OMNI

FEBRUARY 19

MYSTERIES OF SPACE AND TIME:

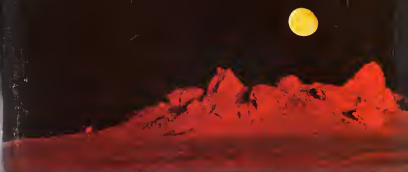
SIR FRED HOYLE ON INTERSTELLAR LIFE

ARTHUR C. CLARKE ON SPACESHIPS

STEPHEN HAWKING ON BLACK HOLES AND THE COSMOS

EXCLUSIVE:

E.O. WILSON ON OUR GENETIC FUTURE



OMNI

FEBRUARY 1979

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This month's cover photo was taken by photographic artist Pete Turner, who also took the photo on the first Omni cover. This untitled landscape shows Turner's imaginative powers at their acme.

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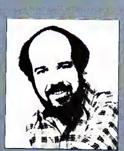

FRANK KENDIG

Whether or not the first test-tube baby is a hoax isn't the issue, rather, it is whether or not scientific journals have a monopoly on the disclosure of new information

Not long ago the *New York Post* ran a banner headline stating that the most heralded birth in 2000 years, that of Louise Brown, the first "test tube baby," was a hoax. When I saw that headline, a question immediately flashed across my mind—*How did they know?*

On the second page of the story I found the answer. It seems that Dr. Patrick C. Steptoe, the British gynecologist who performed the conception of Louise Brown *in vitro* (in a laboratory dish), published his findings in the *National Enquirer*, rather than in a scientific journal. Thus, concluded the *Post*, the report must be a fraud. Why else would the good doctor have chosen the *National Enquirer* instead of, say, the *American Journal of Obstetrics and Gynecology*? (There is an obvious answer, of course. The *National Enquirer* paid Steptoe upwards of $600,000 for the story, whereas many scientific journals would have charged *him* to publish his results.)

Whether or not Steptoe's report of the first test-tube baby was a hoax is not the issue here. Rather it is whether or not the scientific journals have or should have a monopoly on the disclosure of new scientific information.

Even a casual polling of the scientific community suggests that such a monopoly exists. Many scientists absolutely refuse to reveal new information to the popular press before it has appeared in the established journals. Those who do not open themselves to severe peer criticism. Given that the monopoly exists, the question then is: Should it exist? I think not, for two reasons.

First, the scientific journals are, as they should be, extremely cautious about what they print. The process of peer review, by which research is deemed worthy of publication, is complicated and lengthy and a new breakthrough can wait months, even years, before it is published. Meanwhile, the wheels of progress do not roll.

The second problem with the journals' virtual monopoly on new breakthroughs is that the journals tend to be extremely specialized. A new development in biology, for example, may be of great interest to a physicist or a chemist but may never be noticed because it lies buried in the biological literature. Consider, for example, the plight of Gregor Mendel, the Augustinian monk who is now regarded as the father of genetics.

In the mid-nineteenth century, about the time Darwin published his *On the Origin of Species*, Mendel was tending his garden in Brunn, in what is now Czechoslovakia. Mendel was a botanist. He grew peas. He was also a mathematician. He counted the peas he grew. Mendel noticed that even when he crossed a tall pea plant with a short one, he got only tall pea plants. In effect, he discovered that some characteristics (such as tallness in pea plants) are dominant, while others (such as shortness) are recessive. He published his findings in the *Proceedings of the Natural History Society of Brunn*. The point is that Mendel's findings could have cleared up one of the major scientific questions of the time—had the right person read and understood his paper. Darwin's theory of evolution had one serious flaw. It could not explain why, if a superior horse was bred with an inferior horse, the result was not an average horse. Natural selection required that the result be a superior horse, but Darwin could not explain the mechanism that brought this about. While the controversy over this problem raged, Mendel's paper remained unnoticed. Not until 31 years after its publication, after Mendel had died, did science discover that a logical explanation of the mechanisms for natural selection had already been developed and published.

Isaac Asimov has a theory to explain why Mendel's paper was overlooked for so long. "It was a paper with a biological title," he says. "It dealt with pea plants. Therefore, physicists and chemists and people like that wouldn't look at it. The title alone threw them off. Biologists might have looked at the paper because of the title, but as soon as they saw the contents, they would have seen a series of numbers, some of which contained as many as three digits. Now, in those days biologists didn't involve themselves with such higher mathematics, and as soon as they saw those three-digit numbers, they passed the paper by—with the result that there was nobody to look at it, and nothing happened. It just stayed there."

This is, of course, not to say that the scientific journals should not exist. They are absolutely vital to the progress of research. It is their monopoly on technical information that must be broken. Science will be all the better for it. ꝏ

CONTRIBUTORS

OMNIBUS


OVERBYE


Fanto
CHARNAS


CLARKE


OBERG

The publication of E. O. Wilson's *Sociobiology* in 1975 brought to a full boil one of the longest-simmering controversies in the history of science. How much of human behavior is genetically induced? *Sociobiology's* statements about the genetic origins of our behavior literally turned the scientific world upside down. Now Wilson has just published *On Human Nature*, and in this month's exclusive *Omni* interview (pg. 96) he talks about his new book, which promises an even greater impact on the way we view ourselves.

Wilson himself, as *Omni* interviewer *Tabitha Powledge* points out, is first and foremost a man of character and conviction. "In order to formulate his theory," she says, "he did something very few scientists are willing to do—read and learn about subjects far outside their own field of expertise."

British cosmologist *Sir Fred Hoyle* writes in "Lifecloud" (pg. 66) that life as we know it may not have begun on this planet. Along with coauthor *Chandra Wickramasinghe*, he argues that our biochemical ancestry predated the formation of the earth some four billion years ago. The seeds of life, according to Hoyle, formed deep within interstellar clouds and were carried to earth by passing comets.

In "The Wizard of Space and Time" (pg. 44), *Dennis Overbye* profiles perhaps our greatest living physicist, Stephen Hawking. Said to have the most formidable mind since Einstein, Hawking is responsible for revolutionizing the way we view black holes—those strange areas of the universe from which no light can escape.

Tragically, Hawking is the victim of an incurable neuromuscular ailment commonly known as "Lou Gehrig's disease." He is no longer able to walk, speak clearly, or write. As a result, he must memorize long strings of difficult equations when working, a feat comparable to Beethoven's writing an entire symphony in his head.

We all have seen on the sides of food containers the panel "Recommended Daily Allowances," which gives the percentages for nutrients contained in the food. As *Dan Greenberg* explains in "Nutrition Hype" (pg. 100), it is possible to eat 100 percent of these RDAs and still starve to death. Greenberg, publisher of the prestigious biweekly newsletter *Science and Government Report*, is a longtime observer of the health scene. His portrait of governmental workings and our health is an eye-opener.

In "Farming the Planets" (pg. 58), *James Oberg*, who is also our UFO columnist, tells how we may domesticate other planets. In explaining how restructuring the planets can turn the wastelands of Mars and Venus into Gardens of Eden, Oberg projects how man will live far into the future. A book by Oberg based on this same subject is due for publication later this year.

Arthur C. Clarke is the narrator of an exclusive *Omni* pictorial on spaceships (pg. 76). Written more than 20 years ago, Clarke's descriptions are fascinating examples of how the fertile imagination of a science fiction writer often predicts our future facts.

Dracula was always pretty scary, but we have found today's vampire in quite a different place: on a university campus. "The Ancient Mind at Work" is the title of *Suzy McKee Charnas's* fictional account of sleepers, blood, and ... well, turn to page 48 and find out.

Dr. Robert L. Forward, who last month looked into the possibilities of gravity control, is back with a short fiction story. "The Singing Diamond" is a tale of an incredible discovery by an outer-space miner amid far-off asteroids (pg. 70). Also in fiction this month, we offer *Dean Ing's* "The Blizzard Machine," a futuristic look at the ultimate challenge between man and mountain (pg. 92).

Sir Patrick Moore, in Stars, writes about "Shoals in Space"—that area between Mars and Jupiter filled with asteroids. Where did they come from? Moore solves this mystery and others on page 24.

In *Omni's* Arts column, we celebrate a milestone in publishing history—the 200th book of Isaac Asimov. His longtime friend and associate *Ben Bova* (who doubles as *Omni's* fiction editor) takes a warm and personal look at one of this era's greatest science writers. **OO**

LETTERS

COMMUNICATIONS

Super Flight

Just want to compliment you on your superb flight issue. Compared with the articles in such magazines as *Life*, *Popular Science*, *Popular Mechanics*, and all the rest of the mass media, your coverage of this significant anniversary in technological history was more informative and far more interesting. Keep up the good work.

Albert Horn
Centralia, IL

Einstein on Ice

I was appalled to learn from your December Continuum that the final resting place of Einstein's brain is a cardboard box under some scientific moron's beer cooler. With this sort of insensitivity it is little wonder that many people look on science as the exclusive preserve of inhumane and unfeeling clones. Surely the remains of Einstein—a genius, humanitarian, and hero—deserve a proper and respectful resting place. The present situation is vulgar, tasteless, and shameful and should not be allowed to persist a moment longer.

Gerard Van der Leun
London, England

Skylab Fallout

After the first two issues of *Omni* I was very favorably impressed. The December issue is another matter entirely. Ben Bova's item on Skylab is a ridiculous example of sensationalism. This is not to argue whether or not Skylab will fall, but rather to evaluate the impact if it should.

NASA has estimated that the probability of anyone's being injured is one in 200. This seems reasonable since there are 27,878,400 square feet in a square mile, and most of the orbital track of Skylab is over water. On an individual basis, the chances of harm are approximately the same as those for being struck by a meteorite—hardly a "potential tragedy of colossal proportions."

The actual tragedy is that this item should have been printed. There is no better way to turn people off on the space program.

C. A. Ourada
Littletown, CO

There are three ways to lie: lies, damned lies, and statistics. NASA's assurance that only one in 200 of us has a chance of getting injured could be interpreted to mean that a million Americans—or 20 million inhabitants of this planet—have a chance of being injured by Skylab's debris. Not terribly reassuring.—Ed.

Concerned Citizens

I have never considered myself paranoid, but the incredibly severe cutbacks in the space program have me and my friends very worried about the future of NASA.

What can we, the average citizens," do about it? Are there any national organizations of future-minded people out there that we can join?

I think a truly alarming situation has arisen and we must fight against it. We can't remain ostriches for long now.

Mary Alice McGuire
New York, NY

Future-minded organizations include the L-5 Society, 1620 N. Park Avenue, Tucson, AZ 85719, and the Space Studies Institute of Gerard O'Neill's in Princeton, NJ. And perhaps the most important gesture is to write your congressmen—you can be sure they count the letters.—Ed.

Cloning the Galápagos

In November's Continuum it was reported that a certain Dr. T. C. Hsu has established a cloning zoo by collecting the cells of various animals and freezing them for an indefinite period, to be cloned in the future.

In the same section appeared a story on Lonesome George, a Pinta subspecies of the Galápagos tortoise who "faces imminent extinction" unless a female Pinta can be found.

I am hoping *Omni* can contact Dr. Hsu and explain the case of Lonesome George. He may be able to freeze a few of the Pinta's cells for future cloning. It may be possible that some future scientist could introduce or remove a combination of X and Y chromosomes and create a female "George."

Steve Parr
El Toro, CA

Talking to Dolphins
I read with interest "Communicating with Dolphins" (November *Omni*). I'm basically all for Dr. Lilly and what he is attempting to do, but I can't help wishing he could have been a more simple and direct sort of guy.

