cheat. We've formed a panel of eight of the world's finest scientists to help us unearth the unsung and the unpromoted: David Baltimore, a Nobel laureate at the Whitehead Institute, will look for promising geneticists and other medical researchers. Cornell University astronomer Frank Drake, the "father of SETI (search for extraterrestrial intelligence)," will cover exobiology. For robotics we have Joseph Engelberger, founder of Unimation, America's leading robot manufacturer. Olaf Helmer, originator of the Delphi method, is in charge of unsung futurists. Leon Lederman, director of the Fermi National Accelerator Laboratory, will cover physics. In psychology there's Stanley Milgram, the author of the landmark obedience-to-authority experiments. From the National Institute of Mental Health, we have recruited Candace Pert, discoverer of the brain's opiate receptor, to cover neuroscience. And for evolution we have Cyril Ponnamperuma, director of the Laboratory of Chemical Evolution at the University of Maryland.

Within a very few months we'll present to you the unsung and the peerless. You'll have to read about it here; there will be no press conference. ☐☐

Dick Teresi is the Editor of Omni.

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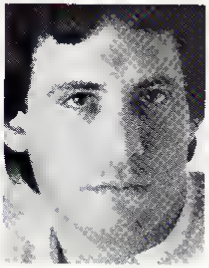
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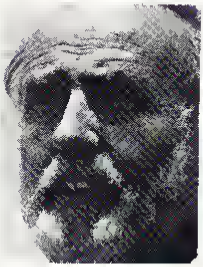

FULLER


HERBERT


WANNING

We know without undergoing it, what hibernation is. We know that bears descend into a state of consciousness somewhere between sleep and death, and that they pass the winter months in this condition. We've seen such celluloid fantasies as Rod Serling's *The Long Morrow*, in which an astronaut enters suspended animation after receiving serum made from the blood of hibernating animals. Today we are closer than ever to making such fantasies come true.

In "Human Hibernation" (page 68), freelance writer *Sherry Baker* reports that scientists may have finally found the material that triggers hibernation in animals. And according to Baker, the substance has the power to cross the bounds of species and produce a host of metabolic changes in nonhibernators. "It is only a matter of time until this trigger is used on humans," Baker says. "And the results may well revolutionize many areas of medicine."

Controlled hibernation could allow patients to undergo surgery without the attendant risk of anesthesia. An astronaut could slumber, without ordinary aging, through long space trips. Insomniacs could sleep without taking barbiturates or other dangerous drugs.

While some researchers dream of benevolent hibernation, others are tracking behavior in a city that never sleeps. "Life in the Wired Society" is the story of the world's greatest computer net worker, Murray Turoff, and his burgeoning community of strangers from all over the country. With connections built up from bits and bytes and telephone lines, the group is already sharing information and gossip, pursuing love affairs, and taking college courses in a vast electronic city. On page 48, *Doug Garr* takes a look at Turoff's information-exchange system.

Garr says, "Murray is a true child of the global village, a communications junkie who needs his daily fix of words and ideas that fall from his terminal. Paradoxically, he can't stand telephones. Our first interview was conducted face to face, but subsequent talks were made on-line—with the mediation of a computer."

Garr's last feature in *Omni*, a profile of Apple Computer's cofounder Steve Wozniak, has been turned into a forthcoming book from Avon.

Amid such celebrations of technology, *John G. Fuller's* "Death by Robot" is a reminder that the most spectacular machines are failures if they threaten the safety of their human operators.

Fuller takes us to the mazelike section of an auto plant in Michigan. The masters of the domain, one-ton robots, roll noiselessly on tracks, their lights playing off the skeletal steel beams. On January 25, 1979, an auto worker named Bob Williams ventured into this no-man's land to perform a routine procedure.

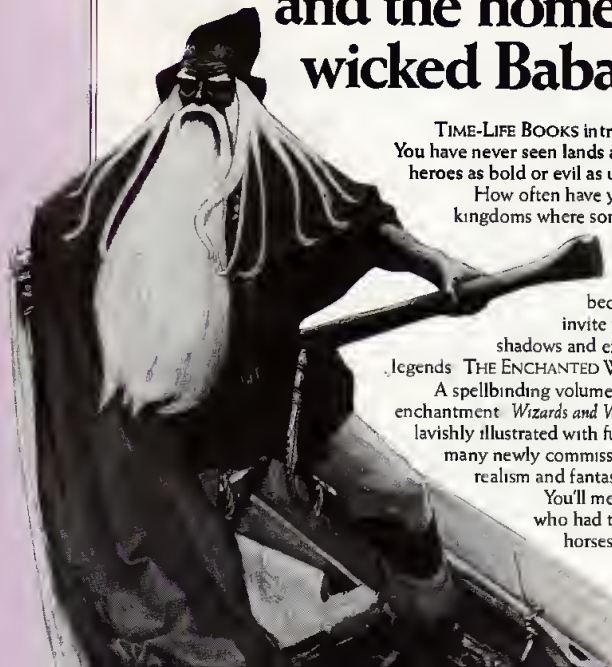
Veteran investigative journalist Fuller narrates what happened next, and shows how a newly designed mechanical system began to take on a life of its own, threatening the human life it was meant to serve. Fuller's latest book, *The Day We Bombed Utah*, will be published in April by New American Library. A selection of the Literary Guild, the book started as an article written for *Omni*.

Scientist Roger Revelle deals with life on a grander scale: oceans, the atmosphere, the effects of two atom bombs dropped on an atoll, the earth's weather. In our interview, which begins on page 76, freelance writer *Esther Wanning* asks Revelle to speculate on some possible results of the greenhouse effect, the bottling up of solar energy under our atmosphere's ever-growing ceiling of carbon dioxide.

Few people have devoted more energy than Revelle toward the management of science for public use. Wanning says, "His overriding concern over the last twenty years has been the extension of the world's resources to adequately feed the eleven billion people the earth may soon expect to entertain. And if Revelle has his way, it will still be an earth with gorillas and whales and butterflies."

Fiction this month comes from *Frank Herbert*, whose novels about the desert world Dune have made him one of the world's best-known writers. The saga continues in "Heretics of Dune" (page 54), an excerpt from the fifth book of the series. The full novel will be published in April by G. P. Putnam's Sons.

You've been to Oz, Camelot and Middle Earth. Now, wend your way to Kaleva...the land of Taliesin... and the home of wicked Baba Yaga.



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MARCH

LETTERS

COMMUNICATIONS

A Novel New Year

This year we're all reading and hearing more about George Orwell's *1984* than any of us really want to. Every semischolar and TV editorial personality will be asked to comment on the novel's accuracy in predicting what life will be like this year. Unfortunately, what is usually said is invariably the same, and sadly, too little of it is particularly insightful.

I was rather disheartened to see that even the contribution of Paul Zweig, a recognized scholar [First Word, December 1983], embraces the most common and perhaps the most detrimental fallacy in today's interpretation of this novel. The book was not written as a prophecy so that Orwell could gain posthumous acclaim for intuitive art, but as a black satire on the world of his day, exaggerated and safely removed to the future—just as Jonathan Swift set his satire *Gulliver's Travels* in the fictional countries of Lilliput and Brobdingnag.

It is important for us to read *1984* at this time not only because it is an engaging and provocative piece of literature, but also because we can respond with sensible discrimination to the barrage of commentary and pseudoexegesis that the media have launched at us. Zweig was correct in one respect. There will be no *1984* in 1984. But to assume that *1984* will never come about is a fallacy.

Timothy Billings
Claremont, CA

Random Compliments

What I like best about *Omni* is the totally uneven quality of its contents: the random way that good, bad, and indifferent, hard facts, sloppy thinking, and flights of fancy are all jammed together, back to back and face to face. Some of what I read in *Omni* is, for me, difficult to comprehend. I find the interviews tough sledding and Games a challenge. Useful information is scattered willy-nilly throughout the magazine, making it a real treasure hunt to read every page.

Please do not ever standardize *Omni*'s performance. It is this surprising range of material that I like best. It is similar to good, rollicking, old-fashioned jazz, only *Omni* is for the mind, not the ears. Keep up the good work. We cherish our friends because they have variety, not because they are perfect. Long live *Omni*!

Nancy Campbell
Clovis, CA

Telescopic Error

I am going to catch a lot of flak from my astronomy colleagues because of an error in my article "The Eyes of CERGA" [Stars, November 1983]. The Schmidt telescope at the Calern Observatory, in France, has a 35-inch aperture. The largest Schmidt telescope in the world has a 48-inch aperture and is in California, at Mount Palomar.

J. Derral Mulholland
Austin, TX

King at His Best

Stephen King is such an enormously successful author that it seems almost superfluous for me to reply to the criticisms made by Mitch Tuchman in his article concerning the motion-picture version of *The Dead Zone* [Film, November 1983]. However, since *Omni* is such an important focus for the science-fiction world, I do not like to read unkind remarks about a movie that represents SF at its best.

In science fiction it is possible to speculate about certain phenomena that are at present only partially understood. Precognition is such a phenomenon. In the real world, if someone assassinated a politician because he 'saw" that that politician would do great evil, the assassin's legal defense would certainly be regarded with suspicion and probably total disbelief. In *The Dead Zone*, however, it is shown that John Smith's precognition is real and his vision true. It is within this context that the character's actions must be understood. Hence the movie is a legitimate study of responsibility under science-fiction circumstances, rather than, as screenwriter Jeffrey Boam puts it, an improper movie that "condones assassination."

David Palter
Hollywood, CA

DIALOGUE

FORUM

Omni welcomes speculation, theories, commentary, dissent, and questions from readers in this open forum. We invite you to use this column to voice your hopes about the future and to contribute to the kind of informal dialogue that generates breakthroughs. Please note that we cannot return submissions and that the opinions expressed here are not necessarily those of the magazine.

Speaking Freely on Chomsky

I was disturbed to note the frequency with which a respected 'scientist' like linguist Noam Chomsky [Interview, November 1983] bases his professional judgment on personal opinion rather than scientific evidence. Note, for example, that to Chomsky, Piagetian psychology simply "seems to be extremely wrong." Chomsky "just knows" that humans have free will (though in his opinion this is something that can never be proved). He maintains that we should have faith in his formulations of linguistics and wait until "someday" when someone comes along with the few missing pieces that will prove that Chomsky is correct.

This is the man who has molded modern linguistic science? Chomsky, relying heavily on his hunches and intuitions, seems oblivious of science as a data-based venture, often plodding and programmatic in nature, as opposed to intuitive and revelatory. Chomsky's swashbuckling personal manner may account for some of his popularity, but it also indicates that, like Chomsky's characterization of behaviorism, his approach to linguistics has "gone absolutely nowhere." He has produced neither scientifically sound techniques for documenting his theories nor usefully applied strategies for teaching language or remedying language difficulties, because his work is rooted almost entirely in speculation.

We behaviorists have been suspicious of Chomsky ever since his review of B. F. Skinner's *Verbal Behavior* revealed that Chomsky misunderstood even the most basic of behavioral principles. More disturbing, it appeared that he had not even finished the book in question. Now it comes to light that Chomsky is ignorant of recent experimental evidence documenting some of Skinner's positions on language: that linguistic structures are defined in terms of discriminative stimuli and consequential operations, and that humans learn two functionally independent verbal repertoires, one as speaker and one as listener. In short, your interview was effective because it highlights Chomsky as a dynamic talker but a weak scientist.

Thomas Critchfield
Pittsburgh

Referring to the sentence "John was killed by a rock falling on him," Noam Chomsky states, "Constructions of this type—where you can or cannot drop the pronoun—are very rare. In fact, they are so rare that it is quite likely that during the period a child masters his native language . . . he hears them [spoken] very sporadically. Nonetheless, every native speaker of English knows flawlessly when you can and can't drop the pronouns in these kinds of sentences."

Well, I believe Chomsky would change his mind if he ever came to Minnesota and heard some of the flawed sentences spoken here. The most common syntactical errors are along these lines: "Are you coming with?" which can mean "Are you coming with us?" or "Are you coming with me?" Another expression is "I borrowed you some money" (meaning "I lent you some money").

It took me a long time before I got my six-year-old child to say these particular sentences correctly. Most of his friends do not. I believe that, if anything, this shows that exposure to others' conversations determines how one speaks.

Michele Gormley
Glencoe, MN

The Noam Chomsky interview contains some misleading information that I would like to correct. Chomsky comments that, at one time, B. F. Skinner "held that, apart from the most rudimentary functions, essentially nothing of importance was genetically programmed in the human brain." Later, Chomsky claims that Skinner "argued that all human behavior was simply a reflection of training and experience." *Omni* reports that Skinner's extreme position has since been modified. As a scholar of Skinnerian behaviorism, I can assure you that Skinner has never held the position Chomsky attributes to him. The lack of scholarly integrity in Chomsky's remarks suggests to me that his careless criticisms of Skinnerian behaviorism are "off the wall."

Kevin Jackson
Gainesville, FL

It is interesting to note that Chomsky says, "I'm not sure that I want free will to be understood." Bearing in mind that popular opinions concerning moral and philosophical issues appear to rely on the existence of free will, it would not be surprising if the subconscious mind blocked the pursuit of logical deduction in areas of investigation likely to give rise to uncomfortable conflicts. In fact, this would be highly adaptive behavior.

Everard Cunion
Dorset, England

Noam Chomsky states, with regard to the problem of free will, which has bedeviled man for several thousand years: "We may be like the rat that simply is not designed to solve a certain type of maze and will never do so, even if it works on it for ten million years."

If we consider the problem of survival to be a maze, we find we do have a method for obtaining solutions to this problem over a period of ten million years: It's called evolution. As human beings, we can easily solve the problem that outwits the rat. In fact, it is so easy for us that it is totally irrelevant. We can do it anytime we choose to.

So, if we rephrase the question asked by the interviewer, "Do you think *man* (as opposed to *science*) will ever solve the problem of free will?" the answer may well be, "When he chooses to."

Judith Arnold
Santa Fe

MIDNIGHT DUMPING

EARTH

By Eleanor Smith

Jim Service was patrolling Queens, New York, one day in December 1982 when he decided to take a look at a company he'd been reading up on. So he parked his unmarked car down the street from Active Steel Drum, a small, family-owned business that buys, repairs, and then resells used chemical-storage drums.

In his grubby work clothes, Service didn't stand out in this industrial neighborhood. He got out of his car and spent the next few hours walking around the block and sitting and reading a newspaper. All the while, however, he kept his attention riveted on the activities inside Active's yard. Every few minutes trucks would pull in and company employees would unload drums off them. Most of the drums appeared empty to Service, but some clearly were not. Service saw workers pouring different colored liquids out of some of the barrels and into others. His interest was piqued; this could be a violation of the company's permit, he thought. Making sure no one saw, he snapped photographs of the operation and watched as Active employees stacked the partially filled drums just outside the fence, on the street. He noted that these rusty, beat-up drums didn't look as if they would hold much of anything, at least not for long. But Active was obviously storing something liquid and possibly toxic in them.

Service, an officer with the New York State Bureau of Environmental Conservation Investigations (BECI), in White Plains, New York, hurried back to headquarters and told his boss, Captain Michael Murry, about his discovery. Murry ordered a stakeout of Active Steel Drum and enlisted the cooperation of the Queens district attorney's special squad—plainclothes detectives from the New York Police Department. Over the next two months, Service and members of the squad took turns watching Active and talking to company employees as well as people in the neighborhood.

Eventually, Service says, his group concluded that Active had been receiving—in violation of its permit—barrels with varying amounts of hazardous liquid wastes from local glue, paint, and varnish manufacturers. Instead of shipping these substances—including toluene, carbon tetrachloride, cadmium, and chlorobenzene—to a licensed hazardous-waste facility, as required by law, says Service, Active had allegedly been pouring them into bins, mixing them with ash and ordinary trash, and paying a garbage hauler $200 a load to dump them in a Brooklyn landfill. Using this method, the company saved at least $5,000 per load.

On August 3, 1983, a New York grand jury indicted Barry Fine (president of Active Steel Drum) and the company itself on 14 counts of illegal handling and disposal of some 47,000 tons of hazardous wastes. Three of the counts are felonies in New York and carry prison terms of up to seven years, as well as fines of up to $100,000 per day of violation.

Ever since residents of Love Canal were evacuated from their homes in 1978, Americans have become increasingly aware of hazardous waste dumps polluting local water supplies and threatening public health. Just as the Love Canal incident was gaining publicity, Kentucky officials discovered the notorious "Valley of Drums," a dump with 20,000 abandoned chemical drums, some of them leaking toxic waste. Experts later detected cancer-causing polychlorinated biphenyls—or PCBs—in three creeks running through that valley, just 20 miles south of Louisville. In 1980 the disposal site of the Chemical Control Corporation in Elizabeth, New Jersey, burst into flames, spewing toxic fumes into the air. And in 1983 residents of Times Beach, Missouri, learned that their streets were contaminated by dioxin, perhaps the most toxic substance known to man. The chemical they discovered had already killed hundreds of animals throughout the state. Today most of the 2,500 residents of Times Beach have left their homes, but they still live in fear of the cancer, liver damage, and genetic mutation that dioxin is said to cause.

Such incidents, moreover, have occurred with disturbing frequency at

CONTINUED ON PAGE 116

SMART CELLS

LIFE

By Kathleen McAuliffe

I experienced metaphysical angst for the first time in a high-school biology class as I peeped down the barrel of a microscope at a paramecium. The creature that confronted me was not the inert blob of cytoplasm I had expected. For all its simplicity, the paramecium demonstrated a dazzling array of behaviors as it agilely maneuvered about clumps of cellular debris, poked its tiny cigar-shaped body into thickets of algae in a feeding orgy and engaged several partners in vigorous sexual flings. It had animus, spirit, consciousness—that indefinable quality that sets living things irreconcilably apart from lifeless matter.

'Smart little buggers!" I exclaimed within earshot of my teacher, who promptly set about squelching such unscientific thinking by accusing me of anthropomorphizing. Paramecia, she pointed out, could not be intelligent since they have no trace of a nervous system or brain. Indeed, a paramecium is smaller than a single brain cell.

Although I accepted her reprimand, I never quite accepted the theory. So it was with great interest and enthusiasm that I greeted new evidence indicating that living cells may actually possess computer "minds"—ultraminiature protein networks called microtubules.

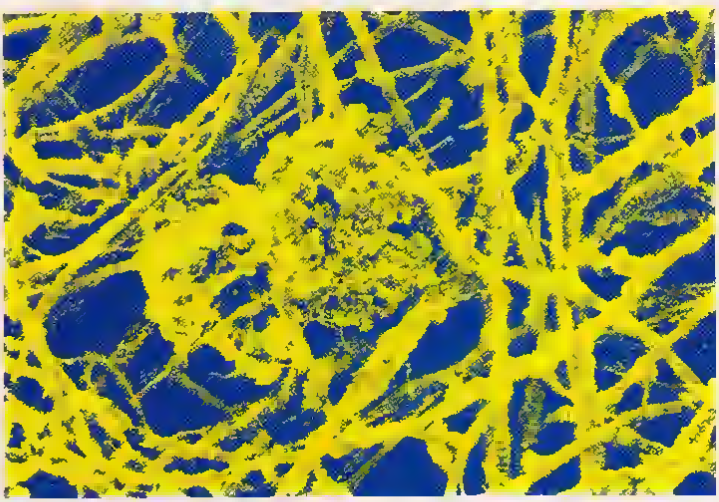
Researchers using high-powered electron microscopes first spotted them in the early Seventies. Microtubules and related proteins were initially thought to be skeletons or supporting frameworks that give cells their characteristic shape. But theoretical calculations have now led investigators to hypothesize that these protein networks might be ideally suited for information processing. Because of their extremely small size, such computers—if that is what they are—would be many times faster and more efficient than any existing electronic device. As such, they might elevate microbes to the status of sentient beings—albeit simpleminded ones.

Interestingly enough, microtubules are also found inside the cells of higher organisms. And that discovery suggests that their role could extend beyond the psychic lives of microorganisms and all the way up the evolutionary scale to man. In fact, these structures are most abundantly represented in brain cells. There, they have been strongly implicated in such key cognitive processes as long-term memory and sensitization to learning. Some scientists speculate that microtubules, because of certain molecular-architecture characteristics, might be capable of generating images and storing information in a form similar to a hologram, a three-dimensional, lifelike image of an object.

The chief champion of this radical new view of microtubules is Tucson-based anesthesiologist Stuart Hameroff, who divides his time between medical practice and basic research at the University of Arizona's Health Sciences Center. Bearded, with a soft-spoken Western style that belies his New York origins, Hameroff entered his specialty with the goal of understanding how something as ephemeral as thought could have its origins in the physical structure of the brain. "If we can understand how anesthetics shut down neural activity," he observes, "we may better understand consciousness."

Although he now believes that anesthetics inhibit the activity of microtubules and associated proteins, what initially caught his attention about these cellular components was their uncanny resemblance to certain computer elements. An isolated microtubule is a long, hollow protein cylinder, reedlike in appearance. Inside the cell, however, these filamentous structures are tightly woven into a jungle-gym configuration that looks virtually identical to a high-tech bubble memory. During university lectures, Hameroff has even been known to slip a slide of such a device in place of one depicting a microtubule array. Invariably, the class mistakes the man-made invention for its biological likeness.

There is one big difference, though: size. Microtubules are dwarfed by today's electronic parts, which are several orders of magnitude larger. If anything, microtubules more closely resemble the futuristic biochips scientists hope to



Microtubules, tiny reedlike structures that surround cellular organelles, may serve as cell computers

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THE COMET IS COMING

SPACE

By James Kitfield

They spotted it on October 16, 1982, at the Mount Palomar observatory in southeastern California. From the recesses of deep space a bright speck could be seen hurtling toward the sun and our own orbit. The comet had been heading this way since 1948, after faltering at the peak of its trajectory somewhere beyond the edges of our solar system. Halley was long expected.

Upon first locking on the comet, observers at Mount Palomar initiated a long rehearsed sequence officially dubbed International Halley's Watch. Soon, nearly every large telescope on Earth would be tracking Halley, collecting vital information on its mass, speed and projected course. Nowhere were the data more anxiously awaited than at the European Space Agency (ESA). At its sprawling Space Research and Technology Center on the windswept coast of Holland, scientists are racing to prepare for the launch of *Giotto*—a Halley space probe scheduled to blast off from the jungles of French Guiana in July 1985. If everything goes according to plan, *Giotto* will fly through the tail of the comet between the twelfth and thirteenth of March, 1986 at a distance 150 million kilometers from Earth. Although Russian and Japanese space agencies are planning their own probes, only *Giotto* is designed to cut across the comet's trail of dust and debris to penetrate within 1,000 kilometers of Halley's nucleus.

"We're in a more kamikaze mode than other space agencies," says British physicist David Dale, project manager for the *Giotto* project. "If things work out the way we hope, *Giotto* will provide Earth's closest link with the comet." A former Ministry of Defense official used to working with hypotheticals, Dale recognizes that intercepting a speeding comet is an exercise lying largely in the realm of the untested and untried.

In contrast to the planets, whose behavior is fairly predictable, comets when near our star, constantly blow off gas and dust particles in response to solar winds. Besides forming dust tails, this reaction acts as a small rocket engine causing the comet to lose mass and alter its orbit around the sun.

Since centuries before Christ, Halley's Comet has intrigued and even frightened man, yet very little is known for certain about it. English astronomer Edmond Halley was the first to conclude that the comets that appeared in 1531, 1607 and 1682 were actually one and the same and since that time there have been only three predicted return visits to Earth. In 1910 the comet passed close enough to spread itself over a third of the sky and ignite widespread fear that the poisonous gases of its tail would contaminate Earth. But scientists were unable to get any closer to Halley than a telescopic view away.

From what circumstantial evidence does exist, most astronomers assume that comets were formed at the same time as our solar system. The most widely accepted theory explaining the makeup of a comet was advanced in the Fifties by Fred Whipple, then professor of astronomy at Harvard University. Equating a comet to a "dirty snowball," he described its nucleus as a mixture of ice, solid dust, and granular material. When heated by the sun, the nucleus releases enormous amounts of energy.

Most of us believe that the comets are made of the leftover material that formed our outer planets. So by studying a comet up close, you're essentially studying one of the building blocks of our solar system that has been kept in the deep freeze of outer space for the past four and a half billion years," says cometary science's elder statesman Whipple, now the director emeritus of the Smithsonian Astrophysical Observatory. Along with other astronomers throughout the world, he's hoping that the 1986 appearance of the comet will provide that close look. For the first time, the comet is passing during the Space Age.

Giotto project scientist Rudeger Reinhard compares preparing for that inevitable moment to riding in a rodeo. "It's a rough ride, and it has its ups and downs, but so far we've managed to stay on the horse. One reason they've

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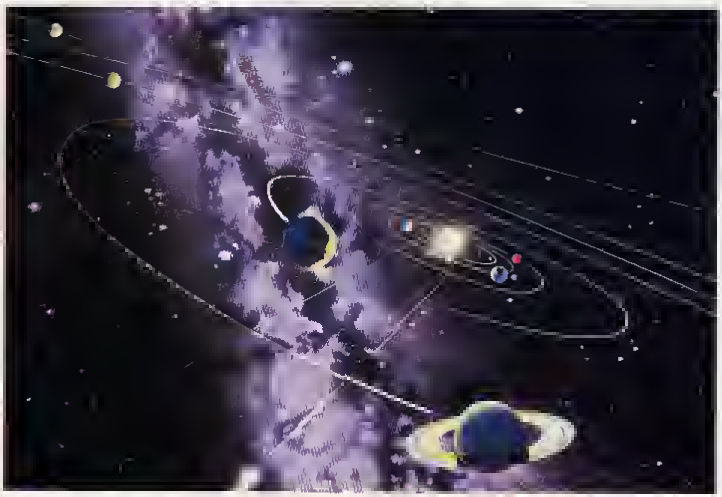

Europeans prepare for a split second, high risk mission to the tail of a "dirty snowball"

SPEECHLESS

MIND

By Patrick Huyghe

If feelings are the basic currency of human emotions, then some of us have been shortchanged. Take the case of the engineer whose history of intractable headaches thwarted his lifelong ambition to become an airline pilot. When asked how he felt about the situation, he replied: "I don't know what you expect me to say when you ask how I feel." Or take the case of the woman who, when asked how she felt about her mother's death, replied: "Well, it wasn't good. But the flowers were pretty."

It is a well-established medical fact that some people lack the vocabulary necessary to express their feelings. The condition, which might be a harmless trait for some people but a severe problem for others, is known to psychiatrists as alexithymia, a term that means *without words for feelings*. Psychiatrists estimate that more than 10 percent of the population may be alexithymic.

Alexithymics are typically described as emotional illiterates. They have little awareness of their emotional lives and normally cannot distinguish between even such common feelings as sadness and anxiety. Their thinking is preoccupied with the minutiae of external events, and they lead bleak fantasy lives. Most deny they ever dream.

"The problem is that these people cannot connect their thoughts with their emotions," says Dr. Peter Sifneos, the Harvard professor of psychiatry who coined the term *alexithymia*.

"Emotions are not the same thing as feelings," he explains, "though dictionaries often don't differentiate between the two. Emotions are biological. A cat can have an emotion when it sees a dog coming at it. But the cat can't have thoughts in reference to the situation. That's something we have that the cat doesn't. So we have feelings—the thoughts attached to emotions. Alexithymics don't have that."

The condition has been observed in hypochondriacs, drug addicts, alcoholics, sociopaths, patients with psychosomatic illnesses, and people who have experienced severe traumas. But alexithymia may also appear in people who are otherwise considered to be quite normal.

An alexithymic's response to a funeral: "Well, it wasn't good, but the flowers were pretty."

"I would say there are quite a lot of alexithymic individuals around," says Dr. Sifneos, "though most of them are unaware of having a problem at all. These people can function quite adequately, particularly in a technological and materialistic society such as ours. They can be creative and intelligent and make a lot of money. It's only when it comes to dealing with feelings and emotions that they have a problem. If one alexithymic marries another, they might have a wonderful marriage. But if an alexithymic husband has a neurotic wife, for instance, then all hell breaks loose."

Though alexithymia is a new word, it is not a novel idea. Sifneos himself began to describe the condition almost a decade before he coined the term, in 1972. He first came across such individuals during his work on dynamic short-term psychotherapy, a form of treatment that Sifneos pioneered in this country. Sifneos discovered that some of his patients didn't do well with this therapy because they were unable to describe how they felt. He noticed that many of these people also seemed to have psychosomatic problems.

Sifneos began to wonder if psychosomatic illnesses—from ulcerative colitis to eczema and rheumatoid arthritis—might not be by-products of the alexithymic personality. Instead of letting off emotional pressures and tensions by talking about them the way most of us do, alexithymics might be releasing their emotions through somatic channels.

But the situation may not be quite so simple, according to Dr. Charles Ford, a professor of psychiatry at the Vanderbilt University Medical Center, in Nashville, Tennessee, and the author of the book *The Somatizing Disorders*. "Alexithymia alone may not be enough to explain the appearance of psychosomatic illness," he suggests. "I suspect that these people come from fairly emotionally restricted backgrounds and lower socioeconomic classes and have been under higher levels of stress all of their lives."

Dr. Ford finds the concept of alexithymia valuable and useful nonetheless. "I think it is a very important concept," he says,

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ARTIFICIAL INTELLIGENCE

By Daniel Kagan

Hackers are able to crack password codes and wander the phone lines, trespassing through data banks. Industrial spies raid secret data files, snatching new product designs. Computer criminals enrich themselves, plundering electronic fund-transfer networks. The Defense Department is positive—almost—that its top-security computer systems are invulnerable to penetration by outsiders or, worse, insiders with evil intentions.

Suddenly data security is the most important issue in the world of computing. In a few years the key element in the most tamperproof computers may not be a password, a secret personal I.D. number, or a data-encryption system. Instead, it may be the authorized user's fingerprint, or the unique blood-vessel pattern in the retina of his eye, or the length of his fingers, or the lines that crisscross his palm. It could be the one-of-a-kind characteristics of his voice or the pattern of his brain waves. In fact, it might actually turn out to be something even harder to quantify—the very *style* with which he uses the computer. It may be the idiosyncrasies of the way he logs on, the order in which he habitually executes commands, the rhythm with which he taps the keys, the pattern of mistakes he consistently makes.

As the future user goes about his computing tasks, a software program would monitor a previously entered statistical 'profile' of these behavioral elements and compare them with his actions. As long as his habits remain the same, the program—let's call it the behavior analyzer—will continue to grant him access to the data for which he is authorized. But should his pattern of use vary considerably, the behavior analyzer assumes a bogus operator is tampering with the system and terminates the man-machine communication.

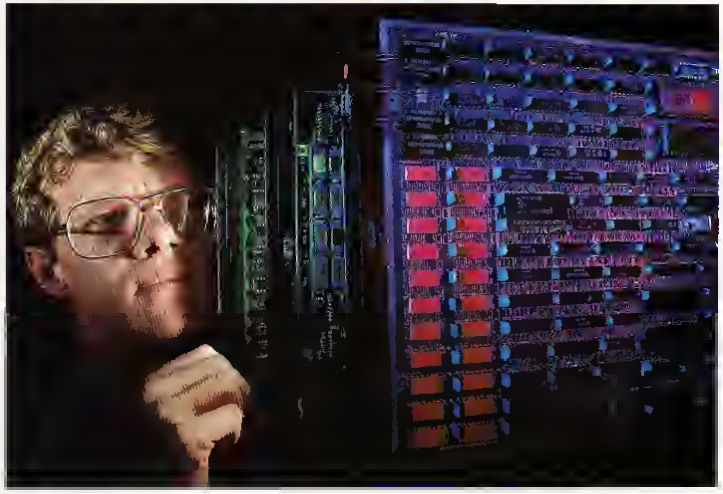
The behavior analyzer would recognize the user's operating profile in the same way telegraphers in the last century could recognize one another's Morse code signals. Each telegrapher had a recognizable 'fist,' a way of tapping out his dots and dashes, pausing here, slurring there—a rhythmic tattoo as distinctive as a signature.

This concept is so new it doesn't have an official name yet. It's being researched by SRI International, in Menlo Park, California, under the guidance of Donn Parker, one of the acknowledged masters of computer-security theory. The work marks a move away from I.D. verification based on what the operator *has* (like a magnetic-stripe card) and what he *knows* (like a password)—since these can be lost or stolen—toward using what the operator *is*. Because behavioral and physical dimensions are measured, the new systems of safeguarding data could be classed as both psychometric and biometric. In several other security systems, some of which will be operational later this year, the approach is purely biometric. Authorized users are identified by unique body characteristics.

"You can't leave your body at home like a card or a key, and no one can steal it," quips Tom Catto, of Palmguard, Inc., in Beaverton, Oregon. His company's contribution to biometric data security is the PG-2000, and although it can't foretell the future, it can identify you by reading the lines on your palm.

The PG-2000 looks at a 2" × 2" area of the palm. The hand is placed over an opening in its reader unit and aligned by means of pegs between the fingers. Below the opening is a glass plate, and behind that is a solid-state camera made up of an array of photodiodes. The camera works much like a vidicon tube, and when a light inside the reader flashes, its 100-by-100 cell array captures and digitizes an image of the target palm into 10,000 bytes of information. This palm pattern is then stored as a template in the host computer the Palmguard is protecting. The process takes about three seconds, and the palm image can't be faked, even if someone were to sever the hand of an authorized user and try to pass it through the procedure.

"There's a time factor here," Catto



In the future, human-personality patterns may be the key to unlocking secret computer data

explains "As soon as the blood stops flowing through the tissues, the lines on the hand change. It's almost immediate." That means it's too short a time for amputation to be useful. Constructing a latex facsimile won't work, either.

According to Catto, the PG-2000 is extremely accurate. Its Type I error rate—that is, refusing access to an authorized user with a template in storage and making him repeat the process—is slightly less than 1 percent. Its Type II error rate—mistakenly allowing someone with no clearance to pass through—is 0.00025 percent.

These high levels of accuracy are comparable to other biometric devices. The EyeDentifyer spots authorized computer users by reading the one-of-a-kind patterns formed by the network of minute blood vessels across the retina at the back of the eye. This acts as an eyeprint, analogous to a fingerprint but, says EyeDentifyer's Dennis Porter, much more accurate. He puts the device's Type I error rate at 0.01 percent and its Type II error rate at 0.005 percent.

To operate the unit, you look through something that resembles a large pair of binoculars mounted on a swivel base. One eyepiece is active and does the work; the other is a dummy. Inside the unit, a tiny 10-watt bulb glows; its light filtered of all wavelengths but the harmless infrared. This beam is focused on the fovea at the center of the retina, illuminating it to produce the distinctive blood-vessel pattern and bouncing it back to be picked up by a photocell array in the device. This retinal pattern is converted to a digital signal. The bits of data are then stored in the host computer as the user's template. The I.D. process takes about five seconds.

The granddaddy of biometric-security systems is the Stellar Systems Identimat, which reads hand geometry—the finger length of four fingers, minus the thumb. Like retinal patterns and palm- and fingerprints, finger lengths are a "uniquely identifiable trademark of individuals," according to Stellar's Kent Sterling. The Identimat has been around since 1968, long before computer technology required routine close data supervision. The device's operation is simple.