In *Omni* he talked about communicating with dolphins through a computer, and in his book *The Mind of a Dolphin* he described how a girl lived with a dolphin for a few months. Meanwhile, another group of scientists successfully communicated with chimpanzees, and more recently with gorillas, using sign language. It is known that dolphins, killer whales, and white whales can all mimic human speech, so if it was so easy to communicate with apes, communicating with whales and dolphins with their much larger brains should be a pushover.

I'm surprised that aquariums have not attempted this, since they've done practically everything else to dolphins. Think of the publicity they could have if a noted reporter interviewed the dolphins.

I realize that there is a lot of resistance to these ideas. I was surprised at the lack of interest when men first started to communicate with apes. Most people regard talking to animals as something you see on children's shows. Also, we have an idea that humans are the most intelligent animals on earth, and none of us likes the idea that it is not true. It may be that the human race is not ready for talking dolphins just yet.

William Bond
London, England

Inactive, but Radioactive
Your list of "active" nuclear plants in November's Explorations column contained an error. I refer to the Humboldt Bay plant in northern California. Far from active, the Humboldt plant was closed several years ago when a dangerous-looking earthquake fault was uncovered beneath the plant. The owner operator of the plant, Pacific Gas & Electric Company, has done some reinforcing, but any reopening awaits a long series of hearings and such. At present, the best guess seems to be that Humboldt will never reopen. Humboldt Bay may be radioactive, but it isn't—and probably won't be—active.

Tom Turner
Friends of the Earth
San Francisco, CA

Atomic Tours
Concerning "Where the Atom Splits" by Stuart Diamond in the November *Omni*, I am gratified to see something positive written about nuclear power, even from a "here's something of interest" view. Having started with nuclear power as a young enlisted man in the navy's sub program, proceeding on to a B.S. in metallurgy from Penn State, and ultimately being employed by nuclear vendors and utilities alike, I can identify with Mr. Diamond's astonishment at his nuclear surroundings. The engineering and science involved in building and operating such nuclear facilities are impressive.

The message of Mr. Diamond's article is clear—go see for yourself.

Eric C. Biemiller
Grafton, MA

Your article glorifying tours of nuclear reactors was insane. Perhaps we can look forward in future issues to photographic tours of cancer wards in our nation's hospitals—filled with all those people whose cancer has been caused by radiation from nuclear-power plants. Happy leukemia.

Richard Asinof
Montague, MA

Last summer I traveled in search of work to Richland, Washington. Word came to me of an excess of job openings with good pay in the nuclear industries there.

While searching I had plenty of encounters with employees of several companies (Rockwell, Westinghouse, Exxon, etc.). It seems that these large corporations bid for government contracts every five years to maintain power plants all along the Columbia River.

I was told of the incompetence of these companies owing to lack of experience and untrained personnel. Employees complained that nobody knew what was going on and they spent half their time doing nothing. Technical changes were nearly impossible, and those that had been made in the past were seldom recorded in the plant's blueprints.

The biggest complaint was that nobody has the solution for disposing of nuclear wastes. They are stored in submerged vats, where they'll probably lie for eternity.

My gripe is against government and multinational corporations that constantly stifle the progress of solar energy. If solar power were developed we would have a constant natural nonpolluting source of energy for less cost, both economically and ecologically, than the present systems. The solar industries would create many many new jobs and give a big boost to our fallen-angel economy.

Incidentally, Richland High School is the home of the "Bombers," complete with a nuclear blast on their T-shirts.

Scott Moon
Santa Cruz, CA

Extraplanetary Habitats Revisited
Unmentioned in Robert Anton Wilson's review of Ben Bova's "Colony" (October *Omni*) is an earlier literary conceptualization of extraplanetary habitats. While Mr. Wilson gives a reasonably well written synopsis of some recent excursions into fantasied extraplanetary habitats, he completely fails to mention *Ringworld*, Larry Niven's novel. It preceded Dr. O'Neill's "new concepts" and possibly even inspired them.

The ideas of O'Neill, Brand, Heppenheimer *et al.* as explained by Mr. Wilson seem but diminutive versions of Niven's but stripped of the grandeur of Niven's and dumped into our stellar neighborhood. Except for extrapolative refinement, the only concept new to them is, seemingly, that proximity implies realizability.

Patrick Smith
Florence, SC

Larry Niven's award-winning novel Ringworld *is indeed a "literary excursion into fantasied extraplanetary habitats," and may well have inspired O'Neill and his followers. But O'Neill's concept of building self-contained colonies between the earth and the moon, using currently known technology and paying for themselves by beaming energy back to earth, is the first step in bringing fantasy into practical reality. And Niven, no doubt, was in turn influenced by physicist Freeman Dyson's earlier work on space habitats that completely surround a star such as the sun. —Ed.*

Laser Acupuncture
I would like more information on laser acupuncture. Please send me the address of the German manufacturer mentioned in the October *Omni*.

James L. K. Gong
Chinese Acupuncture Association
New York, NY

Messerschmitt-Boelkow-Blohm, Robert-Kochstrasse, D-8012 Ottobeuren, West Germany.—Ed.

Test-Tube Superbabies
The article "Test Tube Babies" by Tabitha Powledge in the November *Omni* is little more than a brief for the status quo. In her effort to downgrade the potential of controlled reproduction, the author minimizes the benefits of overcoming infertility, ignores the other possible benefits of test-tube babies, reassures us that total *in vitro* reproduction (presumably a bad thing) is far away and calls those of us who support the project "crazy" for spending "money, time, and brain power" on what she considers a low-priority item.

The truth is that test-tube babies should eventually enable us to eliminate or cure birth defects, create individuals of superior intelligence, strength, and adaptability, extend substantially the life span of the newborn, and perhaps lead to the development of therapies to rejuvenate old people. All these advances would be instrumental in solving the world problems Ms. Powledge is so concerned about.

Of course, test-tube babies will also open the door to abuses—as all advances do. But I think the prospect of unlimited youth, intelligence, wealth, and access to the universe—all of which will depend to some degree on our ability to control reproduction—provides enough motivation to overcome our fear of these abuses.

Saul Kent
Woodstock, NY

FORUM

In which the readers, editors, and correspondents discuss topics arising out of Omni, and theories and speculation of general interest are brought forth. The views published are not necessarily those of the editors. Letters for publication should be mailed to Omni Forum, Omni Magazine, 909 Third Avenue, New York, NY 10022.

Who Came First?

As an aviation writer, pilot, and hard-core *Omni* fan, I was very pleased to see that your December issue on aviation had the same high degree of excellence as the previous two issues.

Unfortunately, I fear that celebrating Wright Brothers Day on December 17 is a great deal like celebrating Columbus Day—we're cheering for the guys who came in second. Actually, it's almost certain that the Wright brothers came in second, and there's a strong possibility they came in third.

On October 9, 1890, a Frenchman by the name of Clement Ader supposedly flew an aircraft powered by a 20-hp steam engine a distance of 50 meters (154 feet). True, the aircraft rose only one foot in the air and had no steering mechanism, not even a rudder, but it did become airborne and sustain flight under its own power. Unfortunately, this flight was viewed only by a few gardeners and foremen on Ader's estate.

On October 14, 1897, a flight was viewed by officials from the French war minister's office. Although the aircraft traveled about 900 feet before a gust of wind sent it crashing to the ground, the same wind caused it to strike the ground several times along the way. The official report was that the aircraft did actually fly. We'll never know.

However, it is well documented that Gustave Whitehead of Bridgeport, Connecticut, flew a heavier-than-air powered aircraft as early as 1901, and possibly as early as spring 1899. On August 14, 1901, Whitehead (according to a signed affidavit by Julius Harworth, a witness) flew "to a height of two hundred feet off the ground or sea beach at Lord-Ship Manor, Connecticut. The distance was approximately one mile and a half and lasted to the best of my knowledge for four minutes."

The editor of the *Bridgeport Herald* witnessed the event and reported it in the August 18 issue. He was berated for having a wild imagination and was ignored by his reading public.

Thus, while the Wright brothers gave us a day to celebrate and heroes to honor, the spirits of Clement and Gustave must be content to sit with those of the Vikings and mutter to themselves, "Well, we know who was first."

Douglas Nelms
New York, NY

Mickey Mouse Cities

I must take issue with Homer Bruce's letter in your Communications column (November *Omni*). You see, I too am an urban designer and, like most of my colleagues (including Mr. Bruce, probably), was trained in the architect-with-a-smattering-of-city-planning mode. Mr. Bruce, if Mickey Mouse were the answer to urban problems, more of our ilk would be gainfully employed. Gee-whiz technology can be applied to finite problems such as improving mass transit and reorganizing bureaucracies, but the true basis for better cities is better civilization.

Endeavors such as John Lilly's communication with dolphins, forays into new theories for social psychology à la Julian Jaynes's *The Origin of Consciousness in the Breakdown of the Bicameral Mind*, or urban-reorganization approaches such as Christopher Alexander's *The Oregon Experiment* all will bear more relevance, in the long run, for our chances of improving the cities than will experimental technotowns such as Disneyworld's Epcot.

Christopher Pine
New York, NY

Mr. Bruce replies: *Architecture, as you should know, is called "the mother art" because it is the generator of civilization. Historically speaking, benevolent technology has created and defined civilization, rather than the other way around.*

But for a long time now, we've let philosophers, sociologists, psychologists, and money men define the urban form. It's time that we either crawled back into the sea (and joined the dolphins) or let Mickey Mouse and the techno-fantasizers take over—since they've already demonstrated that they can do a much more effective job than the former.

Bionic Blood

Several of us at the *Deseret News* read and enjoyed your article on the Bionic Man (November *Omni*), alive and well at the University of Utah. It was excellent, particularly in its scope. You did, however, fail to mention that our "man of the future" will have flowing in his veins a fluorocarbon compound also being tested at the U. of U., or some similar substitute.

Twila Van Leer
Salt Lake City, UT

From the *Deseret News*: *The blood transfusion of the future may be the distant relative of the frying pan, or the freon used in refrigeration systems.*

"Actually, artificial blood is a misnomer," said Alan F. Toronto, project director at the Utah Biomedical Testing Laboratory (University of Utah). "The fluorocarbons have been found to be capable of dissolving oxygen and carrying it through the system and of bringing carbon dioxide back out as a waste product, just as the blood does. . . . The test compounds, however, are not as efficient as the body's own hemoglobin, having only about half the oxygen-carrying capacity. They could, however, be useful in providing the body with a supplemental system when the blood is needed."

Tuning in the Stars

It occurred to me that scientists who are searching for the "cosmic connection" may be searching entirely in the wrong area of the wave band, and I believe that your article "Listening for Life" (October *Omni*) backed me up on this.

The correct area is not the "Waterhole" at all but the noisiest parts of the band. It is here that the voices will come from. The tenuous cries of "Is anyone there?" that we

CONTINUED ON PAGE 137

EARTH

By Kenneth Brower

In 1966, I spent four months in the Galápagos Islands, gathering materials for a picture book on that archipelago My Galápagos, the Galápagos of 1966, had been discovered by science but not by Lindblad Charles Darwin had come 131 years before, but tour boats were not yet calling there were no hotels, and the Ecuadorian government had yet to establish the Galápagos National Park The islands were best known among the citizens of the mainland for their old penal settlements The Encantadas—the enchanted isles, as the Spanish had first called them—for a time had been devil's islands of the Pacific.

As we drove slowly to the boat that would take us there, making our way through the steamy squalor of Guayaquil's waterfront, ragged crowds parted before the taxi I tried to find in the dark Indian faces the descendants of the men who had been shipped westward to those volcanic purgatories There were plenty of hard types in the crowd Guayaquil, we had been told, was once The Most Sinful City in the Western Hemisphere That was easy for me to believe I could not imagine a seamier place All the boards of Guayaquil, even the very concrete, were cracked and distorted, as if by the force of poverty below and the heat the humid weight, of the sky above The streets smelled of urine and tropical decay At least half the owners of the faces outside, I estimated would have happily slit my throat

The cabdriver asked in Spanish where we were sailing When we answered "Galápagos," he turned in his seat to look at us gravely We were, he said brave men

It was a nice compliment but not reassuring This cabbie inhabited an equatorial Tartarus, a city as hellish as any I had seen, and he was worried about *us*

The cabdriver's Galápagos was something like Herman Melville's. "The special curse as one may call it, of the Encantadas," Melville wrote, "that which exhalts them in desolation above Idumea and the Pole, is that to them change never comes, neither the change of seasons nor of sorrows Cut by the Equator, they know not autumn and they know not spring while already reduced to the lees of fire, ruin itself can work little more upon them The showers refresh the deserts, but in these isles, rain never falls Like split Syrian gourds, left withering in the sun, they are cracked by an everlasting drought beneath a torrid sky Have mercy upon me,' the wailing spirit of the Encantadas seems to cry, 'and send Lazarus that he may dip the tip of his finger in water and cool my tongue, for I am tormented in this flame'"

It was not as bad as all that Melville's description applied fairly well to certain lava flows on Santiago and Isabela islands Although rain in fact sometimes fell there it fell sparsely Nothing grew on the black lava, and the temperatures were withering Sometimes we found the weightless carcasses of grasshoppers mummified by the heat, sometimes the bones of wild goats that had fallen into collapsed lava blisters and had died there The bones and grasshoppers seemed to call out for Melville's Lazarus but other parts of the islands did not The summits of many islands above the coastal desert zone, were rain forest The problem for the farmers in the highlands of Santa Cruz Island was not lack of water but too much of it The area is literally afloat

The islands have their lava flows and cinder cones, but they have mangrove swamps and brackeny highlands as well There are sulfurous lakes, but brackish ones too, and one lake is actually fresh The islands have a lot of beauty, though none of it is comfortable They are the finest desert islands on the planet

The absence of a park here was the reason for our presence That the most important archipelago in the history of biology (the archipelago is most famous as the natural laboratory where Charles Darwin began asking his epochal questions) should go uncommemorated, that the ongoing evolution in those natural laboratories, which happened also to be the most beautiful desert islands on earth, should go unprotected was wrong Our book would help rectify that—our photo-

Robert Cook

"On Isabela Island we watched the galápagos, the giant tortoises for which the islands were named."

graphs would celebrate the place, our text would argue for an international preserve

We traveled around the islands in *Nixe* the black, hand-built fishing boat of Fritz Angermeyer, a German settler in the islands. Angermeyer and his three brothers had escaped Hitler's Germany in a sailboat and had found their way here. They were Crusoes, having come when the islands were virtually uninhabited. Fritz, the strongest brother, was a lean, tanned man with powerful hands he kept in constant use. He had built *Nixe* from scratch, using copper wire to make the nails. The fishing boat's marine diesel and her sail took us wherever we wanted to go in the islands. Fritz chartered her at an easy rate, for he loved the islands, believed they should become a preserve, and thought our book would help accomplish that.

I spent much of my time in the company of Fiddi Angermeyer, Fritz's 14-year-old son. I was 21, not long out of my teens myself, and there was plenty of boy-explorer left in me. No one else could keep up with us. We wandered wherever our feet led.

Fiddi's feet were big, the rest of him was skinny and freckled. His voice was changing and occasionally squeaked, especially when he was speaking German. If one can read a boy's feet as one can read a puppy's, then Fiddi was destined to be a big man. His toes were splayed from a lifetime of going barefoot. I began going barefoot myself, and soon my soles were as horny as his. On Santiago Island we ran across trackless lava to investigate one cinder cone, then saw a more interesting cone beyond and crossed another strait of lava to investigate that. On Fernandina Island's beaches, we teased sea lion bulls, dodging away as they lumbered after us. On San Cristobal we hunted goats with Fritz's rusty old English .22. I shot them, Fiddi butchered them, and we climbed down the mountain with the quarters over our shoulders.

As we traveled the islands by sail and by foot, it struck me how lightly they bore the weight of history upon them. The place never felt the least like a museum. The finches and tortoises did not seem to know or care how profoundly they had altered man's view of natural history and himself. I was aware that pirates had been here, and whalers and Melville and Darwin, yet as far as the eye could tell, we were the first.

On Isabela Island we watched the *galapagos*, the giant tortoises for which the islands were named, as they mated ponderously. We might as well have been the first witnesses to that rite. The bull tortoises sometimes mistook large stones for their targets, and mounted those, but they connected with the real thing often enough to perpetuate the race. When mating, the bulls roared, the only time in their lives they spoke.

On Barrington Island we were dive-bombed by Galápagos hawks when we got too close to their nests. They came at us boldly, as if they had never seen shotguns or fowling pieces. On Hood Island mockingbirds drank from cups held in our hands. Fearlessness is characteristic of Galápagos animals. The advent of man in the islands has been too recent for evolution to have provided a better response to us.

On every foot of shoreline, black marine iguanas sunned themselves. Theirs is the only lizard species in the world to have adapted to sea life. They moved away from us with that Galápagos lack of urgency and it was easy to catch them. Fiddi and I endlessly duplicated Darwin's old iguana experiment, tossing the lizards out to sea and watching them make beelines back to us. The instinct of marine iguanas, when alarmed, is to head for the nearest land. From this Darwin deduced that the iguana's principal enemies are sharks and other ocean creatures. That seemed a sensible explanation to us.

Adult iguanas were blunt-headed, black-lipped dragons four feet long. They snorted from time to time, blowing out a salty vapor. One of the lizard's marine adaptations is a gland that removes salt from its body. The lizards seldom bite, which is a fortunate thing in a four-foot lizard. Maybe in a million years evolution will have taught the iguana that its teeth can be useful in persuading boys to leave it alone.

The young iguanas, in the way of all reptiles, were miniatures of the adults. They were small dragons not so heavy to carry around. They seemed somehow more perfect in their reduction. They fit well in the palm. There was something about holding them—the dry, taut sides, the black and perfect scales, the prick of their long claws, designed to hook into porous lava and hold the flattened lizard against the ocean's surge, now lightly hooking you. I couldn't get enough of them. In the islands, handling young iguanas became my principal vice.

In 1976, I revisited the Galapagos. I was a tour leader this time. Our book had come out, I was coauthor, and that made me an authority. Ten years had passed, and I had to read my book again to learn a few facts about the place.

The Guayaquil taxi driver who drove me to the airport did not consider me a brave man this time. I was just another American on his way to the Galápagos. The islands were a national park now and tourists were always going there. Those former devil's islands were a hangout for pale foreigners now, not for murderers and thieves.

I was afraid that plane travel would make the islands seem less dearly earned. The voyage on the *Cristobal Carrier*, the wreck that had taken me the first time, had lasted three days, at the end of which the islands had seemed remote and difficult. But now, as I stepped out onto the Galápagos airfield, the islands looked as beautiful as they ever had. The desert smell brought back memories. Ten years, after all, is not very long. I did wonder a little, now, about my conviction that these were the finest desert islands on earth. Could that conviction have had something to do with their being the backdrop of my young manhood? I put on my tennis hat. The equatorial sun beat down, and I no longer had much hair up there for protection.

The dirt streets of town, at Academy Bay on Santa Cruz Island, looked pretty much the same. I found Fiddi in the bar. He was six feet four now and had recently become captain of *Beagle III*, the Darwin Research Station's vessel. He was, I noted happily, still barefoot. It was odd to see him drinking beer. It shouldn't have been—what could be more natural than a towering 24-

Galápagos, famous as the laboratory where Charles Darwin began asking his epochal questions.

Robert Cook

year-old sea captain drinking a *cerveza* with his crew?

Later, from the deck of our tour yacht, I saw a man sculling his dinghy toward town. He passed close, and I recognized Fritz Angermeyer. I grinned. It was like Fritz, the Galápagos Crusoe, to be sculling places. Everyone else in this harbor used an outboard for short trips to town. I started to call to him, then stopped. I'm not sure why. I think I felt that by not communicating, by just watching him, a man sculling in a movie, the old Fritz Angermeyer would still exist for me.

The next day I relented. I visited Fritz in the house he had built from lava stones. As in the old days, he was laconic, listening with those strong arms folded while Carmen, his wife, did most of the talking. When he did speak, it was to complain, with a strange agitation, about the park rangers. You couldn't just go out and shoot goats anymore, he said.

Bureaucracy, which had driven him from Europe, had now after 40 years found him on this furthermost end of the earth. He was given the park he had wanted; now he wasn't sure he wanted it.

For a month the yacht took us around the islands. The park rules were admirably strict. There were now designated spots where tourists could stop; every place else was forbidden. It was against the rules to touch the animals. It was necessary for the group to stay together, accompanied everywhere by our naturalist guide. At each of the places we put ashore, a line of small, black-and-white stakes designated trails from which we were not to stray.

The trail stakes were unobtrusive—models, very likely, of how to do these things well—but the first time I saw them they stopped me in my tracks.

These are peculiar moments for an environmentalist. In a way they are worse than seeing the pipeline your efforts failed to prevent. Your book succeeded, and you got the park you wanted; you can't very well complain.

I was at a loss to explain my feeling to the people I led. They had not known the Galápagos before. The archipelago was still huge and roomy. Days passed without our seeing another party—once a whole week. Those tiny stakes hardly altered the sweep of this landscape.

"A wonderful thing about islands," I had promised in our book, "is their capacity for discovery. They can be discovered, rediscovered, and rediscovered again, yet still seem virgin ground. Nowhere is it easier to imagine yourself the first than when you're alone on a desert island in the center of a blue sea."

That had ceased to be true, or possible. Where Fiddi and I once had rambled in freedom over the lava, I was now following, at a snail's pace, down a staked path, the ample and elderly ass of one of my female charges.

My explorations of 1966 would not have satisfied any of the Galápagos buccaneers, the real explorers. These explorations of 1976 did not satisfy me. The people in my tour, who did not know any better, thought the experience was great.

As human numbers grow, this is how freedom and space depart the planet, in small increments, with few the wiser.

One day, under a growing compulsion, I slipped away from the others. I had to be careful. I was the leader, and my conduct was supposed to be exemplary. Making certain one turn of the beach lay between me and the naturalist guide, I ran down to the water. I selected my victim, and after a short scuffle I caught it. I straightened and for a moment held the taut sides, the black and perfect scales, the black-lipped dragon's head, in my hand.


Robert Cook

For most kinds of life the Galápagos are virtually uninhabitable, but the iguanas survive easily

IN WILDNESS IS PRESERVATION

The Galapagos Islands and Alaska are as far apart in almost every sense as any two areas in the world. Where the Galapagos have become a haven for tourists and travel agents, Alaska is pristine, a wilderness that is basically not touched by human influence.

Although there are great pressures to open up and use Alaskan lands for their mineral resources and timber, President Carter has taken an important step in saving these treasures by placing 56 million acres under Federal protection.

When added to the 54 million acres of Federal land that the Secretary of the Interior, Cecil Andrus, recently placed under Federal protection, the 110 million acre total is larger than the state of California. In addition, Carter has now surpassed Teddy Roosevelt as the nation's leading protector of wilderness areas.

The President used the little known Antiquities Act of 1906 to designate these lands as wilderness forever. Included are such areas as the Yukon River Valley, the Gates of the Artic, the Bering Land Bridge, the Wrangell-St. Elias mountain ranges, and Glacier Bay.