The hand is placed on the unit so that the fingers rest along four grooves that have strips of photocells along their bottoms. An 800-watt blast of light illuminates the hand from above, tripping the exposed cells, which record finger lengths. These data are made into a template, which is stored in the machine.

The Identimat is the first and longest lived biometric security device. It has been used for years to guard not data but entryways at such high-security locations as nuclear-fuel-processing plants, military areas, and other sensitive high-technology-research zones.

Back in the mid-Seventies Texas Instruments (TI) invented another biometric security device, a voice-pattern identifier, as part of a security-research contract with the Air Force. In fact, TI installed a voice-pattern doorway-security device at its own facilities in 1974. It is still in use there, as is one sold to Allied General Nuclear Services in North Carolina. At $100,000 per unit, these were extremely accurate but too expensive to market, so these two are the only ones in existence. With the release of its new TMS 320 signal-processing chip this year, TI expects some entrepreneurs to use the processor to program a less-expensive voice-recognition device for widespread use as a data protector.

At the moment, the only fully operational biometric I.D. system in widespread use is the Identimat. The newer, more sophisticated systems are "developmentally operational," according to Mike Eaton, director of the entry-control systems division at Sandia Laboratories in Albuquerque, New Mexico, which evaluates all new biometrics as they are introduced. But right now, they are all still too expensive for wholesale use in typical multiterminal computer systems in business, banking, and other fields. "The next breakthrough," says Eaton, "will be to get single-unit costs down from the five-thousand to ten-thousand-dollar range to the one-thousand-dollar range."

"The EyeDentifyer spots authorized users by reading the one-of-a-kind patterns formed by the network of minute blood vessels at the back of the eye."

That would make the ultimate goal a reality: installing an EyeDentifyer, Identimat, Palmguard, voice-recognition system or other device at every terminal on every existing mainframe-computer system where security is important. The foolproof biometric-authentication step would be added to the familiar routine of logging on with an I.D. number and/or password. The system would keep fund transfers secure, keep the engineering boys out of the accounting data and the accounts people away from new-product designs. And it would completely outfox hackers, since they could not enter the system without the proper biometric I.D.

Perhaps the ultimate biometric identifier would be one that would read, average, digitize and store for comparison every authorized user's brain-wave pattern. All that's necessary will be for someone to develop a safe, easy way to administer an electroencephalogram without using contact electrodes or a bulky helmet. Even then, the human brain will still be the key to unlocking crucial knowledge.

NEW WARES, HARD AND SOFT

For every single software program sold, as many as eight to ten programs are illegally copied. Now it is possible to "fingerprint" a software program—a set of instructions to a computer—so that it can't be copied. Vault Corporation's ProLok disk system is a 5.25-inch disk with a unique, nonreproducible code mark embedded in its surface. To protect a program, the user loads it onto the ProLok disk. When the ProLok disk is inserted into a disk drive, the computer will run the program only after it detects the code. Because the ProLok code cannot be copied onto another disk, and the protected program won't run without the code, it is virtually impossible to make a usable, unauthorized duplicate. (About $10 each, from Vault Corporation, 2469 Townsgate Road, Suite 500, West Lake, CA 91361.)

Pint-size computers are becoming as powerful as desktop models. Sharp Electronics Corporation's PC-5000 is an 11-pound portable machine slim enough to fit into a briefcase. But it runs the same software programs as the popular IBM PC. Sharp's PC-5000 has several space-saving features. Instead of a screen, it has a fold-down liquid-crystal display that holds eight 80-character lines. And instead of floppy disks, it uses miniature bubble-memory cartridges to run and store programs. (In bubble memories, data are packed into sets of tiny, magnetized areas—called bubbles—in thin films of magnetic material.) An optional double-sided, double-density disk drive is available. The PC-5000 comes with 128 kilobytes of random-access memory—enough to store up to 80 typewritten pages—that can be expanded to 896 kilobytes. ($1,995 with word-processing and communications software, from Sharp Electronics Corporation, Systems Division, 10 Sharp Plaza, Box 588, Paramus, NJ 07652.)

Now anyone with a push-button phone can call up a database 24 hours a day to get the latest quotes on more than 15,000 stocks and options, or to obtain an automatic rundown of a particular portfolio. U.S. Quotes is a computerized service that delivers the data over the phone lines in an eerie-sounding electronic voice. The service costs about 12 cents a minute and is credited against an initial fee of $45. (U.S. Quotes, 307 East Forty-fourth Street, Suite 602, New York, NY 10017.)

FOX HOLES

STARS

By Charles Pellegrino

In our work on the early history of the asteroids, meteoricist Jesse A. Stoff and I came across a feature in need of a name. Peering out at us from the models, equations and meteorites was a "crazy" suggestion that asteroids once contained underground streams.

During the solar system's birth, the interiors of the asteroids became hot—very hot indeed. Between their molten cores and their cold, airless surfaces, water could (and did) exist in a liquid state. Here were aqueous environments outside the earth. But what to call them? I've a weakness for puns, and since everybody else at the time seemed to be raving about black holes, white holes, and wormholes, we elected to confuse matters further by introducing fox holes. We named these warm, moist zones in honor of University of Miami molecular biologist Sidney W. Fox, who demonstrated that amino acids mixed in water and cooked in certain ways will knit themselves together to form very large spheroid molecules—protocells.

Sure enough, there has been found in certain crumbly, wet and carbon-rich meteorites a stunning variety of molecular ornamentation, including fatty acids, amino acids, purines, pyramidines, precursors to chlorophyll (the pigment that green plants use to store the sun's energy), and perhaps the early stages of life itself. Unfortunately, asteroids are small as celestial bodies go, and they quickly lost their internal heat. By 4 billion years ago, most of the fox holes contained within them had disappeared. Though the first steps in the direction of life had already been taken, the process was apparently interrupted in mid-stride.

Still, the granddaddy of all (known) fox holes circles Saturn. We know from analyses of *Voyager 2* images that its moon Enceladus has been reshaped by volcanic forces. Some of its craters have been split in two by upwelling crust, an unusual phenomenon in a body composed mostly of ice, especially one so small that it would fit comfortably inside New Mexico. Stranger still, there are hints of an ocean inside that little world. The hidden sea is one of the solar system's oldest fox holes and also one of the first places we must consider when we think of extraterrestrial life.

But a world as small as Enceladus should have long ago frozen to its very core. By now, its surface—every square meter of it—should have been saturated with craters much like our own moon, which has been quiescent for more than 3 billion years. Enceladus didn't know this. It developed smooth plains anyway, its old craters filled with water that oozed to the surface and froze. Deep down, something has melted the ice. That something is the tide. Enceladus is in the middle of a gravitational tug-of-war. On one side is Saturn. On the other are Tethys (a 1,050-kilometer-wide satellite that sometimes sweeps past Enceladus) and Dione (a 1,120-kilometer-wide satellite that approaches within one half the distance separating Earth from the moon). Tidal friction between Saturn and its satellites generates enormous energy in Enceladus's interior and keeps it liquid. In all likelihood, sodium compounds, ammonia, crystalline forms of methane, and other nonwater substances help to induce melting. Together, they lower the freezing temperature of the water, just as salt spread on highways melts snow and ice in the winter.

Measurements of Enceladus's density show it also possesses a rocky core which measures some 155 kilometers across. This core is literally a world within a world, a planet so small that a submarine could take you all the way around its 488-kilometer circumference in a single afternoon. Down there, on the bottom of a fox hole, during the first half billion years of Enceladus's history, amino acids, porphyrin molecules, and other complex biochemicals were synthesized. We can be reasonably sure of this because such molecules were being manufactured in terrestrial seas and inside asteroids and comets. Two billion years later, on Earth, prelife chemical evolution matured from droplets of protein and tangled threads of nucleic acid to chromosomes tucked inside nuclei and powered by photosynthesis. A cupful

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Does the ice world now orbiting Saturn harbor primitive forms of life in its core?

CONTINUUM

HONEGGER HOTLINE

Presidential aide Barbara Honegger had a mission to identify every U S law discriminating against women She finished her report known as the *Gender Discrimination Review* on July 4 1983 But later that month the Reagan Administration claimed the review wouldn t be complete until 1984 Convinced that the President would betray the women of America Honegger vented her wrath in a *Washington Post* editorial Overnight her name appeared on the front pages of virtually every newspaper in the country and "people everywhere ' she says 'wanted to know more about the woman who blew the whistle on Reagan '

Mainly they discovered that Honegger was an outsider an oddball on the Washington scene Not only did she sport a mystic scarab necklace (signifying her quest for spiritual perfection) she'd also received the nation s first accredited graduate degree in experimental parapsychology (psi) from John F Kennedy University, in Orinda California

As Honegger herself explains it she got her 'entrée to the pinnacle of power in 1979 from Martin Anderson a former Reagan adviser ' While writing a book on the military draft at the Hoover Institution, Anderson hired Honegger as a research assistant "But one day ' she says while sitting at the boss s desk I saw the sun break through the clouds and I had this uncanny sense of empowerment I knew that Reagan would win the election that Anderson would follow him to the White House and that I d be taken along And that s what happened

White House staff members say the Honegger editorial was an overreaction pointing out that Reagan probably had sound political reasons for withholding the review from the public Honegger however insists that an experience in 1976 with Stanford University psychiatry professor Karl Pribram (father of the holographic-brain theory) had "sensitized" her to the Dr Jekyll/Mr Hyde personality and politics of Reagan

While she worked as a secretary for the mild-mannered professor, she claims in a California court paper he suddenly turned on her and beat her up in a violent rage (Pribram explains Ms Honegger had been answering invitations asking me to present my work, saying that I was unavailable but that she could present *her* ideas instead She manipulates the situation with consequences that lead to her complaints) When Reagan turned on me like Pribram, Honegger says ' I knew it was a dangerous beginning and I was right '

After she resigned from the White House Honegger claims officials launched a smear campaign to humiliate her by publicly revealing her involvement with psi Presidential press secretary Larry Speakes directed reporters to investigate Honegger s bizarre psychic streak and others called her work in psi 'simply un-Christian But to Honegger the reaction was full of hypocrisy Officials knew all about her degree in psi when they hired her she claims, and the CIA surely didn t give her the required top-secret clearance without investigating her background That background she adds was tapped after she offered to help the President and his advisers formulate crucial national defense policy based on the advice of psychics

Why for instance did Reagan decide against underground shells for the MX missile? According to Honegger because *she* convinced him that psychics could glean the position of underground targets And why did the President put 5 500 additional warheads on our 33 nuclear submarines? Because, Honegger explains *she* told him that psychics could *not* sense the movement of subs ("When brain waves meet the churning sea she says they are absorbed, scattered and confused ')

Moreover she claims if she d stayed on, she could have saved the White House from former Secretary of the Interior James Watt who she believes suffered from glossolalia or automatic speech, an illness that parapsychologists are trained to cure Watt s executive assistant Steve Shipley says Honegger s charge is garbage But Honegger who now plans to run for Congress says Let s face it They need someone like me

What does her former employer Martin Anderson make of all this? He says Honegger was an 'excellent worker who seemed to keep outside interests to herself But he doesn t rule out the possibility that she advised White House officials on psi Nonetheless he adds the White House staff consists of over two hundred people, including secretaries and clerks So who knows who she may have talked to?

As for the White House official spokesman Doug Elman put it this way 'We cannot confirm deny or discuss claims made by former employees, because when they're gone from here they re gone —*PETER RONDINONE*

CONTINUUM

CO_2 REBEL

In the ever-lengthening lineup of global-disaster scenarios, one of the most solemn—and sacrosanct—is apocalypse by CO_2, or carbon dioxide. This theory, which is based on computer models of future weather, holds that increasing concentrations of carbon dioxide in the atmosphere will bring about a worldwide warming trend, disrupting agriculture and ultimately flooding coastal areas with rising seawaters created by the melting of the polar ice caps.

But now a maverick physicist has come forward to challenge the doomsayers. After taking a long look at the data, Sherwood Idso, of the U.S. Water Conservation Laboratory in Phoenix, has reached two startling conclusions: first, that the net temperature effect of increased CO_2 concentrations may be a slight global *cooling*; and second, that a doubling of atmospheric CO_2 will create an agricultural abundance of unprecedented proportions: *increasing average worldwide crop yields by as much as 33 percent*. "The deserts," says Idso, "will blossom like the rose."

Rejecting computer modeling techniques favored by other experts, Idso has based his conclusions on such "real-world" data as global temperature readings, which show a marked cooling trend since the mid-Forties, and on the average size of world snow covers, which has been on the increase. His predictions on agricultural yields are derived from his colleagues' analysis of some 70 experimental reports, the great majority of which show that increased CO_2 concentrations yield significant improvements in photosynthesis, leaf size, and water retention.

The physicist's contentions—sometimes known as Idso's Facto—have made him some mighty enemies. The National Academy of Sciences (NAS) in particular has attacked his work, saying that it is "based on incomplete assessments." But Idso has counterpunched the august NAS, calling its adherence to computer modeling techniques "science by caveat" and "camel swallowing."

—Bill Lawren

Nebraska cornfields. According to "real world" statistics, the more carbon dioxide in the atmosphere, the better the harvest.

"No matter how eloquently a dog may bark, he cannot tell you that his parents were poor but honest."
—Bertrand Russell

LAWRENCE-LESS LIVERMORE

Despite his many distinguished accomplishments—including the invention of the cyclotron, which helped win him a Nobel Prize in physics—Ernest O. Lawrence is perhaps best remembered as a prime mover in the development of the atomic and hydrogen bombs. His name has been so strongly identified with nuclear-weapons research that when his Lawrence Berkeley Lab spawned a new national-defense laboratory at Livermore, California, in 1971, Lawrence's name went along with it. In 1979 an act of Congress officially established the name Lawrence Livermore National Laboratory.

But Lawrence's widow, Molly, now seventy-three (Lawrence himself died in 1958), is having second thoughts. Although she acknowledges his role in early nuclear weapons work, she insists that he became involved only out of patriotism to aid his country in a time of danger. Mrs. Lawrence now feels that the Livermore Lab, with its heavy concentration on defense work, is no longer a "suitable memorial" to her husband's name. It began to get to me," she says, "a little while after Reagan took office. I'd be sitting there watching television, and there it was again—some horror coming out of that place. It got to be almost embarrassing."

When she asked the Regents of the University of California—who administer Livermore for the government—to delete her husband's name, she was told that required an act of Congress. She promptly wrote all 11 congressmen in the San Francisco Bay area. "I'm determined," she said, "to do something

The late great E. O. Lawrence. For this tribute, no thanks.

about this before I die Now Congressman Ron Dellums of Berkeley, plans to sponsor a bill that would officially drop the Lawrence from Livermore

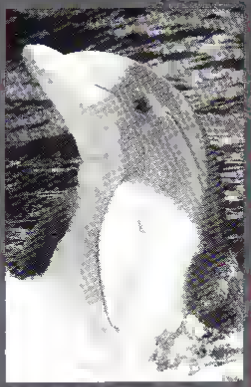
My husband," says Molly Lawrence did support the H bomb and did talk a great deal about a strong America At that time we all felt that way But that was pushing thirty years ago

I can t speak for the dead ' she adds but I m sure he would feel differently now '—Bill Lawren

PORPOISE SECRETS

The secret to the porpoises legendary sonar, say a pair of Seattle University scientists is a sophisticated 'sound lens' in the center of the animal's forehead

The central part of the porpoise's forehead is made up of a kind of fat that is structurally and acoustically different from surrounding areas according to Donald Malins and Usha Varanasi who are also affiliated with the National Oceanic and Atmospheric Administration They claim that this tissue has evolved into an organ that can modify sound waves



The porpoise uses what a sound lens in its forehead

Porpoises produce sonar, explains Malins by making a sound near the base of their blowholes the sound is projected forward to bounce off the forehead bones into the central lens Focusing the sound into a narrow beam the lens projects it into the water where it bounces off any object By distorting the lens Malins theorizes the porpoise can control the direction of its beam Finally its highly developed brain interprets the deflected sound waves as a sonar picture of its world

Porpoises see in three dimensions, and Malins suspects Their sound can penetrate when it is beamed out I find no reason why it wouldn t penetrate a fish for example The animal would not only see the shape of the fish but I believe it can also see the heart beating inside '

—Joel Schwarz

"Draw the curtain, the farce is over"

—François Rabelais on his deathbed

CRIMINAL GENES

To produce a criminal add an unwholesome childhood environment to bad genes But of the two factors, it's mostly genes that make the convict

This message, chilling or not comes from official adoption records in Sweden Peering into the lives of more than 1 500 Swedish adoptees born between 1930 and 1949 psychiatrist C Robert Cloninger, of Washington University School of Medicine in St Louis sought the ingredients of criminality

Among the study s 862 men he found, 7 percent of those with a bad early environment and a *noncriminal* ancestry became criminals—while 12 percent of those with a good early environment and a lawbreaking biological parent turned to crime But add bad genes to a bad environment and you get a whopping 40 percent risk of run-ins with the law

'Environmental factors alone don't produce criminal tendencies ' concludes Cloninger 'But expose genetically high-risk children to such influences as an unstable home life or low social status and you get a strong likelihood of criminality ' Criminal genes he speculates, probably involve the inheritance of such traits as impulsiveness restlessness and a low threshold of boredom

Cloninger and Swedish co worker Michael Bohman of the University of Umeå, have also analyzed 913 female adoptees and found that, in girls, ' criminal genes' alone were no more influential than environment But again, the combination raised the risk drastically

Potential delinquents? An unwholesome environment has been linked to lawbreaking but the real problem may be genetic

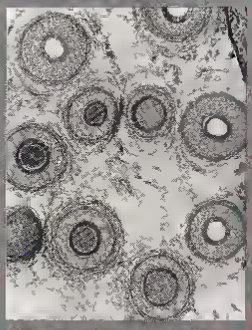
Another psychologist, Sarnoff Mednick of the University of Southern California recently turned up similar statistics among Danish male adoptees 'The main difference is that our study weeded out those people with a record of alcohol abuse, which is strongly associated with crime ' notes Cloninger

—Marc McCutcheon

CONTINUUM

HAIR AND VIOLENCE

At thirteen John S had already developed a history of spectecularly violent behavior A school failure and chronic troublemaker John was prone to seemingly incomprehensible destructive outbursts, culminating in attempts to murder two of his schoolmates But now after a year in a radical new diagnosis-and treatment program the once incorrigible John is according to researchers 'bright normal and doing very well in school'



Human scalp and hair. Trace minerals may prevent crime

The science that set John straight began with an analysis of his hair chemistry part of a research program that has been going on at the Argonne National Laboratory and the Health Research Institute both in the Chicago area for the last six years First a team of chemists under the direction of William Walsh profiled the quantity of 11 trace minerals in 60,000 normal people They then compared those profiles with hair samples of 96 extremely violent prisoners, ex-convicts and juvenile offenders When the results were in, Walsh s team found that as many as 97 percent of the chronically violent subjects showed imbalances in their levels of copper zinc sodium, and several other trace minerals

But it was not enough to establish the correlation Preliminary treatment programs were soon begun at the Health Research Institute (A similar program is under way at Princetons Brain Bio Center) The treatment consists of nothing more than supplementing the deficient minerals and correcting metabolic disorders that caused other minerals to be present in excess No counseling no psychotherapy no drugs

Walsh has yet to conduct controlled placebo or double blind studies, and so is understandably cautious about trumpeting his results Still, the early data are impressive 'We are seeing some spectaculer reversals in behavior" Walsh says 'Sociopaths are becoming nice people instead of being ferocious all the time

Despite his caution about the present, Walsh is extremely sanguine about the future 'This has tremendous possibilities for crime prevention,' he says 'It appears that we may be able to predict if a person is prone to violence by a chemical analysis of his hair It may be giving us a key to the cause of violent crime'—Bill Lawren

CARDBOARD HOUSES

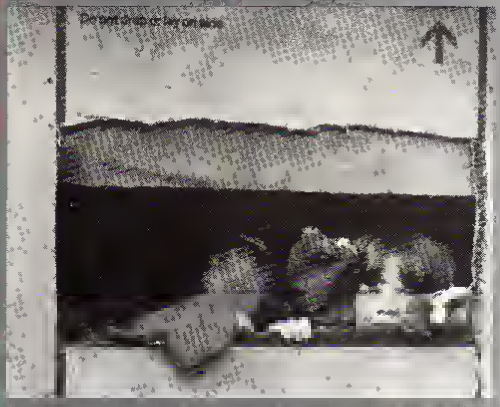
Houses of tomorrow may be made from Cleboard a chemically treated cardboard that is hard inexpensive, and able to withstand all sorts of abuse

Cleboard was developed by Henry B Cleveland, whose family has been building truck bodies in Alabama for 65 years About seven years ago a truck driver s cargo—salted hides picked up at a slaughterhouse—was literally eating up his truck To protect against the brine, Cleveland recalls we sprayed the truck with a special chemical mixture Some accidentally got on a piece of cardboard and hardened it'

Today, with a patent pending on his treatment process Cleveland is scaling production of Cleboard up to manufacturing levels The process starts with ordinary three-eighths-inch-thick cardboard Each piece is sent through a 354-foot tube in which temperature and humidity are controlled Four to six chemicals (including a fire retardant) are applied under high pressure

What comes out is rugged A Cleboard pier withstood an unexpected trip out into storm-tossed Mobile Bay during torrential rains four years ago A Cleboard septic tank is surviving sewage acids Cleboard truck bodies resist high winds and rough roads In addition the corrugated cardboard serves as an excellent insulator in refrigerator trucks

The most important use for Cleboard may be in home construction Building cardboard houses is easy as well as inexpensive The house panels come prewired precolored and preinsulated the windows



children s forts in [illegible] dream house

are preset, the doors prehung Says Cleveland, "All you do is fasten it to a concrete slab and put up a roof '—Carol A Johmann

"When I die I intend to take my music with me I don't know what's out there but I want to be sure it's in my key '

—George Burns

ASBESTOS SUBSTITUTE

To sugar substitutes and coffee substitutes, add another the esbestos substitute It was discovered by an engineer and his students at UCLA and it comes from the scrap heaps of Vermont

Asbestos is best known as a fireproofing roofing and insulation material but its chief industrial use is as a cement and concrete strengthener Because cement is highly alkeline and asbestos is immune to alkali the two were a perfect match—until of course, asbestos proved to be carcinogenic

But now thanks to John D Mackenzie chairman of UCLAs materials science and engineering department, there's a cheap safe ersatz asbestos The U S Bureau of Mines had asked Mackenzie to find a use for the mountains of scrap metal and slate produced by Vermont mining operations Responding to their request, he combined marble and the slate, heating the mixture to 2500°F When the slate and marble were mixed in certain proportions, the result was glass fiber as resistant to alkali as asbestos

The remarkable UCLA fibers, Mackenzie adds can also make glass wool, an efficient and nonflammable insulating material

—Eleanor Smith

Pouring concrete in Chicago A safe asbestos substitute may take the carcinogenicity out of future construction work

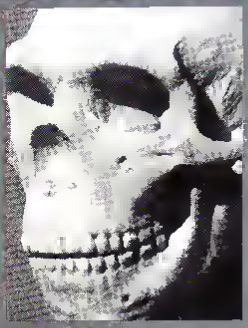
NILE NEANDERTHAL?

Archaeologist Fred Wendorf was surveying the desolate arid land on the west bank of the Nile near the village of Kubbinaya when he caught sight of an odd mound rising above the ground Bending down to inspect it Wendorf was amezed to see human vertebrae protruding from the top of the mound and a skull lying in pieces nearby ' I suspected I'd stumbled upon a very old and important find,' says Wendorf But little did the archaeologist know that he'd actually stumbled upon the oldest human skeleton ever unearthed in Egypt

Wendorf, of Southern Methodist University in Dallas began the arduous work of geological dating and soon discovered that the sediment in which the skeleton rested was at least 60 000 to 80,000 years old He and his colleague—anthropologist T Dale Stewart of the Smithsonian Museum of Natural History—now speculate that the creature may have been a remnant of the long-extinct Neanderthal man thought to have lived in Europe during the late Pleistocene Epoch some 45,000 years ago

If the speculation is correct says Stewart then this is 'the first Neanderthal ever to be unearthed in Egypt ' But the implications are just as startling if it's an archaic modern human since up until now there has been very little evidence of modern *Homo sapiens* living that far beck.

Stewart is currently making casts of the skeleton and examining it for specific Neanderthal traits like fullness in the midface and a particular placing of grooves in the shoulder blades He and Wendorf are also collaborating on a



European Neanderthal skull Was his cousin an Egyptian?

book about the anthropological and archaeological aspects of the Egyptian find And while Stewart's casts will be exhibited here and in Egypt, the skeleton itself already deemed a national treasure will be available for scientific study by experts only

—Kathrine Jason

'As soon as man applies his intelligence and only his intelligence to any object at all he unfailingly destroys the object '

—Lev Tolstoy

"For there is no day, however beautiful, that is not followed by night '
—Carved on the tombstone of Jean d'Orbesan, in Padua

CONTINUUM

MIND SCANNER

While Patient X, a schizophrenic tells psychiatrist Charles Stroebel about a childhood trauma, magenta shadows move across the video-screen image of his brain On the right side of the split screen his body also has a tale to tell The hands turn midnight-blue, and a snowflake-shaped blip beats faster over the heart

"I guess I'm feeling a lot of stress,' the patient confides Then he concentrates on warming his fingers, 'transferring" the glowing orange-pink blob from one part of his skull to another The knot of terror in his solar plexus subsides

Such technological mind reading is the work of the CAP scan developed by Dr Stroebel and his co-workers at the Institute of Living, in Hartford, Connecticut The newest in the line of marvelous machines the Computerized Automated Psychophysiological device weds computerized electroencephalography (brain-wave measurement) to biofeedback-type monitors of physiological changes

Fear anger nostalgia, or wistful longing are expressed in the body's code of clenched muscles rapid heartbeats unsynchronized brain waves in right and left hemispheres constricted blood flow in the fingertips, and the like, Stroebel explains The computer translates that into a moment-to-moment color portrait of brain and body—which the patient can regulate through biofeedback Within a decade he predicts, his CAP scan will be an everyday adjunct to the analyst's couch At $65,000 for the prototype and about $25 000 for a commercial version, it's a relative bargain, and it's noninvasive The patient will merely don a cap fitted with 18 sensors to pick up scalp electrical potentials and muscle-group movements

Meanwhile the Institute of Living is compiling a large sample of EEGs (brain waves) as a norm against which abnormal patterns can be rated 'We'll be able to tell a patient 'See if you can match that picture—move that pink area over there, ' Stroebel explains

—Robert Kall

The CAP scan The new art of psychiatry in Technicolor

"I don't believe in an afterlife, but I'm taking a change of underwear just in case"
—Woody Allen

With amniocentesis (shown above), doctors can now screen the fetus for thalassemia and several other dread genetic diseases

GENE FETUS TEST

A test for previously undiagnosable genetic disorders has been developed by researchers at the City of Hope National Medical Center, in Duarte, California The technique can actually track abnormal changes in single nucleotides—the individual links in the complex chemical chains making up DNA

The test can be used on pregnant women likely to carry genetic diseases resulting from changes in a single nucleotide Among these diseases are beta-C-hemoglobin (similar to sickle-cell anemia) alpha-1-antitrypsin deficiency which can cause either fetal liver cirrhosis or a predisposition toward emphysema, and beta-O-thalassemia which causes severe anemia and early death in Italian populations

The method, already in use at the City of Hope and the University of California at San Francisco involves withdrawing amniotic fluid from the pregnant woman's uterus, then extracting fetal DNA from certain cells in that fluid Next the researchers introduce synthetic gene fragments—one normal and the other a cloned replica of the defective gene being sought—to the DNA The normal synthetic can bind with only the normal gene pair while the abnormal clone can bind with only the defective gene pair Thus if the DNA binds to only the abnormal clone the fetus has the disease If one of the genes in the pair binds with the normal and the other binds with the defective clone then the fetus is a carrier of the disease

"Ultimately' says the City of Hope's Dr Bruce Wallace who developed the test with Dr Brenda Connor 'we hope the method will have broader application in diagnosing other genetic diseases —Bill Lawren

BODY OUT OF CONTROL

After contracting a medi cal problem that seems to be unique in all the world forty-two-year-old Marcia Cates volunteerad har living body to NASA Every day the Chatham Virginia housewife dresses in tube filled garments like those worn by astronauts under their space suits and a computer in California pon ders her vital signs

The condition that plagues Cates is called severe desynchronosis Her body is incapable of regulating heart rate blood pressure and temperature This has made her into a living laboratory for researchers studying temperature desynchronosis a phenomenon that may affect shuttle astronauts

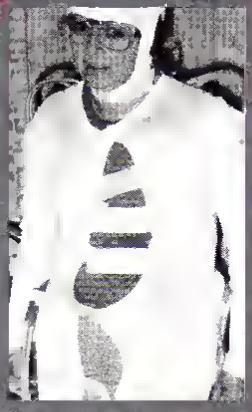
Cates's problems began with headaches and seizures in 1960 followed by surgery for a brain aneu rysm The aneurysm probably damaged her hypothalamus tha body s inner thermostat Later her husband Grady noticed that her temperature didn t register on an ordinary thermometer

Then Grady happened to watch a segment of the television show *That s In credible* about NASA's body-temperature research weightlessness may make body temperature fluctuate during long-term stays in space A faw phone calls later, Marcia came to the attention of Bill Williams then NASAs experl on liquid-cooling lechnology

With her body temperature ranging from 93°F to 105°F, ' Marcia doesn't know whether she is cold or hot Williams explains If her temparature moves too much in one direction she might die

We had some experimental suits used for anvironmental control, he adds, and we arranged for her lo have one Used under space suits the mesh outfit consists of a vest hat, end pants filled with tubes that carry cooled or heated water to stabllize Catess body temperature On her belt she wears a NASA-developed Vitalog which gives a readout of her rectal underarm end forearm temperature every two minutes and buzzes loudly when she gets too hot The recorded information is sent to the University of California at Riverside for computer analysis

—Sherry Baker



Special astronaut underwear keeps Marcia Cates alive

Abbie Hoffman at the University of Kansas 1970 Was the old power-to the people crowd really into personal aggrandizement?

SIXTIES PEOPLE

Ah, the Sixties If you were involved—even peripherally—in the radical movement of that era, chances are you saw the times as somehow charmed end your fellow radicals as well, charming They seemed *nicer* somehow, more altruistic and self-sacrificing—even noble

Well a new study may change lhat notion Dan McAdams of Loyola University of Chicago Stanley Rothman of Smith College and Robert Lichter of George Washington University, used an attitude survey known as the Thematic Apperception Test lo compare 72 radical leaders with 88 people who classified themselves as moderates during the Sixties

The result? Prominent adull radicals of the 1960s New Left ' say the researchers "were more concerned in their fantasy lives with power and less concerned with intimacy than were subjects in the comparison group Former radicals, male and female, revealed fewer themes of interpersonal warmth and dialogue

' I m sure says McAdams that some of these radicals were genuinely committed to social power to something larger than themselves On the other hend, I m sure thal some of them were on a personal power trip, and the movemant served as an extension of themselves

' My guess,' he adds ' is that you had individuals who were high in power motivalion before the movement came along and they found the movement e very appropriate arena in which they could display their power '—Bill Lewren

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This fool wents to turn the whole ert of astronomy upside down '

—Martin Luther on Copernicus

CONTINUUM

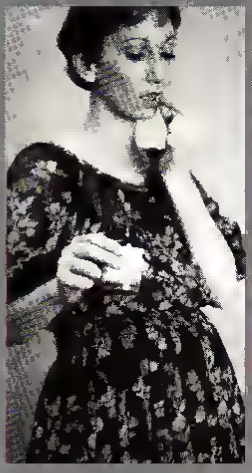
MULTIVITAMIN BIRTHS

Birth defects are the major cause of infant mortality in the United States Now there's evidence that common multiple-vitamin tablets may actually prevent two of the most serious birth defects spina bifida, a spinal-cord malformation that can end in fatal paralysis of the infant and anencephaly, a lethal condition in which the infant is born without any skull above the eyebrows

The occurrence of these two closely related birth defects was drastically reduced when pregnant women took a multiple-vitamin tablet (Pregnative Forte F), a recent study of almost 1 000 pregnant women at the University of Leeds in England suggests The women had previously given birth to infants with spina bifida or anencephaly, and were prone to repeat their misfortune But recurrence was nearly sevenfold less among those women who took the multivitamin tablets for three months, beginning at least one month before pregnancy

Multivitamins alleviate the expectant mother s imbalanced diet and promote normal development of the embryo theorizes pediatrics professor Richard W Smithells, who tried the multivitamin strategy after noting a correlation between birth defects and expectant mothers poor nutrition 'If we are really going to use this approach to prevent birth defects ' he says, 'then all females of child bearing age must either take vitamin supplements or modify their diets

The Center For Disease Control (CDC) in Atlanta plans a follow-up study 'Right now though cautions CDC pediatrician Godfrey Oakley there are not enough data to determine that vitamins prevent anything '—Eric Mishara



Vitamins may save your baby from serious birth defects

'When a man knows he is to be hanged in a fortnight, it concentrates his mind wonderfully '

—Samuel Johnson

DONOVAN'S BRAIN

Lately, neuroscientist Rodolfo Llinás has been hearing himself compared to scientists in the novel *Donovan s Brain*, the story of a dead criminal whose brain is brought back to life in the laboratory Llinas and his colleague Kerry Walton have actually removed the brains of several dozen guinea pigs and kept them alive in isolation for up to ten hours in their lab at New York University Medical Center

The First Lady (then a ess Nancy Davis) starred in the horror movie, now real-life science has caught up with Donovan s Brain

To preserve the extracted brains the scientists immerse them in a saline solution containing proteins and oxygen which is circulated through the cerebral arteries They use the solution rather than blood because blood clots

The brains die in a matter of hours when the neurons become waterlogged But the scientists hope that by varying the pumping motion of the solution or perhaps by switching to artificial blood they will be able to keep the brains alive for weeks or even months Once that's accomplished they will attempt the procedure with larger animals perhaps monkeys

Already Llinás has learned that a preserved brain emits waves indicating cycles of sleep and wakefulness It's probably similar to the animal s being in an ordinary situation of sensory deprivation he says

What s the purpose of all this? We re studying the relationship between different parts of the brain,' Llinas explains 'and this technique enables us to modulate ell the physiological aspects without the animal s body trying to change them back "

This research raises an inevitable question What is the possibility of maintaining the life of a human brain à la Donovan after the death of the body? 'We can t get into that yet ' says Llinás "First we've got to learn a lot more about what we're doing '

—David Dreier

Like beasts of fiction, the machines at a Michigan auto plant rolled quietly through a maze where men were unwelcome

DEATH BY ROBOT

BY JOHN G. FULLER

"The greatest task before civilization at present is to make machines what they ought to be, the slaves instead of the masters of men."
—Havelock Ellis

It was called a core stacker. It was not a machine, it was a place. Five stories high, it looked like the skeleton of an unfinished skyscraper. When the men from the foundry climbed inside the latticework of beams and girders, they often felt lonely, cut off from the world.

On each of the five levels, there were robots. They had no arms, no legs, but many eyes. They ran on rails like small locomotives. They carried and stored heavy loads of casting material, called cores. Atop each robot a whirling red light flashed like the light on a police cruiser. The rays bounced off the beams in strange patterns. The movement of the robots, on command from the central computer, was jerky, sporadic, unpredictable.

Robert Sugarbaker, ready to close down his night shift on January 25, 1979, remained in awe of the way the robots worked, obedient as West Point cadets. He was wary of them. They moved so softly on their urethane tires that they belied their gut strength to lift and move as much as 800 pounds. Sitting in the computer control room, Sugarbaker went over the computer printouts to pass along to Bob Williams and Curt Howard when they came in for the day shift that morning.

No one suspected what was to happen later that day. There were no villains. It seemed almost as if there were an inevitable convergence of man and machine—but a tragic and senseless one, a symbol of an unforgiving technology in the present and future world.

Even before Bob Williams left for work, January 25 was a special day for him and his pretty wife, Sandra. There would be cake and ice cream and presents for two-year-old Jeff—and two candles to blow out at a family celebration when Bob returned from his 7 A.M. to 4 P.M. workday at the Ford foundry in Flat Rock, Michigan.

At two, Jeff was bright and frisky. Almost a carbon copy of Bob, Sandra often thought. Jeff would scramble to the window every evening when he heard Bob's car pull into the driveway of their suburban home in Dearborn Heights. Although Renee was four, she could hardly compete in the race to the window. Lisa, at ten months, could only wait for Bob to pick her up and swing her in the air. Bob, husky and bearded and more than six feet tall, liked to take

PAINTING BY MARSHALL ARISMAN

two cars in the supermarket when he and Sandra went shopping—one for the kids, the other for the groceries.

Bob kissed Sandra good-bye that morning and got into his car to drive to Flat Rock. He said he might bring Curt Howard home from the plant to share in the ice cream and cake, although Curt would probably enjoy a six-pack more.

Ford called it the Michigan Casting Center. It was less than an hour's drive from Bob's house. It was such a giant hulk of a structure, you could see it from several miles away as you approached it on I-75, south of Detroit. It looked like a stack of huge, monochromatic cereal boxes. Inside, it was cavernous. It spread over an area of two to three Superdomes. Outside, mud-brindled steel slats covered its windowless sides. Small smokestacks poked through the roof—dozens of them, like truncated toadstool stalks. The structure was awesome. If wasn't a pretty place. If was considered one of the most modern automated casting plants in the world. It churned out hundreds of castings each day: engine blocks, engine heads, transmission housings. They moved in endless lines, suspended from overhead racks in sweltering temperatures. Some places in the plant reached more than 100°F.

When Williams and Howard came in for the morning shift, Sugarbaker briefed them. If had been a routine night, with nothing special to report. Smart as they were, the robots sometimes acted up and needed taming. All of the hand-picked crew who were assigned to the storage-and-retrieval area were ambivalent about the robots, even though they liked their jobs. "You become part of the damn machine yourself," Howard once said. "You can't work without it, and it can't work without you. That's the way it is." Howard also remembers his father's experience with a robot designed to pick fenders out of the racks and position them for welding. About once every three months it would slam a fender out in the aisle and smash it up, as if in a surly temper. "They finally put the thing in a cage, like a wild animal," his father told him.

But the robots Howard, Williams, and Sugarbaker worked with were more placid. They operated on computer command, running on rails formed by the giant jungle-gym grillwork of the core stacker. The machines' job was to place heavy loads of cores into temporary storage in assigned storage lanes. The cores were made of hard sand. They were used to shape the interiors of hollow car parts. Depending on the demands of production, the robots were also assigned to retrieve the cores from storage and send them on to the molding room, where the final castings were made.

On each of the five levels of the core stacker, two robots worked together as a team. One, the transfer robot, was like a small flatcar with a six-foot-high cab on one end. The cab ran empty; it was designed for repairmen to use occasionally. The second robot, called a mole, nested in the low flatbed of the transfer robot. Together, the two would move down the center aisle. When an assigned storage lane was reached, the mole robot would slide off at right angles and pick up or deposit whatever load was involved.

When a core was formed on the first floor of the building, it was placed on a carrier along with other cores of the same kind. The carriers looked like deep, tall book shelves. Each carrier had several shelves. Some held half a dozen of the big cores, like those used to make engine blocks or engine heads. Some held several dozen of the smaller cores. The carriers hung down from overhead tracks, like carcasses in a meat-packing plant. When they were filled, the carriers moved along tracks like an endless freight train, toward either the molding room or the core stacker, as required. The tracks ran down the length of the huge building, then coiled back on themselves like a meandering river, using every available foot of space. If the coil of tracks were ever straightened out, it would stretch to 18 miles in length. At the core stacker area, the carriers selected for storage were shunted off on a siding and detached from the overhead tracks. Then the robots took over.

> *"About once every three months, the robot would slam a fender out in the aisle and smash it up. They finally had to put the thing in a cage."*

The multiple eyes of both robots were in the form of solid-state sensors. They could read the numbers on the posts that marked the lanes. They could sense the carriers already stored in the lanes. They could see where to position loads exactly. But they could not see people.

There was constant but erratic movement within the stacks. Production pressure was intense. For each carrier stored, one had to be retrieved and passed on to the molding room. The call might be for cores used to make engine blocks, engine heads, four cylinders, six cylinders—whatever the order, the cores were needed fast. And computer control would know exactly the lane and position of every one of the 1,600 core carriers stored in the maze. Commands would go out. The full cycle of storage and retrieval could be completed on an average of 145.8 seconds. The system could handle as many as 123 trips an hour, from input station to output. It was called an unattended system, twenty-first-century technology well ahead of its time.

To Williams, to Howard, to Sugarbaker, it was a good but an awesome system. They were proud to be among those picked for the job of running it. Three men could handle the job, while 40 were needed before. The three alternated between the jobs of computer control, feeding the carriers in, or being a troubleshooter, or floater. Although the operation was supposed to be an unattended system, it didn't quite live up to its name. A fallen core would block an aisle or a lane, stopping the robot vehicles. A core carrier would swing out of line. The transfer robot might stop a shade short of a designated lane.

When things like this happened, operators like Williams and the others were often forced to climb into the maze, or the production lines would come to a halt. There was no time to wait for a maintenance man. Inside the stacks, on the long central aisle where the transfer robots glided, there was a strange atmosphere. The men felt isolated from the world. They were alone in the company of the whining sound of the five robot teams. Through the latticework and the open floor gratings above their heads or below their feet, they could see the robots moving on other levels like restless animals. The transfer robot would start up, stop, dismiss its mole into a storage lane with eerie precision. Then the mole would burrow underneath a carrier, lift it up, and obediently bring itself back into its mother vehicle. The sporadic movement on all five levels appeared nervous, unexpected. There wasn't too much noise, just a whining sound like that of a vacuum cleaner. Only the computer's memory knew what the next stop-and-go movement would be.

Visitors who viewed the operation from outside the open steelwork of the stack were stunned, sometimes shocked. "How does it know how to do all that?" they would ask. Howard felt that same way himself. "It's sort of spooky when you get up inside the stacks," he said. "Once those robots receive the computer commands, you know they are going to carry them out, no matter what gets in the way. They have a will of their own, and nothing is going to stop them. You always have to keep one eye on the robots and one eye on the job you're trying to straighten out. The only way out of the maze is a barrel ladder or an open elevator. Sometimes a chill runs down your spine that something might happen in there. Then you figure it's never going to happen to you."

Sugarbaker, too, was overwhelmed by the size of the plant and the complexity of its operation. "When I first walked in there, I couldn't believe it," he said. He was concerned when he went inside the stacks, and he kept a sharp watch on the robots. He had a scare one time when he rode up to Level 3 to free a mole robot that was

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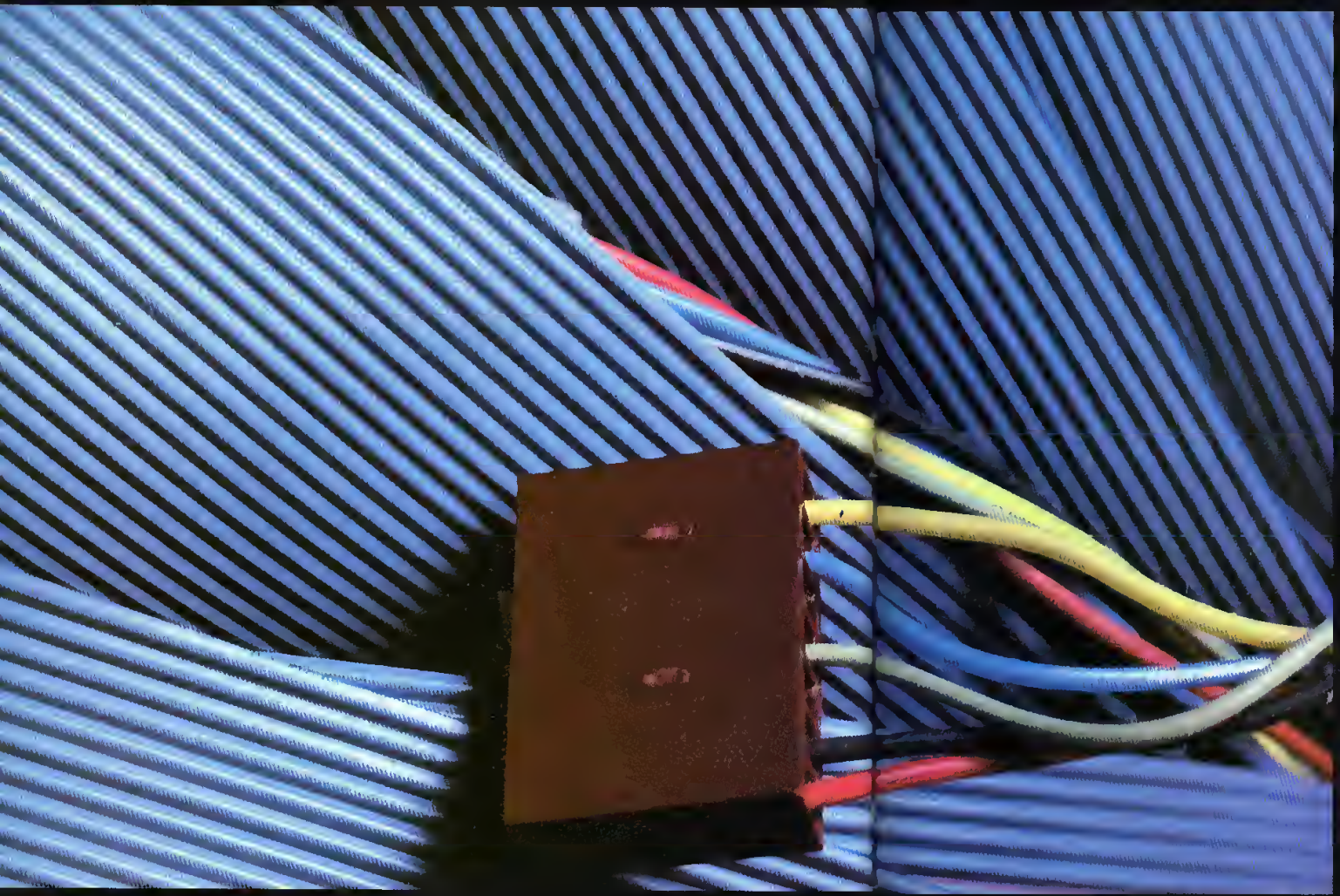

At first glance he looks like your typical middle-aged college professor. All the signs of academia are there: the thick-framed eyeglasses, the pipe drooping from the corner of his mouth, the overstuffed black briefcase, the 19-page curriculum vitae. But then you notice things that don't comfortably fit the image: the long, pyramid-shaped sideburns, the windbreaker and blue jeans, and the dour face that dreads a meeting with his boss, the department chairman.

Murray Turoff is a professor of computer science at the New Jersey Institute of Technology, in Newark. But on any given day, he would certainly prefer to be sitting at a computer terminal, gazing at messages from his small, faithful flock, the 1,526 people who are currently hooked into the Electronic Information and Exchange System, or EIES (pronounced *eyes*). EIES is one of the longest-running (eight years) and most prestigious computer networks in the country.

It has emerged as one of the nation's most important communications think tanks, because it houses the Center for Information Age Technology, where the big question about our era is constantly being asked. What kind of impact does all this new-age technology have on society, if any?

EIES is providing the answers or at least asking the questions. It is Turoff's brainchild, his laboratory; it's the embodiment of his vision of the future of human communication, a kind of electronic global village that fosters a togetherness unencumbered by geography.

LIFE IN THE WIRED SOCIETY

BY DOUG GARR

Welcome to the ultimate computer network, where the most elite electronic citizens in the world live and love—cognitively

PHOTOGRAPH BY CAMERON DAVIDSON

In other words, the wired nation Turoff has become an icon of the Eighties, the Marshall McLuhan of the microchip. He sees a widespread trend evolving in which thousands of people in communities will be linked with one another through the cathode-ray tubes on their terminals. In the new electronic village, instead of shouting out the window to your next-door neighbor, you'll be gossiping with someone thousands of miles away, even on another continent, with your computer.

With a microcomputer, or even a dedicated ("dumb") terminal that cannot compute on its own, a person connected to EIES can be linked with others, call up information from the network's core memory, attend conferences over the network, even attend classes taught by a teacher in another state—all without leaving home. For example, some of the interviews for this article were done over EIES. I used my Apple IIe to send requests for interviews and to ask my questions. Later, when the interviewees had a chance to mull over their answers, they sent their responses to me by way of the network.

At the moment, electronic mail—messages sent from terminal to terminal—is the predominant use of EIES, and teleconferencing is second. Largely because Turoff is a maverick, an antibureaucratic type who believes that an on-line computer-network meeting can be more productive and timesaving than a convention in a Hilton ballroom. You don't have to worry about hotel reservations, airplane tickets, car rentals and other travel logistics, and you can listen in at your own convenience. Also, at a network convention, "everyone has the floor at the same time," according to Turoff.

Public conferences held on the system tend to be quite academic, with topics like "The Future of Telecommunications," in which user/participants gripe about such problems as hardware glitches and "uploading" programs.

For all its serious uses, EIES also has a sense of humor. An interactive graffiti bulletin board features bathroom scribblings collected and contributed by various EIES users. And there is an ongoing soap opera, largely originated by Art Kleiner, editor of the *Whole Earth Software Catalog*. "In the first soap opera, which ran for six months of 1980, I was a writer, reader and character," Kleiner says. "I died and went to my own funeral."

The EIES headquarters is located on the ground floor of Weston Hall, at the New Jersey Institute of Technology, in downtown Newark. There, in the middle of a glass-enclosed, air-conditioned room, stands the hub of the network's activity, a Perkin-Elmer 3230 minicomputer, the central processing unit of EIES. Off to one side are four disk drives that look like washing machines vibrating quietly in the spin-dry mode. One corner serves as what programmer John Eoster calls the graveyard, where an ancient, cannibalized disk-storage system sits among unused terminals.

The institute doesn't have the budget of a Stanford, an MIT or a Carnegie-Mellon, so the staff is accustomed to making do with outdated equipment.

The rest of the offices are home to EIES's five programmers, all guys in their twenties, all wearing jeans and sweaters, and all working toward their master's degrees in computer science. In the background a rock-music station plays softly. On one office door hangs a computer-graphics portrait of Einstein. About a half-dozen microcomputers are scattered over the desktops, as are circuit boards, pliers and screwdrivers. Computer terminals are stored wherever there is room for them—on the floor, atop a filing cabinet. It's a kind of controlled chaos.

At EIES headquarters Turoff encourages a relaxed work atmosphere. One of the whiz kids here is Bobbie Michie, a nineteen-year-old, sandy-haired sophomore and computer programmer. He is part of a new generation, the kind of kid who grew up playing with an Atari, an Apple, a Commodore—well, just name a microcomputer, and he probably has had one in his bedroom. When computer break-ins became de rigueur after the movie *War Games* came out, Michie told Turoff that the EIES system was probably similarly vulnerable. Turoff challenged him to find a weakness. It didn't take long before Michie found several weaknesses in the system's protection code. Only a handful of people at EIES have a top-priority status, complete access to all the information in the system's database. Michie managed to break in to that level. The bugs were fixed, and Michie was rewarded with a higher-level access to EIES. "I think the computer-professional societies should give awards to people who find easy access to systems," Turoff says, "so that people can call attention to the gaps. I don't think we should threaten to put them in jail."

All the programmers are experienced in working with EIES, but indisputably the ultimate time-sharer of them all is the forty-seven-year-old Turoff. By his own count, he has been on-line for more than 25,000 hours (approximately three solid years) on various network systems. Since he first signed on to EIES in 1975, Turoff has accessed the system 13,495 times. And of the 922 conferences held on the network, he has participated in 444. Over an 18-day period in October he sent 216 messages—each the equivalent of a letter—to various members of the system. What is especially ironic is that Turoff strikes you as the kind of befuddled professor who could never find the time to buy a stamp and an envelope, let alone write a letter.

> *"Largely because Turoff is a maverick, he believes that an on-line computer-network meeting can be more productive than a convention in a Hilton ballroom."*

One reason for his prolific output is an addiction to his terminal. It's a dependency he admits is incurable. When he finally took a vacation, a trip to Europe with his coresearcher and spouse-equivalent, Roxanne Hiltz, it was ostensibly to enjoy some time away from the system. While in Paris, however, he could not resist borrowing a friend's computer and logging on. After he returned, his staff remembers, he walked around like a zombie for a week. The reason given: information withdrawal.

"There isn't a baud rate high enough for Murray," says Tom Moulton, an EIES programmer. Moulton was referring to the data-transmission speed used by modems, devices that link computers over phone lines.

EIES is not the only time-sharing system. There are many others, the two largest being The Source and CompuServe. These are strictly commercial operations, which offer such services as interactive video games, shopping by computer, and dozens of database directories from which users can summon airline flight schedules, current stock prices, newspaper articles, and other information. In addition, there are hundreds of smaller, more informal networks, many built around special-interest groups such as gay journalists, genealogists, or weekend aviators.

EIES is unlike all these in that it is a nonprofit, nonadvertised network of academics and serious researchers. EIES has had a number of luminaries log on, including author Alvin Toffler, A. C. Nielsen, the late futurist Herman Kahn, physicist and former Defense Department expert in advanced weaponry Ruth Davis, and former Federal Communications Commission head Nicholas Johnson. Also, two of the largest computer companies in the country, Digital Equipment Corporation and Hewlett-Packard, have active group accounts, and one religious sect, apparently wanting to network about the messiah, has requested an EIES account (chances are Turoff will okay it).

Every EIES member is a sort of guinea pig continually scrutinized under the sociological microscope of Turoff and Hiltz, a former visiting sociology fellow and now professor and chairwoman of the department of sociology, anthropology and social work at Upsala College in East Orange, New Jersey. Hiltz is one of a handful of professionals studying behavioral response to this new technology. Among her works is the forthcoming book *Online Communities: A Case Study of the Office*

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FICTION

A young girl is left alone in the desert to wait for the great sandworm, Shaitan

HERETICS OF DUNE

BY FRANK HERBERT

In her third year with the Priests of Rakis, Sheeana lay atop a high curving dune. She peered into the morning distance, where a great rumbling could be heard. The light was a ghostly silver that frosted the horizon with filmy haze. The night's chill still lay on the sand.

She knew the priests were watching her from the safety of their water-girded tower some two kilometers behind her, but this gave her little concern. The trembling of the sand beneath her body demanded full attention.

It's a big one, she thought. *Thirty meters at least. A beautiful big one.*

The gray stillsuit felt slick and smooth against her skin. It had none of the abrasive patches of the old hand-me-down she had worn before the priests took her into their care. She felt thankful for the fine stillsuit and the thick robe of white and purple that covered it, but most of all, she felt the excitement of being here. Something rich and dangerous filled her at moments such as this.

The priests did not understand what happened here. She knew this. They were cowards. She glanced over her shoulder at the distant tower and saw sun glint on lenses.

A precocious child of eleven standard years, slender and dark-skinned, with sun-streaked brown hair, she could visualize clearly what the priests saw through their spying lenses.

They see me doing what they do not dare. They see me in the path of Shaitan. I look very small on the sand, and Shaitan looks very big.

From the rasping sound, she knew that she too would soon see the giant worm. Sheeana did not think of the approaching monster as Shai-hulud, God of the Sands. She thought of the worms mainly as "they who spared me," or as Shaitan.

They belonged to her now.

It was a relationship begun slightly more than three years ago, during the month of her eighth birthday, the Month Igat by the old calendar. Her village had

PAINTING BY MICHAEL PARKES

been a poor one, a pioneer venture built far beyond more secure barriers such as the qanats and ring canals of Keen. Only a moat of damp sand guarded such pioneer places. Shaitan avoided water but the sandtrout vector took away any dampness. Moisture captured in windtraps had to be expended each day to renew the barrier. Her village was a miserable cluster of shacks and hovels, with two small windtraps, adequate for drinking water but with only a sporadic surplus that could be apportioned to the worm barrier.

That morning, much like this morning—the night's chill sharp in her nose and lungs, the horizon constricted by a ghostly haze—most of the village children had fanned out into the desert to seek bits and fragments of melange, which Shaitan sometimes left behind in his passage. Melange could buy the glazed bricks that were needed to line a third windtrap.

Sheeana, wearing her patched stillsuit and flimsy robe, went alone to the northeast, toward the faraway smoky cloud of air that told of the great city of Keen, with its moisture richness lifting into the sun-warmed breezes.

Hunting for scraps of melange in the sand was largely a matter of focusing attention into one's nostrils. It was a form of concentration that left only bits of awareness attuned to the rasping sand that told of Shaitan's approach. Leg muscles moved automatically in the nonrhythmic walk that blended with the desert's natural sounds.

At first Sheeana did not hear the screaming. It fitted so intimately into the saltated friction of windblown sand across the barracans that concealed the village from her sight. Slowly the sound penetrated her consciousness—and then it demanded her attention.

Many voices screaming!

Sheeana discarded the desert precaution of random strides. Moving as swiftly as her childish muscles would carry her, she scrambled up the slipface of the barracan and stared along it toward the terrifying sound. She was in time to see that which cut off the last of the screams.

Wind and sandtrout had dried a wide arc of the barrier at the far side of her village. She could see the gap by the color difference. A wild worm had penetrated the opening. It circled close inside the remaining dampness. The gigantic flame-shadowed mouth scooped up people and hovels in a swiftly tightening circle.

Sheeana saw the last survivors huddled at the center of this destruction, a space already cleared of its rude hovels and tumbled with the remains of the windtraps. As she watched, some people tried to break away into the desert. Sheeana recognized her father among the frantic runners. None escaped. The great mouth engulfed all before turning to level the village.

Nothing but smoking sand remained of the puny village that had dared to claim a scrap of Shaitan's domain. The place where the village had been was as unmarked by human habitation as it had been before anyone walked there.

Sheeana took a gasping breath, inhaling through her nose to preserve the moisture of her body. She scanned the horizon for a sign of the other children, but Shaitan's track had left great curves and loops all around the far side of the village. Not a single human remained in view. She shouted the high-pitched cry that she knew would carry far through the dry air. No response came back to her.

Alone

She moved trancelike along the ridge of the dune toward where her village had been. As she neared the place a great wave of cinnamon odor filled her nostrils carried on the wind that still dusted the tops of the dunes. She realized then what had happened. The village had been sited disastrously atop a pre-spiceblow. As the great hoard far under the sand came to fruition, expanding in an explosion of melange, Shaitan had come. Every child knew Shaitan could not resist a spiceblow.

> *"Sheeana scanned the horizon for a sign of the children. She shouted the high-pitched cry that would carry far through the dry air. No one responded."*

Rage and wild desperation began to fill Sheeana. Mindlessly, she raced down the dune toward Shaitan, coming up behind the worm as it turned back through the dry place where it had entered the village. Without thought, she dashed along beside the tail, scrambled onto it and ran forward along the great ridged back. At the hump behind its mouth, she crouched and beat her fists against the unyielding surface.

The worm stopped.

Her anger suddenly converted to terror, Sheeana ceased pounding on the worm. She realized only then that she had been screaming, and she was gripped with an agony of fear.

The worm continued.

Sheeana did not know what to do. At any moment the worm could roll over and crush her. Or it could burrow beneath the sand, leaving her on the surface to be scooped up at leisure.

Abruptly a long tremor worked its way down the worm's length, from its tail to Sheeana's position behind the mouth. The worm began to move ahead. It turned in a wide arc and gathered speed on a course to the northeast.

Sheeana leaned forward and gripped the leading edge of a ring ridge on the worm's back. She feared that any second it would slide beneath the sand. What could she do then? But Shaitan did not burrow. As minutes passed without any deviation from that straight and swift passage across the dunes, Sheeana found her mind working once more. She knew about this ride. The priests of the Divided God forbade it, but the histories, both written and oral, said Fremen rode thus in the ancient days. Fremen stood tall atop Shaitan's back, supported by slender poles with hooked ends. The priests decreed that this had been done before Leto II shared His consciousness with the God of the Desert. Now nothing was permitted which might demean the scattered bits of Leto II.

With a speed that astonished her, the worm carried Sheeana toward the mist-dazzled shape of Keen. The great city lay like a mirage on the distorted horizon. Sheeana's threadbare robe whipped against the thin surface of her patched stillsuit. Her fingers ached where she gripped the leading edge of the giant ring. The cinnamon, burnt-rock and ozone of the worm's heat exchange swept over her on shifts in the wind.

The priests will see me and be angry

She could now identify the low brick structures that marked the first line of qanats and, beyond them, the enclosed barrel-curve of a surface aqueduct. Above these structures rose the walls of terraced gardens and the high profiles of giant windtraps, then the temple complex, within its own water barriers.

A day's march across open sand in little more than an hour!

Her parents and village neighbors had made this journey many times to trade and to join in the dancing, but Sheeana had accompanied them only twice. The size of Keen filled her with awe. So many buildings! So many people! Shaitan could not harm such a place as that.

But the worm plunged straight ahead as though it would ride over qanat and aqueduct. Sheeana stared at the city rising higher and higher in front of her. Fascination subdued her terror. Shaitan was not going to stop!

The worm ground to a halt.

The tubular surface vents of the qanat lay no more than fifty meters in front of its gaping mouth. She smelled the hot cinnamon exhalations, heard the deep rumblings of Shaitan's interior furnace.

It became apparent to her at last that the journey had ended. Slowly, Sheeana released her grip on the ring. She stood, expecting that at any moment the worm would renew its motion. Shaitan remained quiescent. Moving cautiously, she slid off her perch and dropped to the sand. She

paused there. Would it move now? She held a vague idea of dashing for the qanat, but this worm fascinated her. Slipping and sliding in the disturbed sand, Sheeana moved around to the front of the worm and stared into the fearsome mouth. Within the frame of crystal teeth flames rolled forward and backward. A searing exhalation of spice odors swept over her.

The madness of that first dash down the dune and onto the worm came back to Sheeana. "Damn you, Shaitan!" she shouted, shaking a fist at the awful mouth. "What did we ever do to you?"

It entered Sheeana's awareness that she stood in the deadly path. Her thoughts recognized only that she had done a crazy thing. She had wanted Shaitan to take her into the company of her dead.

A grating sound issued from beneath the worm. Sheeana stifled a scream.

Slowly at first, then faster, the worm backed off several meters. It turned there and gathered speed beside the twin-mounded track it had created coming from the desert. The grating of its passage diminished in the distance. Sheeana grew aware of another sound. She lifted her gaze to the sky. The *thwock-thwock* of a priestly ornithopter swept over her, brushing her with its shadow. The craft glistened in the morning sunlight as it followed the worm into the desert.

Sheeana felt a more familiar fear then. *The priests!*

She kept her gaze on the thopter. It hovered in the distance, then returned to settle gently onto a patch of worm-smoothed sand nearby. She could smell the sickly acridity of the thopter's fuel. The thing was a giant insect nestled on the sand, waiting to pounce upon her.

A hatch popped open.

Sheeana threw back her shoulders and stood her ground. Very well, they had caught her. She knew what to expect now. Nothing could be gained by flight.

Two richly robed priests, their garments all gold and white with purple trim, emerged and ran toward her across the sand. They knelt so closely in front of Sheeana that she could smell their perspiration and the musky melange incense that permeated their clothing. They were young but much like all the priests she could remember: soft of features, uncallused hands, careless of their moisture losses. Neither of them wore a stillsuit under those robes.

The one on her left, his eyes on a level with Sheeana's, spoke.

"Child of Shai-hulud, we saw your Father bring you from His lands."

The words made no sense to Sheeana. She had been told that priests were men to be feared. Her parents and all the adults she had ever known had impressed this upon her by words and actions. Priests possessed ornithopters. Priests fed you to Shaitan for the slightest infraction or for no infraction at all, for only priestly whims.

Sheeana backed away from the kneeling men and cast her glance around. Where could she run?

The one who had spoken raised an imploring hand. "Stay with us."

"You're bad!" Sheeana's voice cracked with emotion.

Both priests fell prostrate on the sand.

Faraway on the city's towers, sunlight flashed off lenses. Sheeana saw them. She knew about such flashings. Priests were always watching you in the cities. When you saw the lenses flash, that was the signal to be inconspicuous, to "be good."

Sheeana clasped her hands in front of her to still their trembling. She glanced left and right and then at the prostrate priests. Something was wrong here.

Heads on the sand, the two priests shuddered with fear and waited.

Sheeana did not know how to respond. The crush of her immediate experiences could not be absorbed by her eight-year-old mind. She knew that her parents and all of her neighbors had been taken by Shaitan. Her own eyes had witnessed this. And Shaitan had brought her here, refusing to take her into his awful fires. She had been spared.

This was a word she understood. *Spared.* It had been explained to her when she learned the dancing song.

"Shai-hulud, spare us!
Take Shaitan away . . ."

Slowly, not wanting to arouse the prostrate priests, Sheeana began the shuffling, unrhythmic movements of the dance. As the remembered music grew within her, she unclasped her hands and swung her arms wide. Her feet lifted high in the stately movements. Her body turned slowly at first and then more swiftly as the ecstasy of the dance increased. Her long, brown hair whipped around her face.

The two priests dared to lift their heads. The strange child was performing. The Dance! They recognized the movements. The Dance of Propitiation. She asked Shai-hulud to forgive his people. She asked God to forgive *them!*

They turned their heads to look at each other and, together, rocked back onto their knees. There, they began clapping in the time-honored effort to distract the dancer. Their hands clapped rhythmically as they chanted the ancient words:

"Our fathers ate manna
in the desert
In the burning places
where whirlwinds came!"