"Because of the risk of immediate damage to these magnificent areas, I felt it was imperative to protect all of these lands and preserve for the Congress an unhampered opportunity to act next year," said Carter.

"While we have moved to protect these important lands, using our administrative authorities, our goal is still passage of legislation to designate these areas as units of the national conservation system," said Secretary of the Interior Andrus.

We had a unique opportunity to preserve the Galápagos ten or twenty years ago, as Ken Brower points out so eloquently. As he also notes, many other problems arise once lands have been designated under some protective status. Does the land protected by the Carter Administration's act face the same future as the Galápagos? In years to come might we be seeing marked trails in the Alaskan wilderness with strict rules prohibiting anyone from deviating from guidelines.

Protecting lands is much more complex than would appear on the surface. We need now to be concerned with how this protection will be provided and, equally important, how will it be administered. With foresight and vision, Jimmy Carter has seen that all of our descendants will have an opportunity to visit and treasure some of the most intriguing and scenic areas on earth. What we must continue to monitor is how these preservation acts are structured, what access they allow for visitors and how limited the usage of the land will be. We want to preserve and protect our resources, but at the same time we must stand guard that in preserving land we do not so limit its usage that we change the very nature of what we have set out to save. —*Eric D. Rosen*

SPACE

By Mark R. Chartrand III

Flash! A meteor zips across the heavens, momentarily adding its tiny extra light to the night sky—then disappears.

Traveling at 40 kilometers per second, this pebble from space has just vaporized 80 to 100 kilometers over your head. Some of it, maybe a few grains, maybe only dust, will remain to drift slowly earthward. Each day 25 million potentially visible meteors add ten tons to the mass of our planet. Another 400 tons a day are added by particles too small to emit streaks of light. These are micrometeorites—space dust captured by the earth's gravitational field.

In "empty" space, about 1000 particles exist in each cubic kilometer. Such particles range in size from a hundred-thousandth of a centimeter for micrometeorites to a millimeter for meteors that produce visible streaks. The particles can be a centimeter across and rival the brightest stars or up to 20 centimeters across and produce meteors as brilliant as the full moon. The bigger ones are exceedingly rare. On the average only one moon-bright meteor is seen for every billion billion just-barely-seen flashes.

Whatever its size, that streak of light, or "falling star," you see in the sky is a *meteor*. It is caused by a particle from space called a *meteoroid*. And if it survives its incandescent plunge to earth, it becomes a *meteorite*.

(You may have noticed some linguistically odd things about meteors. They have nothing to do with meteorology, the study of weather. But the Greeks thought meteors were "fiery exhalations" in the atmosphere, where the weather happens; hence the name. The Greeks were partially right but didn't guess that they were particles from space. Another oddity is the use of the adjective *meteoric* to describe the career of an up-and-coming person. That is actually backward: Meteors are down-and-coming rocks!)

On any clear, dark night, away from city lights, you can see about ten meteors in an hour. These are sporadic meteors, unrelated to one another. There are also shower meteors, which emanate from streams of old comet debris strung out in orbit around the sun. Unlike sporadic meteors, the shower variety seems to radiate from one small region in the sky called the radiant. This is the way we name meteor showers: Lyrids from the constellation Lyra, Orionids from Orion, and so forth. This apparent radiation from one point is an illusion of perspective, which you'll understand if you've ever driven in a snowstorm. The flakes seem to radiate from a point in front of your car, but they are really moving in parallel paths.

And just as you get more snowflakes on the front windshield of your car than on the back window, so too are there more meteors seen from the "front" of the earth, the side facing in the direction of our orbital motion. This is the side we are on between midnight and noon, so the hours from midnight to dawn are best for meteor watching.

Around the date of a meteor shower, the number of streaks visible per hour increases over a period of days, or even a week, to the date of the maximum number of appearances, then decreases. The frequency can approach one meteor a minute or even more in exceptional cases. Some of the best meteor showers are listed in the table on the following page.

Once in a while the earth encounters a great clump of meteoroids in orbit, and we get a spectacular shower. Every 133 years, the Leonid shower puts on a show of more than 2000 meteors a minute. The last was in 1966. There also seem to be increases in a 33-year cycle, so maybe 1999 will bring another good show. About the only thing we can predict for certain about meteor showers is that we can't be certain.

Also rare are the exceedingly bright meteors called fireballs, or bolides. Many are so bright that they can be seen in daylight, and some explode with a thunder heard for hundreds of kilometers. Often buzzing or humming sounds are heard as they speed overhead. Rarely do bolides drop particles that can be recovered. Astronomers estimate that about 1000 fireballs a day enter the atmosphere around the world, but most do so over the

Paolo Koch, Photo Researchers, Inc.

Barringer Crater near Winslow, Arizona, left by the impact of a meteorite the size of a train car

MISSION IMPOSSIBLE? NOT FOR HUGHES.

The mission:
Build two different kinds of spacecraft. To take two different flight paths to Venus. And send back to Earth a stream of new information.

Orbiter arrives.

The first spaceship was Orbiter. Crammed with a dozen scientific instruments, it was launched last May by NASA. 300-million miles later, it arrived at Venus. But it's still traveling. It's now on a series of 243 one-day elliptical orbits around the planet—studying its atmosphere and mapping its terrain, close in and far away.

Multiprobe arrives.

The second spaceship was Multiprobe. Carrying 18 instruments, it was launched in August by NASA on a more direct 220-million mile trip. At a point 7.8 million miles from Venus, it divided into five fact-finding probes. And then these probes, including the parent "bus" that took them there, entered Venus' atmosphere to explore five widely separated planet areas. The information they beamed back about the planet's winds, clouds, and atmosphere will help clarify the mystery of how our own weather operates here on Earth.

A bostile neighbor.
The twin mission was the most complex unmanned space venture ever undertaken. What made it still tougher was tbe downrigbt bostile nature of our nearest planet neighbor, as experienced firsthand by Multiprobe.

920° hot.

Venus has a surface temperature of 920°F.—hot enough to melt tin or lead. Its surface pressure is as crushing as the ocean 3,000 feet deep. Its atmosphere is almost pure carbon dioxide. And its dense clouds aren't innocent water. They're sulfuric acid.

Aluminum blankets.
But scientific ingenuity at Hughes took up the challenges. For example, Multiprobe's fragile internal electronics were guarded by blankets made of special aluminized plastic sheets with great resistance to intense heat.

Titanium shells.

Special titanium shells proved to be ideal pressure vessels. Light in weight, they still could resist corrosion and 1,400 pounds of pressure per square inch.

A diamond window
Finally, our designers needed an unusual window for an instrument that senses radiant energy. Typical window materials weren't rugged enough. Sapphire windows used for other probe instruments would block infrared wavelengths. Solution: a 13-carat diamond window the size of two pennies stacked together. It worked.

90 revealing minutes.
In 90 minutes, the twin mission managed by NASA's Ames Research Center told 115 scientific and technical investigators more about Venus than astronomers have learned in the five centuries since Galileo.

Mission impossible?
NASA didn't think so.
And neither did Hughes.

Creating a new world with electronics
HUGHES
HUGHES AIRCRAFT COMPANY

ocean or over uninhabited places so few are seen (a single observer can scan only six millionths of the sky visible from all over our planet)

In August of 1972 a meteoroid estimated to be half a meter across blazed its way across the skies of the U.S. and Canada. It came as close as 58 kilometers from the ground. Before flying off into space again it was seen by thousands, and it was even photographed by one vacationer. In 1969 a large bolide broke up and fell in Mexico. Over 1000 kilograms of material were recovered. In China a few years ago, the largest stony meteorite ever found fell in many pieces over a wide area.

A great number of meteors are picked up by air-defense radar, giving us information on meteors around the clock. We now know that there are showers that occur only in the daytime. Last fall, air-force radar tracked a large meteor over Wyoming and provided enough data to enable ground-search parties to locate it.

About 20,000 years ago, a lump of iron from space perhaps the size of a train car and weighing 50,000 tons hit northern Arizona, leaving a crater a kilometer and a half across and 200 meters deep. The scar can be seen today as Barringer Meteor Crater near Winslow, outside of Flagstaff. In Canada, on some of the oldest exposed rock in the world, meteorite-impact scars millions of years old have not yet healed. The Manicouagan Reservoir, in Quebec, is an old crater only one of many discovered by aerial photography. And in Europe, several million people live in the Ries Kessel thought to be an old crater, with scant thought for its fiery formation.

A look at the moon shows clearly that it too has been the target of celestial bombardment. More than 30,000 lunar craters are visible from earth. Because the moon has neither atmosphere nor water to erode features, craters billions of years old are still preserved. In fact, the continual flux of meteoroids onto the moon's surface is one of the very few sources of lunar erosion. Until recently, Project Apollo seismometers left on the moon continued to record moonquakes and a few meteorite hits.

Will the earth be hit again by a large meteoroid such as the one that blasted the Barringer Meteor Crater? The answer has to be yes—but the size, place, and date are unpredictable. Certainly a large object hitting a populated area would do great damage, but the chances of this occurring are minimal. (Recall that 70 percent of earth is covered with water. Only about 20 out of some 500 meteoroids each year are ever recovered.) The dramatic possibilities of such an event have not escaped science fiction writers, nor Hollywood. A feature "splat" film just released has a large meteoroid targeted for Phoenix.

Rough estimates of the amount of rocks and debris in space indicate that a meteoroid of 100 metric tons (about 5 meters across) could hit the earth every three or four years; a million-ton monster (100 meters in size) could hit every few thousand years; and a ten-billion-ton juggernaut (a couple of kilometers across) is likely every few million years. The possibility of meteor impact should decrease as the solar system gets older since much of the meteoroid material, particularly the large stuff, gets swept up by the planets.

Even though small meteoroids are trillions of times more numerous than large ones, chances are you will never be hit by one. You could probably get very good insurance rates against it—but it can happen. One of the most famous cases occurred in 1954 in Sylacauga, Alabama, when a woman sleeping on her sofa was hit and bruised by a meteorite that crashed through her roof and ceiling. Other meteorites have hit buildings. There are reports of a dog being killed by a meteorite in Egypt in 1911, a calf skinned (!) in Ohio in 1860, and an unconfirmed report from 1511 of a meteorite fall killing "birds, sheep, and one Franciscan friar." The latter is probably wrong, for there have been no authenticated human fatalities due to meteorites.

A freshly fallen meteorite will not necessarily make a crater or be hot. As it flies from space into the earth's atmosphere at several tens of kilometers per second, the surface of the particles heats up, but by the time it reaches 60 or so kilometers from the surface, its cosmic velocity has been retarded by the air's friction until it is reduced to mere free fall. Little of the heat gets to the inside, and fresh meteorites will occasionally frost over as their interiors warm up slowly from the cold of space. The fall may even be quite gentle, for meteorites have been found lying on top of plants and even on the surface of a frozen lake.

Meteorites are of three types: irons, mostly composed of iron with nickel and other minor ingredients; stones, largely silicates; and stony-irons, a mixture of the two types and by far the rarest. Most meteoroids seen in space seem to be stones, but most meteorites found on the earth are irons, for two reasons. First, a lump of iron sitting in a field is much more likely to attract attention than a stone. Second, stony meteorites weather away faster than iron ones, and most meteorites are found long after their fall. Sporadic meteors seem to be about equally divided between iron and stony types, but shower meteors appear to be all stony.

Meteorites have been found to contain minor amounts of most of the known elements. Some have even contained low-quality diamonds. A type of stony meteorite, called a carbonaceous chondrite, contains organic compounds not of biological origin. It seems that a natural cosmochemistry can produce some types of organic materials. (The discovery by radio astronomers of vast molecular clouds in deep space lends credence to this idea.)