The priests excluded all but the child from their attention. She was a slender thing, they saw, with stringy muscles, thin arms and legs. Her robe and stillsuit were worn and patched like those of the poorest. Her cheekbones had high planes that drew shadows across her olive skin. Brown eyes, they noted. Reddish sun streaks drew their lines in her hair. There was a water-spare sharpness about her features: the narrow nose and chin, the wide forehead,

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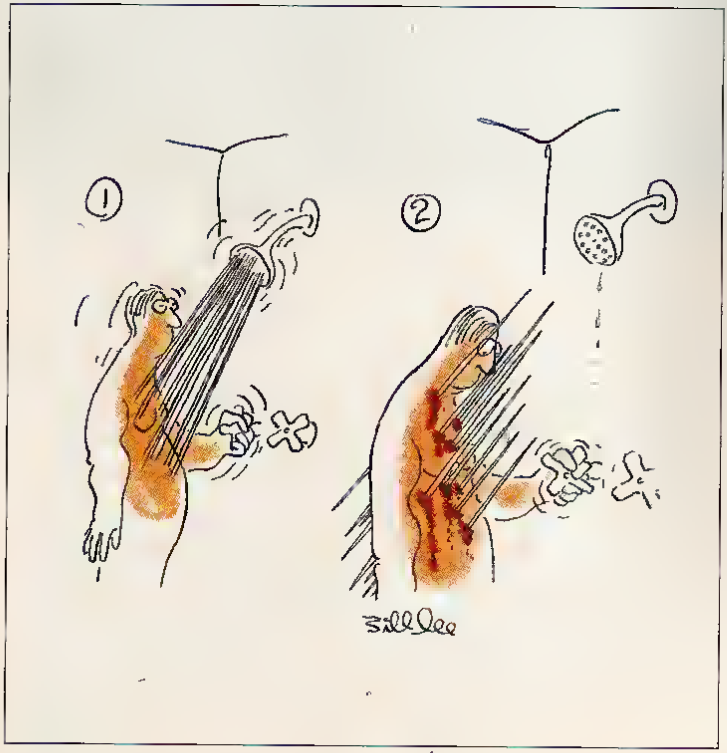
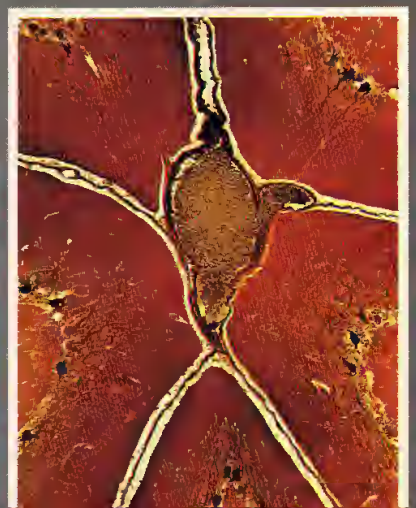
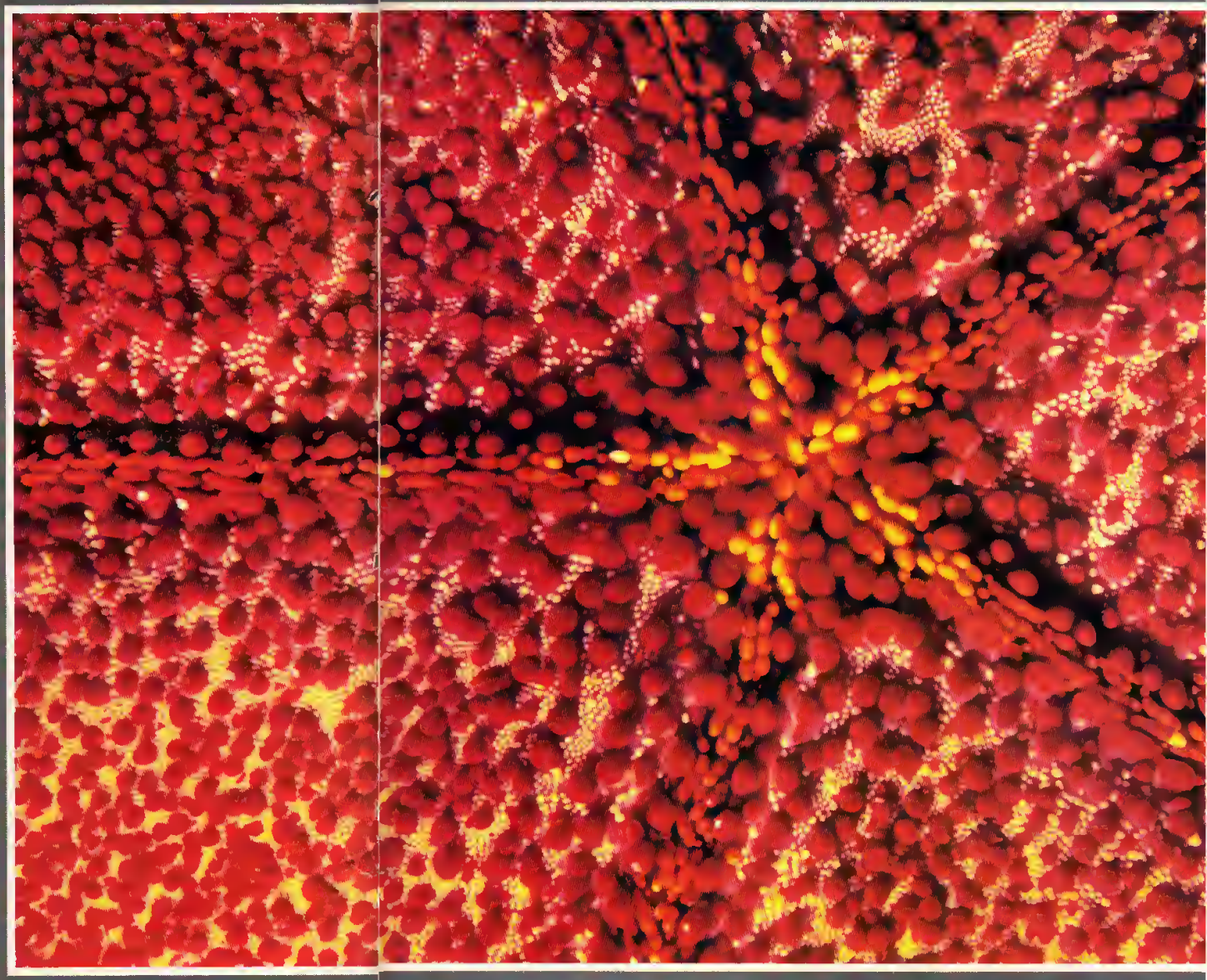


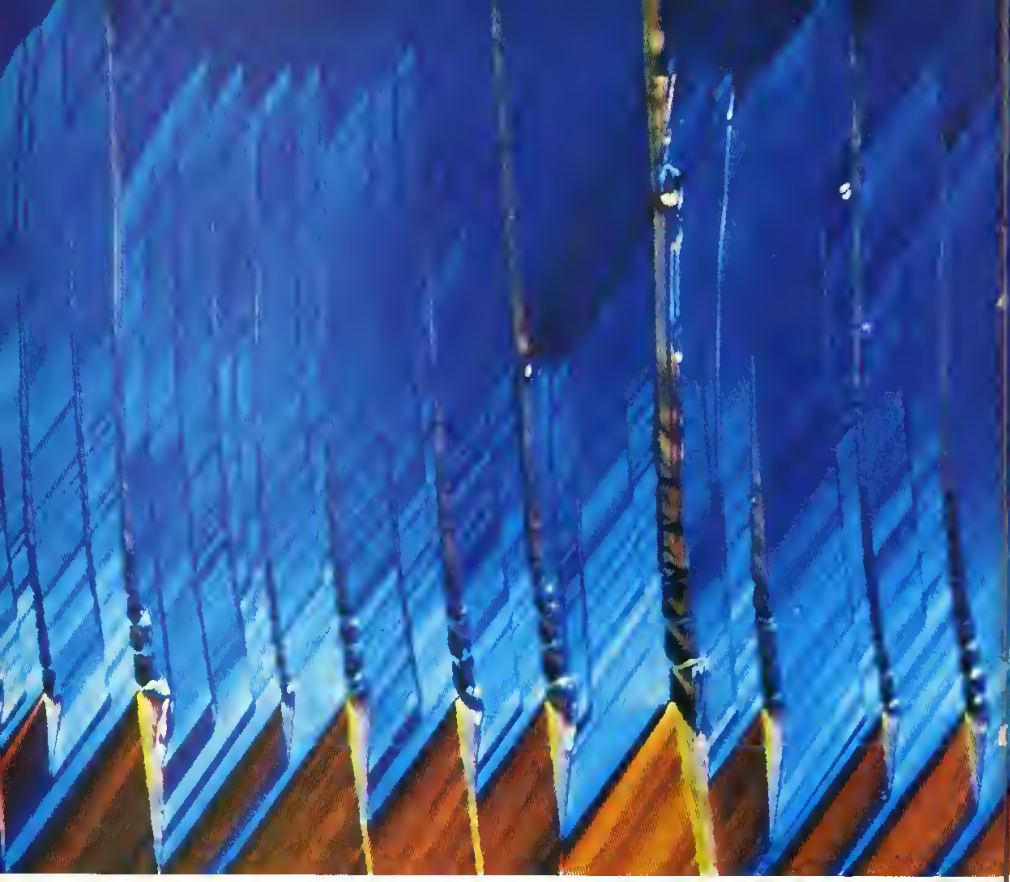
WHICH IS THE GRANDER VIEW?

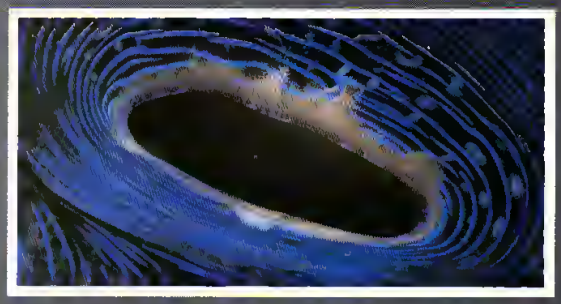
BY FRANK BUCK

Where the telescope ends, the microscope begins," wrote Victor Hugo in *Les Miserables*. "Which of the two has the grander view?" The question, of course, is largely rhetorical. Nature is more concerned with diversity than grandeur. Human vision, amplified by technology, finds few matching images as it zooms from the landscape of the atom to the distant reaches of the universe. For example, volume increases more rapidly





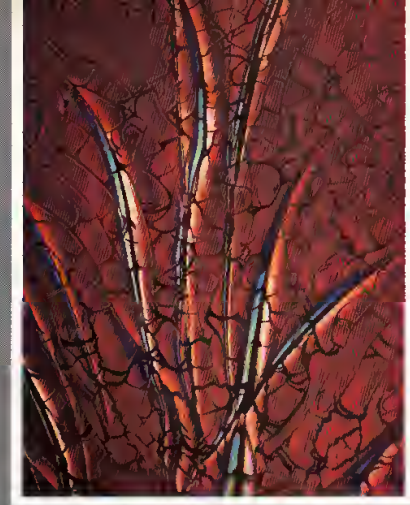




than surface area as a solid figure grows, an immutable fact of nature well noted by J.B.S. Haldane in his classic essay *On Being the Right Size*. "It is easy to show that a hare could not be as large as a hippopotamus," he wrote, "or a whale as small as a herring. For every animal there is a convenient size, and a large change in size inevitably carries with it a change of form." Or as a more contemporary author so succinctly put it, "A poodle as tall as a giraffe would damn well fall over."

Occasionally, the technology-assisted eye finds similar patterns in alien domains. On these pages, we compare landscapes measured in microns with creatures on the ocean floor. Each pair of photographs juxtaposes macroworld with microworld. Two of nature's dominant patterns emerge in the rings of a giant clam's siphon (left) and the peaks and valleys that traverse a silicon crystal (above). Sharp-eyed observers

"Size determines form: A poodle as tall as a giraffe would damn well fall over."



of nature will find such basic shapes abound virtually everywhere—in the ripples a stone makes on a still pond, in the growth rings of a tree, in the sudden rise and fall recorded in a graph of the brain's electrical energy. Other repetitions, however, are more subtle, less expected. On the opening pages of this article, the five branching arms of a brain cell (small picture) find an unlikely mirror image in the underside of a pincushion starfish (large picture). Similarly, the fingerlike pattern of a Gorgonian sea fan (left) is reflected in the surface of a vitreous ceramic material (above). Here are two windows on the world—the microscope and the underwater camera—both offering distinctive yet matching views. There is something almost chilling about the repetition, as if you had traveled light-years to some distant planet, only to discover that everything there resembled your backyard.

The photomicrographs displayed here are the work of the German photographer-scientist Manfred Kage (pronounced *Cog-eh*), who used everything from a color-scanning electron microscope to a kaleidoscopic array of symmetrical reflector lenses. The underwater images were produced by Hawaii-based marine-life photographer Chris Newbert. Melding art and technology, both men set out to produce unique, intensely personal images of the world around them. Kage, founder of the Institute for Scientific Photography and Cinematography, and cofounder of the German Group Zero, trained his camera on the microscopic, inorganic realm of the crystals and ceramics used in microcircuitry. Newbert chose to focus his attention on a totally different realm—the vibrant, living world beneath the sea. Which is the grander view?

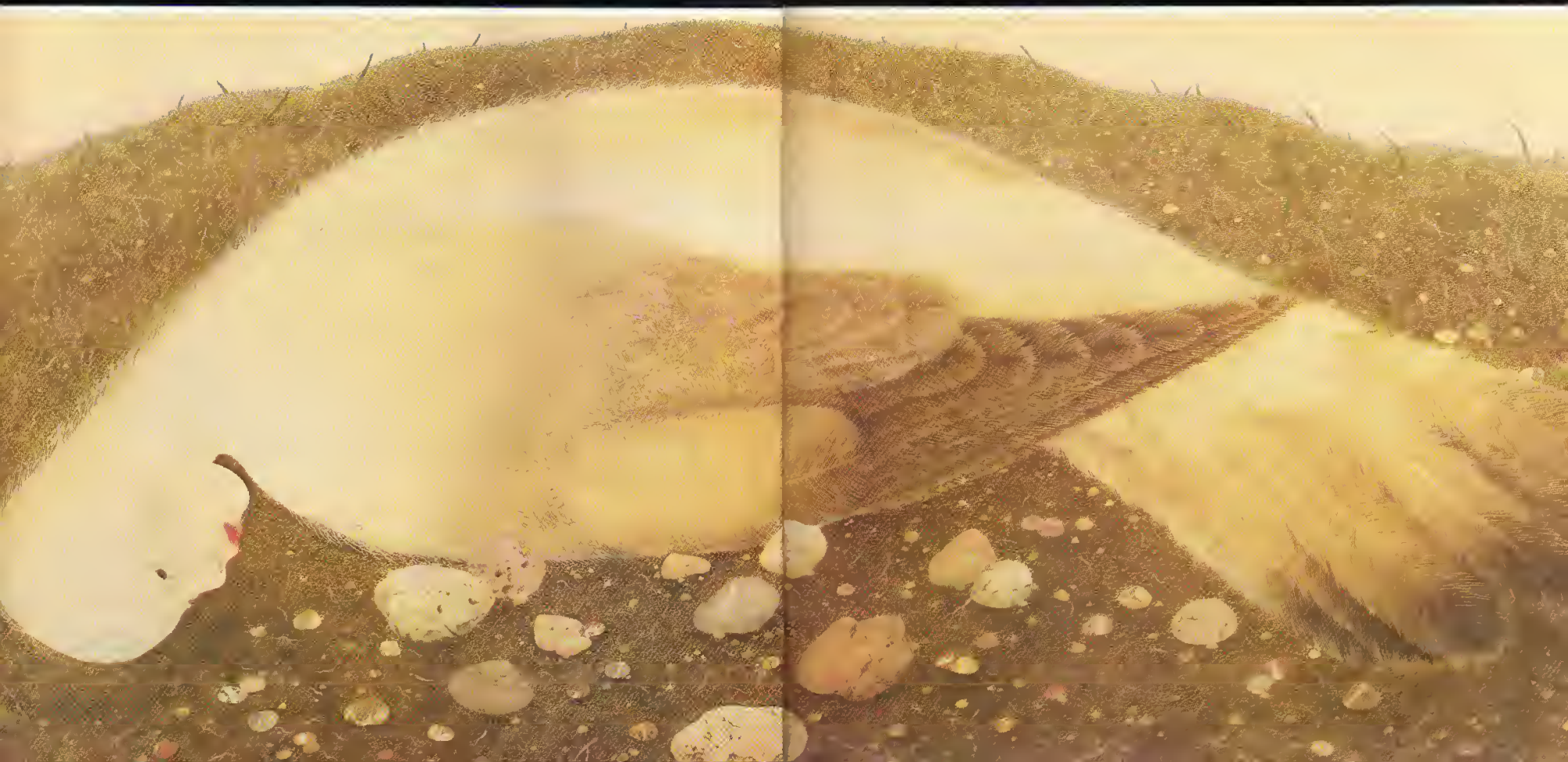
"The microscope and the underwater camera offer two windows on the universe through which nature is caught repeating itself"

HUMAN HIBERNATION

When we harness the hibernation trigger, we'll revolutionize surgery, control obesity, and agelessly slumber through outer space

BY SHERRY BAKER

PAINTING BY LISBETH RAIDL



His name is Spock, and his shaved head makes him look disturbingly alien. Yet the physical appearance of this rhesus monkey is appropriate. For soon he will journey into a realm that has never been the province of his kind. It is a journey, scientists speculate, that could lead to revolutionary changes in anesthesia, organ transplants, weight control, and the treatment of sleep disorders. One day they say, this extraordinary passage—into the state of deep hibernation—might even be made by astronauts slumbering agelessly through interplanetary space.

Seated in a box-shaped chair, Spock rests comfortably as scientists inject him with plasma from the blood of hibernating woodchucks. His eyes flicker with curiosity as that plasma flows into a small blood vessel near the hypothalamus, the part of the brain controlling such autonomic functions as body temperature and heart rate.

The scientists conducting the experiment—Wilma Spurrier, Peter Oeltgen, and Robert Myers—wait for a response. They know that some mysterious, still-unidentified substance is in the plasma. They have injected it into active woodchucks and squirrels, and they have seen those creatures curl up into silent, dormant balls of fur in the middle of summer. Oeltgen has dubbed the stuff HIT, for hibernation-induction trigger.

So far only rodents have responded to the trigger. Will it work on Spock? Does HIT have the power to affect animals that have never hibernated? Animals that are, like men, anthropoids?

Within 15 minutes, the researchers begin to get an answer. And it is a dramatic one. Although he can pull a lever and eat all the banana-flavored pellets he wants, Spock refuses food. He yawns, and his eyes shut. He tries to hold them open, forcing them into a wide, exaggerated stare. But his eyelids seem too heavy. He gags, and then he blows his lips out as though sending a slow-motion kiss. Again his eyes jerk open and he rocks his head slightly, rolling it from side to side. A few hours later the monkey slumps over and appears to be asleep. But this is no ordinary repose. His body temperature has dropped several degrees; his heart rate has plummeted from 150 beats per minute to half that.

While the scientists won't say that Spock actually hibernated, they admit that these specific physical and behavioral changes have been seen only in natural hibernators. And it is only a matter of time before HIT is tried on another branch of primates—humans.

Hibernation—a semistate between sleep and death—has always fascinated scientists and lay people alike. Socrates sent his students on treks to find hibernating animals (most likely the European hedgehogs), and the creatures seeming return from death sparked philosophical inquiries into the nature of life. Arousal from "winter sleep" has long been associated with rebirth, and the coming of spring—Groundhog Day is a good example. And the possibility that man, too, could be subject to long bouts of nonfatal sleep is a recurring theme in literature and myth. Think of Rip Van Winkle and Sleeping Beauty.

But despite interest in hibernation, for centuries the curious could unravel its mysteries only through direct observation. People noted a variety of animals—squirrels, woodchucks, and hamsters—disappearing in the winter and reemerging in the spring. Certain bats were found to hibernate deep within dark caves. Bears were long assumed to be hibernators (debate continues over whether their winter dormancy is hibernation at all). And for generations legend has held that one branch of primates—dwarf lemurs—"slept" through the cold months on the island of Madagascar. Scientists have not verified these reports. But they do not dismiss them.

"Human logic may insist that breathing is one absolute necessity for mammalian life. But hedgehogs have been found to go as long as 150 minutes without taking a single gasp of air."

because the history of hibernation research is filled with the unexpected.

In 1760, for instance, one Samuel Williams described something strange on the banks of the Charles River, in Cambridge, Massachusetts. He watched some men dig a bird—a swift—out of two feet of thick mud. The bird was obviously dead. It had to be. Yet, said Williams, the creature recovered in 30 minutes.

This account and similar reports were treated much as UFO sightings are treated today. Preposterous. A mistake. Impossible. But in the Fifties, scientists learned that some birds, including the swift, do enter stages of extreme metabolic depression. Some may actually hibernate.

It was in the Fifties, in fact, that the years of observation began to yield a cohesive picture of the phenomenon. Natural hibernators descend into hibernation as fall approaches. After a summer crammed with breeding and raising offspring, activity slows. Endocrine activity is suppressed. Some hibernators begin to store food for the winter, but most just get enormously fat, turning into waddling caricatures of their summer selves. Appetites shut down by late autumn, and the animals are drawn to their caves, burrows, and nests to begin their secretive winter sleep.

It may take minutes or weeks for an animal to pass into deep hibernation. During the initial phase of the process, brain activity is reduced, and the heart rate slows. A bat's heart, for example, contracts and pumps furiously during the summer—300 to 500 times a minute when resting and over 1,000 beats per minute in flight. But when the bat is hibernating, its heart slows to less than ten beats a minute.

As hibernation continues to engulf an animal, oxygen consumption decreases and body temperature falls approximately 30°C, until it is only a degree or two above that of the environment. Respiration also continues to slow. Human logic may insist that breathing is one absolute necessity for mammalian life, but hibernators can stop breathing for what seem like impossible lengths of time. Hedgehogs, for instance, have been found to go as long as 150 minutes without taking a single gasp of air.

Nonetheless, hibernation does not render the animal helpless, shut off from the outside world. Despite the depressed metabolism and brain activity, hibernators remain keenly sensitive to their environment—a necessity, should predators try to dig them out of their winter havens.

Perhaps in response to internal rhythms, hibernators arouse spontaneously throughout the winter. Squirrels may wake up every couple of weeks, bats, every 30 days or so. As spring approaches, hibernators become more and more sensitive, and arousals increase in frequency. While still in the burrow, in total darkness, an animal's endocrine system is reactivated, preparing the body for another season of life. And then, around March, the animal reenters the active world.

During the Sixties, this scenario convinced some scientists that hibernators were like cold-blooded reptiles and amphibians. A toad can crawl into a riverbank's thick mud and ride out a blistering freeze in a sluggish state, its body temperature near that of the environment. An alligator, faced with the onslaught of winter, enters into a lethargic, dormant condition when exposed to the cold—until the sun warms his blood, or until he finally dies. Other researchers believed hibernation was similar to the helpless, often irreversible state of hypothermia that befalls any mammal, including man, when exposed to prolonged, freezing temperatures.

But talking about hibernation, cold-bloodedness, and hypothermia all in one breath never sat well with some researchers. There were too many unanswered questions. Were warm-blooded hibernators really sliding back each winter into some ancient, cold-blooded ancestry? And how could they awaken on their own, without the application of heat?

"I always had a gut feeling—several of us did—that hibernation was something else," says Loyola University physiologist

Wilma Spurrier "Something unique"

But it wasn't until 1968 that the unique nature of hibernation began to emerge. In that year Spurrier and U.S. Navy physiologist Albert Dawe decided to search the blood of hibernators for an agent that could break the tight seasonal regulation. If they succeeded they would prove that hibernation was due to a specific chemical trigger—not just the cold. That trigger, they hoped, might even work on man.

To do their experiment, the researchers first punctured the aorta of a hibernating ground squirrel as it slept in a hibernaculum—a specially made cold laboratory. Then they extracted the squirrel's blood and divided it into one-milliliter doses. Holding two squirming, summer-active squirrels, Dawe and Spurrier injected each with the hibernator's blood. Then the animals were transferred to the laboratory hibernaculum, and the wait began. Within 48 hours the squirrels were hibernating. "We knew then that we had something exciting," Spurrier recalls. "We had broken that tight, internal rhythm."

The following summer—in a season even further removed from the normal months of hibernation—Dawe and Spurrier conducted tests on more animals. This time, they injected 23 active squirrels with blood drawn from hibernating squirrels in the preceding winter (the blood had been frozen in liquid nitrogen). They also injected blood from a hibernating woodchuck into three additional squirrels. Whole blood, washed cells, and serum were all used in the experiment, and the results were the same. Something very small and very powerful was in the blood and its fractions. Within 52 days, all the animals injected with woodchuck blood—and 20 out of 23 squirrels injected with squirrel blood—were rolled up in tight, snoozing balls.

The researchers had proved that hibernation was set off by some sort of chemical. Their next step: to learn what HIT, the elixir of suspended animation, really was.

Peter Oeltgen, a biochemist at the Veterans Administration Hospital and the University of Kentucky in Lexington, set out to answer that question in the mid-Seventies. One of his first efforts relied on a sievelike device that allowed only small molecules to squeeze through. After processing the plasma with the device, Oeltgen tested the material that passed through for trigger activity. But squirrels injected with the resulting plasma didn't hibernate. So Oeltgen concluded that the trigger was probably a large molecule, perhaps a protein or a lipid.

Trying to define the trigger further, he turned to a special resin with a high affinity to the blood protein albumin. The resin held on to the albumin in the plasma of hibernating animals, and further experiments showed that the albumin contained trigger activity. So Oeltgen concluded that HIT, whatever it is, sticks to albumin.

Oeltgen's next step is to isolate the trigger on a molecular level—separating albumin into fractions and testing each fraction for HIT activity. Toward that end, he's recently signed a long-term contract with a genetic-engineering firm. He and a group from that company are analyzing the albumin mixture for the specific amino-acid sequence of HIT. "Once we find that," says Oeltgen, "we can determine the structure of the HIT gene. First we can use the gene as a probe. If we inject it into the animal, it should gravitate to the brain area manufacturing HIT. And just as important, that gene can be put into bacteria, just as the insulin gene was; then we'd be manufacturing large quantities of the trigger for research and clinical use in humans."

Not knowing just what the trigger is, however, hasn't stopped Oeltgen and colleagues from researching its potential for humans. Recently, he says, he's completed his most dramatic experiment to date, charting the power of HIT on one of man's relatives, the rhesus monkey.

"I know it sounds strange—as if we skipped a whole group of animal models and then went straight to primates," says Oeltgen. "But it was a question of opportunity." University of North Carolina physiologist Robert Myers had been using monkeys for some of his studies. "He offered us his primates, and I had the trigger. So we went ahead and did it."

"Something very powerful was in the blood and its fractions. Within 52 days, all the animals injected with woodchuck blood were rolled up in tight, snoozing balls."

To conduct the experiments, Oeltgen, Myers, and Spurrier placed the animals in restraining chairs and gave them a supply of banana-flavored pellets and water. Then they infused four milligrams of HIT-bearing albumin through a stainless-steel tube implanted in the brain.

Within hours the monkeys refused food. Body temperatures dropped several degrees, and heart rates were cut in half. In additional experiments, Spurrier, Myers, and Oeltgen upped the dosage of HIT-containing plasma to eight milligrams, and the changes were even more pronounced.

According to Oeltgen, these experiments also revealed what may be the most crucial clue to the nature of HIT. Dosed animals stuck out their lips, gagged, and retched in much the same way humans do when injected with opiates like morphine. Moreover, when Oeltgen infused some of the primates with naloxone, an opiate blocker that works by binding to opiate receptors in the brain, the monkeys abandoned the hibernation state, becoming alert and oriented to their environment almost immediately. The implication: The trigger, whatever it is, activates the brain's opiate receptors either directly or indirectly. "It seems to me," Oeltgen says, "that HIT is an opiatelike molecule, or it is a neurohormone that causes the brain to manufacture opiates. The trigger could set off a whole cascade of chemicals, each one producing the next, until all the effects of hibernation have been experienced. An opiate might be one of the initial chemicals in that cascade, and a crucial step in the process could be the binding of the opiate to receptor sites in the brain."

While the opiate idea is just a theory, scientists are gathering evidence to back it up. Oeltgen and colleagues at the Addiction Research Center, in Lexington, Kentucky, are seeking a variety of opiates in the brains of hibernating animals. The Soviets have already found elevated levels of opiates called enkephalins in hibernators. And researcher Alexander Beckman, of the Alfred I. Du Pont Research Institute, in Wilmington, Delaware, has found that if summer-active squirrels are given morphine and then taken off the morphine, they exhibit withdrawal symptoms. Hibernating squirrels, on the other hand, show no such symptoms. The suggestion is that during hibernation, morphine can't affect the brain's opiate-receptor sites, because those sites are occupied by another chemical—HIT or one of its derivatives.

No one can predict when human experimentation will begin—it will be only after the trigger and its various derivatives are identified and after more detailed primate studies are carried out. But once the research is complete, scientists say, we'll derive benefit from almost every one of the vast array of effects induced by the hibernation state.

The first and most obvious payoff could be a superior treatment for insomnia. According to Stanford neurophysiologist Craig Heller, hibernation may be sleep in the extreme. Heller speculates that warm-bloodedness, hibernation, and sleep evolved together. "The earliest mammals could have lowered the metabolic cost of being warm-blooded by lowering their body temperatures during their inactive periods," he says. "And when food was limited, those animals that lowered their temperatures a little bit more, or that had longer sleep periods, would have survived more than the others. Selective pressures could have led to the whole suite of things that are characteristic of hibernation."

To document the idea that sleep and hibernation are related, Heller has been measuring brain waves with an electroencephalograph, or EEG. There are four recognizable stages of sleep, he explains,

each with a characteristic brain-wave pattern that the EEG records by means of electrodes placed on the head or in the brain. And as it turns out, animals consistently enter hibernation through the stage known as slow-wave sleep.

"The medical profession," Heller notes, "has always treated insomnia as a psychosomatic problem. But we have to realize that sleep disturbances may be organic. And if hibernation is an extreme form of sleep, it may be that its trigger will enable us to come up with a natural sleep-inducing substance that's not a drug."

Heller is currently searching for that substance, which he believes may resemble the blood-borne peptides implicated in human sleep. "There's a real possibility that these peptides could be related to HIT or one of its derivatives," he says. "When HIT is finally isolated, we can compare it to the peptides on a molecular basis. I have some of the peptides in my desk drawer right now, just waiting."

Another person waiting to understand the chemical basis of hibernation is University of California at Davis physiologist Barbara Horowitz, who believes that humans could harness the process in their effort to control weight. Hibernation, Horowitz explains, has two distinct effects on weight. When an animal first enters hibernation, it eats a lot, becoming obese and building up large supplies of fat. Some of that fat is ordinary white fat, and some of it is brown fat—specialized tissue that has the ability to generate quantities of heat. As hibernation ends, the brown fat warms a hibernator's blood, burning up calories during the crucial period of arousal.

Both phases, Horowitz notes, might have application for humans. If we can learn just how hibernation *stimulates* appetite, that may yield a helpful treatment for anorexics. And "there's some evidence that genetically obese rodents, and perhaps other mammals, have a defective ability to burn brown fat. So it may turn out that by understanding how hibernators manipulate brown fat, we'll learn to modulate it in overweight humans as well."

But if HIT is valuable because it induces sleep and alters appetite, its ability to act as an opiate while sustaining the body at a reduced temperature is just as important. Transferred to humans, this ability would virtually revolutionize anesthesia and surgery. "Any surgical procedure, no matter how well it's done, is a definite stress on the body," explains Spurrier. "But if we can inject someone with an opiatelike anesthetic made from HIT, temperature and metabolism should be lowered and there may be less stress on the brain, heart, and lungs. Tissues will need less oxygen, and a lot of energy will be conserved."

Lowering body temperature under ordinary circumstances, Spurrier notes, comes with several inherent risks. The most devastating problem is that low body temperature often brings on wildly erratic heart arrhythmias or fibrillations, which can be fatal. But if temperature reduction could be achieved through the infusion of the hibernation-induction trigger, she adds, the heart might be able to withstand the cold.

Canadian researchers, for instance, have found that when rabbits are injected with the plasma from hibernating animals, they exhibit a lowering of the critical temperature at which fibrillation occurs. And Spurrier talks about the open-heart surgery she performed on several woodchucks, for which she used only hibernation as anesthesia. "We didn't even give them oxygen, and they came through beautifully. They woke up in a couple of hours and then resumed hibernation," she recalls. "They required no medicine at all and came out fit the next spring."

Scientists also speculate that HIT may revolutionize the storage and transplantation of organs. Remove the heart or kidneys from an active animal and the organ is "dead"—useless for transplantation purposes—in about ninety minutes, according to physiologist Colin Green, of the British Medical Research Council. The reason: When organs are put in a maintenance medium after being removed from a body, they lose electrolytes (substances like sodium and potassium) needed for muscular contraction and other functions.

> *"If a human were placed in a state of hibernation, he'd use less energy, less food, less air. There would be less excretion. And the lower metabolism might slow the aging process."*

But when Green excised kidneys from hibernators just recently, he discovered that they could survive for up to eight days with simple refrigeration. Other researchers have removed hearts from hibernators and seen them function for up to eight hours, even when deprived of oxygen.

Somehow, cellular-membrane integrity is altered in hibernation. Oeltgen suggests, perhaps because of changes in free fatty acids and the loss of electrolytes just doesn't seem to occur.

Finally, if the more obvious features of hibernation can benefit mankind, so will subtle characteristics observed only in the lab. Specifically, researchers have noted that hibernation might stave off a range of maladies, including viral infection, cancer, and even radiation sickness.

Time and again, hibernators injected with pathological bacteria and viruses have not become ill. And virulent cancer tumors, placed in the cheek pouches of hibernating hamsters, have failed to grow. Zapped with high doses of radioactivity, hibernating animals have consistently lived longer and sustained less radiation injury than their active control counterparts.

Putting these findings together, physiologist Charles Lymon, of Harvard Medical School, suggests that studies should be done to see how therapy affects cancer in active and hibernating animals. It may be, he says, that hibernation could protect an animal—and hypothetically a "hibernating" human—from the dangerous side effects of chemical and/or radiation therapy. And since tumors are inhibited by the hibernating state, cancerous growths may prove more susceptible to chemicals or radiation, while the rest of the body is protected from the treatments' toxicity.

Still other scientists have suggested a particularly seductive possibility for HIT: slowing or halting the aging process. Physiologists have found that the red blood cells of hibernators enter a kind of cold storage during hibernation—they don't take up iron as normally aging cells do. By studying hibernators' tail tendons, moreover, researchers have found that the cross-linking of proteins in collagen fibers—a portent of aging in all animals, including man—is inhibited. And while elderly and bedridden humans are often subject to osteoporosis (a loss of calcium from the bones), hibernators somehow defy this condition despite total disuse of their limbs for weeks at a time.

The antiaging powers of HIT, in fact, might lead to the most spectacular application of all. Consider this scenario: Astronauts on a long, monotonous voyage through the black void of space lower their metabolisms with HIT and spend the trip in a timeless sleep.

Although scientists emphasize that the immediate importance of hibernation research is its application to medicine, they have speculated on incorporating suspended animation into space travel ever since the early days of NASA. Now, with the identity of the trigger near at hand, that dream may become reality. "The concept," notes Myers, "is even simple. 'If a human were placed in a state of hibernation,' he explains, 'he'd use less energy, less food, less air. There would be less excretion. And the lower metabolism might slow the aging process as well.'"

Myers does question the advantage of being a Rip Van Winkle. "Would you want to be out of life in order to prolong it?" he asks. For Myers the answer is no; but, he asserts, the potential is there.

Even the cautious Wilma Spurrier agrees. "The whole concept of human hibernation is way on down the road—although I keep getting letters from people who are ready to volunteer," she says. "And the idea of astronauts' sleeping through space is still very far out. But the truth is, it's no longer beyond the realm of possibility."

Warming climates, melting ice caps, agricultural anomalies—here's an eminent authority on the greenhouse effect who will be disappointed if it doesn't happen

INTERVIEW

ROGER REVELLE

Roger Revelle is tall, deliberate, and so trusty that when he looks you in the eye and contradicts your dearest articles of faith about land and sea, you feel your own opinions evaporate. When he speaks, his voice starts out flat, then grows richer as he warms to his subject. The warmth declares that no man is his enemy, that he has no bone to pick, and that his conclusions rest on irrefutable fact.

Of course Revelle probably does know more than most of us. He would be called an old man if it were polite to call people old. At age seventy-five he has been thinking and learning for a long time, and his expansive mind attaches itself to many subjects. His friend, prominent oceanographer Walter Munk, says that Revelle has "pursued the study of the planet Earth with romantic attachment and dogged determinism."

Revelle's accomplishments are enough to distinguish several lifetimes, and he's not tired yet. Now a professor of science and public policy at the University of California at San Diego (UCSD), he first made his mark in oceanography, a field in which everything was yet to be discovered when he joined it in 1931. His career has been intimately entwined with the destiny of La Jolla, California's Scripps Institution, the country's oldest oceanographic center. Scripps made Revelle into an oceanographer and then Revelle made oceanography into big science.

Revelle was working toward a doctorate in geology at the University of California at Berkeley when he received a call from Scripps—still a small, cozy place—inviting him to come study muds from the ocean bottom. What appealed to him was not so much the mud but the location. Revelle was engaged at the time to a young woman from La Jolla named Ellen Clark—now his wife of 52 years—who is also a great-niece of the legendary

PHOTOGRAPH BY MALCOLM KIRK

and immensely wealthy newspaperwoman Ellen Browning Scripps, whose farsighted support was indispensable to the fledgling institution's survival. Arriving at La Jolla in 1931, Revelle immediately went to sea. The small, oily ships made him lyrical. At sea, he later wrote, the past and future disappear, and only the present remains. The spell of the ocean "comes partly from outside the senses, from half-forgotten memories and images deep below the surface of consciousness."

Through most of the Thirties, the Scripps research vessels plied the coast of California, often with Revelle aboard. The crews mapped the Gulf of California for the first time, and Revelle wrote his dissertation on ocean muds.

During World War II, Revelle and fellow oceanographers helped to advance the Navy's submarine hide-and-seek intelligence. Research on sea and beach swells led to successful landings at Normandy. By the time the war was over, Revelle had been marked a leader of men. From 1951 to 1964 he served as the director of Scripps. This period was, in Revelle's words, "a new age of exploration," when research gathered during a series of long sea voyages revolutionized knowledge of the seafloor. Revelle kept Scripps in the forefront of the research and was successful in luring scientists from around the world. Revelle was also a main force behind the founding of UCSD in 1960. He recruited a stellar list of faculty members by persuading them that they could do their best work at this new university.

Throughout his career Revelle has persuaded no end of scientists to do no end of work. He has also persuaded people around the world to work together on problems of population, hunger, and agriculture. He persuaded his colleagues to undertake the production of a massive treatise, *The Sea: Ideas and Observations on Progress in the Study of the Seas*. By 1974 it had swollen to five volumes, summarizing the accumulated body of knowledge in the field of oceanography. And yet, when he says he isn't an oceanographer anymore, he's probably telling the truth. He is a man who likes big problems, and this quality, combined with his inventiveness, has taken him away from the oceans.

In 1961 Revelle began a new phase of his career. As a science adviser to President John F. Kennedy, he was sent to Pakistan to examine irrigation problems. There he found the real problem: feeding Pakistan's ever-growing population. In 1964 he founded Harvard's Center for Population Studies, which he directed for the next 14 years. His primary interest there was the application of science and technology to world hunger.

Most recently he has emerged as a leading authority on the greenhouse effect, the controversial theory that predicts global climatic changes resulting from the gradual warming of the earth's atmosphere. The greenhouse effect, so named because the phenomenon would occur in somewhat the same way as glass traps sunlight-heated air in a greenhouse, is brought about by rising levels of carbon dioxide (CO_2) in the atmosphere. This increase in CO_2 results largely from the burning of fossil fuels, which releases half a billion tons of the gas into the atmosphere every year. Last October the Environmental Protection Agency (EPA) and the National Academy of Sciences (NAS) issued reports warning of this approaching warming trend. They said it could start within the next decade. According to Revelle, who was on the NAS committee, it may have already begun. For him, it would be a big surprise if the temperature rise did *not* take place. If the climate didn't, in fact, warm up after the CO_2 concentrations reached a certain level, the whole geophysical model of the earth would have to be rewritten. Although, as Revelle says, "We may not have thought of everything."

Revelle and his wife live in La Jolla, in a handsome house hidden from public view by a garden wall. Besides teaching, writing, and advising, Revelle continues to be one of the world's most peripatetic scientists, attending conferences around the globe. His constitution, which doesn't recognize jet lag, is a source of wonder to his colleagues. His omnipresent cigarettes, his jug of coffee, and his wholesome attitude to cocktails mark him as one who hasn't succumbed to California's obsession with health—aside from his taking an occasional turn around the swimming pool.

> *"The increase in temperature will be two or three times greater at northern latitudes. But we might like New England better if it were six degrees warmer."*

Writer Esther Wanning interviewed Revelle in and around his office at UCSD's Revelle College. (Says Revelle: "They named a college after me instead of making me chancellor.") As Wanning and Revelle stalked the campus grounds one day, a man popped out in front of them and said to Revelle, "I made it. You wouldn't remember me, but thirty years ago you worked out a way I could find the currents to drift on a raft to Hawaii. It took me ten years all in all, but I got there." The rafter, DeVere Baker, turned to Wanning and explained: "Dr. Revelle was tremendous. I was just some nutty kid he could have ignored. But he sat down with me and told me about the currents. He was a huge help. He's the admiral." Baker produced a book he'd written about his trip and opened to a 1952 picture of himself with Revelle. Revelle focused on the photograph and said: "I was a handsome dog in those days."

He's craggier now and slightly bent. But people from all over the world still come to him for advice. That afternoon's lineup included a United Nations dignitary, a colleague with whom Revelle is pondering the feedback effects of carbon dioxide, and an official from the American Association for the Advancement of Science (AAAS), who noted that he had never heard an explanation of the greenhouse effect clearer than Revelle's. "That's my job," says Revelle, "making complex things simple."

Omni: One of your fellow scientists has said that you are without peer in bringing to problems a balanced understanding of the earth's geology, chemistry, biology, and physics. A problem that has occupied your attention for many years is the increasing levels of CO_2 in the atmosphere, which could cause the earth's climate to become warmer. Is this actually happening?

Revelle: I think so. We've got good figures showing that there has been a steady increase in CO_2 in the atmosphere since 1957. The figures come from sites that were set up at Mauna Loa, in Hawaii, and at the South Pole during the International Geophysical Year in 1957. Those two places were chosen because they're free from local contamination and offer well-mixed air for sampling. Carbon dioxide is being measured in lots of places now, and we've found it to be increasing at a rate of one and a half parts per million per year. When the studies began, there were 315 parts per million. Today there are 344 parts per million. That's a nine percent increase since 1957. I estimate that the total increase over the past one hundred years has been about twenty-one percent. But whether the increase will lead to a significant rise in global temperature, we can't absolutely say.

Omni: What makes scientists think that's likely to happen?

Revelle: CO_2 warms the air because it absorbs infrared radiation that would otherwise be transmitted back into space, and the CO_2 back-radiates it toward the earth. For the earth to remain at a constant temperature, the planet's infrared emissions must balance the absorbed incoming solar radiation. The general notion, according to the theoretical models, is that as the level of CO_2 doubles, the temperature of the earth as a whole goes up an average of two to three degrees centigrade.

Omni: You don't argue with that?

Revelle: No. I don't understand the models well enough to argue. That's a subject beyond my ken. [*Editors note:* Syukuro Manabe, of the Geophysical Fluid Dynamics Laboratory at Princeton University, described how a climate model works. You put the equations of heat and radiation

balance and other data into a "static Earth," and then you turn on the engine—the atmosphere and the sun. This reproduces all the movements of energy in complex multiple equations, creating a general simulacrum of the earth's climate as it is now. Then you add some more CO_2, crank up the engine a bit, and you get predictions of future conditions.]

Omni: A worldwide temperature rise is still just conjecture, though, isn't it?

Revelle: We do have one strong piece of evidence. The planet Venus, whose atmosphere is mostly CO_2, has a hellish greenhouse effect. The temperature on the surface of Venus is a dull red heat of about seven hundred degrees Fahrenheit. There's no question that CO_2 does something. The question is, How much will it do?

Omni: What is causing the increase in CO_2 in the atmosphere?

Revelle: The burning of fossil fuels and the clearing of forests release CO_2 into the atmosphere. Over geologic time vast quantities of CO_2 were emitted by volcanic eruption. But almost all of it was chemically transformed into calcium carbonate and magnesium carbonate or into organic matter. This was buried in marine sediments, some of it in the form of fossil fuels. Because the CO_2 was buried in sediment, our greenhouse effect is only moderate as compared with that on Venus. In a few short generations, population growth and industrialization are using up fossil fuels that accumulated over five hundred million years.

Omni: How does clearing the forests increase CO_2 levels?

Revelle: Burning wood produces CO_2 and water. Part of the CO_2 stays in the air. If you don't actually burn wood, it still oxidizes—just more slowly.

Omni: It was once thought that excess CO_2 was absorbed by the ocean, which already holds sixty times as much CO_2 as does the air. Then, in 1957, you and fellow oceanographer Hans Seuss showed that the oceans absorb CO_2 at a much lower rate than had been thought. Could you explain this so-called Revelle factor?

Revelle: The ocean has a well-mixed layer of water, some seventy meters deep on the average, in which gases are readily exchanged between the ocean and the atmosphere. In studying this layer, we found that if the amount of CO_2 in the atmosphere increases beyond a certain amount, the content in this surface water increases by only a ninth as much.

Omni: And that led you to conclude that eight ninths of the CO_2 remains in the air?

Revelle: Not exactly. We thought about two thirds would remain in the air and another third would go into the ocean because CO_2 penetrates beneath the surface layers. The buffer factor applies to only the mixed layer of ocean that has constant contact with the air. Below that layer, all bets are off.

Omni: So you're not predicting what proportion of CO_2 has gone into the ocean?

Revelle: We try. It's hard to measure directly, but you can do so indirectly by measuring all kinds of tracers. For example, tritium and carbon 14 were produced in the Fifties during atmospheric testing of hydrogen bombs and atomic bombs. The tritium got into the rain and joined the ocean waters at the surface. It was then carried below by the ocean's circulation.

It's possible to think of the ocean as a deck of cards, a whole series of stratified layers of water of slightly different densities, with lighter water on top. You get a lateral motion along these cards, and it's on a scale of a few thousand miles. These are the ocean currents, and the process is called advection. But the layers of equal density are sloping, not horizontal. So tritium, let's say, is carried down from the surface to a depth of maybe two hundred or three hundred meters in some places, a thousand meters in others. And it is that whole layer of water, mixed with the atmosphere, that has taken up some of the CO_2.

Omni: Someone with a passion for accuracy could go mad in this business.

"Humankind is conducting a great geophysical experiment. We are returning to the atmosphere what was originally there a long time ago."

Revelle: Yes. CO_2 is increasing in both the ocean and the atmosphere, though it doesn't matter in the ocean. There's so damn much in the ocean already that a little more doesn't make much difference.

Omni: What will the warming of the earth mean to us?

Revelle: There may be lots of effects. Increased CO_2 in the air acts like a fertilizer for plants. Experiments show that if you increase the CO_2 content in a greenhouse, you get more plant growth because photosynthesis is increased. It also causes more of the sugar produced in photosynthesis to be translocated in the body of the plant. In forest trees it would be translocated from the leaves into the wood. The third thing it does is to slow respiration, the part of the plant cycle in which plants decay, in which plants absorb oxygen from the air and give off CO_2. Increasing CO_2 levels also affect water transpiration, causing plants to close their pores and sweat less. That means plants will be able to grow in drier climates. That's another way biomass is increased. Moreover, a plant's response to light is also affected. Plants will grow at lower light intensities, which once again increases the size of the biomass.

Omni: Does the increase in CO_2 have anything to do with people saying the weather is getting worse?

Revelle: People are always saying the weather's getting worse. Actually the CO_2 increase is predicted to temper weather extremes—at least in northern latitudes where the projected temperature increase is much larger during the winter than during the summer.

Omni: If there's more CO_2 in the atmosphere, is there less oxygen?

Revelle: The amount of oxygen is of course affected by the change in CO_2 levels, but in amounts so insignificant that we haven't been able to detect any change at all in the period we've been measuring. There are two hundred thousand parts per million of oxygen in the atmosphere and only about three hundred parts per million of CO_2. So increasing CO_2 levels by sixty parts causes only three hundredths of a percent decrease in oxygen levels.

Omni: Has the temperature risen in the last one hundred years?

Revelle: According to [climate modeler] James Hansen and his colleagues at the Goddard Institute for Space Studies, the mean global temperature rose about one half degree centigrade between 1880 and 1980, which seems to be consistent with the rise in CO_2. There are other variables that could have affected the temperature, however. So far, it can't be said that there exists any warming trend above the noise level of yearly temperature fluctuations.

Omni: When do you think the trend is going to be significant?

Revelle: People say that within ten years we'll know. On the other hand, you might have had many grandchildren by the time it happens. We expect to see important consequences when the CO_2 level is double what it was in the nineteenth century. At the present rate that would happen in the middle of the next century. But by that time we'll be running out of petroleum and natural gas, so the determinant is really whether we substitute other energy sources for future consumption of coal.

Omni: What would happen if the temperature goes up two or three degrees?

Revelle: According to the models, the temperature increase will be two or three times greater at northern latitudes than at southern latitudes. So there may be a temperature increase of six or seven degrees centigrade in the northern United States and only a three-degree rise for the world as a whole. The tropics might be only one or two degrees warmer. What difference would it make? I don't know. We might like New England better if it were five or six degrees warmer. Remember, that's almost ten degrees Fahrenheit.

Omni: What would be the overall effect on food production?

Revelle: Most critical and worrisome is the effect on water distribution. On the earth as a whole, we're going to have about a nine percent increase in evaporation. Of

course, what goes up must come down but it's not going to be uniform over the earth. The dry belts, deserts, and semiarid areas are likely to move north—right across what are now the most productive agricultural areas, like the Colorado River basin. Because of higher temperatures and possibly less precipitation, irrigation water will be a lot scarcer.

Omni: Will other climates improve?

Revelle. Canada and northern Siberia would have a longer growing season. The wheat-belt climate will move north. But then you'd have another problem, because the soils are much poorer farther north. The best soil in the world is in Iowa—lovely, thick, loamy soil. Whereas Canada has thin, acid soil. But as far as rain-fed agriculture is concerned, I think the results on the whole will be beneficial. Other interesting things are also going to happen. The West Antarctic ice cap may melt, causing a rise in sea level of about twenty feet.

Omni: When would this take place?

Revelle. Probably quite slowly—maybe over a period of five hundred years at the rate of about three or four feet per century. That would have quite serious repercussions on all sea-level places—Venice, Holland, Bangladesh, Florida, La Jolla. I've been thinking lately about another interesting possibility that might result from the warming of the ocean waters. There are other greenhouse gases besides CO_2. Methane, which is a natural gas, is one; nitrous oxide is another. All three share the same property of absorbing and reradiating infrared radiation. There's something called methane hydrate, or methane ice, contained in the mud under the seafloor. It is stable only at low temperatures and high pressures. If you raise the temperature of the seawater, this stuff becomes unstable and escapes, which adds to the methane in the atmosphere. You don't have to add very much to achieve the same effect as you would by doubling the CO_2 level. This is called a feedback effect because it is the result of the temperature rise caused by the increased CO_2.

Omni: Would you be disappointed if these things didn't come to pass?

Revelle. Yes, I would be. I won't stake my future career on it, because I don't have a future career, but I would like to see it happen. As Seuss and I wrote in 1957, mankind, in spite of itself, is conducting a great geophysical experiment—probably the greatest geophysical experiment ever conducted in terms of possible effects. We're returning to the atmosphere what was originally there a long time ago. The changes are going to happen slowly, almost imperceptibly from year to year, but it's not too soon to begin planning how to make use of them.

Omni: Why is it that we are unable to accurately predict the weather?

Revelle. We can predict the weather only for about a week, although we hope to be able to predict climate—the statistics of weather—perhaps from one year to the next or even for decades. But the atmosphere has very little memory. After a few days a small random event—someone in China blowing his nose—can determine where and when a storm will be.

Omni: Once we've exhausted our fossil fuels, do you have a good candidate for an alternative source of energy?

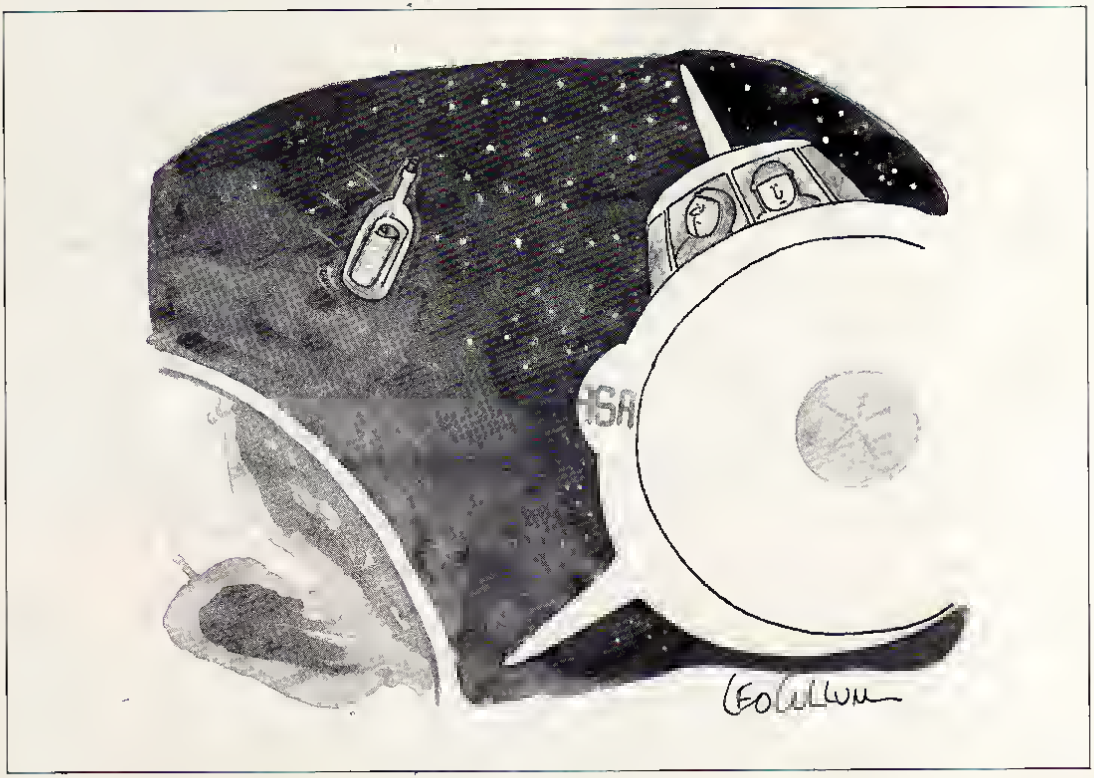
Revelle. The sun. Although it has a finite lifetime, it's still good for more than five billion years.

Omni: Do you think there's a real possibility for a breakthrough in solar energy?

Revelle. If I could say yes, it wouldn't be a breakthrough. A breakthrough is by definition something unexpected.

Omni: You could have faith.

Revelle. Faith is a bad thing to have when it comes to technical problems. What you can say is that there's plenty of solar energy, but it's diffuse. The best way to capture it is through trees. You can cut down a tree and burn it. There are other ways to use trees' captured energy too—for instance, by making methane or methanol. Within ten to fifteen years I think it will be possible to produce from trees the energy equivalent of about thirty tons of coal per hectare, or about twelve tons of coal per acre per year. I am talking about cutting



down existing trees and planting new ones in areas where trees now grow. That sounds harsh, but I think we have to do it because existing trees grow so slowly. Nature doesn't care about productivity; it cares about survival. So trees don't see any reason for producing a lot of wood unless it helps them survive. And the way they survive is by outcompeting the other trees. They grow tall so their crowns are above the others. They shade out the other trees and prevent them from getting enough sunlight. It's a harsh, cruel world among trees. But once they've gotten tall enough to shade out the others, they don't see the need to get taller. So they don't grow and don't produce much wood.

Omni: So you are suggesting that we plant fast-growing trees?

Revelle: To keep planting and replanting them—pioneer trees, the first ones to move in when you burn the forest.

Omni: What about the forest's ecology?

Revelle: What does that mean?

Omni: The animals that live there, for instance. I would suggest that they have a right to live.

Revelle: Of course, but not as much as we have. We've decided that. The problem is that people have decided they want to have more and more people. They can't do that and preserve everything else. There are going to be many more people, and I don't want them to live in misery. Unfortunately, most people couldn't care less about the gorillas or the butterflies or the birds. They're just interested in their own families or in themselves. That being the case, we've got to be able to provide a fairly decent life for them.

Omni: Do you think there should be a certain amount of land preserved?

Revelle: Oh, yes. I do. Close to twenty million acres of land are being cleared each year for agriculture. At that rate the less-developed countries will end up pretty much without forests. That's because people are desperately trying to get enough to eat. But you can solve that problem by increasing the yields, by improving agricultural technology so you get more per acre. With a given amount of land and water, you can get a lot more crop if you do it right. I'm on record as saying that productivity could be increased by fifty percent. But all in all, it costs a lot of money.

Omni: You caused a lot of controversy in 1974 when you called for the formation of a World Food Reserve. Some people said that to feed the hungry is not to reduce their numbers, because the hungry then produce only more hungry people, who again produce more hungry people.

Revelle: That's unadulterated Malthusianism! It doesn't turn out that way. When people have hope for the future, the birth rate goes down. As people become more prosperous, the birth rate goes down. But they require more than food. They have to see a way to improve their conditions in life. Besides, all you have to do is to save five to ten percent of the world's food pro-

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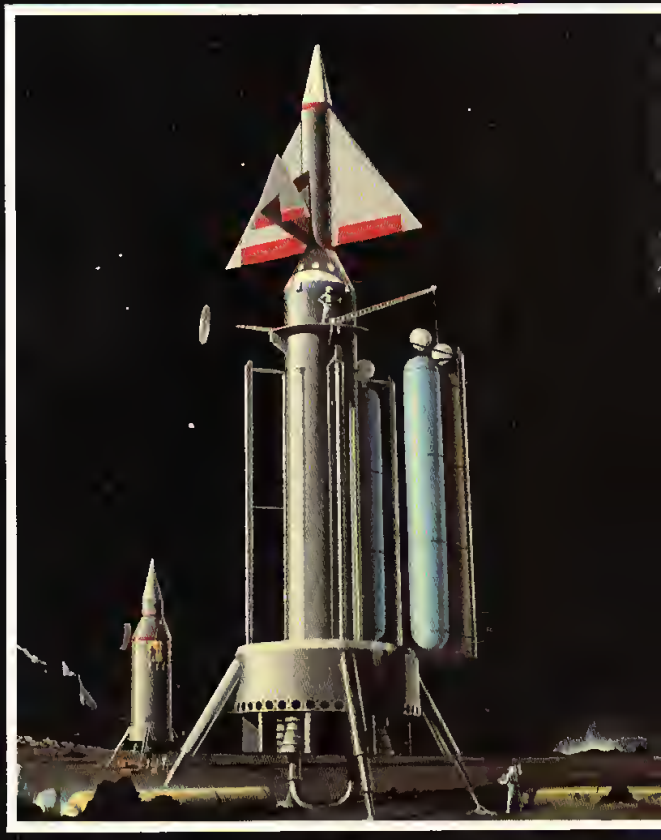
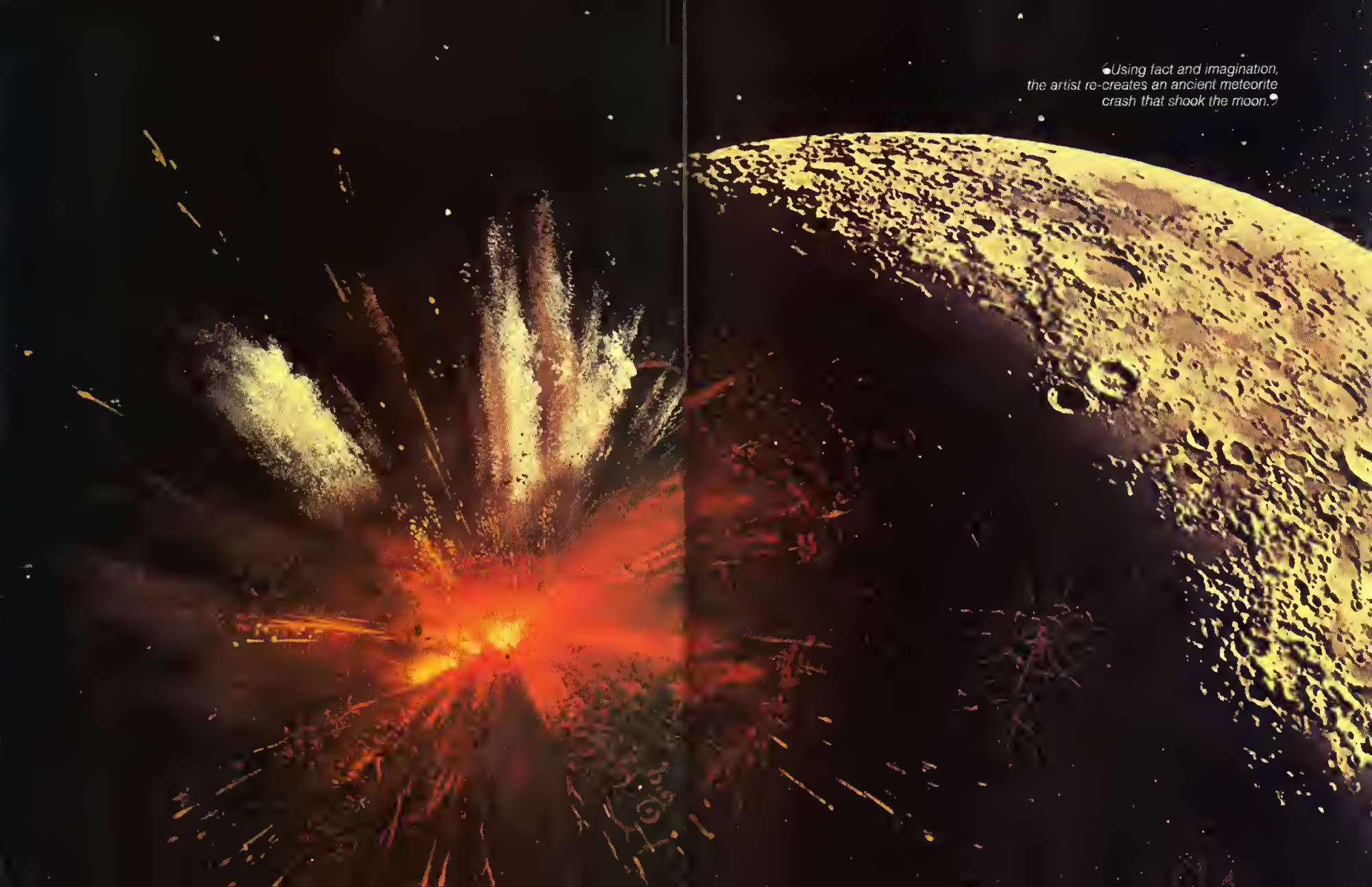
Meet our first planetary probe: artist Chesley Bonestell

PRELUDE

BY FREDERICK C. DURANT III

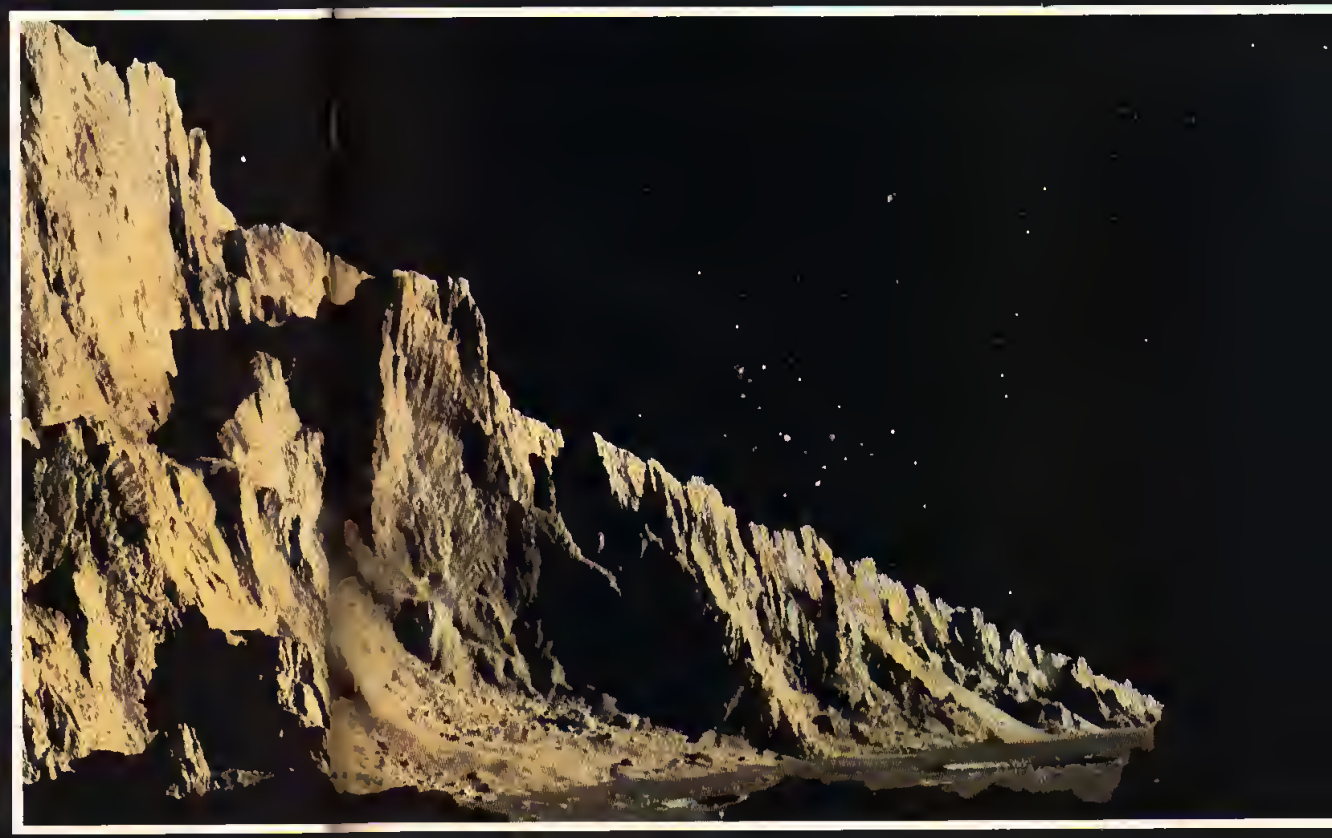


Years before satellite images revealed the varied terrains of our solar system, pioneering artist Chesley Bonestell began creating his own astronauts kicking moon dust for the first time (left) and a now fanciful-looking moonship preparing for lunar takeoff (above). Advised by such experts as Wernher von Braun and Willy Ley, Bonestell foresaw our journeys into space.



Using fact and imagination, the artist re-creates an ancient meteorite crash that shook the moon.

"Before the technology for spaceflight existed, Bonestell had already explored the moon."



In Bonestell's art we find the universe within our grasp. Whether it is the moon's Great Wall intersected by the Milky Way (right), or a detail of a solar-powered "baby space station" in orbit over the East Coast of the United States (above), the vast and illusive worlds of our galaxy take on a vibrant closeness and remind us of the wonders that lie beyond our own horizon.

'At first I thought these people had it together but then I realized they really believed this junk'

ANTI MATTER

UFO UPDATE

She fell into a deep sleep and woke seconds later in a glowing "organic" chamber on the planet Ancore. Her host, a ten-foot-tall creature named Aranon, took her to a small egg-shaped spacecraft and in just seconds they arrived at Colony Five, a planet for displaced Earthlings. Their next stop was a rocky world with oaklike palm trees and menacing cavemen. Fortunately, Aranon uttered a secret word, stopping the savages in their tracks. Then the travelers reentered their spacecraft, arriving at Ancore in a matter of seconds.

That, at least, was the story told by Christy Dennis, thirty-seven, a housewife from Phoenix. While meditating at home after breaking her hip in a traffic accident, she says, she momentarily lost consciousness, waking up in another world. Though she blacked out for only a minute on Earth, she claimed she spent 14 days in space. By the time she returned, her hip had healed so well that she could walk across the room. Afterward, she wrote a book about her experiences, sketched the aliens, and drew schematics of the spacecraft and its power drive.

The Dennis story caught the attention of Leo Sprinkle, a counselor at the University of Wyoming and a leading finder of supposedly repressed UFO abduction experiences. Sprinkle accepted Dennis's story and recruited her help in a 1981 conference for abductees.

Participating in the conference, Dennis soon met Dan and Eileen Edwards, of UFO Contact Center International, a support group for UFO contactees. "It seemed like a good avenue for me to investigate," says Dennis, who decided to visit the center. 'At first I thought these people really had it together. But slowly I began to realize that this was screwy. They really believed all this junk despite a great deal of missing or twisted information."

After Dennis got back from her second week-long session with the Edwardses, in fact, she rocked the nation's UFO establishment by admitting that her dramatic 'UFO abduction" was a hoax. 'I am not a contactee,' she told the UFO world in an open letter. 'I never had an extraterrestrial experience. The stories I have told and the book I have written are nothing more than fair science fiction." She concluded her letter with a warning to UFO investigators: "Take a good look at what you are willing to believe. If I could get your attention, how many other frauds have been able to do the same?'

Now, however, Dennis is repudiating her earlier repudiation. She admits she was never abducted by aliens but insists her story was not a hoax. "I was just barking up the wrong tree,' she says. "I was meditating and I simply experienced a space-time continuum shift. When we encounter something alien to our symbolic reference patterns, we have to make up the words to explain it."

Though Dennis can't validate her story, she claims the experience has had some tangible results. "My I.Q. went from 110 to 165," she explains, "and I developed a sensitivity to earthquakes, as well as a deep knowledge of nuclear physics.'—*ROBERT SHEAFFER*

ROBOT SEXISM

They call her 'Sweetheart' and she recently created quite a stir at the University of California's Lawrence Hall of Science, where she was featured in an exhibition entitled "Rendezvous with Robotics." Sweetheart (above) is a robot all right, but one designed with some stereotypical notions in mind. She has a pair of large metal breasts—fashioned by her creator, artist Clayton Bailey, out of aluminum desk lamps—and her one job in life is to serve coffee.

It was this depiction of Sweetheart as a feminine role model that ultimately got her banned in Berkeley. First a group of 35 Lawrence Hall workers and members of the public filed an impromptu petition with hall director Robert Knott to have Sweetheart removed on the grounds that "a nude female robot whose sole function is to serve coffee is objectionable to women." Although the petition did have some influence, Knott says, "The real reason I had her removed was that a couple of kids had come up to the robot and hung their arms over one of her breasts. It just boiled down to whether Sweetheart was in good taste for the average-age student we get coming through here."

Sculptor Bailey was not impressed with Knott's reasoning. "The issue here," he says, "is robots' rights. Robots have just as much right to have breasts as people do. Besides," he adds, "I thought that kind of artistic censorship went out with the Sixties."

He also notes that another robot he made for the exhibition—a mele charmer with a distinct genital bulge—was a great hit, inviting every woman in sight to come home with him. Although there were no takers, Bailey says, "there weren't any complaints either."—Bill Lawren

"For whatever a man may do, he does it in order to annihilate time, in order to revoke it, and that revocation is called space."
—Hermann Broch

"Ritual is the husk of faith and loyalty,/ and the beginning of confusion."
—Tao Te Ching

[illegible]

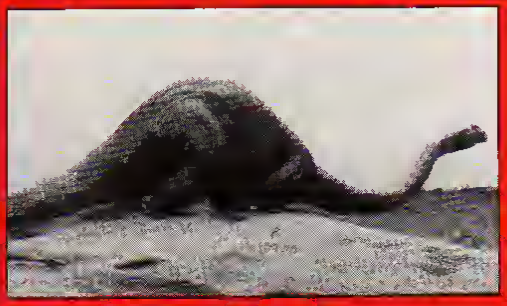
East African legend tells of a swamp-dwelling creature that kills hapless tribesmen paddling by in canoes. The creature is said to be bigger than a hippo, with a long, sinuous neck that snakes out to uproot plants along the shore. To modern day biologists, the legend describes a creature from the brontosaurus family, extinct for more than 100 million years.

Now an African biologist claims he has seen the creature. In a report in a recent issue of the journal *Cryptozoology*, Congolese scientist Marcellin Agagna says he spent 20 minutes watching and filming the animal called Mokele-Mbembe in a remote part of the Congo. He was hiking through the underbrush, he says, when one of his guides called out, "Come quickly, bring the camera!" There, in a shallow lake, Agagna says, was the reptilian beast.

Could Agagna really have seen Mokele-Mbembe, the African version of the Loch Ness monster? Roy Mackal, head of the Cryptozoological Society, says Agagna is no crank. "He's completely rational and a healthy skeptic," says Mackal, a University of Chicago biologist who participated with Agagna in two previous expeditions. "I'm confident he saw what he said he saw."