The largest known meteorite is the Hoba in South Africa, still in the hole it made and estimated to weigh 50 tons. The largest meteorite "in captivity" is the Ahnighito, 34 tons, found in Greenland and now at the Hayden Planetarium in New York. The largest meteorite found in the U.S. weighs 14 tons and was found in a pine forest near Willamette, Oregon.

How do you recognize a meteorite on the spot? It is not easy. A lump of iron is suspicious, and the existence of thumb-shaped depressions on its surface—caused by the ablation (vaporization by the heat of friction) during its flight—is a further clue. Of course, a crater is strong evidence. For stones, a dark fusion crust over a lighter gray interior is one indication. But any suspected meteorite must actually be analyzed by experts at a local museum, observatory, or planetarium, where you can often see exhibits of meteorites.

Meteorites are valuable, not so much because of intrinsic worth—although there are a number of collectors bidding up the price—as for their scientific value. They are messengers from space, and they are particularly valuable if they are seen falling and are recovered immediately before they are contaminated by terrestrial materials.

If you find what you think is a meteorite, take it immediately to your nearest astronomical institution. You may be holding a piece of cosmic real estate that dates back to the formation of the solar system. ▢▢

METEOR SHOWERS

Name	Date of Maximum Intensity	Hourly Rate at Maximum
Quadrantids	Jan. 3	40
Lyrids	Apr. 22	15
Eta Aquarids	May 5	20
Delta Aquarids	July 29	20
Perseids	Aug. 12	50
Orionids	Oct. 21	25
Geminids	Dec. 14	50

Meteor showers are visible from anywhere in the world, with best viewing times between midnight and dawn.

STARS

By Patrick Moore

I began a recent lecture by stating that for the benefit of absolute beginners I would spend a few moments going back to square one—anybody who knew the difference between an asteroid and an adenoid could take a quick nap Many people in the audience had no idea what an asteroid was, but asteroids are important, if only because they have been regarded as real hazards to spacecraft traveling through the solar system

At the moment we have had four vehicles (two *Pioneers* and two *Voyagers*) that have threaded their way through the danger zone without meeting disaster This may indicate that there is less cause for concern than was supposed regarding the density of the asteroid belt But it would be foolish to be overconfident for one simply cannot maneuver a spaceship, manned or unmanned to dodge an asteroid as it happens along

Asteroids are dwarf planets Most of them move around the sun between the orbital paths of Mars and Jupiter thereby dividing the solar system neatly into two parts Ceres, the largest asteroid is no more than 1100 kilometers across and there are many members of the swarm that are no more than a kilometer or two across Only one Vesta, is ever visible to the naked eye and even Vesta appears only as a dim starlike point

Oddly enough the asteroid belt—or rather a planet in the same region—was predicted prior to the nineteenth century, long before it was actually found Two German astronomers Titius and Bode calculated a mathematical relationship linking the distances of known planets from the sun Their calculations indicated a gap in the solar system between the orbits of Mars and Jupiter

Known as Bode s law, it was, in fact first drawn up by Titius (science is not always logical) Frankly I have a profound distrust of the law, and regard it as being in the category of those juvenile "take-away-the-number-you-first-thought-of games Yet when first proposed it was taken quite seriously

Some asteroids may wander away from their main orbital zone and approach the earth In 1937 Hermes, a mere kilometer in diameter brushed past us as close as 775,000 kilometers less than twice the distance to the moon One British newspaper printed the memorable headline 'World Disaster Missed by Four Hours Tiny Planet Whizzes Past ' There is always a chance of a direct hit and the damage while it may not result in worldwide devastation would be quite serious

Other peculiar asteroids are known One Icarus goes within 25 million kilometers of the sun so that at times it must be red-hot Another Eros is shaped like a cosmic sausage 29 kilometers long and about 14 kilometers wide We also have a true oddity Chiron, which wanders around the solar system between the paths of Saturn and Uranus Whether Chiron is a real asteroid we still don't know—it is approximately 640 kilometers across which by asteroidal standards is large What made the asteroid belt? One theory is that a planet in that part of the sun s family exploded for some unknown reason It may be that there were two old planets that met head-on, with cataclysmic results Or more plausibly the asteroids were produced from material that never formed into a larger body

They must be barren worlds—bleak airless, waterless and lifeless Go to one, and you will weigh little more than a postage stamp You would be able to leap clear from a small asteroid by sheer muscle power, thereby becoming a tiny independent planet in your own right

There have been suggestions of mining valuable minerals from asteroids (if such material exists) Perhaps their best use might be as unmanned observatories—particularly Icarus from which the sun would be magnificent indeed But well-placed probes *could* tell us the mineral value of asteroids

There was a film in which the hero went up in a spaceship equipped with a large net, and began asteroid fishing Even though so far as I know he had little luck these dwarf planets are full of interest Surely we must hold them in less contempt now that we have successfully navigated these shoals in space

Two Pioneer unmanned vehicles have successfully passed through the asteroid belt

LIFE

By Dr Bernard Dixon

If I were to ask whether flying bats avoid stationary objects more successfully than moving ones, and whether the health of an army of soldiers would deteriorate if the army were suddenly moved to insanitary conditions at high altitude, your replies might well be affirmative. If so, you would be wrong in both instances.

The unexpected in science is a teasing challenge to those who delight in gentle mockery of researchers who work assiduously and often expensively to establish what everyone knows already. Take the example of the bats. Philip H. S. Jen and J. Kenneth McCarty, working at the University of Missouri, were doing some experiments recently on the well-known ability of these amiable creatures to navigate by generating ultrasonic signals and listening to the echoes. In the laboratory, scientists studied this skill by making bats fly repeatedly between two wires and monitoring the number of hits and misses. Jen and McCarty set up an arrangement of this sort, using six vertical wires 30 centimeters apart. They then released little brown bats (*Myotis lucifugus*), which have an average maximum wingspan of 23 centimeters. Another set of trials was carried out with the array of wires oscillating horizontally.

For Jen and McCarty the results were totally unexpected. "When an agile bat flew between the stationary obstacles, it negotiated them almost without hesitation," the Missouri researchers report in *Nature* (Vol. 275, p. 743). "However when the barrier was moved, the bat hovered first at one side of the flight room before flying between the obstacles." Evidently these wary creatures were using their echo-location ability more cautiously when confronted with moving barriers. Indeed, all of the bats hit the oscillating barriers less often than the stationary ones—regardless of the size of the obstacles. The average percentage of misses in the two sets of experiments differed by 6.5 to 15 percent. Presumably, if one has to catch flying insects to survive, one concentrates more intently on moving objects. Could this explain Jen and McCarty's unanticipated discovery about bats' ability to navigate ultrasonically?

My other example was just as perplexing to the scientists involved—in this case members of the Armed Forces Medical Services, New Delhi. Their report, published in the *International Journal of Biometeorology* (Vol. 21, p. 93), records an unexpected aftermath of the outbreak of hostilities between China and India on the disputed northwest frontier in September 1962. Indian soldiers found themselves stationed for the first time at altitudes of between 3692 and 5538 meters. During the early weeks many of them developed acute mountain sickness or pulmonary edema. The medical scientists accompanying the troops felt extremely anxious about the soldiers' future health and performance. However, detailed studies made at the time and since have shown that a two- or three-year stay in the mountains is beneficial to health, with many diseases common at sea level actually decreasing in prevalence. Rates for bacterial, viral, and protozoal infections, diabetes, hypertension and ischemic heart disease, asthma, rheumatoid arthritis, gastric disorders, skin diseases, psychiatric ailments, and anemia were markedly lower at high altitude. And this despite the fact that the troops in the mountains took fewer baths than their colleagues below, changed their underwear less often, were colder, had less oxygen to breathe, and were more exposed to ultraviolet light and ozone.

Dr. I. Singh and his colleagues have had little success so far in accounting for their findings. True, there are beneficial changes in the body's circulatory system at high altitude, but these are short-term effects, quickly overtaken by acclimatization. Singh's team has shown very much more long-lasting merit in mountain living, even under harsh conditions.

Evasive bats, robust health at high altitude: two curious cases, but both recent examples suggesting that though accurate prediction is one of the hallmarks of science, there is nothing on the agenda for scientific investigation that can be dismissed in advance as "obvious." ◘◘

Monitoring hits and misses of brown bats, in pursuit of what everyone already knows.

BOOKS

THE ARTS

Who is Isaac Asimov, and why does he write all those books?

Just this month, Asimov's *two-hundredth* book is being published! In fact, his two-hundredth book is actually two books. His autobiography, *In Memory Yet Green*, is being released by Doubleday, and his *Opus 200* is coming out from Houghton-Mifflin.

In Memory Yet Green is in itself a two-volume work of more than 1500 pages. *Opus 200* contains selections from Asimov's second hundred works.

Two hundred books is an immodest amount of production. After all, Hemingway was satisfied with about a dozen books. Most writers are known for one or two. Asimov is a one-man book-of-the-month club, churning out books at a rate that threatens to denude the North American continent of its last trees.

Why would a writer rattle off book after book in this way? For money? Possibly. Samuel Johnson pointed out long ago that anyone who writes for any reason except for money is a blockhead. But that can't be the whole of Asimov's story. After all, the man began life as a scientist, a researcher, and a teacher with an assured career.

For fame? Again, possibly. Asimov is an internationally known figure, as famous in Russia (where he was born) as in America. His books have been translated into dozens of languages. I can personally attest to the fact that they are sold at kiosks in Paris, Rome, Athens, Tunis, *et many cetera*. But there must be more to this phenomenon than a mere craving for recognition.

There are at least three Isaac Asimovs: the writer, the public personality, and the private man.

Asimov the writer is someone whom nobody knows, because—like all writers—Asimov is alone when he is working. The public often gets a romantic view of the writer's life, but that's because the public sees the writer only when he's having fun, attending parties or giving lectures or signing autographs. Nobody sees the writer sweating over a stubborn scene that doesn't want to come alive. No one sees the writer racking his soul to find the exactly *right* words to describe a character, an event, an emotion.

Asimov has often said that he enjoys writing, enjoys the physical process of transferring his thoughts into words on paper. There is no reason to believe he would lie about this, but he is the only writer I know who actually enjoys the work.

Then there's Asimov the public personality.

Isaac has built up a public *persona* that obscures his basic shyness with overkill. He loudly proclaims himself a genius and then goes on to prove it. He ogles, fondles, pinches, and makes lewd (but witty) remarks at any and every female in sight. And he gets away with it!

It's not just that people put up with him because he's a famous writer. Many another famous writer has acted just as boorishly and gotten the bum's rush for his efforts. Asimov gets away with it because he obviously is joking, and the joke is on him, really. He enjoys being the center of attention, and everyone quickly realizes

Isaac Asimov, author of more than 200 books.

that everything he's saying and doing is strictly in fun. No one gets offended, or if someone does get miffed he or she simply doesn't understand the situation.

Asimov gets away with his boisterous routines, also, because he is by far the best public speaker most of us will ever have the privilege of hearing. He is witty, often sidesplittingly funny, cogent, always incredibly interesting—in short, brilliant.

There was one time, though, at a Star Trek convention (of all places), when we turned the tables on him. A little.

Several hundred Trekkies had gathered in the auditorium that morning to hear a writers' panel. The writers assembled on the dais were, in order of their seating, Asimov, myself, Harlan Ellison, Harry Harrison, Barry Malzberg, Hal Clement, and Gordon R. Dickson. The moderator of the panel, scanning this mighty array of talent, asked each writer to introduce himself and tell the audience a little about his work.