Still, Mackal and other biologists are waiting to see Agagna's film. If it's compelling enough, they say, it may trigger another expedition. So remote is the jungle where the sitting occurred that a few hundred of the creatures could live there undetected. Yet even a crystal-clear picture of Mokele-Mbembe will not establish that the dinosaur lives. "We're still in the strictly anecdotal stage," says Mackal. "Nothing like this is solved until you have the animal in a cage."
—Douglas Starr

"Around us are pseudo-events, to which we adjust with a false consciousness adapted to see these events as true and real, and even as beautiful."
—R. D. Laing



CAVE WORKS

Italian scriptwriter Piero Tellini wes walking near a cave in Ansedonia Itely some 20 years ago when he stumbled upon a small carved stone Thet night a storm cast his room into darkness Tellini recalls and he began rotating the stone idly in front of his flashlight Suddenly, he says 'an incredible three-dimensional shadow of a primitive beast-man leapt on the wall its mouth gesticuleting and its pupils moving wildly"

That experience changed Tellini s life He compromised e brillient movie ca reer he claims 'to roam the hills looking lor stones,' while friends 'Fellini and Dino De Laurentlis were in their comfortable homes looking for stories"

Immersing himself in archeeology Tellini soon hypothesized that cavemen had developed the tech nique of working stone not as a mere pastime but as a sophisticated artistic endeavor "By manipulating the stones in the right light at a certain speed and angle, the cave dweller could project e succession of images—a short story the filmmaker explains "One English stone for ex ample shows a hooded figure plunging a knife into a victim another shows a couple moving into en embrece

The discovery gave Tellini "a spiritual high I could've been a monk ' he says But though he believed he had discovered dozens of priceless relics the few scientists who sat through a ' viewing" saw nothing Yet Tellini explains "In the derkest hours when the whole world was egainst me, I had only to examine the stones to be happy again

Finelly, Tellini says there was a breakthrough He captured Ihe images on video Nonetheless he admits those who saw the tepe were still beffled Met ropolitan Museum curator Lois Katz, for one found it 'stimulating but incomprehensible ' And *Omni* editor Dick Teresi says ' couldn't see a thing He even had trouble working the tape machine It s hard to believe he was once a filmmaker

Now, however Tellini claims that one 'Professor Gaietto a paleontologist from Genoa, has verified that the stones are artifacts dating back to 350 000 ec Gaietto does in fact hold that opinion When asked for his university affiliation though he seid "I've studied prehistoric art for twenty-five years, but I'm not a professor I sell antiques —Kathrine Jason

EXTRATERRESTRIALS ONLY

Are you far from home and miserably earthbound? Tired of that human disguise? Then you need Extraterrestriels Only (E O) the first organization for transplanted aliens Membership includes an official alien I D card and a chance to meet other creatures like yourself That at least is the promise made by E O founder Andrew Ferguson a New Hampshire real-estate agent who claims that after only three months in operation, he's registered 283 aliens and 28 families, mainly from Venus

Ferguson believes that aliens are like homosexuals were during the earliest stages of the gay-liberation movement "They fear ridicule he says 'and that's why they need a bona fide human like me to bring them out of the closet

Eventually Ferguson says he hopes to establish a nationwide network of E O centers to help aliens cope with the problems of the human world "For example" he explains ' I got a letter from en eight-year-old boy whose mother was upset because he joined my group She was afreid he'd take his extraterrestrial origins too far and lose sight of who *she* thought he was But E O he says, could provide group therapy to help the family accept the boy and overcome the difficulty of explaining to relatives, ' My son is a Mertian '

According to Ferguson, the popularity of movies like *E T* proves that we've become infatueted with the idea of aliens visiting the planet And that is why, he predicts more aliens will be coming out of the closet now than ever before

For information, write E O , Box 355 Intervale NH 03845, don't forget to include your alien name and address, planet and galaxy—Peter Rondinone

"What counts is communicating the indispensable, skipping all the superfluous, reducing ourselves to a luminous signal that moves in a given direction "

—*Italo Calvino*

PREGNANT DREAMS

Could the dreams of pregnant women hold clues about their unborn babies' health? According to Robert Van de Castle, the answer may be yes. The dreams of pregnancy, says Van de Castle, may predict such things as length of labor and even the likelihood of postpartum depression.

The theory, explains Van de Castle, a psychologist at Blue Ridge Hospital in Charlottesville, Virginia, "is based on the idea that any malfunctioning in the body usually doesn't register during the day. But at night we are like a tuned-in radio. We can better process messages from our body *without* all the disruptive static that comes across in the waking hours."

To document this hypothesis, Van de Castle is currently soliciting dreams from pregnant women, and he's already noted certain patterns. In the early months, expectent mothers dream of small animals, like fish and kittens. But by the last trimester, there is a sevenfold increase in references to the baby. Some women dream of rejecting or ignoring their new child—and that may prove to be a clue to the development of postpartum depression.

While nightmares about unborn children usually indicate nothing more than common anxiety, says Van de Castle, some women have frightening dreams that appear to be portents of danger. For example, one woman dreamed that her baby was floating on a cloud and waving goodbye. She suffered a miscarriage a few days later. "I've heard a lot of tragic stories from women who dreamed about their babies' deaths or about birth defects, and the dreams came true," he adds. "There seems to be some kind of internal communication."

Despite Van de Castle's evidence, Atlanta obstetrician Julien Fuerst disagrees. "I cannot recall in seventeen years of practice any woman who ever told me of even one dream that was so vivid or bothersome that she worried about it," he says. "And I've never heard of a woman having a dream that in some way predicted the outcome of her pregnancy."

Van de Castle, however, insists that the results of his study may be of practical use to expectant mothers. "If a pregnant woman has dreams that are very vivid and dramatic," he says, "it may be that she needs to have herself checked out by a doctor."—Sherry Baker

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"This shock which separates the end of one life from the beginning of the next . . . is too strong for ordinary man, who has no choice but to forget and fall asleep."

—Rodney Collin

UNMARKED HELICOPTERS

While teaching his religious-studies class at Colorado's Denver University, professor Carl Raschke observed two helicopters circling the campus. Later, his students and local residents saw the same thing. According to reports, the copters were completely black and unmarked, and they vanished as quickly as they appeared.

One theory, Raschke explains, posits that the copters are part of an international terrorist conspiracy to spray a "mind-altering" virus across the United States. Yet another theory suggests that the virus comes from Denver's Lowry Air Force Base. "It could be a top-secret experiment in biological warfare," says Raschke, "with the U.S. government using us as guinea pigs."

But according to Sergeant Chuck Kubin, public-information officer at Lowry, there isn't a single black helicopter on base. "Besides," he says, "I myself saw one of those black babies when I was driving to work. I'd like to know what's going on, too."

Denver TV reporter Linda Howe may have the answer. She says she's linked the helicopters to extraterrestrials who, she believes, are responsible for a rash of cattle mutilations in the Denver area.

Vance Reed, an investigator for the Mutuel UFO Network, disagrees. He says he's found religious totems near the mutilated cows, suggesting they were slaughtered at the hands of a Satanic religious cult. Nonetheless, he adds, this doesn't rule out the possibility that the helicopters are extraterrestrials caught in an "extradimensional" time warp, slipping from past to future. "Until there is more veritable evidence we've got to agree on one thing. Something is happening in Denver."

—Peter Rondinone

CONTINUED FROM PAGE 26

"and we use it a great deal because it has profound implications for the kind of treatment you might suggest for patients."

Alexithymia makes it quite clear that the psychoanalytic approach is not always the best one, especially for people who are incapable of expressing their emotions in words. Psychoanalysis only tends to make alexithymics more anxious. Sifneos recommends mild medication, behavior-modification techniques, or group therapy.

Ford favors group therapy himself. "That can help improve the situation," he says, "but it won't turn an alexithymic into the kind of sensitive, emotional, empathetic—and sometimes neurotic—individual many of us tend to be. Life is relatively simple for these people, and if the condition is not causing them any distress, I would not recommend any treatment at all."

Alexithymia has proved to be an attractive concept among psychiatrists, and as a result there has been no dearth of theories to explain the condition's causes. Sociocultural explanations stress the correlation with lower socioeconomic class and lack of social learning; psychoanalytic theories emphasize early developmental difficulties where mother-child interactions have been disrupted so that the child has not learned to describe his feelings.

But the most promising of all theories comes from neurophysiology. It seems that many alexithymic characteristics can be understood as an interruption of communication between the brain's two hemispheres. Lending support to this hypothesis are studies conducted on split-brain patients by UCLA clinical psychiatrist Dr. Klaus Hoppe and his colleagues.

Split-brain patients have undergone a commissurotomy, an operation in which the brain's right hemisphere is severed from the left hemisphere. The right hemisphere tends to be important in generating and interpreting emotions; the left seems to be more involved in verbal expression.

Dr. Hoppe's latest study indicates that people who have undergone commissurotomies show a much higher degree of alexithymia than those from similar socioeconomic backgrounds who have not had the operation. This suggests to Hoppe that people who are naturally alexithymic may be functionally commissurotomized, that is, they tend to have weak connections between their two brain halves.

Despite these insights, there are still questions that need to be answered. For example, researchers are still unsure whether alexithymics can recognize their emotions but simply can't express them verbally. "I think these people have emotions but that they can neither recognize nor express them," suggests Ford. "Of course, if they can't express them, it is very difficult to know whether they can recognize them or not. That's the Catch-22."

DEATH

CONTINUED FROM PAGE 46

jammed by a fallen core. The elevator was small and open, like the lifts running on the outside of a building-construction job. Getting ready to slide the core onto the elevator platform, he put a glove over the electric eye of the elevator to prevent it from unexpectedly starting up. He had one foot on the elevator and the other on the Level 3 platform when the glove fell off.

The elevator began to move up. He barely had time to jump back on it before he would have been crushed between the elevator and the next floor.

But there was nothing that suggested anything out of the ordinary when Williams arrived at 7 AM on January 25 to relieve Sugarbaker. They had a half-hour overlap to discuss the coming day's schedule before Sugarbaker left. Williams wanted to know what parts the molding line was going to run that day, whether the traffic would be mainly in engine heads or engine blocks or other parts. Howard arrived at about the same time.

Williams's assignment that day was to act as the floater, to troubleshoot any snags that developed during the shift. Production was hungry for the cores, and it was hard to keep up with the demand. Howard would be handling the control station, where the Hewlett-Packard computer continually monitored the operation, diagnosed the errors displayed them on the console, and brought both Howard and Williams into action. These were not uncommon events—a traffic jam or conveyor malfunction. A robot failing to respond to command. A storage lane reported empty when it was full. Or many other foul-ups. If this day was like any other, Williams might have to go into the stacks 15 or 20 times to bail out the robots.

The system was part of the growing robot industry. Sales of such equipment totaled $190 million in 1982 and were expected to amount to $240 million in 1983. In 1981 there were approximately 4,700 robot systems in America. One study from the Upjohn Institute for Employment Research predicted that there would be at least ten times that many robot systems—some 50,000—in use during the Nineties. And roughly 15,000 to 25,000 of the 50,000 would be employed in building cars.

The growth generated fears about jobs and safety. In Pittsburgh late last year, a local union filed an unfair-labor-practice charge aimed at a mine-inspection robot that eliminated four humans' jobs. And though construction-union leaders in the United States have given a qualified welcome to new machines designed to improve productivity and safety, the rank and file remain wary that robots are job killers.

And some are afraid that they are people killers as well. Robot manufacturers argue that many of the huge machines entering the workplace have the potential to

save lives. One example. Roughly 100 fatalities occur each year in underground coal mines. Researchers at Carnegie-Mellon University (CMU), in Pittsburgh, are currently working on a robot that would help build the mine roof, one of the most dangerous jobs in the deep tunnels. That robot alone could save dozens of lives annually. Another effort at CMU aims to create a snakelike robot to dig up natural-gas pipes, then blow away fumes before humans enter the area. Without robotic help, that work claims 150 lives a year.

The fact remains that robots themselves sometimes injure and kill people. In Japan, one survey of 190 factories using sophisticated robots revealed that the machines injured nine workers and killed two others between 1978 and 1981. In both fatal incidents, robots crushed men. The survey indicated that most injuries did not occur during normal operation. Accidents were more likely to happen as machines were being programmed to do their jobs or during maintenance.

"Robots are just now becoming a part of the industrial world, so there isn't much in the [scientific] literature about safety questions and hazard controls," says John Sneckenberger, a professor of mechanical engineering who recently ran a study of industrial robots. "There are reasons to be concerned."

Back in 1975 such worries were seldom expressed. That was the year that the engineers of Unit Handling Systems, a division of Litton Industries, drove hard to land the contract for the robot storage system with Ford Motor at the Flat Rock foundry. The system was inventive and skillfully designed. From its experience with other blue-chip companies, Litton had several things to sell: major space saving, automatic inventory control, and increased productivity. Ralston Purina, Michelin Tire, Dow Chemical, and others were already utilizing Litton know-how.

The ultimate dream, of course, at Ford or Litton or any other firm, was to make a profit and, in the process, to provide a system to ease man's labors and flawlessly fuse man's intelligence with the machine's brute strength. Beyond that, was the impossible dream of infinite production at no cost. From R2-D2 to the bionic woman, the public was tempted to dream the impossible dream, while the engineers were inspired to reach toward it. Litton's transfer-and-mole robot system was already proving itself a model of ingenuity as the engineers began to appraise Ford's special needs in the immense Flat Rock plant.

There wasn't much that escaped the eye of the Litton engineers as they sat down to make their robot system work for Ford. All of the 222 storage lanes on each side of the main aisles had machine-readable addresses. Like a harrassed traffic cop, the computer was designed to scan a product directory file, search the lane file to find an empty lane, assign the lane, and even make lane adjustments if the assigned lane didn't have space available. All the while, it would be making split-second decisions and talking with a stand-by computer to take over in case of a breakdown.

With the robot storage system classified as "unattended," the design provided for a minimum of human intervention. So confident was Litton of this, that it did not provide any walkways in the storage lanes. The robots and the carriers they stored and retrieved simply straddled the open steel gridwork as they rolled along the open rails. If anything went wrong and needed adjustment, however, someone would have to shin out along the girders to try to fix it. That someone would have to be a trained maintenance man, Litton figured. Not the day-to-day operators like Williams, Sugarbaker, and Howard. They would have so much on their minds keeping up with production demands, it would be too risky.

Safety was important to the Litton engineers. They showed it in their planning. Signs were posted everywhere: THIS SYS

> *"The robot eyes could sense carriers already stored in the lanes. They could see exactly where to position loads. But the eyes could not see people."*

TEM IS COMPUTER CONTROLLED, they read, AND CAN START AT ANY TIME WITHOUT ANY OPERATORS IN SIGHT. ALL UNAUTHORIZED PERSONS KEEP OUT FOR YOUR OWN SAFETY. Beyond that, the system had many built-in safeguards—from bumpers that would stop the robots on contact to emergency stop buttons—to protect "authorized" people.

By July 1977 the intricate operation was almost ready to go into action. As expected, there were bugs. A "punch list"—the engineers' term for a checklist—of some 219 items was drawn up by Ford before even an acceptance test could be run. With nearly $1.5 million at stake, it was a painstaking job to clean up the final items. Carriers jammed on fallen cores or because a shelf on the carrier was bent. Or a carrier code plate would be in error. But some operations worked better than expected. The input lift cycle showed that it could handle 109.85 carriers an hour, when only 105.9 were expected.

Thomas Carlyle once said, "Mighty events turn on a straw, the crossing of the Rubicon decides the conquest of the world." In the assembling of the highly sophisticated technology for Ford, in spite of the most careful planning, the system began to change in small ways, almost as if it had a life of its own. The changes were easy to pass over, especially since the system began to work. Before long there was no question that as a high-density storage system, Litton's equipment saved space, manpower, and time. It prevented bottlenecks. But with production demands high for 24 hours a day, some procedures needed to be altered. The three operators on a shift often found they couldn't wait for a maintenance man to be called in. They had to do what they could themselves: enter the robots' domain to check a false inventory figure, adjust a crooked carrier, remove an obstruction from the robot rails. The "unattended" system had quietly become an "attended" one.

Litton hadn't initially envisioned that everyday operators would go into the stacks. According to one of Litton's engineers, that was one reason why the company failed to install a device—like an audible beeper—to broadcast a warning when the robot was in motion. Yet, strangely, the manual for the equipment gave specific instructions on how and when operators should enter the core stacker ("... the operator should go on board the vehicle [robot] to determine the problem").

The "attended" system now required some modifications. The stacks needed walkways after all, for example, so men would not be forced to walk a tightrope of girders while performing repairs or checking inventory. Litton offered a bid to install the walkways. (The contract went to another company, and the walkways went in.) But no one bothered to upgrade the warning devices even when it became clear that operators would spend many hours a week moving through the same labyrinth as the robots. The Litton designers did include a "lockout" system, however. It permitted workers who had to enter the stacks to turn off power temporarily to any of the five levels, shutting down the huge robots. Yet the operators' manual made no mention of any lockout procedure, nor of any other safety precautions. And turning off the equipment would have made it difficult to satisfy the hungry demands of high production.

Litton had no intention of ignoring the human factor. Nor did Ford. But the mechanical and technological questions became so overwhelming that they commanded the most attention.

There have been several warnings in recent years about the danger of slighting human factors. The most striking was the accident at the Three Mile Island nuclear reactor, in March 1979, where operators compounded a technological breakdown. The power plant vented radioactive gases into the surrounding air—and spurred human-factors engineers to conduct dozens of studies on making machines match the people who use them.

Even before Three Mile Island, engineers were aware of some guidelines. Ac-

cording to Richard Pew, an expert on human factors, designers of all automated equipment have to take into account the attention spans of workers. In the presence of machines, men can concentrate on only one thing at a time, Pew asserts. A corollary: Workers cannot be expected to be fully aware of what is happening outside a fairly narrow focus of consciousness. Reaction time to threats is highest when the danger is expected, Pew reports. People respond more slowly to unanticipated perils.

Some of Pew's axioms sound like common sense, although—like THIN ICE signs—they are often ignored. A worker around moving equipment can think he is safe even when he is in danger; workers often overestimate their ability to deal with a problem; safety instructions must be explicit.

At the Ford plant, some of these factors were taken into account—the lockout system and the lights on the robots were evidence of concern about safety. Some other factors were apparently ignored.

By January 25, 1979, Bob Williams and the shift crew who worked with him were adept enough to handle the flaws in the system to keep the production line content and to solve the unexpected problems. The shift that day had not been running long when it became apparent that the molding line was running badly. The core carriers traveling along the overhead tracks were beginning to back up, since the core production was continuing to turn out its usual quota. This meant that the core stacker would be kept busier than usual to store the carriers that would ordinarily go straight to the molding room. Curt Howard, in charge of computer control that day, sat at the console and checked the carriers to make sure they were coded right and they were going out from the stacker in the proper order. As the floater, Williams sat beside him, ready to enter the stacks in case there were problems.

A minor one came up around 11:30 that morning. Production called, and in spite of the problems on the molding line they needed a quick supply of what were called black shells. These were made of contoured black plastic. They fitted over some of the sand cores to protect them. They were in fact like plastic molds that were shaped to hold a dozen cupcakes or muffins in a supermarket. Production needed this particular item faster than the core stacker could supply them.

When the call came through to the control room, Howard checked the computer readout. The inventory of the black shells in stock did not match what production thought it should be. There should be more available. Howard asked the computer again, and the same answer came back. Since there was a clear discrepancy, it was obvious that all of the 222 storage lanes would have to be checked manually.

This was not a quick job. It often took up to two hours of careful checking. Williams, as usual, was ready to take on the job. It would mean climbing into the open grillwork of the core stacker, then walking down the long aisles where the transfer robots carried their heavy loads. Every storage lane on each of the five levels would have to be checked visually. The robots would be moving back and forth on computer commands—something to keep an eye out for, of course. They couldn't be shut down if production was to be kept on schedule.

Williams detached the computer printout, snapped it on his clipboard, and got ready to climb into the stacker area. He did not take his walkie-talkie with him. The radio would be useless inside the metal framework, where interference ruled out communication with the control room.

It was a common practice to take a short break after an hour or so inside the stacker. Howard looked forward to having a cup of coffee with Williams at that time. The break and the camaraderie were important. They relieved the pressure of the job. Every day Howard felt that he was pitting his brain against the machine, a difficult but interesting challenge. What was intriguing was that nothing could stop the machine's will. Often he would say to himself, "I'm going to make this damn half-human machine work the way it should today."

"Researchers are working on a snakelike robot to dig up natural-gas pipes, then blow away fumes. Without robotic help, that work claims some 150 lives a year."

The delicate eye sensors on both the transfer and the mole robots were enough of a problem in themselves. Dust and dirt would collect on them. They had to be constantly checked and wiped off, on the lane-code reader especially. It sat on the side of the cab about six feet high, in a metallic box next to the red flashing warning light. As it moved past the posts that separated the storage lanes with about three inches clearance, it read the lane numbers unerringly and stopped the transport robot exactly on the lane where the storage or retrieval was to be made. Then the mole robot would move into the lane to do its job. No wonder visitors were amazed at the operation. It was almost human.

Half an hour had gone by, and there was no word yet from Williams, still in the stacks. Production was not at all happy about the delay. They kept phoning Howard. "Where are the shells? Are we going to have to stop the line? What's going on?"

Meanwhile, Sandra was making the final preparations for little Jeff's birthday party back home in Dearborn Heights. Everything was laid out neatly. The cake and the candles were ready. So were the ice cream, paper plates, paper hats, and favors.

Bob and Sandra had met in junior high school, gone to high school together. When they were married, Bob decided to become a Catholic and join Sandra in her religion. In addition to going to church every week, Bob was in the process of completing his lessons in Catholicism in the local parish with Father Joe, a friendly pastor who was popular with the entire community. Bob was fond of him, and the transition to Catholicism went smoothly. For Sandra, religion gave her support and courage.

The party for Jeff would be a festive occasion. Curt Howard would be coming home with Bob. Several of Bob's sisters, who had grown close to Sandra, and other members of the family would be there. Dinner would include some of Bob and Sandra's home-grown vegetables from their garden. Just before that, the presents would be opened, the balloons released, and the birthday song sung by everyone.

In the control room at Flat Rock, Howard was beginning to wonder how Williams was doing out in the aisles and storage lanes of the stacker. Howard was hoping that Williams would hurry up and find the missing black shells so that the continual howls from production would be at least temporarily silenced. It was now well over an hour since Williams had disappeared into the stacks, and usually he would have reported back into the control room in less time. If he didn't show up soon, Howard was planning to go into the stacks himself to see what the delay was. There were all five levels to be checked, and that of course could take a lot of time.

Meanwhile the computer was tracing the endless movements of the five transfer robots and their busy mole robots throughout the levels. By 11:48, the transfer robot on Level 3 had made six consecutive moves from Lane 13 Left to the output buffer station. By 12:07, the robot had completed five consecutive moves from the input station to Lane 11 Right. Similar unpredictable moves were being made on the four other levels—the robots, like army ants, moving in and around their tunnels.

By 12:50, Howard began to get a little concerned. Williams must be having some trouble getting in to check some of the storage lanes, he thought. There might have been some other problems that delayed him. Howard decided to check personally. He went out of the control station to the barrel ladder that sat beside the input elevator. It was uninviting: a slim steel ladder with protective metal openwork hoops around it that prevented anyone from

falling backward as he climbed. Howard reached the fourth level, climbed on the buffer platform, and listened.

The only sound was the high whine of the robots on the floors above and below the aisle grating he stood on. Then he called out. "Bob! Bob Williams? Can you hear me?"

There was no answer. The red rotating warning lights from the robots on all five levels splashed on the steel beams supporting the structure, creating strange irregular shadows. Some people didn't like those flashing lights. They were constantly going, all during the times when the robots were "armed." Some felt that they were simply crying wolf, because they failed to indicate when a robot vehicle was going to start up. The light showed only that they were *capable* of starting up, and failed to give a real warning of movement.

Howard was now convinced there was something wrong. Williams could not have come out of the stacks without being seen. He must be in the stacks. But why didn't he answer? It could only be that Williams was hurt. And if he was—how could Howard get him out of the stacks? The slim barrel ladder could handle only one person going up or down at a time. The open shaft elevator would be precarious.

Howard looked down through the grating to the third level, below. His heart was pounding now, and he began to sweat. Quickly he skimmed down the ladder, hoping to hell he wouldn't slip. He kept repeating to himself, "There's nothing wrong. There's nothing wrong." Stepping onto the grating platform of Level 3, his eyes scanned the long aisle that ran from the north on his left to the south on his right. He saw nothing in its entire length. Then he brought his eyes back along the grating of the aisle floor across from where he was standing on Lane 10 Left. Extending from the lane into the aisle were a pair of legs and feet. For a moment, he was stunned. He could not believe what he saw.

He ran to the lane. Williams was partly under a core carrier that was turned askew in the lane. But he was not caught under it. Howard carefully touched him. There was no response. He was bleeding badly from the back of his head. On the post of Lane 9 Left and on the lane-reader box of the transfer robot, there was hair and blood. Howard knew by instinct that Williams was dead. He rushed to the ladder, down the rungs, and into the control station. He called an ambulance.

The ambulance reached the scene at 1:02 PM, the plant doctor shortly after. Bob Williams had expired approximately half an hour before the doctor arrived. He was carefully removed from the stacks and lowered to the floor level.

In late afternoon Sandra Williams was still completing the finishing touches for Jeff's party. She knew that Bob would want everything perfect for Jeff. A car drove up. Jeff ran to the window as usual. Outside the window, Sandra saw a small group of people approaching. One of them was a woman in a nurse's uniform. One of them was Father Joe. That's strange, she thought. Bob must have invited Father Joe and some of the people from the plant. But why are they so early? Or maybe it was a church committee? She opened the door to let them in. When she heard the news, she went blank. The nurse gave her a sedative. She remembers little else.

They pieced together what had happened. The hair and blood on the lane post and on the robot sensor eye were the same height as Bob Williams. The transfer robot must have moved up silently behind him as he leaned out into the aisle. He was struck and spun into Lane 10 Left, where Curt found him. The robot's weight was more than 2,500 pounds.

Several months later, attorney Paul Rosen studied the case in his office on the thirty-second floor of the Cadillac Tower in Detroit. He was a partner in the law firm of Goodman, Eden, Millender and Bedrosian. It was an unusual firm, the first racially integrated law partnership in the country, the first with a unionized clerical staff. The firm was noted for representing the underdog. Rosen, who had worked part of his way through law school as a punch-press operator, had strong convictions about the social responsibility of the corporation to the worker. That is why he didn't hesitate when an attorney and close friend of Williams's family called and asked if he would take the case. Deep in Rosen's philosophy was the belief that modern technology was constantly putting production needs ahead of human needs. It was a question of priorities. Industry was not placing them in the right order.

> *"Quickly he ran down the ladder, hoping to hell he wouldn't slip. He kept repeating to himself, "There's nothing wrong. There's nothing wrong."*

He brought the action against Litton, as designers and builders of the core-stacker and robot system. Rosen took depositions from the Litton designers and engineers. His conclusion: The death was senseless and unnecessary. The human sorrow it brought to Bob and Sandra Williams's two large families was overwhelming.

What became apparent as Rosen went over the massive material of the case was that there was nothing venal involved. But there was a form of mechanistic indifference, a neglect of the soul in favor of the passion for a perfect machine. The god was productivity. Humans were meant to serve it. The planners had concentrated on the machine's performance. They had failed, Rosen came to believe, to assume that people were going to make mistakes. They had designed a twenty-first-century miracle without incorporating twenty-first century safety.

Underneath everything was an unspoken premise on the part of the robotics engineers. People should not stand in the way of technological progress. As one Litton engineer put it, "Robots don't make mistakes, people do." In its justifiable pride in building such a technically advanced system, Litton had obviously failed to make it equally advanced for the people who would be working with it.

The trial didn't take place until four and a half years after the accident, in August 1983. Paul Rosen and his law partner Joan Lovell presented the case swiftly and succinctly. Litton continued to claim that operators were never required to go into the stacker. Yet Rosen noted that there were specific instructions in the manual for the operators to make constant adjustments in the lanes and aisles. Litton failed to put in a beeping warning system to sound off when the robot was about to move down the aisle. And, Rosen argued, Litton's training had been tragically inadequate.

The irony was that the safety precautions that could have prevented the tragedy were years old, extremely common, and in wide use elsewhere. A dishwasher shuts off when you open the door. A beeper sounds when a bulldozer backs up. The engineering intricacies of the robot system had simply smothered and buried the safety simplicities of the past.

The trial was short. The verdict of the jury came swiftly. The Unit Handling Systems of Litton Industries was found guilty of negligence.

Following the trial, a Litton spokesman told *Omni* that the company still believed its instructions to operators had been sufficient. Spokesman Bob Knapp argued that Williams had ignored the first rule of the system: to shut it down before approaching the machines.

The jury, though, was clearly on the side of the Williams family. The award was $10 million. Some complained that this was too much. It may not have been, if this becomes a sharp reminder to high-tech engineering to balance technological advancement with human life. And as Rosen said in summing up the case, how many million dollars would a robot cost that could replace love, affection, earning power, and a father's smile?

Meanwhile, little Jeff Williams, now six, still tends to run to the living room window whenever a car pulls into the driveway.

GAMES

ANSWERS TO GAMES (PAGE 128)

BEAST The letters in *Ronald Wilson Reagan* have an ominous sum 1984

Furthermore the sum of the squares of the first seven odd primes (3 5 7 11 13 17, 19) is 666 This shows the link between 666 and the occult number 7

ENTRANCE The sign said PULL on Yoshigahara's side of the door Through the glass he could see the PUSH sign printed on the door's other side

DIM $63^2 = 3,969$ or $83^2 = 6,889$

LAYOUT The one solution including rotations and reflections is at right

NEBULOSITY The number base is called the radix hereafter designated as R

Noting that S, L, U, B, E, or N cannot be 0 and that each of the letters (digits) must be less than R, we can calculate a maximum and minimum sum for each column and thus put upper and lower boundaries on the possible values of the Ks This procedure yields the following

$1 \leq K_1 \leq 4$ $4 \leq K_2 \leq 5$, $4 \leq K_3 \leq 6$, $2 \leq K_4 \leq 5$ $3 \leq K_5 \leq 4$, $2 \leq K_6 \leq 3$, $K_7 = 2$, $K_8 = 1$, and $K_9 = N = 1$.

"Now," says Williams, "the problem gets a little hairy Each of the column additions can be converted to equations in terms of R, the Ks, and the remaining (unknown) letters We should be able to combine the equations in such a way that we get a formula for R in terms of only the Ks Then we will have reduced a problem of infinite possibilities to one of finite proportions"

	4	6	
7	1	8	2
	3	5	

This can be done by applying a little high-school algebra Such an equation is

$$R = \frac{13 + 6K_6 + 4K_4 + K_3 - 5K_1}{7 + K_6 - K_5 + K_4 - K_3 - K_1}$$

Furthermore, we find that $S = K_4 - K_1 + 4$, $T = 9 + 4(K_6 + K_4 - K_1) + (K_1 - 4)R$, $O = R - 4$, $I = R - 2$, $L = 17 + 7K_6 + 8K_4 - 8K_1 + (K_6 - K_3 + 2K_1 - 6)R$, $B = -11 - 6K_6 - K_5 - 7K_4 + 7K_1 + (K_3 - 2K_1 + 4)R$, $E = -K_6 - K_4 + K_1 - 3 + R$, and $U = -13K_6 - 16K_4 + 15K_1 - 30 + (-2K_6 + K_5 + 2K_3 - 4K_1 + 10)R$

Next test each of the possible combinations of possible choices of the Ks to find values of R for which R is an integer greater than 9 This yields 69 such cases

All that remains is to study each of these cases to ascertain when $0 < T, L, S, E, U, B < R$ and $N \neq E \neq B \neq U \neq L \neq O \neq S \neq I \neq T$

There are several near misses For example, when $K_1 = 4$, $K_2 = 4$, $K_3 = 5$, $K_4 = 4$, $K_5 = 3$, $K_6 = 2$, and thus $R = 26$, all the conditions are satisfied except that $B = 0$ However, the only solution satisfying *all* the criteria occurs for $K_1 = 2$, $K_2 = 4$, $K_3 = 5$, $K_4 = 5$, $K_5 = 3$, $K_6 = 2$, $R = 10$ Since here, Y must be 0, the solution is unique

FLUSH The two events are equally likely You may prove this by doing pages of calculations or by using shortcut reasoning If two players hold all the cards in one suit, the other two players are necessarily void in that suit—the two events occur together, hence they are equally probable

DEAL Since the deal traditionally goes clockwise around the table, starting to the dealer's left, the last card of the 52 goes to the dealer To complete the hands, deal from the bottom of the pack, first to yourself, then counterclockwise around the table until the rest of the cards are dealt out

PERFECT All stories of perfect deals in bridge should be taken with a grain of salt The odds against one are 2,235,197,406,985,633,368,301,599,999 to 1 This is so remote that a perfect deal has probably never occurred by chance (as opposed to a prank or a poorly shuffled deck) in the entire history of the game If everyone in the world were dealt 60 bridge hands a day, a perfect deal would occur only once in 124 trillion years ∞

SPACE

CONTINUED FROM PAGE 22

managed to hang on is the high motivation of the project team which is made up of 20 separate project specialists chosen back in 1981. Even for an assignment that promised long hours and constant deadline pressures, ESA officials were able to select from a flood of applicants.

"You might say that it's a very sexy project," Reinhard admits. "From a scientific viewpoint, it offers fascinating challenges. Even so, on this project you always wish you had forty-four hours in a day."

The problem on which the success of the *Giotto* probe may hinge is the unearthly speed at which the comet and the spacecraft will close on each other. With ten on-board experiments, including a camera to photograph the comet's nucleus, *Giotto* has precious little room for large fuel reserves. To gain orbit velocity, the spacecraft will have to intercept the comet at the spot where it crosses Earth's elliptical plane. According to calculations, *Giotto* and Halley will pass each other at a flyby velocity of 70 kilometers per second. At this speed—roughly 30 times that of a bullet—a 0.1-gram dust particle will strike the spacecraft with enough force to penetrate an 8-centimeter-thick metal wall.

To cope with the barrage, ESA scientists and engineers have designed a unique bumper shield as protection for *Giotto*. "We believe we have a pretty good chance of getting close to the comet," says Dale. "We've tested the shield with velocity guns and then placed those figures into a computer model to try to approach the seventy-kilometer-per-second realm. But it's all based on models, and at some point it could all break down."

Even if the shields buy *Giotto* enough time to fly through the comet's tail, the protection may not prove enough. A large dust particle could hit the probe with enough force to shift *Giotto*'s antenna by more than 1.5°. At that point, its tenuous telecommunications link with Earth would be severed. Mission terminated.

"Once we're in the air, we have a one-time kamikaze strategy," says Reinhard. "Get in as close as possible, immediately relay all data to Earth in real time, and find out as much as we can before our probe dies."

Giotto project scientists have calculated the risks, factoring in possible computer errors and the unknown. And they know exactly how long they have to prepare for all these eventualities. "We're constantly aware that we have to be ready by July 1985," says Reinhard. "If we miss that launch window, then we'll miss intercepting the comet in March 1986. In that case, we'll have built a museum piece."

Although the project manager has repeatedly stressed that on launch day he will press the button regardless of last-minute problems, the warning is hardly necessary. The comet is coming.

SOCIETY

CONTINUED FROM PAGE 50

of the Future, which examines the phenomenon of working at home. Many of the interviews for her book were conducted over the network. Hiltz felt many of her subjects tended to be more candid and responsive than they might have been in a face-to-face interview.

In another study, she analyzed the pros and cons of working at home with the computer, based on the experiences of EIES users. On the plus side, it offers the ultimate in work flexibility. One EIES user said that he was able to stay at home with his baby and continue working after his wife returned to her job. Having a computer at home lets people juggle many projects at once and set the work pace themselves.

There are a few drawbacks as well, Hiltz admits. "We often work until four or five in the morning, and on Sundays and Christmas Day, too; the network is always there. It is a workaholic's dream/nightmare." Also, there is something to be said for working outside the house. Some EIES users said their families resented the intrusion of the network and the work it brought into their homes. Work frustrations sometimes tend to be taken out on family members, too, since they are the most convenient whipping posts. Aside from that, there is the danger of too much togetherness, which may not always be an asset to family life. Even so, it is Hiltz's guess that the home electronic workplace will become increasingly common in the future for at least part of the work week.

The human aspect of the network continues to fascinate both Hiltz and Turoff, perhaps more than the advanced technology itself. The system fosters a kind of relationship they call cognitive bonding, and nowhere is this more evident than in computer-generated romances. In one instance a couple corresponded on-line for some time without ever having seen each other. Finally they decided on a face-to-face meeting, at which point they found they couldn't stand each other. "They spent a few hours together and got back on the airplane," says Turoff, smiling. "They had a passionate dialogue about the potential for an affair, but when they got together, they found they just weren't going to have it. But they kept up their electronic friendship, and they still have it today."

In at least one instance, however, EIES did help one couple perpetuate an affair. The woman tells the story: "I was first introduced to George over the network by a mutual friend. We started out corresponding back and forth. But what correspondence! A lot of the conversations were of an explicit sexual nature. I never had so much fun, and no other man I have ever met brought out what he brought out in me. This continued for a couple of months. After we had made several dates, and me not keeping a single one, I decided that I should just get it over with. We went for a ride and out for a drink. All through the ride he just stared at me. It made me very nervous. Anyway, we went back to his apartment, and the rest is history."

The network has caused potentially embarrassing social situations, too. In one instance a poor, black teenage girl with cerebral palsy began a flirtation over the network with a professional man on the West Coast. It progressed to the point where the man wanted to fly out to New Jersey to meet her. The girl didn't want him to make the trip and finally confided to Hiltz that she had a difficult situation on her hands. She hadn't meant to deceive the man, but he, of course, had no idea what the story was. In the end, she told him what her circumstances were. Turoff believes there was value in the exchange, however. The girl, he says, experienced a "cognitive affair," something she would never have had the opportunity to do without EIES.

EIES users span a wide variety of people, from computer hackers, librarians, and handicapped people to plain old insomniacs who need someone to talk with at 3 A.M. Eight-year-olds as well as octogenarians have logged on at some time or another in the past eight years. And there are a great many EIES users in France, New Zealand, Australia, Japan, England, Africa, and the Caribbean.

> *"We often work until four or five in the morning, on Sundays, and Christmas Day, too; the network is always there. It is a workaholic's dream—or nightmare."*

EIES was originally funded through several National Science Foundation grants, and though it is now completely user supported (individual fees are $75 per month), it operates in the red, subsidized by the New Jersey Institute of Technology. EIES also grants a number of free accounts on a trial basis because the applicants are interesting, and Turoff figures he can learn something from how they use the network. Turoff's curiosity is such that there is a consensus among the EIES staff that he would give away the store if he thought it was propitious to do so.

He was not always that way. Turoff comes from a very traditional background in computer science. After getting a degree in math and physics at Berkeley, he went to work part-time for IBM in Boston. In those days he had neatly trimmed sideburns and wore a white shirt and tie to work. As a programmer and systems analyst, he got his first taste of computers. Later he went to work for the Institute for Defense Analysis, a think tank funded primarily by the Defense Department. Around that time a Defense Department subagency, the Advanced Research Projects Agency, had begun one of the first networks, a primitive system known as Arpanet. Based on that idea, Turoff decided to design his own network to make use of the Delphi method, a forecasting technique that pooled the collective insights of a group of experts.

Turoff later earned his doctorate and went to the Office of Emergency Preparedness, a now-defunct but once quite powerful government agency that had its heyday in 1972, when its task was to monitor President Nixon's wage-and-price freeze. Since time was critical, the government needed a system that could share data and transmit them quickly. The agency decided to give Turoff's network a tryout. Although the wage-and-price freeze was a crashing failure, Turoff's network worked splendidly. Turoff then began to see the potential of his idea. "We quickly realized we were talking about a totally new form of communications," he says. People used it for more than just business. They used it to relax. They wrote poetry on the network. They sent best wishes to the guy whose wife had a baby. Later the man reciprocated and sent a computer-graphics "cigar" to everyone who had sent him an electronic greeting card. One subscriber regularly put a news summary on the network, and one day when she called in sick, the main office was flooded with complaints. Where callers wanted to know, were their morning newspapers?

Turoff realized he had stumbled onto something important, but he got little initial support for his idea of a comprehensive communications system. For one thing, computers had a sacred image at the time. Only *real* programmers were allowed to touch them. "As a result, a lot of people I talked to in the early Seventies thought I was crazy," Turoff recalls. The people at the Advanced Research Projects Agency told him that they knew individuals were using their network to send personal messages and even admitted that private use outweighed official use, but they didn't want this to become public knowledge. It was technically an illegal use of government property. Yet years later, at a computer meeting, Turoff would hear an Arpanet official brag about the many "glorious" by-products of the system and how the agency practically invented networking.

In spite of the lack of receptiveness by 1973, Turoff believed that computer networking had the potential to become as common as the telephone. He decided that he needed an academic place where he would be left alone to work on the idea. The New Jersey Institute of Technology seemed to have the kind of friendly and

conducive atmosphere he sought The National Science Foundation indulged him, and within 18 months of grant approval he had EIES operating with an experimental starting group of 150 scientists and researchers Because his work was supposed to produce insights into the impact networking would have on human behavior, his collaboration with Hiltz began

Turoff designed EIES according to his whims though the 80 man years of development work took considerable input from others So summing up EIES is not easy When people ask what this network is all about the programmers fidget and explain that it's continually evolving.'

The idea of the system stresses Turoff, is that it should be simple You needn't be a computer maven to learn it To demonstrate this Turoff and Hiltz now have several courses entirely on line One professor, Norman Holland, is using the network to teach a course from his home in Gainesville, Florida "It's like being in a class with no time and no place, yet it is still as vivid to me as it we were all sitting around talking," Holland observes

Textbooks are listed, and students are asked to contribute chapter reviews by publishing them on the network Students attend classes simply by sitting at their terminals Among other things, it apparently has proved a boon to crammers Says one student who is wont to read the entire text the night before an exam, "Not only do you not have to copy anybody's notes you don't even have to take them I knew that I had cut an inordinate number of seminar classes when I logged on and my computer screen sternly but gently inquired: THERE ARE 53 ITEMS WAITING DO YOU WISH TO ACCEPT ABOVE ITEMS?"

At EIES headquarters Turoff promotes a liberal work atmosphere Programmers come up with improvements or features to add to the system then they write the appropriate programs One current project involves a group graphics capability "We'd like to have true interactive graphics," says John Foster "You start drawing a picture, send it across the country, and have somebody else add to it"

This will take a lot of programming, however, and it must be accessible enough in its design to accommodate several kinds of home terminals and computers But Foster thinks that artists—with special touch screens, tablets and light pens—will be able to use their terminal screens as sketch pads to compose pictures

The people at EIES have considerable admiration and respect for Turoff, but they also grumble about his compulsive work habits Basically Turoff is a college student who hasn't grown up Says staffer Mark Heimerdinger, "Murray designed a system to accommodate the all-nighter Turoff relishes the opportunity to wade through a sea of printouts at 3 A.M. in the office of his home in Scotch Plains, New Jersey His campus office is unused Cartons containing his books and papers have sat there unpacked for a year and a half Hiltz, whose home office is also buried in printouts, describes Turoff's space this way "His cave is a disgusting mess He seems to revel in clutter We tried a joint office—once—if drove us both crazy."

Turoff is the first to recognize he has become a slave to the network If the system crashes in the middle of the night, he calls his programmers immediately to repair it No one who works for Turoff fails to mention the occasional desperate 2 A.M. phone calls from the boss Tom Moulton, the chief system troubleshoofer says he expects the system to go down about twice a month Because Turoff is so dependent on EIES for his contact with others he crashes when it does "When the system is down, Murray absolutely cannot function," says Anita Graziano, EIES's manager of services Turoff agrees "About all I can do is pick up a science-fiction book," he says

When the network and Turoff are functioning, his output, by any academic standards is prodigious Five years ago he and Hiltz coauthored an award-winning text *The Network Nation*, considered the seminal work on computer time-sharing and its impact in the future Since his arrival at the institute a decade ago, more than 100 technical papers have poured from his terminal His stature and success have tormented envy among his campus peers "He is not well liked here," admits Graziano While the typical institute professor is content with a quiet, tenured existence, Turoff has continued to scramble for grant money And though he is a dedicated academic, he refuses to succumb to the tweed-jacket/afternoon-tea atmosphere that is so prevalent on many campuses He enjoys his visibility and as a result other professors feel he makes them look lazy

"If the system crashes in the middle of the night, he calls his programmers No one who works for Turoff fails to mention the 2 A.M. calls from the boss"

Turoff is optimistic about the future of networking He may be a little too optimistic One possibly strong competitor is a system called videotex which uses modified television sets as two-way interactive systems by which people can get information services—from news bulletins to shopping—in their home In 1979 Prestel, the British videotex system began operating, and there have been experiments in France with a similar idea These systems strike at one of networking's vulnerabilities, lack of reliability It is still new enough that the hardware is frequently troublesome, and the system itself is never completely free of bugs Yet Turoff is confident that networking will ultimately triumph over videotex The microcomputer's widespread impact in American family rooms he says, will compete with videotex and might even cause its demise

Then too, networking isn't yet the egalitarian communications system Turoff would like it to be It is not cheap Local carriers of the network—computer-hookup services like Telenet and Uninet—charge several dollars an hour for connect time above and beyond the monthly EIES account fee By comparison, the U.S. postal system, with all its flaws is still a lot cheaper than electronic mail

Not surprisingly, Turoff dismisses the last criticism and says the potential is there for really inexpensive networks, thanks to decreasing costs in equipment After all, five years ago, who would have thought that average middle-class folks would be able to afford sophisticated computers? Within seven to ten years the hardware of the EIES system will cost ten thousand dollars, as compared with four hundred thousand dollars today Turoff predicts "There will be a tenfold or greater decrease in price, so anyone in his garage could set up a community system for a thousand people This is what it's coming to

"If you put digital information on video discs, it will be really cheap When you have cheap videodisc writers [devices capable of recording data onto videodiscs]—right now they cost about forty thousand to fifty thousand dollars—fixed information will become valueless Anyone will be able to phone up a database, make a videodisc copy, and give it to friends for a couple of dollars apiece If will be like videotape So the big database industry is going to be in trouble"

If it is anything like the scenario that Turoff envisions the network future will mean a nation full of home authors and information salesmen and saleswomen You will own the copyright to anything you put online—from a recipe to a poem—and you'll be able to sell it in bulk or piecemeal Your royalty will be computed by a host utility, and your account will be tallied electronically every month with the network acting as your agent (and taking a small commission) This would cut out the cost of hard-copy distribution (books, magazines, newspapers, and other physical media) thereby eliminating huge expenses

Electronic cookbooks, network poets, videodisc books, electronic art—they all lie within the realm of the possible in Turoff's brave new electronic world Only one thing might prevent it all from occurring a terminal case of information overload And if that happens, the first victim will undoubtedly be Murray Turoff

STARS

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of ocean water would have told you that life on Earth had started, and the presence of little green cells would have told you that energy from the sun sustained that life.

But in the warm, dark recesses of Enceladus there was no sunlight and no photosynthesis. So if we are to imagine cells with genes inside one of Saturn's moons 2 billion years ago, then we are forced to ask what they were using for food.

There is an alternative to sunlight. Sulfur compounds, especially hydrogen sulfide (H_2S), can be slowly oxidized, or burned, by cells. The energy derived from this process can then be used to power life-sustaining activities and to liberate oxygen as a by-product, which in turn is used to oxidize more hydrogen sulfide.

An extraterrestrial ecology based upon sulfides instead of sunlight is not the product of abstract fantasy. It is the result of careful observation right here on Earth. The process is called *chemo-* rather than *photo*synthesis, and it occurs near sulfide-rich hot water vents located some 2.5 kilometers under the Pacific Ocean.

If, during the first 2.5 billion years of Enceladus's history, there existed sulfide oases (as ubiquitous sulfur droplets in certain stony meteorites suggest), the satellite's seafloor might have supported dense communities of cells. It is fun to speculate about what could have become of them given another 2 billion years of evolution. As an indulgence, let us imagine that multicellular life evolved in such a world and that it led to the emergence of intelligent beings. Would they discover space?

If we assume they are creatures blessed with curiosity and a taste for the mysterious, then surely they would go into their sky (the sea) to learn whether it ends. And they would find the strangest of things. The sky does end. You would go only so far, then bang your head on a ceiling of ice.

Other minds would invariably try to look beyond the ice. If radio telescopes could be operated underwater, our hypothetical Enceladans would detect Saturn as a huge disk-shaped radio source slashed through by edge-on rings. Moving on the other side of the sky, this disk would be seen to eclipse a smaller but more powerful radio source, the sun. Seismic studies might reveal that the ice sky has a finite thickness, that there is indeed an "outside."

What would they do next? Start a mining operation? Or would they simply start chipping away at the ice? If one party of explorers did manage to break through to the other side, the result might be most unpleasant. Stepping out of a water environment into a vacuum would bring on rapid decompression—a very poor advertisement for space exploration. But for the sake of argument, let's permit them to break through the ceiling and emerge safely onto the surface of their planet. Clad in space suits, they look up. What would they think the stars were? (Their situation is analogous to that of the pygmies, who, brought out of the dense forest for the first time, could not immediately comprehend the vast distances of 'the outside' and thought that men near the horizon must indeed be very small.) Would the Enceladans even have eyes to see the stars? Like cave-dwelling organisms on Earth, they might lack eyes, sensing their surroundings instead as vibrations, smells, textures, or minute changes in temperature.

The questions go on and on; some of them are so new that science can barely furnish criteria for how we might go about answering them. Through the eyes of *Voyager 1* and *Voyager 2* we have glimpsed ice worlds and seen in them infinite possibilities. Always there are possibilities. So many, in fact, that the Jet Propulsion Laboratory in Pasadena, California, has one rule for judging fox-hole theories. It's called the giggle factor, which states simply that nobody is allowed to laugh. ☒

Charles Pellegrino, an astronomer and paleobiologist with the National Observatory of New Zealand, is the author of the book Time Gate *from which this column is adapted.*

'Mission Control, we've solved the mystery of the craters."

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duce each year and you could solve all the world's food shortages

Omni: India has slowed down its population growth. Would you credit this to birth control or to something else?

Revelle: Birth control programs help, but one reason they work is because children have a better chance of living, so parents don't have as many of them. We have to work as hard as we can on birth control, on raising the standard of living, and particularly, on giving women more power to make decisions by giving them more status. The countries in the world where the birth rate hasn't gone down are the countries where the status of women is low, primarily the Islamic countries and many countries in Africa.

Omni: Are there poor countries in which the status of women is not low?

Revelle: Yes, and in those countries or parts of countries, the birth rates have gone down—as in Sri Lanka or Kerala in India. The people are poor as church mice, but they have a relatively low birth rate, and there's no discrimination against women.

Omni: How did you leap from oceanography to population studies?

Revelle: In 1961 I was invited to be science adviser to Secretary of the Interior Stewart Udall. Stewart didn't quite know what to do with a science adviser. So instead of working for him, I worked mainly for Jerry [Jerome] Weisner, who was President Kennedy's science adviser. Kennedy didn't want to give Pakistan arms because he thought, rightly, that if the Pakistanis got arms, they'd use them against India and not against the Soviet Union. So Kennedy refused to give them arms but said, "I'd like to do something else for you. How can we help?" So they said, 'We've got this problem involving the salinity of our irrigated land. The land is deteriorating."

Omni: I see. "Saltwater—get Revelle."

Revelle: Exactly. I was an oceanographer. I had to know about salt.

Omni: How does a scientist get involved in policymaking?

Revelle: Well, I was acting director of the Scripps Institution in 1950 and director from 1951 to 1964. I was bound to be involved in the political end of science. It really started during World War II, when I was the Navy's oceanographer. I was in charge of the oceanographic measurements of Bikini Atoll and the surrounding ocean during the Crossroads Operation in 1946. In that expedition two atomic bombs were tested—one in the air and the other at the bottom of Bikini Lagoon. We blew up dozens of Navy ships anchored in the lagoon to see what would happen. Of course they sank. Among them were the *U.S.S. Saratoga*, a famous World War II aircraft carrier, a Japanese battleship, and *The Prince Eugene*, a German battleship. We measured the waves produced by the explosions and the dispersion of radioactivity in the water. We surveyed the ecology of the atoll to establish a baseline for the effects of the explosions on plants and animals—particularly the effects of radioactivity. And I was very much involved in writing up the results and interpreting the data. Then a year later I organized a survey of Bikini to check up on what had happened. That was a much smaller expedition, but still about two thousand people took part in it.

Omni: That had a lasting effect on you?

Revelle: In several ways. For one, I learned a good deal about the relationship between science and policy. And I came back more interested in helping other people than in doing science myself.

Omni: In your address as retiring president of the AAAS, you said that scientists can no longer afford to maintain an arm's length from politicians—that the threat of nuclear weapons required that scientists speak to the results of what they discover.

Revelle: To a considerable extent that's true. I feel we have a social and political responsibility to use our scientific knowledge properly. But we're not very good at practical applications of this knowledge. The National Academy of Sciences [NAS], of which I'm a member, exists to advise the government on scientific matters. The NAS runs a big business, about fifty million to sixty million dollars of advisory committees each year. We're pretty good when we advise the government on the consequences of technology. For example, the NAS advised the government to regulate the use of fluorocarbons, and the government has done that. What we don't do well is to recommend how bureaucratic organizations should handle the matter.

> *"The ocean is awfully big. It is the world's biggest hole in the ground, and it is the obvious place to dispose of many human wastes."*

Omni: You've long been concerned about divvying up the ocean's resources. And you were a delegate to the Law of the Seas convention. What's happening there?

Revelle: I've been working—and consistently losing—on this issue since the Fifties. It's a very serious problem nowadays. The convention provides each coastal state with an exclusive economic zone extending two hundred miles from its shore. Within that zone, the coastal state has exclusive jurisdiction over all the natural resources and scientific research. So for a country like the United States or France to work in those waters, it must get the consent of the coastal state. The coastal states have been very niggardly about giving this consent.

The new Law of the Sea is better than what we had before, which was almost complete anarchy. And yet, the United States has refused to sign the Law of the Sea convention because the Reagan Administration doesn't like the provisions about deep-sea mining that set up a United Nations seabed authority to grant licenses for mining deep-sea nodules and do some of the mining itself. The Reagan people perceive this plan as being socialistic, and they disapprove of American firms having to share their technology with less-developed countries. It's very curious behavior. The Navy badly wanted aspects of the treaty—such as free passage through such narrow straits as Gibraltar or Malacca. But we may have given that up by not signing. It's typical of the modern Pentagon, which is full of hard-boiled nuts. Maybe they're planning on just boring their way through the straits.

As far as scientific research is concerned, we're back in limbo. American oceanographers who were involved in the convention from the beginning proposed rights and obligations to share with the coastal states all data gathered within their waters and to make the ships open operations. Elliott Richardson, a wonderful man who ought to be president, was our chief negotiator to the convention during the last years before the Reagan Administration. He worked very hard to get this.

Under the two-hundred-mile exclusive zone, between thirty and forty percent of the ocean is under private jurisdiction, and that's the most interesting part of the ocean. It's where the major currents are, where most of life is, and where the most interesting geology is. At present the only way we'll be allowed to do research in other people's waters is through bilateral agreements. And the developing countries are run by politicians who don't understand or give a damn about science but just like to have control.

Omni: Do scientists from different countries manage to cooperate without being too affected by nationalism?

Revelle: Certainly, in oceanography. Except we don't cooperate well with the Soviets—not because of suspicion or dislike but because the Soviets don't take very good measurements. They're just not accurate enough. They're backward.

Omni: You'd think this would affect their military development as well.

Revelle: Not necessarily. In a closed society like the Soviet Union, everything is compartmentalized in airtight watertight boxes. Their military development may be very good, and another type of development not very good. There is, however, some very good theoretical oceanography being done in Russia.

Omni: To what problems do theoretical oceanographers address themselves?

Revelle: Well, mostly physical oceanography—the motions of the oceans and water properties and how they change. It's a highly mathematical subject. Young physical oceanographers are using mathematics today that were hardly invented when I was in college.

Omni: Do you concern yourself with ocean pollution?

Revelle: Not much. That's a serious problem in shore waters, coastal waters. It's not a problem for the ocean as a whole.

Omni: But as I recall, didn't Jacques Cousteau say he saw—

Revelle: Jacques Cousteau is not a scientist. He's a good engineer and a good man, but he has very little interest in scientific truth. Cousteau says the ocean is dying because of pollution. That's just nonsense. Cousteau's very unhappy because when he's diving in his scuba gear he sees that there are beer cans on the bottom of the ocean; these are distressing to him. He likes to see the ocean pure. He's a good friend of mine, and I don't want to belittle him. He's a great man. He's just not an oceanographer.

Omni: So his seeing a beer can bobbing somewhere in the mid-Pacific doesn't mean the ocean is endangered?

Revelle: Of course not. The ocean's awfully big. It's the world's biggest hole in the ground, and it's the obvious place to dispose of many human wastes. Sewer outfalls, if they're properly constructed, don't really hurt the ocean at all—if they're in the open ocean. Pollution *is* a serious matter in inland seas like the Mediterranean. Mediterranean beaches are usually covered with tar, old condoms, and all kinds of things that tend to persist. The Mediterranean countries have joined forces to try to clean it up.

Omni: I understand that ocean life is disappearing at a rapid rate.

Revelle: That's not so! Many species of fish are overfished, particularly in the North Sea. The California sardine fishery has pretty much disappeared; it has been replaced by anchovies. The anchovy fishery off Peru has been partly replaced by sardines and mackerel, but that's because of overfishing rather than pollution.

Omni: Don't you think these things need to be controlled?

Revelle: Oh God, yes. We need more wilderness areas, more national parks. The parks we have are very much overused. We need to conserve public lands, not let them be raped by cattle ranchers. People with private interests always take a very short-range view. Whales were hunted to near-extinction in a few years because it was more profitable to do so than to maintain the whale population. That's the way cattle ranchers are, too. They don't give a damn about the future; they want to get as much in their pockets as possible. The duty of society is to worry about the future and to take measures to ensure that there is a future. The problems are very serious, very great. Our mutual ideal of preserving part of the earth for its nonhuman inhabitants may not work out because of political ineptness, social disorganization, ignorance, greed, and human weakness.

I was in northeastern Nigeria recently. I had been invited by the vice-chancellor of the university there—an old friend named Sibril Aminu. He's a nice guy, but he's got an impossible job. They don't produce anything. I came home depressed about the possibilities for that part of Nigeria. The future looks grim for them. The population is growing rapidly, and the economy isn't developing quickly enough. They're spending a hell of a lot of money. They've spent something like two billion dollars trying to develop approximately one hundred fifty thousand acres of land. That comes to about twelve thousand dollars per acre. The money comes out of oil revenues, but now those are disappearing. Nigeria is in serious financial trouble—along with other kinds of trouble—and it's the richest, most populous, most highly developed, and politically sophisticated country in Africa. Nigeria could do well if the people got themselves organized and educated, and did some work—none of which seems to be happening.

Omni: But when people are jolted from their ancestral ways, they don't always adapt well. Take the Eskimos. They sit around not doing anything. They used to do something before we went up there and brought our kinds of benefits.

Revelle: It's true about the Eskimos. But doing something is not necessarily a good thing. Look at a cat. What does a cat do? It sleeps eighteen hours a day. Same with dogs. The only animal that thinks work is good is man. That's a uniquely human quality, and it's not shared by all humans by any means.

Omni: But most people who witness the Eskimos lying around watching TV don't think this is a desirable evolution of their culture.

Revelle: That's because those observers all have the Protestant ethic.

Omni: Is it satisfactory to plan for a world in which people have little to do?

Revelle: That's a very difficult fundamental question. I don't know the answer, even though that may be the way the world is going to be.

I was on the Scripps Institution's Capricorn expedition in 1952 and 1953. We spent a lot of time in the South Sea Islands. In some ways I was much impressed by the Polynesians—in some ways not. They are certainly not intellectuals. They have very little curiosity about how the world is made. They just accept it. They don't do very much—just enough to be able to eat, which isn't much because there is plenty of food. They love to fish. Everything they did seemed fun—kind of a game.

Omni: Do you feel it's our job to save these peoples from themselves?

Revelle: I don't think we can. Many anthro-

pologists would like to keep these people in a sort of museum or zoo for observation. I was a very good friend of Margaret Mead's. We spent three years together in the hierarchy of the AAAS, and I got to know quite a bit about her. In his recent book [*Margaret Mead in Samoa*], Derek Freeman claimed that Samoa was never as idyllic as Mead portrayed it to be. But she didn't think all primitive tribes were idyllic. She spent a lot of time around New Guinea. Many New Guinea tribes had very unpleasant customs. They hated one another, stole one another's yams, put spells on one another's yams so the yams wouldn't grow—and things like that. She didn't like those people at all. The Manus islanders were the ones she studied most, and she went back repeatedly to watch their transition. She said they went from the Stone Age to the Jet Age in one generation. It was inevitable, and the people made the transition very rapidly.

Omni. What do you think of the recent discrediting of her work?

Revelle. I think it's sort of a typical revisionism. It's easy to attack Margaret Mead. She's dead, for one thing. She also had some very fixed ideas. One was cultural determinism—the idea that human nature is very malleable and that human behavior is determined by culture and environment, not by innate characteristics. She probably carried that position to an extreme.

Omni. Could you explain your theory of slavery and energy?

Revelle. It's quite simple. Any civilization requires energy to do work—energy simply means doing work. And you have either human energy or some other kind of energy. All ancient civilizations, no matter how enlightened or creative, practiced some sort of slavery because human and animal muscle power was the principal energy available for mechanical work. It is not because we are enlightened that we abolished slavery but because we found a cheaper source of energy. A man can produce in a day about one kilowatt-hour of mechanical work. To keep him working, feeding him the meagerest of diets, costs about twenty-five cents per kilowatt-hour. A kilowatt-hour of electrical power or the equivalent in gasoline costs only a few cents, even at present oil prices. By discovering a less expensive source of energy than human muscle, Western civilization has been able to make men free.

Omni. If we ran out of energy sources tomorrow, do you think some people would attempt to thrust others into slavery?

Revelle. In a nightmare world, the most vicious will run the show. They might force others into slavery. If we have an atomic war and really destroy the structure of civilization, the people who are going to come out on top will be the strongest physically, the most ruthless mentally and emotionally, and the most uncaring of others. It will bring out the worst in human beings.

Omni. Do you think that riches bring out the best in humans?

Revelle. I wouldn't say that, but I would say that if people don't have to compete on a physical basis for survival, their worst characteristics are suppressed. The guys who are best able to survive in a really brutal world are the Mafia types. That's the kind of world in which they prosper.

Omni. Do you think there's an increase in greed in the modern world?

Revelle. Bernard De Voto once said that, as far as he could tell, people have always engaged in the maximum possible amount of sexual intercourse in all times, in all places, in all societies. You might say the same about greed.

Omni. Is it because of De Voto's theory that you don't believe birth control will solve population problems?

Revelle. No. That's a much more interesting problem. People generally have the number of children they want to have. Malthus's early theory to the contrary.

Omni. What is Malthus's early theory?

Revelle. I give lectures on this, so I can give it to you cold. Malthus stated that the passion between the sexes is continuing and great, the consequence being that people will have all the children they're capable of having. With the advent of modern birth-control methods, that statement no longer holds true. He further stated that food supplies increase arithmetically, but population grows geometrically or exponentially. Therefore, population will always be limited by food supply. Actually, Malthus put it more dramatically. "Misery and vice," he wrote, "limit the numbers of mankind." And if misery and vice don't do the job of limiting population, "then gigantic, inevitable famine stalks in the rear and with one mighty blow levels the numbers of mankind." Later, however, Malthus posited a theory called the preventive check, which states that people don't have children if they don't want them or can't afford them.

Omni. Even before the advent of modern birth-control methods?

Revelle. This was before the vulcanization of rubber. People were probably practicing birth control before they tamed fire. Plus abortion, plus not sleeping together, plus not getting married. There wasn't a lot of extramarital sex back then. So Malthus rewrote the essay, and this time it was about ten times as long and much more difficult to read, so few people ever read it. We still associate Malthus with his simple principle of population, not with the complexity of the world as he finally saw it.

Omni. You said once that we are becoming more clever than wise.

Revelle. Did I? Well, it's probably true.

Omni. You also said that Arctic explorers as a group are crazy, and that Admiral Byrd was certifiably insane. What brought you to that opinion?

Revelle. When I was head of the geophysical branch in the Office of Naval Research from 1945 to 1948, we supported the Finn Ronne expedition to Antarctica. Like most Antarctic explorers before the days of the great scientific expeditions funded by the

Navy and the National Science Foundation. Ronne was so single-minded and egocentric that he was outside the circle of ordinary human beings. Byrd was even more egotistical. He was still furious with Ronne after twenty years because he said Ronne had "betrayed him" by talking with reporters in New York when he returned from an earlier Byrd expedition a few days before the admiral did.

Omni. You've spent a lot of time working with politicians. Didn't you at times find that to be discouraging?

Revelle. Scientists and politicians are different kinds of people. Scientists are interested in power over nature, politicians, in power over people. I suppose the fundamental solution is for both sides to try to understand each other and join in a cause.

Omni. You were Kennedy's science adviser. Did you know him?

Revelle. Not really. I met him only a few times. I thought he was a very cold fish, very hard-nosed. I didn't like him very much. I liked Eisenhower a lot. He once invited some members of the NAS to a formal dinner at the White House and I was impressed with him as a very decent human being. And he showed himself to be one—particularly in his farewell address, when he criticized the military-industrial complex. He was really concerned with peace and justice. Of course, like everyone else, he had his weaknesses.

I had quite a bit more to do with Johnson than with either Kennedy or Eisenhower. Johnson was a monologuist. It was impossible to get a word in edgewise with him. He talked all the time. He once decided he wanted me on an advisory board of scholars. We worked our asses off on a report on the world food problem. It took a couple of years to prepare, and we were given an hour to tell the President about our findings. We talked for about three minutes; he talked for fifty-seven. Maybe he just didn't want to hear about the world's food problems. There were many things he didn't want to hear about. Lady Bird was a charmer—a very nice human being and a gentle sort of person. Johnson did have some good qualities. I was particularly impressed with his civil-rights policies and interests in poor people. He came from a very poor family himself. But he was venal. He didn't give out money, he made money. Well, nobody's perfect.

Politicians are hard to know. They have to be tremendous gamblers. They have to throw their whole lives on the scale every time they run for election. That instills a kind of wariness of other people, a lack of warmth, an inability to make personal relationships. The politician I liked best was Hubert Humphrey.

Omni. Have you ever been tempted to sell your talents to industry?

Revelle. I couldn't have done it. I would have been bored stiff. I love being a professor. Professors are such spoiled creatures. Most of the time we do what we want when we want to do it. ◻◻

EARTH

CONTINUED FROM PAGE 18

hundreds of sites around the country. The Environmental Protection Agency says that at least 14,000 illegal dump sites pose fire hazards, threaten groundwater, or emit fumes. And many environmentalists say that figure is low. U.S. industries generate 88 billion pounds of toxic waste a year, they claim, and 90 percent of that has been improperly disposed of.

Under the stream of revelations, public fear has recently turned into outrage, forcing a reappraisal of what to do about dangerous industrial wastes. The result has been stricter laws and beefed-up enforcement efforts by people like Jim Service and Mike Murry. New York, New Jersey, Pennsylvania, Texas, California, and Massachusetts are among the states that have recently passed stronger statutes on hazardous-waste disposal and adopted aggressive enforcement programs. And the county of Los Angeles has set up an innovative program to stop illegal hazardous-waste dumping within its jurisdiction.

In a sense, today's awesome troubles began in the mid-Seventies, when Congress passed the first laws regulating the disposal of hazardous chemicals. Because of the dangers, these chemicals were to be separated by kind and carefully sealed at the generating site. Then they were to be shipped by a licensed hauler to a high-temperature incinerator, a licensed storage facility, or a "Class 1" landfill (one that is lined to prevent liquids from leaching into the soil). Such measures sent the cost of legal disposal sky-high.

The cost investigators discovered made the temptation to dump outside the law irresistible to operators of many small- and medium-size companies. Moreover, it was simple to get rid of unwanted hazardous wastes cheaply and relatively inconspicuously. Besides dumping a few drums off the back of a truck onto a roadside or in a field at night (the so-called "midnight dumping" technique), illegal dumpers were opening tanker spigots and leaking toxic liquids on roads, burying tanker trailers loaded with corrosive and flammable chemicals underground, mixing used fuel oil with toxic solvents and reselling it to apartment-building owners so it could be burned for heat (a big problem in Manhattan), and pumping liquid toxic wastes into sewer systems, old mine shafts, and public waterways.

The problem came to a head in 1976, when New Jersey the state that generates more hazardous waste than any other, discovered that toxins stored at its largest licensed disposal site posed a serious threat to public health. New Jersey shut the facility down. Soon after, officials learned that dangerous industrial wastes were being randomly dumped all over the state: on roadsides, in fields, rivers, lakes, and bays, even in the pristine Pine Barrens, the site of New Jersey's future drinking water supply. State enforcement officials went after a few of the most flagrant violators. With the help of the U.S. attorney's office, they eventually succeeded in convicting William Carracino, manager of Chemical Control, Inc., for illegally dumping hazardous wastes throughout northern New Jersey.

By 1978 the New Jersey Division of Criminal Justice knew it had a major enforcement challenge on its hands, says Steven J. Madonna, head of the division's environmental prosecutions section. With the help of a $1.5 million federal grant, the division pioneered a program to investigate and prosecute criminal violations of hazardous-waste disposal. Working alongside state-organized crime investigators, these early hazardous-waste sleuths succeeded in obtaining indictments against 16 corporations and 40 individuals. Their effort eventually led to the creation of a special program, the New Jersey Interagency Hazardous Waste Strike Force, consisting of representatives from several U.S. and New Jersey environmental and law-enforcement agencies: 23 full-time investigators, and 10 attorneys.

Spurred by the number of indictments coming out of New Jersey's early investigations, New York officials launched their own test program in 1979. After initial investigations, Mike Murry says, state officials realized that a permanent investigative unit—one trained not only in hazardous-waste investigation but also in white-collar crime—was vital. Thus, in 1982, New York established BECI.

Meanwhile, the county of Los Angeles established its own Toxic Waste Strike Force. "Before the strike force was set up in 1982," says Los Angeles Assistant City Attorney Barry Groveman, "it was hit or miss; there was no focus to our labors. Now members meet once a week and discuss investigations. It's a team effort."

For Murry, the process begins once he receives a tip about a particular company—either from an environmental inspector, a uniformed police officer, a disgruntled employee, a competitor, or a curious citizen. An investigator checks fo

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see whether the company has a permit to handle, transport, or dispose of hazardous wastes. Then he or she checks the company's manifest, a form that describes what a company plans to dump where and who will be hauling the load.