Asimov, being first, said, "My name is Isaac Asimov, and right now I'm writing a book about the collapsing universe."

The writers instantly flashed to the possibilities of the moment.

My turn, so I said, "My name is Isaac Asimov, and I write all of Asimov's history books."

A murmur swept through the audience.

Harlan Ellison's turn. "My name is Isaac Asimov and I'm writing Asimov's guide to senescence."

Laughter from the audience.

Harry Harrison. "My name is Isaac Asimov, and I'm writing Asimov's guide to hemorrhoids, or 'Hang in There.'"

By now the audience was convulsed, and as each succeeding writer solemnly declared that he was Isaac Asimov, the uproar grew.

The poor moderator, faced with a circus instead of a panel, finally restored order and, red-faced, said, "Come on now, you guys. Will the real Isaac Asimov please stand up?"

Isaac remained seated, of course, while the rest of us rose.

To this day, there must be Trekkies from that audience who are convinced that they—and they alone—know how Asimov

CONTINUED ON PAGE 140

THE ARTS

Fantasy writer Harlan Ellison, winner of three Writers Guild awards for most outstanding teleplay, three Nebula awards for fiction, and seven and a half Hugo awards for fantasy pieces, didn't answer his phone. A mechanical device, technically a robot, did it for him. (Scratchy '30s ballroom music under Ellison's voice.) "It's swell of you to join us here in the lovely *lucite* room of the palatial Hotel Sheets in downtown Plunketville. Thrill to the cardiac-arresting music of Ambrose Bierce and his Royal Plunkettvillevanians here in the beautiful gold, yellow, copper, steel, iron, cardboard, lucite, and plywood ballroom of the Hotel Sheets in downtown Plunketville, overlooking the uptown section of downtown Pottstown. Stay with us, won't you, and scratch along to the sweetest music this side of old Stonehenge. And now, to get things under way, Ambrose and his loyal Banditos suggest you leave your current name, phone number, and a brief message. Twenty seconds is all you've got, so loosen your tie, put on those old dancin' shoes, and wait for the musical beep rendered in lilting lyric by little Harlan Ellison." (Music for one second, followed by beep.)

As I leave my message a voice interrupts. It is Ellison. After brief introductions we discuss his current project, the screen adaptation of Isaac Asimov's *I, Robot*. "The story cycle appears in two books," Ellison explains, "*I, Robot* and *The Rest of the Robots*. Although *I, Robot* has been under option for fifteen years, no one has been able to translate it from book to screen because it's made up of an unconnected cycle of stories. Although one or two characters appear a few times, there's no thread connecting them. The stories were written between 1939 and 1950, off and on, and the only character who reappears throughout is a woman named Susan Calvin. She's the foremost robo-psychologist of U.S. Robots and Mechanical Men, which is the company that first began making robots. Even Isaac agrees that the stories are outdated, but people misremember them. One may think they're very exciting and that there's a lot going on, but there isn't. Most of the stories are just conversations between two people about some crazed robot and the nature of dealing with the problem. They just work it out, and that's it."

Robots, both man-made and alien-produced, have played a major part in science fiction and fantasy films. The different strains of robots represented on screen have included everything from exact replicas of human beings to the most outlandish creations imaginable. Contrary to Isaac Asimov's three laws by which robots live (robots would not harm human beings, would follow orders and would look after themselves), the screen machines we have watched in the past six decades have sometimes been as villainous as the monsters who created them. But for the most part, movie robots have helped mankind, saved lives and generally served their masters well.

The most popular robots today are R2D2 and C-3PO, George Lucas's *Star Wars* co-stars. But the past has had its share of robot cult heroes as well. *Forbidden Planet*, the 1956 space opera that was essentially Shakespeare's *The Tempest* retold on another planet, boasted Robby the Robot, the only robot to appear in more than one film as himself. His immense popularity demanding a second look in *The Invisible Boy* (1957). Though once the idol of movie-goers, Robby was scrapped by M.G.M. Studios several years ago when they saw no further use for him. With the recent interest in science fiction films, though, Robby once more came into demand. A dedicated fan rebuilt him, and he now makes personal appearances at supermarket openings and is expected to return to the screen in the near future.

During the '50s and '60s every other science fiction and horror film seemed to feature robots: giant ones, magnetic ones, atomic ones, even robots with hearts. Asimov's stories, as seen by Ellison, will not dramatize the sentimental aspects of the machines. Instead, they will show how symbiotic the relationship between man and machine has become. The approach will be sure to draw praise from purists, but it remains to be seen if a mass audience will accept the concept of a normalized relationship between humans

Isaac Asimov (left), author of the novel I, Robot, *and Harlan Ellison, who is writing the screenplay.*

and robots. Without the excitement of a conflict, the chance of success seems lessened.

In 1977, producers John Mantley, Edward Lewis, and Mildred Lewis made a deal with Warner Bros. to produce the film. After some initial difficulties, Ellison was cleared through the Warner Bros. decision makers as writer, and he began the screenplay in November of that year. He is still at work, refining the 200-page script to suit his personal vision. "The only way to do the film is by using Susan Calvin as the central thread of the story. It's like a homage to *Citizen Kane*. The development of the story line will examine who Susan Calvin was, where she came from, and so on. In exploring her personality, the film will tell five of the stories in sequence: "Robbie," "Liar!," "Runaround," "Lenny," and a vignette from "The Evitable Conflict." They'll present a panoramic portrait of the interaction between robots and humans as seen through Susan Calvin's personality.

"I've tried to parallel Welles's *Citizen Kane*, through scene after scene after scene. When I sat down to do this film, I realized that because it's an epic film, and you must have some kind of grounding to do one properly, I needed a model. The story's got to move. Well, obviously, I decided to use *The Odyssey*, and *Citizen Kane* is just a reinterpretation of that, as is *Stagecoach* by John Ford. *I, Robot* is a journey into the soul of a woman. She literally saves the world. But why does she do it? How does she do it? We don't find out until the end. We find out that she did it because she was alienated from the human race. People weren't kind to her. Her father, like my father, was a man who was never able to realize any of his dreams. She's paying the price for him, trying to buy his immortality."

It's all very well for a writer to add his own point of view when he adapts a story from one medium to another, but when the story is as well known as *I, Robot* the danger of alienating the original author becomes a hazard as well. Ellison has taken pains to see that that doesn't happen. "Isaac has been kept informed every step along the way," he points out. "In fact, he's technical advisor. We're very, very close, have been for twenty years, and he's delighted with the results."

Ellison feels he'll satisfy the audience with his interpretation of the material. "I've kept the book's integrity in my translation of it to the screen, but there's no way of living up to people's memory of the original. Because it's such a major work, there are set ideas about the material. People remember it the way they *wish* to remember it."

Though unwilling to speculate on the film's special-effects possibilities, Ellison did confirm the presence of a single spacecraft flying through the galaxy. "It's the only spaceship left in existence, because that style of transportation has been supplanted by teleportation. There *must* be a progression of technology and culture. You cannot have a society with swords and knives and also laser rifles. That just doesn't work. A man is not going to fence and duel with a sword when someone 13 meters away can plug him in the head with a gun. I've tried to keep the chronology consistent with history." One of the things Ellison does is to take the faster-than-light mode of travel beyond spaceships and move it into a teleportation booth. "The sole remaining spaceship has the job of planting the next receiver booth at the end of the line, and its two pilots are the only spacemen left, two old guys named Donovan and Powell. Their purpose in life is gone because they've been replaced, outmoded."

Theorizing on the visual presentation of the more than 20 robots that will populate the film, Ellison said they would be created by leading cybernetic designers in conjunction with technical adviser Asimov.

"It's a 200-page script, and it will probably be budgeted at $30,000,000, so we're talking about a very big, big film. And because I despise *Star Wars*, *Close Encounters*, and crap like that, I have really broken my back to make this a story of human beings with the sensitivity of a film like *Charly* and the science that one would expect from an Asimov story. When the script was handed to the studio, their response was, and this is a direct quote, 'It's brilliant. It's a work of genius. We'd like to make a few changes.'"

After having spent over a year on the project, Ellison is less than happy at the possibility of his script being rewritten by another writer. Nevertheless, he refuses to make any changes that he feels will compromise his vision. "I write with what Balzac called 'clean hands and composure.' I write a film the same way I would write a book. I do not debase my material. I will not demean my craft. I will not insult my potential audience, which I conceive of as being the most intelligent, witty and perceptive audience in the world. I write for an audience of one, and that's myself, okay?

"I write the film to please me. Afterward, if they want changes, I will go along only insofar as I can see they do not hurt the material. And if I won't do the rewrites, they always have the option of removing me. They can do what they want with the film, but my draft exists on paper. And if it only appears in a book somewhere, if it only appears in a collection of mine, if it's only reprinted in a paperback, then it's still my film, still *my* film. I'm a dynamite writer, and I'm not going to waste my life altering things to satisfy the needs of clerks. There's no compromise. I *bled* for this script. There's my father in this script, there's my life in this script, there's Isaac's life in this script, there is Isaac's dream, and my dream. If they don't want to do 100 percent of what I gave them, 97 percent when I make the alterations that I think are acceptable, then tough! Fuck 'em!"

What is Ellison trying to do? Why is he so adamant? "A film of this sort *could* add enough to the body of work that exists on science fiction films to change things slightly, the way *Star Wars* did. That is my hope. My secret hope. I'm almost afraid to say it. I'm not given to that kind of pomposity, thinking that my work will alter *anything*, but that is my secret hope. People have heard me say that *Star Wars* stinks, that *Close Encounters* is bullshit, and that *Battlestar Galaxative* [sic] ought to be deep sixed, and they keep saying, 'Well, what should we have?' *I, Robot* is my answer." —James Delson

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ASTRONOMY AND THE FLYING SAUCER

UFO UPDATE

By James Oberg

Why aren't professional astronomers reporting UFOs? If extraterrestrials really are visiting our planet, shouldn't astronomers be the first to know?

The question is much more complex than that. Astronomical telescopes peer deep into the universe, but they cover very small areas of the sky (airplanes for example, rarely appear). Moreover, astronomers these days don't spend much time looking through telescopes, preferring instead to examine photographic plates or watch closed-circuit-tv monitors.

Those few reports on file read like everybody else's. Astronomers, more familiar than the average person with sky phenomena, do tend to report fewer "unidentified" sightings, but they still from time to time report UFOs.

According to a survey of astronomers' opinions concerning UFOs, conducted in 1976 by Dr Peter Sturrock of Stanford University 70 of the 2611 astronomers polled replied that they had "witnessed or obtained an instrumental record of an event which (they) could not identify and which may be related to the UFO phenomenon." This figure of less than 3 percent represents only about one quarter of all those Americans who claim to have seen UFOs.

More than 90 percent of average cases readily yield to prosaic explanations. The residue of "unexplaineds" possibly would be higher for astronomers since they might be expected to recognize sky phenomena that could mislead ordinary citizens. But Sturrock did not investigate those reports sent to him, since that was beyond the scope of his study.

Still, the astronomers' stories are intriguing. Many such cases involved "nocturnal lights" for which there could have been numerous explanations (one case ultimately was identified as a distant rocket launch, which UFO investigators were reluctant to accept), but some of these were definitely noteworthy. In particular several astronomers reported seeing lights hover motionless for many minutes, only to suddenly shoot up into the sky and vanish. Other lights appeared in bizarre formations, executing enigmatic maneuvers. Similar-sounding cases from other witnesses, when investigated, *have* yielded explanations, but these stories continue to sound strange nonetheless.