After that's done, Murry says, the investigator goes out and takes a look, tailing individuals and—occasionally—as in the Active Steel Drum case—staking out a site. To locate drums or tankers buried underground, an investigator may even use sophisticated metal detectors.

Los Angeles investigators employ similar techniques, as well as some innovative high-tech equipment. Automated sewer and storm-drain monitors take samples and measure the acid content of the effluent flows underground, remote television cameras monitor "pirate" hookups in narrow sewer passageways where humans cannot go, infrared binoculars help investigators locate chemical hotspots, and harmless chemical tracers, added to a suspect company's waste, track the toxins as they journey to their final resting ground.

Once investigators succeed in discovering what *company* is responsible for a dumping, they must find out which *individuals* are involved. But this isn't easy, as Edwin Stier, former New Jersey assistant attorney general for organized crime, points out. "A relatively small number of people who have a certain amount of technical knowledge in the toxic-waste disposal area have become very sophisticated in setting up businesses that satisfy at least superficially, licensing requirements," he explains. The white-collar owners of these apparently legitimate companies, he adds, "have created a whole series of insulators between themselves and their illegal operations."

Murry elucidates the tactics employed. "Most of the guys that are dumping illegally rent their land, lease their equipment and their office space, and usually have another company pay their payroll. And the laws in this country don't require that the principals of a corporation be included in the corporation's records. All this makes the task of "piercing the corporate veil" the bane of an investigator's existence.

Finding out who's behind a corporation that's suspected of illegally dumping hazardous wastes, Murry explains, requires a tremendous amount of paperwork and sleuthing. "We go into corporate backgrounds, check the company's manifest for names of individuals, interview a lot of employees, subpoena the corporation's books, and [if those things don't work] we go in with warrants and seize records. After we complete our investigation," Murry adds, "we usually turn the case over to a grand jury for indictment."

That's when the merry-go-round of legal maneuvers begins. A prosecutor's job of convincing a jury is not a simple one. First of all, prosecutors have virtually no experience in handling such cases. And proof that a particular chemical causes a particular disease or disorder is often hard to establish. Add to these setbacks the challenge of proving that a particular defendant had malicious intent, and the prosecutor's job of making the charges stick becomes a lot like nailing Jell-O to a wall.

These factors explain why so few people have actually been convicted of hazardous-waste-dumping crimes. To date, only four people in the United States have gone to prison for violating federal statutes; a few more have done time for state crimes. As Murry says, a handful of investigators—no matter how aggressive or dedicated—are not going to stop these guys. Illegal dumping is too pervasive and still too easy to get away with. As long as the costs of legal disposal outweigh the risks, Americans will suffer the consequences.

Nevertheless, toxic-waste investigators and prosecutors are making headway. In August 1983 the president of Culligan Deionized Water Service, Inc., of Los Angeles received California's stiffest penalty for illegally dumping toxic waste into the municipal sewer system. He was sentenced to 90 days in jail and fined $100,000. Two months later Los Angeles prosecutors succeeded in obtaining another 90-day jail sentence for the chairman of the board of Magnum Resources, an oil drilling and refining and ore-mining company. Magnum was found guilty of illegally dumping cyanide and metals in a national forest.

"If you don't prosecute these cases," Madonna says, "nobody even knows that you're out there." His program is already having an impact, he concludes, and from what he hears on the street, "They're not laughing at us anymore."

LIFE

CONTINUED FROM PAGE 20

build with the aid of genetic-engineering technology out of molecules. For example, Gentronix in Rockville, Maryland, a company in the vanguard of the burgeoning field of molecular electronics, believes the ultimate computer will take the shape of a three-dimensional protein lattice small enough to fit inside a cell. As Hameroff observes, Gentronix might just as soon be describing microtubules—a coincidence that does not strike him the least bit odd. "It's perfectly logical," he notes, "for technology to evolve toward biology, since natural selection would heavily favor the most efficient information-processing systems."

In bacteria, certainly, microtubules are instrumental in "sensing" external stimuli, processing the incoming signal, and orchestrating an integrated response—activities normally performed in higher organisms by the central nervous system. Microtubules inside the amoeba can somehow detect a nearby food source and orient their filaments toward it. As if woven by a spider, the protein web then grows out in that direction, dragging the main body of the amoeba with it until the particle is fully engulfed. Likewise, the hairlike cilia that paramecia use both to "feel" their environment and direct their propulsion are composed of microtubules. And when it comes time for the bacterium to replicate, its microtubules pull dividing chromosomes to opposite poles in much the same way as iron filings are affected when put on a piece of paper and held over a magnet. This phenomenon has led some scientists to theorize that microtubules may be capable of generating and sensing low-intensity electromagnetic fields.

In complex multicellular organisms, microtubules perform many of the same functions—only their role is considerably expanded. During fetal development, for example, they not only mastermind cell division but they are thought to play a key role in determining which descendants will be specialized into skin, muscle, bone and other body tissue. Just as an amoeba uses its protein network to gauge events in the outside world, Hameroff theorizes, a fetal cell may employ the same structure to sense changes in surrounding cells and thus "learn" what tissue it is to become.

It is within brain cells, however, that microtubules demonstrate the most intriguing properties. John Cronly-Dillon, a British professor at the University of Manchester, has uncovered evidence suggesting that these structures are vital in cognitive development, shaping the brain's internal-wiring scheme during the so-called critical period—a limited span in early life when the organism is particularly sensitized to learning. Experimenting with rats, he discovered that the animals' critical period for visual learning coincides with the availability of tubulin—the protein

building blocks of microtubules. Cronly-Dillon reports that on the thirteenth day of life, when rat pups usually open their eyes for the first time, the genes in the visual cortex that control the manufacture of tubulin suddenly step up their production. The excess of this raw material causes a neuron to spin out intricate protein gossamers, bridging the entire length of the cell and inducing it to form numerous connections with neighboring neurons. On day 35, when the critical phase for visual learning comes to a close, the rats' genes drastically reduce the level of tubulin output.

What happens at this stage, according to Cronly-Dillon, is that many nerve connections dissolve without a steady supply of tubulin. The effect would be similar to Ma Bell's suddenly being forced to limit the number of trunk lines leaving Manhattan from, say, 10 million to 10,000. How would the phone company decide which communications links to keep? If Cronly-Dillon is right, it would find much the same solution as the brain would: Maintain only those connections that are used most frequently. What survives, then, is by definition useful. Cronly-Dillon's model might also explain a paradox: Why is it that the more an organism learns, the less adaptable its nervous system becomes? Perhaps the plasticity of youth depends on a high level of tubulin.

Still other studies suggest that brain cells may store memories in their microtubule matrix. In goldfish, for instance, drugs that prohibit neurons from spinning out more protein webs effectively block the establishment of long-term memory, whereas drugs that have stabilizing effects on these structures facilitate learning.

In a related finding, the brains of mice that were reared in stimulating environments were found to have a much greater density of microtubules than the brains of mice raised otherwise identically in boring, impoverished environments.

Of course, none of this proves that microtubules are the physical framework on which consciousness rests. Yet enough clues have surfaced to make scientists like Hameroff wonder whether inherent properties of these proteins could endow them with information-processing capabilities. As his survey of the literature revealed, the tubulin subunits within individual filaments are arranged on a cylindrical grid, like kernels on a hollow ear of corn. To Hameroff, this design immediately suggested the stacked array of on/off switches that computers use to record binary code. To test this hypothesis, he and electronic engineer Richard Watt set about "programming" a computer-graphics generated model of a microtubule. They found that they could induce it to simulate some of the functions of its real-life counterpart. From their model, they were also able to show that every time a neuron fires, microtubules inside the cell generate a different pattern of on/off states, setting a new cycle of information processing in motion.

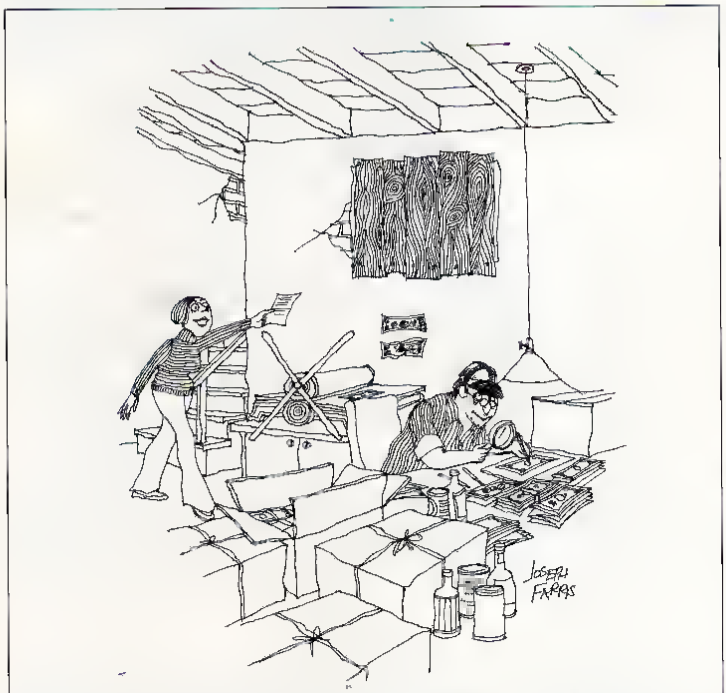
Apart from operating at much faster speeds, their hypothetical microtubule seems to process data in much the same manner as today's linear processors. New dynamics apparently come into play however, when microtubules are considered not as individual computer elements but as the tightly interwoven group they form in nature. Borrowing mathematical equations from a new branch of physics that goes by the arcane name of nonlinear electrodynamics, Hameroff, Watt, and computer scientist Steven Smith have shown how a nerve impulse could cause clusters of microtubules inside the cell to oscillate in unison, much like reeds swaying in the wind. These vibrations would in turn set up traveling wave fronts of energy. Where wave fronts overlap, the scientists have further shown, the pattern of interference could generate hologram-type images in the brain.

Not everyone is convinced by the sensational theories that have sprung up around microtubules. A major criticism is that such notions rest on layer upon layer of circumstantial evidence. "Sure, microtubules might have computing capability," says James McAlear, president of Gentronix and an acknowledged leader in the field of biochip development. "But no one has been able to demonstrate conclusively that they play a key role in the intelligence of higher organisms."

As father of the holographic-brain theory, Stanford neuroscientist Karl Pribram is more favorably disposed to Hameroff's ideas. "The model is highly theoretical," he concedes, "but it's also very elegant in that it could explain within one coherent framework many baffling phenomena in the field of consciousness studies."

When the pros and cons of the theory are tallied up, even critics agree that Hameroff has opened up an avenue of research that warrants further investigation. Microtubules may not turn out to be the double helix of the science of consciousness. But today's scientists are more willing than they were a decade ago to consider the possibility that tiny organisms have awareness. Ironically, this notion puts scientific thinking closer to that of such early naturalists as Charles Darwin, who assumed consciousness was manifested—at least in a rudimentary form—in the lowliest one-celled creatures. Reflecting this popular viewpoint at the turn of the century were books bearing such evocative titles as *The Animal Mind* and *The Psychic Life of Micro-Organisms*, the latter penned by none other than Alfred Binet (as in Stanford-Binet), best remembered as the father of intelligence testing.

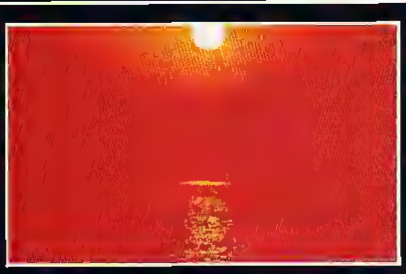
Perhaps the tendency to anthropomorphize is not so unscientific after all. It may yet be vindicated if this irresistible temptation is shown to reflect the continuity of consciousness across all living forms, from paramecia to people. ∞



"Good news, Dear! You got your Guggenheim grant!"

COMING IN THE APRIL Omni

SATELLITE RESCUE

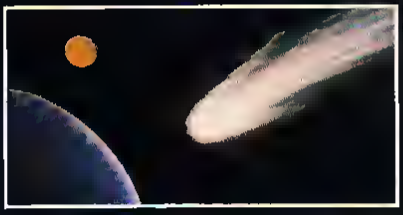


The satellite had been designed to reap data about solar flares and other activity on our star. But five months after it was launched, the Solar Maximum Satellite began wobbling in orbit when a fuse burned out. Now, in one of its most adventurous missions, NASA is about to stage the first attempted satellite rescue. Astronaut George Nelson will leave an orbiting shuttle more than 200 miles above Earth. He'll ride a rocket pack to the crippled satellite and try to return it to the shuttle cargo bay for repair. Space writer James Oberg provides an inside look at this bold plan.

FICTION

An innocent love song from the hit musical *Oklahoma!* inspired Harvey Jacobs to speculate on the nature of obsession and revenge. His first *Omni* story, "My Rose and My Glove," is a cautionary tale about a collector of useless objects who bears a grudge against his childhood tormentors. This humorous story also proves that reclaiming your past can be hard work. Another first-time *Omni* contributor, Elizabeth A. Lynn, wrote "At the Embassy Club," a tale of forbidden love and political protocol. An embassy-staff member on the planet Tanderai must decide whether he is willing to lay his career, and maybe his life, on the line to win the woman he loves.

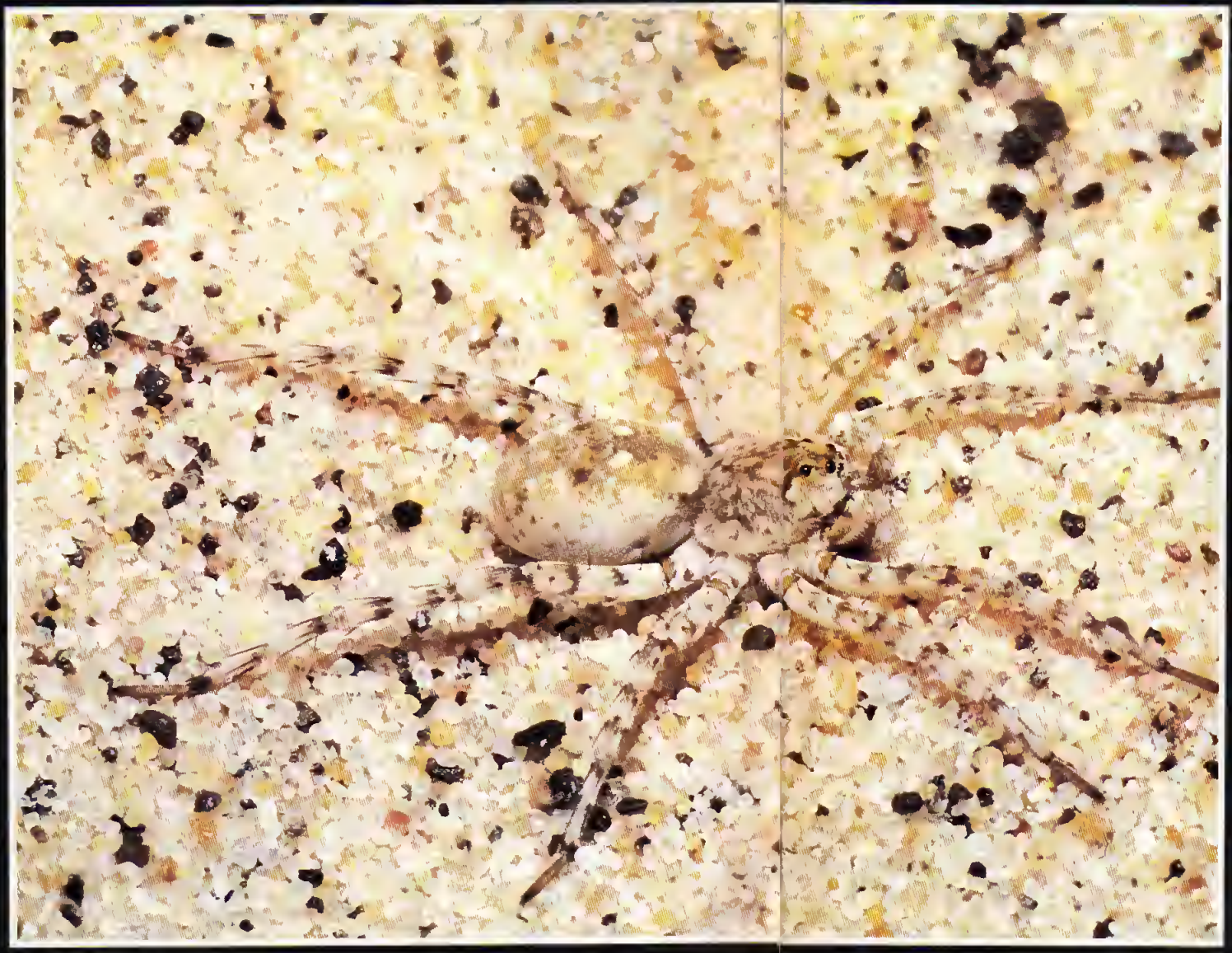
COMET RIDES



While some scientists draft plans for intricate vehicles to carry humans to the stars, other futurists are looking to "natural" spaceships: comets. Future settlers may land on frozen cometary surfaces and build mines and solar collectors. Then the pioneers will construct space habitats to support future generations on their way to the stars. These plans, from two U.S. scientists—as well as speculation about the people who would hitch their fortunes to a comet—are outlined in *Omni*.

BIOCHEMISTRY OF DESIRE

The search for the ultimate aphrodisiac has led the lovelorn to try everything from moss taken from the skull of a murdered man, to a bracelet made from the right testis of an ass. But now it looks as if we don't need outside help. New findings indicate we all come with our love potions already installed, and researchers have now managed to isolate some surprisingly potent hormones that help keep our sex drives in tune. For example, prolactin, the same hormone that triggers milk production in breast-feeding mothers, also surges into the bloodstream during sex. One brain hormone, LHRH, is so powerful it even stimulates animals that had their sex glands removed. The biochemical triggers of love and lust can also go awry. There can be too much of a good thing, such was the case with the man who had to have sex at least three times a day. Read all about the biochemistry of love and lust, and the aphrodisiacs of the future, in the April *Omni*.



PHENOMENA

While wandering along the south shore of Lake Superior one summer day, nature photographer John Shaw spotted a small creature skittering across the stones that lined the beach. Stooping down, Shaw caught a glimpse of this speckled sand wolf spider (*Arctosa littoralis*) just as it hopped onto the beach and faded to near-invisibility. "It was a textbook example of camouflage," he recalls. "It looked exactly like its surroundings. Once it walked out there, it just disappeared." With a 105mm lens and an extension attached to his Nikon, he quickly took this picture of the tiny arachnid before he lost sight of it. The image was recorded on Kodachrome 25 film. The next summer he walked along the same stretch of beach, deliberately looking for more spiders to photograph, but he had no luck. "I never saw one again," he says DC

HERETICS

CONTINUED FROM PAGE 58

the wide, thin mouth, the long neck. She looked like the Fremen portraits in the holy of holies at Dar-es-Balat. Of course! The child of Shai-hulud would look thus.

She danced well, too. Not the slightest quickly repeatable rhythm entered her movements. There was rhythm, but it was an admirably long beat, at least a hundred steps apart. She kept it up while the sun lifted higher and higher. It was almost noon before she fell exhausted to the sand.

The priests stood and looked out into the desert where Shai-hulud had gone. The stampings of the dance had not summoned Him back. They were forgiven.

That was how Sheeana's new life began.

Loudly in their own quarters and for many days, the senior priests engaged in arguments about her. At last they brought their disputations and reports to the High Priest, Hedley Tuek. They met in the afternoon within the Hall of Small Convocations, Tuek and six priestly councillors. Murals of Leto II, a human face on the great wormshape, looked down with benevolence upon them.

Tuek seated himself on a stone bench that had been recovered from Windgap Sietch. His councillors took lesser modern benches facing him.

The High Priest was an imposing figure—silky gray hair combed smoothly to his shoulders. It was a suitable frame for the square face, with its wide, thick mouth and heavy chin. Tuek's eyes retained their original clear whites surrounding dark blue pupils. Bushy, untrimmed gray eyebrows shaded his eyes.

The councillors were a motley lot. Scions of old priestly families, each carried in his heart the belief that matters would move better if *he* were sitting on Tuek's bench.

The scrawny, pinch-faced Stiros put himself forward as opposition spokesman. "She is nothing but a poor desert waif, and she rode Shai-hulud. That is forbidden, and the punishment is mandatory."

Others spoke up immediately. "No! No, Stiros. You have it wrong!" She did not stand on Shai-hulud's back as the Fremen did. She had no maker hooks or—

Stiros tried to shout them down.

It was deadlocked. Tuek saw three and three with Umphrud, a tat hedonist, as advocate for "cautious acceptance."

"She had no way to guide Shai-hulud's course," Umphrud argued. "We all saw how she came down to the sand unafraid and talked to Him."

Yes, they all had seen that, either at the moment or in the holophot that a thoughtful observer had recorded. Desert wait or not, she had confronted Shai-hulud and conversed with Him. And Shai-hulud had not engulfed her. No, indeed. The Worm-of-God had drawn back at the child's command and had returned to the desert.

"We will test her," Tuek said.

Early the following morning an ornithopter flown by the two priests who had brought her from the desert conveyed Sheeana far out, away from the sight of Keen's populace. The priests took her down to a dune top and planted a meticulous copy of a Fremen thumper in the sand. When the thumper's catch was released, a heavy beating trembled through the desert—the ancient summons to Shai-hulud. The priests tied to their thopter and waited high overhead while a terrified Sheeana stood alone some twenty meters from the thumper.

Two worms came. They were not the largest the priests had ever seen, no more than fifteen meters long. One of them scooped up the thumper and silenced it. Together they rounded in parallel tracks and stopped, side by side, not six meters from Sheeana.

She stood submissive, fists clenched at her sides. This was what priests did, she thought. They fed you to Shaitan.

In their hovering 'thopter, the two priests watched with fascination. Their lenses transmitted the scene to equally fascinated observers in the High Priest's quarters at Keen. All of them had seen similar events before. It was a standard punishment, a handy way to remove obstructionists from the populace or priesthood, or to pave the way for acquisition of a new concubine. Never before, though, had they seen a lone child as victim.

The Worms-of-God crept forward slowly. They became motionless when only about three meters from Sheeana.

Resigned to her fate, Sheeana did not run. Soon, she thought, she would be with her parents and friends. As the worms remained motionless, anger replaced her terror. The bad priests had left her here! She could hear their thopter overhead. The hot spice smell from the worms filled the air around her. Abruptly she raised her right hand and pointed up at the 'thopter.

"Eat me! That's what they want!"

The priests overhead could not hear her words, but the gesture was visible, and they could see that she was talking to the two Worms-of-God. The finger pointing up at them did not bode well.

The worms did not move.

Sheeana lowered her hand. "You killed my mother and father and all my friends!" she accused. She took a step forward and shook a fist at them.

"If you don't want me, go back where you came from!" She waved them away toward the desert.

Obediently, they backed farther and turned in unison.

The priests in the thopter tracked them until they slipped beneath the sand more than a kilometer away. Only then did the priests return, fear and trepidation in them. They plucked the child of Shai-hulud from the sand and returned her to Keen.

The Bene Gesserit embassy at Keen had a full report by nightfall. Word was on its way to the Chapter House by the following morning. It had happened at last!

Tale of a tragedy, beastly number, and big yen winner

GAMES

By Scot Morris

In December 1982 *Omni*'s list of the ten best games of the year included the Rainbow Stunt Kites created by Steve Edeiken, of Venice, California.

In our June 1983 column on kites for adults we predicted that before the summer was out, a college team in Washington would bring the record for the world's largest kite back to the United States. At the time, the Dutch held the record with a 5,952 square-footer.

On September 24 the Edmonds Community College team gathered at Long Beach, Washington with their 14,260-square-foot craft. They tried all day to get the 1/3-acre monster aloft, but the winds wouldn't cooperate. Edeiken, who had come up from Southern California for the event, acted as launch director, coordinating the 24-person team. He warned everyone about the powers of the Jalbert parafoil, and about staying away from the 108 ropes that would hold the kite in its airfoil shape once aloft.

Finally, at the end of the day, after seven hours of disappointment, a sudden breeze caught the kite, and it went up. Tragically, Edeiken, at the head of the crew, got his legs tangled in the ropes and went up with it. About 45 seconds later the photo above, at right, was taken. Shortly after, Edeiken freed his feet and hung by his hands for about four more minutes. Then he lost his grip and fell almost 300 feet to his death.

A thirty-year-old aerodynamics expert was gone. Domina Jalbert, seventy-nine, inventor of the parafoil, had been the launch director on the only previous attempt to fly this kite, but wasn't able to attend on that fateful day. "Steve was one of my best friends," Jalbert told me. "It was the worst thing that ever happened in kiting. And it could have been the best thing. That was the most magnificent kite ever flown."

Edeiken's widow, Cindy, continues to operate the Rainbow Kite Company from 221 Hampton, Venice, CA 90291.

Disaster during the record-breaking flight. "the worst thing that ever happened in kiting."

BEASTLY PROPHECY

For numerologists, 666 is satanic. It is "the number of the beast, [and] the number of a man" (Rev. 13:18). Throughout the Christian Era people have found ways to demonstrate that their enemies are the "beasts" prophesied in the Bible by showing how the number 666 can be derived from their names. Usually this is done by numbering the alphabet in some way, then adding up the values of the letters in a person's name. In centuries past, religious zealots found ways to prove that the beast was Nero, Muhammad, Luther, Calvin, and various popes. More recently the number has been tied irrefutably to Sun Myung Moon.

Napoleon, Stalin, Mussolini, and Hitler have all been "proved" to be the beast. *Hitler* is easy. As Martin Gardner explains in his article "The Number of the Beast," in the July 1983 issue of *Isaac Asimov's Science Fiction Magazine*, just number the alphabet thus: *A* = 100, *B* = 101, *C* = 102, and so on. Add the letters in *Hitler* and you get 666.

Showing that *Ronald Wilson Reagan* is the beast is almost too easy. Just count the letters in each of his three names and you're done—OED. William Remme, of Eureka, California, has discovered that if you take the code used above with *Hitler* and apply it to President Reagan's full name, the sum isn't 666 but another very significant number. What is it?

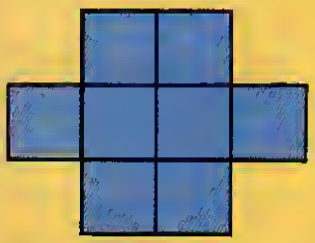
For the record, this same code shows that the only beastly day of the week is, as you might have expected, *Monday*. And what do religious fundamentalists think of gambling? Just add the numbers on a roulette wheel (1–36) to find out.

ENTRANCE. Nob Yoshigahara, who writes a games-and-puzzles column for the Japanese science magazine *Quark*, has allowed me to share with *Omni* readers a couple of puzzles of his own. He says that he saw the strange sign below on the glass door of a Tokyo office building. Can you decipher it?

DIMOUT. When the batteries on Nob's calculator got weak, all the vertical lines

on the readout disappeared, leaving only the horizontal lines. Represented at right (left side) is a two-digit number. At its right is the four-digit *square* of this number. Can you supply the missing digits? (There are two possible solutions.)

LAYOUT. In the grid of eight boxes below you are to place the numbers 1 through 8—a different one in each box—so that no number is next to a consecutive one in the counting sequence. For example, the 4 must be placed so that neither the 3 nor the 5 is adjacent to it—horizontally, vertically, or diagonally.



NEBULOUS NO MORE

In the November 1983 Games column we bet that *Omni* readers would succeed where members of the Tokyo Recreational Mathematics Club had failed in solving the challenge of the alphametic puzzle called NEBULOSITY. The problem was (a) to solve the puzzle below in decimal (base 10) arithmetic, and (b) to prove that there is no other solution in any other base.

SUN	741
LOSE	5672
UNTIE	41982
BOTTLE	369952
ELISION	2587861
NINETEEN	18129221
NONENTITY	161219890
EBULLIENT	234558219
+ INSOLUBLE	+817654352
NEBULOSITY	1234567890

We won our bet. Seven readers sent solutions judged correct by our referee, the poser of the problem, Harry Nelson, former editor of the *Journal of Recreational Mathematics*. Since Nelson's original prize to the Japanese mathematicians was 5,000 yen, *Omni* doubled the ante to 10,000 yen. It goes to our grand prize-winner, Greg Williams, of Portland, Oregon, whose entry had the earliest postmark. Other correct solvers were Randy Berkowski of Seattle, John H. Kool, of La Grange Park, Illinois, Michael Reed of Columbus, Ohio, Nick Kleszczewski of New York City, Anthony Bruni of Spring, Texas, and Steven F. Hoysan of Metairie, Louisiana. Nelson notes that most of the incorrect answers proved *only* (by noting the 'free' use of the letter Y) that there could be no *unique* solution in, say, base 37 or any base other than 10. But that was *not* what the problem asked.

To simplify the problem, Williams first matched each letter in the sum word, 'NEBULOSITY', with a similar letter in the column above it and dropped both out. This yields the diagram below, where Ø represents zero and O represents the letter O, and the Ks represent the carries from one column to the next.

$K_9K_8K_7K_6K_5K_4K_3K_2K_1$	
	SUN
	LOSE
	UNTIE
	BØTTLE
	EØIØION
	NINETEEN
	NONENTØØØ
	ØØØLLIENT
	INSOLUBLE
	NØØØØØØØØØ

Thus, the letter Y has been eliminated, we have a row of zeros in the answer, and the sum of each column must be a multiple of the number base. Got that?

To understand the solution you need to know something about solving alphametic puzzles with nondecimal arithmetic. The rest of Williams's proof appears on the answer page.

OVER TROUBLED WATERS

In a bridge game, all the cards are dealt to four players—13 cards to each—who usually play as partners, one pair against the other. That should be all you need to know in order to answer these three questions about situations that might arise in a game.

FLUSH. You and your partner have been dealt a surprising hand. Together you have all 13 cards of one suit. Is this event more or less likely than one in which you and your partner together have no cards in one of the suits?

DEALER'S DILEMMA. You are dealing a hand of bridge, and after you have dealt about half the cards out, the phone rings. You answer it, tell the salesman you aren't interested in his once-in-a-lifetime offer, and return to the table. You can't remember where the deal left off, so you think you'll have to collect the cards and deal them over again. But there's a shorter solution, and it doesn't require counting the cards already dealt or the cards left in the pack. Can you find a way to resume the deal so that each player gets the same hand he or she would have gotten without the interruption?

PAPER PERFECT. Every few years a newspaper story will report that players at a local bridge game were witness to a 'perfect deal'. That is, each player got all 13 cards of a suit. How many of these deals would you expect to occur anywhere in the world during the Eighties? (a) 100+, (b) 50–99, (c) 11–49, (d) 1–10, (e) about 1, (f) about 0.

Answers on page 104 ∞

LAST WORD

By Pope Brock

"To forestall Information Overload, be selective. Marginal facts like "Ruffles have ridges" take up just as much space in your head as a bit of I Ching."

Dear Healthline:
In the supermarket yesterday I saw a small crowd eyeballing a woman by the frozen meats. She was holding a turkey and seemed to be checking the cooking instructions. But someone was trying to speak to her, and she didn't hear a word. Dead to the world. Finally, a couple of us had to lift her by the elbows and carry her out of the store. The manager said it must be I.O.

That reminded me of a guy I saw sitting in the park with a newspaper in his lap. He was leaning to one side, smiling, as if he was remembering something nice, or maybe he was getting instructions from outer space. There was a pigeon on his head. I thought at the time he was just thinking deep, but now I'm wondering if that wasn't I.O. too. And then there's my wife. She took a shower for a day and a half. I'll bet she got to reading the label on the shampoo.

It looks as though nobody's safe. I never thought Information Overload could strike us ordinary people. And that's making my wife and me pretty nervous. Could you please tell us exactly how I.O. develops and if there are any precautions we can take?

Reading Scared

Dear Scared:
Don't be. I.O. is not a disease, but knowing what induces an attack can help protect you. Scientists tell us that the human brain works somewhat like a self-regulating oven. When the oven gets too hot, it shuts itself off for a while, to maintain a good, even temperature. In a similar way, when the brain has taken in all the information it can, it will turn off. Later, when there's space available, it automatically clicks back on.

Apparently, the brain has always operated this way, but researchers have come to discover it only in this Age of Information Glut. As you know, we are bombarded with facts 24 hours a day—from television, radio, books, advertisements on the bus, you name it. More and more of us are reaching the point where our brains become saturated, and that's when the protective mechanism of I.O. takes over. So relax. It's just nature's way of keeping your head in equilibrium.

How can you know if you are having these spells? Here are some tests:

1. Do you find yourself having a lot of *déjà vus*? "I think I've been here before," you say to yourself. What may have happened is that your brain took a walk around the block, so to speak, and you are just now emerging into consciousness. This is what is technically known as *le déjà vu faux*, or fake *déjà vu*.

2. Is there a pigeon on your head? How long has it been there?

3. Has it been several hours since you started reading this article? If so, you may have just popped out of I.O., and you should not try to take in any more of the information here at this time.

By now you are probably saying to yourself, "Oh, modern life. It's too much trouble. You may be longing for earlier, simpler times. *Those fortunate cavemen*, you think, *they didn't have to worry about I.O.* Actually, a life of ignorance was full of its own stresses and frustrations. Primitive people spent much of their time roaming the countryside, picking up rocks and small animals, demanding, "What's this?" Then the stars would come out and scare everyone. As a result, cave dwellers were always either afraid or confused.

So let's not feel sorry for ourselves. Especially since I.O. may be just a temporary problem. Within a few years, most of us should be carrying wallet-size personal computers in which will be stored virtually everything we must now so laboriously keep in our brains. Won't that be a relief? You'll be able to punch up information of any kind—from your political views to the names of your children—instantly. No more having to remember things. Your head can be as empty as the sky over Montana.

For now, though, faced with the limitations of in-skull storage, we have to deal with the problem. But as more of us slip into I.O. comas, the social awkwardness and fear surrounding them will dissipate.

One rule of thumb concerns reverie. Do you enjoy sitting with your chin in your hand, letting your thoughts drift? Is it safe to do this? Perhaps. But remember, there's a fine line between introspection and trance. Don't ask for trouble. Think your thoughts in the company of others. *Don't think alone.* To be on the safe side, don't think while operating machinery.

To forestall I.O. attacks, you must be selective. Marginal facts like "Ruffles have ridges" take up just as much space in your head as a bit of *I Ching*. If you want wisdom, leave room.

Second, stay away from abstract art: any paintings with splotches or geometric forms. The next time you're in a museum, take a good look around. Note how many people viewing these artworks are glassy-eyed. They have been deliberately tipped into I.O. comas by artists with no sense of social responsibility.

Third, avoid redundancies, *particularly stories you've heard before*. If at a dinner party your spouse begins an anecdote you already know—especially if you know it well—politely excuse yourself and go into the bathroom. Hum loudly. Splash water on your face. Wait for the hostess's cheerful "All clear!"

Finally, if you live in an outlying area, consider getting a wristwatch with a beeper, or—better yet—get a dog. In severe I.O. cases, known as the Van Winkle effect, a dog will start barking at you. That should bring you around. ∞

Pope Brock is a freelance writer living in New York who no longer reads frozen turkeys.