Some "classic" flying saucers were reported. An astronomer and his family watched a "silvery disc-shaped object" with "bluish-green lights at the rim and a red light at the center" zip over their car shortly after sunset one summer. A glowing sphere was seen to dance around a tall tree one night (possibly it was ball lightning, but scientists do not really understand ball lightning, either!). A flying platform complete with rotating radar antenna reportedly buzzed the Princeton University campus one evening in April 1969. A flat silver-gray disc flew in front of an astronomer driving along a mountain road in New Mexico; his truck stalled when he tried to speed up after the object.

While fascinating, these cases have not actually been checked by experienced UFO investigators. Indeed, they probably never will be. Such stories do show, however, that astronomers see UFOs like everybody else—but much less frequently despite their greater attention to the sky.

One "identified flying object" (or IFO) is a testament to the observer's acute perception—and to the element of luck that often is the only way some baffling cases ever get solved. While driving along the coast in daylight near Pensacola, Florida (some 20 years ago), the astronomer noticed a bright aluminum-hued flying saucer in the sky ahead of him. The sharply outlined disc was about the width of the full moon.

But as the man drove on, the "saucer" faded from view without moving. Carefully scanning the sky where the UFO had been seen, the astronomer noticed a very thin cloud layer. He concluded that he had been watching a reflection, evidently from an inversion layer (such thermal effects have led to numerous reports of "shiny silvery discs"). The UFO had been a phantom. It had not been an object, nor was it ever flying, and it was now no longer unidentified.

There is, however, one phase of astronomical research that relates directly to the UFO question. These are so-called "full-sky" searches for meteors and

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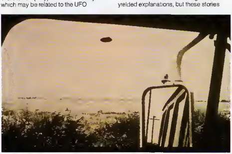


Authenticity of Rex Heflin photo (above) is subject of internecine battle among UFO buffs

CONTINUUM

THE INFORMATION EXPLOSION

Every day newspaper headlines warn us of shortages—the scarcities of food in the Third World, of arable farmland, of energy But there's one resource that is certainly not scarce and is, in fact, growing at an almost uncontrollable rate That resource is information, and its unprecedented proliferation in the last two decades has closely paralleled the development of today's multibillion-dollar computer industry As we shall soon see, it is no accident that computers and information have chosen to explode upon society at roughly the same time

In science, perhaps more than in any other area, the impact of the information explosion has been strongly felt. Over ten million authors are producing scientific writings at a current rate of 6000 to 7000 articles per day Between 1960 and 1975, the world production of periodicals increased fivefold to an estimated 100,000 The total volume of scientific and technical information now increases by 13 percent each year, and this rate may jump to 30 or 40 percent after the introduction of new, more powerful computer data handling systems

These figures only serve to reinforce that of which most of us are already aware We are rapidly becoming what Harvard sociologist Daniel Bell calls the "information society" As early as ten years ago, the information industries produced 46 percent of the Gross National Product, and nearly half the labor force was employed in information-related jobs. As Andrew Molnar of the National Science Foundation points out "Information has become a national commodity and a national resource and has altered the very nature of work"

An overabundance of something, however, can produce as serious and compelling problems as not having enough of it The remarkable data-processing capability of computers, rather than easing the burden, seems only to be burying us deeper under mountains of unmanageable data At a recent meeting of information specialists in Washington, D.C., the French economist Georges Anderla warned that "information pollution" now threatens in the wake of the onrushing flood of scientific and technical writings "It takes more time to find out if an experiment has ever been done before than to carry out the experiment from scratch," lamented one scientist. He is not alone in grappling with this problem Even experts in extremely specialized fields are finding it impossible to keep abreast of new developments in their field Important findings may go undiscovered for several months or years, and in a nation whose technological growth is spurred on by scientific innovation, this time lag represents an enormous loss to the economy

Clearly, vast amounts of information must flow at ever faster speeds between the layers and substructures of our society if solutions to complex problems are to be found. But how can we keep from drowning in data?

Computers, a major source of the problem, are also the key to the solution

The interconnection of large computers to form extensive networks has already begun. From terminals linked up to this system in offices or homes, individuals will soon be able to gain immediate access to a vast data bank ranging from up-to-date abstracts or newspaper articles to government reports

In the scientific publishing field, where long lead times often make information obsolete by the time it appears in print, a computerized system could revolutionize the industry Rather than publishing new discoveries in magazine or journal form, editors could enter specialized technical information immediately into a computer data bank

But a major problem remains As computers become increasingly indispensable in science, business, and government, the gap widens between those educated in their use and the rest of the population Individuals ignorant of computing skills will lack an essential tool for coping with a rapidly expanding information base As Molnar emphasizes, a national effort is needed to introduce computers into educational curricula from kindergarten to the university so that students will experience computer uses on a day-to-day basis "In an information society," he writes, "a computer-literate populace is as important as energy or raw materials are to an industrial society"

Imagine yourself in the 18-million-volume Library of Congress, but with no card catalogues, no Dewey decimal system, no alphabetical arrangement of the books according to author or subject matter Every single book that has ever been printed in America is there, haphazardly arranged on the shelves In a world drowning in information, computer illiterates may feel the same sense of bewilderment —*KATHLEEN McAULIFFE*

CONTINUUM

BUILDING A BETTER MOUSE

Joining the modern rat race is a pink-eared do-it-yourself microcomputerized mouse from Richland Washington The robot rodent designed by three computer experts from Batelle Labs and called Moonlight may be the smartest mouse made by man

Built to race in the "Amazing Micro-Mouse Maze Contest" sponsored by the Institute of Electrical and Electronics Engineers' *Spectrum* magazine the Moonlight Special began its test run by exploring every blind alley of the one-and-a-half-by-two-and-a-half-meter maze Then on the third try Moonlight computed the best route and rolled directly to the exit—in a sizzling 51 4 seconds

To top it off on a victory run' after the competition Moonlight flashed through the labyrinth again in 40 seconds flat to demonstrate how much it had learned from the previous trip

Moonlight s owners, Art Boland Phil Stover, and Ken Dilbeck, used infrared emitting diodes coupled with photodetectors and a Z-80 microprocessor to create the small, self-contained self-directing unit capable of making decisions at 99 different points in the maze

The race isn t over for Moonlight, however, who posted the record time in a Los Angeles preliminary time trial Moonlight is expected to face tough competition in the Micro-Mouse finals to be held at the National Computer Conference in New York this June

—Phyllis Burns

IEEE

Moonlight See-through photo reveals electronic inner organs

THE HEALING TREE

It was Asia that gave us the Japanese beetle, archfoe of many U S gardeners Someday a second Asian

USDA

Neem tree A new beetle killer

import may make up for the damage The neem tree, a tropical species also found in Africa seems to repel the Japanese beetle

In China and India the neem tree is an almost mystical source of healing drugs Its leaves have been used to treat ulcers, its bark to cure fever, nausea, and the bites of scorpions and snakes Hindus hold the neem tree sacred

In the U S , its reception has been more prosaic Scientists at the Department of Agriculture's Japanese Beetle Research Laboratory in Wooster Ohio have been crushing its seeds for their oil

When the oil is sprayed on soybeans and sassafras Japanese beetles avoid the leaves In one test they starved to death rather than eat neem-oil treated leaves Only one plant has been found whose appeal is strong enough to overcome neem oil the rose

My guess is that neem oil makes leaves taste bad to Japanese beetles," says Dr Thyril L Ladd, Jr, research leader of the laboratory

There are only five neem trees in the whole United States four of them under the charge of Dr Robert J Knight Jr, at the Department of Agriculture's Subtropical Horticulture Research Station, in Miami, Florida

Dr Knight believes the neem could flourish in southern Florida and the Caribbean In 1977, he points out a neem tree survived Florida's worst frost in the past 60 years

—Barbara Ford

VERY SMART CHIMP

Experiments at the University of Pennsylvania may have brought us several steps closer to the goal of communicating with the animal world

Psychologists David Premack and Guy Woodruff recently tested Sarah a 14-year-old chimpanzee (shown at right) for her ability to pick the right answers to a series of problems She got high marks

Premack and Woodruff showed Sarah a videotape of a problem—say, being unable to reach a bunch of bananas—acted out by a human she had never seen before Asked to find a way around the visual dilemma she chose between two photographs one showing a workable solution—in this case stepping on a box to reach the bananas—and the other showing the actor doing something unrelated to reaching the bananas

Sarah picked the right one more than eight times in ten This implies comprehension of an unfamiliar problem and suggests that reasoning is not a uniquely human skill

The next step is to find out whether human babies exhibit the same sort of comprehension Sarah does

Organic chemistry is the chemistry of carbon compounds Biochemistry is the chemistry of carbon compounds that crawl

—*Mike Adams (in newsletter of Nebraska-Western Iowa Mensa)*

Sarah: An 80 percent score.

STOPPING THE SEAL SLAUGHTER

The Greenpeace Foundation best known for its attempts to prevent the

Harp seal: A new plan to stop the killing . . . but nobody's talking.

slaughter of whales, also hopes to stop the annual harp-seal hunt which begins next month in Newfoundland, Canada.

Greenpeace refuses to divulge their current strategy. Last year, the widespread publicity that preceded their arrival in Newfoundland enabled the Canadian government to enact legislation to block their plans.

Greenpeace then intended to spray the harp-seal pups green Since the baby seals remain white for only three weeks, the dye would have effectively prevented the hunt The Canadian government hurriedly amended its Seal Protection Act to ban any attempt to tag or mark a live seal in any manner

Despite this setback Greenpeace plans to try again this year For further information, write Greenpeace, 240 Fort Mason, San Francisco, California 94123

"It is easier to believe that a Yankee professor would tell a lie than that a stone would fall from the sky"

—Thomas Jefferson, in response to a report by a Yale chemist who had personally witnessed a meteor falling to the earth

"If it would take a cannonball $3\frac{1}{3}$ seconds to travel four miles, and $3\frac{3}{8}$ seconds to travel the next four, and $3\frac{5}{8}$ to travel the next four, and if its rate of progress continued to diminish in the same manner how long would it take to go 15 hundred million miles?"

—Arithmeticus Virginia Nevada

"I don't know"

—Mark Twain

"BULLET-PROOF"

Investigators with the International Association of Chiefs of Police in Gaithersburg Maryland were recently chagrined to learn that many bullet-proof vests are not worthy of the name Nearly half of the products meant for wear in life or death situations their federally funded study proved are so poorly constructed that they provide scant protection

The association's published report describes tests on 53 models of bullet proof vests and other body armor 25 of which failed to stop speeding bullets of various calibers With eight of these so-called protective garments shells not only penetrated but went on to leave sizable depressions in the targets behind

UPI

Cop with vest Lots of luck

CONTINUUM

COSTLY RUST-OUT

Corrosion—the breakdown of metals by air water and chemicals—is considered by most people to be a somewhat trivial nuisance A

Billions of dollars are already being spent to slow the natural corrosion process Bridges are painted, industrial machinery is coated with special lacquers and such familiar

Rhoda Galyn Photo Researchers Inc

Rusted out car Corrosion now costs Americans $70 billion a year

car rusts silver tarnishes an iron tool pits But a study by the National Bureau of Standards has concluded that corrosion costs U S consumers an astounding $70 billion a year In other words the bureau says the annual cost of corrosion would equal a stack of thousand-dollar bills nearly eight kilometers high

Almost as soon as metal items are made they begin to crumble Nuts bolts bridges, boats wrought-iron fences bronze copper brass—their strength and substance are eaten away by the action of saltwater air pollution heat and a variety of chemicals

items as car bumpers and household appliances are electroplated with corrosion resistant metals such as nickel and chrome But at least $10 billion of the annual cost of corrosion—and perhaps as much as $30 billion—is avoidable by such means as the proper maintenance of equipment, the coating of rust spots on cars with antirust compounds and better finishing of products when they are manufactured The bureau provides a consumer guide for such protection Address Consumer Information Center Pueblo Colorado 81009 Ask for ' Corrosion Facts for the Consumer

SHUTTLE LIFESAVERS

The Space Shuttle carries a crew of up to seven astronauts At most, four will be supplied with space suits That brings up an obvious question In case of trouble, how do the unsuited crew members get from the damaged shuttle to a rescue craft?

NASA's answer is an 86-centimeter plastic ball Made of the same plastic laminates as the space suits themselves the "personal rescue enclosure" collapses into a small package weighs far less than a space suit, and costs only $25 000, compared with $200,000 for a full-fledged suit

In time of trouble the ball is inflated from the shuttle's oxygen supply, the astronaut dons a chest pack containing an hour s supply of oxygen and crawls inside, drawing his legs into a fetal curl Then a suited astronaut carries the ball across to the rescue ship as demonstrated by NASA personnel in the photograph at right

"Ideally, both craft should be stable so that they can run a line between ships and haul themselves across on it, comments James McBarron section chief of NASA s space suit assembly section "In an emergency, though I guess you'd take your chances and jump across "

There are several alternatives to the ball McBarron notes You could dock the two ships or run a rigid tunnel between them if the craft are stable, or NASA could supply space suits for the entire crew

But these plans, he says, both are more expensive and require far heavier equipment

"We've made only a few prototypes so far" the engineer reports "The rescue enclosures are not needed until we have at least two shuttles flying—one to get in trouble the other to perform the rescue That will be in 1981 or 82 "

'The demonstration that no possible combination of known substances, known forms of machinery, and known forms of force can be united in a practical machine by which men shall fly long distances through the air seems to the writer as complete as it is possible for the demonstration of any physical fact to be "

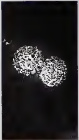
—Simon Newcomb, American astronomer 1906

NASA

Astronaut carries rescue ball

DANGEROUS SEX

All the anxiety and effort that go into sex—attraction and avoidance, courtship and copulation—is a waste of time and energy for most



Philip A. Harrington/Peter Arnold

Amoeba reproducing asexually

species, according to Martin Daly of the Department of Psychology at the University of California at Riverside. Asexual reproduction would be far more efficient, he argues, and free of the multifarious dangers of mating: injury to the female or male, vulnerability to predation during elaborate sexual displays, and the risk of venereal disease, not to mention nonvenereal diseases transmitted during close encounters.

Daly contends that the industry of two individuals working to accomplish what one asexually reproducing animal could achieve on its own is a questionable tack for evolution to have taken. He is not at all sure that the one obvious advantage of sex—genetic variation in offspring—offsets the disadvantages. Only in certain species, he says, where social habits and long periods of infantile development require the attentions of two parents (birds and humans, for example), does the high cost of sex pay any real dividends.

The assumption here is that the pleasure of sex, which is motivation enough for most people, came along as an adjunct to sexual reproduction—an evolutionary fail-safe mechanism to ensure our taking the risk and trouble to procreate.

FLIPPANT EARTH

Earth scientists have long been baffled by geomagnetic reversal. We know by the existence of reversely magnetized rocks at least 30,000 years old that the earth's magnetic field in ancient times was opposite to today's north-south configuration. In fact, the earth's magnetic field has probably switched several times.

Now one scientist thinks he knows why. Our planet occasionally flips end over end in space. Many times in the past, writes P. Warlow in the *Journal of Physics*, the earth may have somersaulted so violently that the North and South poles changed place.

The earth spins relatively slowly, which, Warlow thinks, makes it unstable and easily flippable. A near miss with an asteroid or other cosmic body, according to Warlow, could provide the turning force necessary to flip the earth. These astronomical events happen often enough to explain the large number of geomagnetic reversals known to have taken place.

A somersaulting earth would theoretically cause massive upheavals, especially if, as Warlow suggests, the flip-flop could occur in as little time as one day. He calculates that the effect on land animals might be minimal, although oceans would be drastically affected.

LET'S GET SMALL

In this age of energy consciousness, shorties may be one up on tall people. The big don't just fall harder. According to Thomas Samaras, writing in *The Futurist*, they need more clothing and pollute more as well.

A person 30 centimeters (one foot) taller and proportionally heavier than another consumes over 50 percent more food. For a population of 500 million, each added 30 centimeters of average height increases costs by $500 billion per year.

Samaras also believes that shorter people live longer. In studying the records of over 260 famous people, he found that lifespan declined gradually as height increased. Those under 1 meter 72 centimeters (5 feet 8 inches) lived up to 12 percent longer than those over 1 meter 82 centimeters (six feet).

Perhaps a new era is beginning. Thanks to ABC Television, we already have a short hero—Herve Villechaize, who plays the part of Tattoo on *Fantasy Island*. Villechaize has drawn more publicity than his taller, more energy-intensive co-star, Ricardo Montalban.

ABC

Villechaize and Montalban: Short people are ecologically sound.

CONTINUUM

DRINKING GARBAGE

The garbage dump, once considered an acceptable way to dispose of wastes, is proving to be a potential poison for residents in the eastern half of the country. A federally funded study has found that almost 90 percent of the waste-disposal sites east of the Mississippi River are leaking deadly chemicals and other noxious materials into the underground water supply, which is used for drinking by half of the population.

The study, by a Long Island, New York, firm, Geraghty & Miller, found that rain constantly washes through the disposal sites, picking up the poisonous chemicals dumped there. The contaminated water then continues through the underlying porous soil to the drinking supply. Once underground, the contaminated water migrates laterally—up to half a mile in some cases—to areas where wells may be sunk for drinking.

At a Connecticut site, groundwater concentrations of ketone, a paint thinner, were found to be ten thousand times the health limits for drinking water. Cyanide, lead, and a variety of pesticides were detected in the underground water supply.

Putting liners under new disposal sites and installing treatment systems may reduce the contamination, researchers concluded. But such methods have been installed in only about 5 percent of the dumps—and they are quite costly. Officials in many areas are now banning new dumps from areas with very porous soil, but this does not alter the legacy of poisons from the past. Many areas are now faced with million-dollar programs to detect the chemicals in drinking water, close contaminated wells, and drill new ones with purer water.

Ray Ellis/Photo Researchers, Inc.

Garbage dump: Its chemicals may end up in your drinking water.

SUSPICIOUS EARTHQUAKE

Soviet seismologists predicted a devastating earthquake in Iran last September

Wide World Photos

Tabas: Victim of Soviet bomb?

about two weeks before it occurred. Just how they managed the feat, no one is quite sure, but there are strong suspicions that the Soviets may have actually triggered the quake with an undergound nuclear test in Siberia.

The earthquake, a Richter 7.4 catastrophe, leveled the town of Tabas, southeast of the Caspian Sea, killing an estimated 25,000 people.

According to Soviet academician A. G. Babaev, of the Turkmen Academy of Sciences, he and his colleagues were able to forecast the time, intensity, and approximate location of the Tabas quake from changes in the groundwater levels and land slope at Ashkhabad, in the Soviet Union, about 480 kilometers away.

Outside the Soviet Union, seismologists are not satisfied with this explanation. True, Ashkhabad is the focus of one of the world's most active fault zones. In 1948, an earthquake destroyed the city, killing 80 percent of its inhabitants. The region suffers about 1000 tremors each year.

And in recent years, the shocks have grown more powerful. Apparently a new canal that stretches 1360 kilometers east from Ashkhabad has raised groundwater levels in the area, promoting transmission of shock waves.

But the shock waves of this earthquake just didn't follow the normal pattern. For one thing, the tremor appeared to originate far nearer the surface than usual, only 15 kilometers or so down. More significant, natural earthquakes are almost always followed by less powerful aftershocks within a day or so. None were detected.

Skeptics point out that about 36 hours before the Tabas disaster, the Soviet Union detonated an underground nuclear test 4000 kilometers away, in Semipalatinsk, Siberia. The test was considerably larger than most, about ten megatons.

Was it the nuclear blast that touched off the Tabas earthquake? And if so, was it knowledge of the impending test that enabled Soviet seismologists to predict the temblor? Many geologists are wondering.

—Owen Davies

TERROR BIRD

What is as big as a man, runs faster than a horse, eats meat and has feathers? Answer: The flightless *Andalgalornis*, or "terror bird," the nastiest bird ever to have lived in South America. Luckily, the animal has been extinct for 3 million years.

Actually, between 3 million and 35 million years ago, South America was inhabited by many Phororhacidae (the scientific name for an entire group of terror birds that included several species, one of which, the *Onactornis*, was two and a half meters (eight feet) tall.

But the most dangerous terror bird was *Andalgalornis*, speculates paleontologist Larry G. Marshall of Chicago's Field Museum of Natural History. It was one and a half meters (five feet) tall and may have moved faster than a horse. Fossils from Argentina show that it had long, slim legs and a massive beak and head. It probably ran down its prey, struck it with its feet, and tore it apart with its beak.

Andalgalornis model: Most dangerous bird ever to have existed.

"*Andalgalornis* must have been a nightmarish terror to animal life of its day, and it was probably the most dangerous bird ever to have existed," says Marshall.

The terror bird, he adds, managed to flourish for so long because South America was cut off from North America by water for a long period. Other than marsupial carnivores, there were no other meat eaters around to compete with these birds. Three million years ago, however, a land bridge reformed between the two continents, allowing carnivorous canines and felines to move south.

These carnivores evidently proved to be fiercer competitors, and before long the world's most dangerous bird became extinct.

Could the terror bird return? Today one distant descendant remains—the *Cariama*, a long-legged bird two thirds of a meter (two feet) tall. "It is intriguing to speculate," writes Marshall, "that if all carnivorous mammals were to vanish from South America, cariamids would again give rise to a group of flesh-eating ground birds . . . strikingly similar to *Andalgalornis* and its bygone allies."

We will have solar energy as soon as the utility companies solve one technical point—how to run a sunbeam through a meter.
—*Anonymous from* M Pulse, *newsletter of Dayton, Ohio, Mensa*

FUTURE MOUTH

All that mushy food we've been eating in recent millennia has produced a modern jaw inadequate for modern teeth, according to Milford Wolpoff, a University of Michigan anthropologist. He says the modern jaw is just too small—not for beauty but for our 32 teeth.

Prehistoric man had a jaw, mouth, and teeth two to three times as big as ours, the result of eating hard-to-chew unprocessed food and using the teeth as a tool for grinding, tugging, and other purposes. Today we have the same number of teeth as our iron-jawed ancestors but a much smaller mouth and jaw. The result: overcrowded teeth and dental problems. Eventually, speculates Wolpoff, we may evolve a mouth with fewer teeth to accommodate our changed eating habits.

"We can get by with 12 teeth," he asserts. "Six in each jaw. Why do we need a lot of teeth to chew most of our food? You can eat a McDonald's hamburger without any teeth."

Prehistoric human skull: A jaw two to three times as big as ours.

CONTINUUM

MORE ANCIENT ASTRONAUTS

Ancient-astronaut theorists may not be as much in the public eye as they were a few years ago, but they are far from a vanished breed. The Ancient Astronaut Society is alive and well and sending out press releases.

Latest in their 'proof' that earth may have been visited by extraterrestrials long ago is this two-inch gold model, a replica of a Colombian artifact now in the Smithsonian Institution. The original was found in a 1000 year old grave, according to Smithsonian archaeologists. About 25 similar varieties have been discovered.

Mainstream scientists view the object as a stylized insect. Believers in ancient astronauts, on the other hand, point out that it looks more like a fighter plane or a space shuttle. "Who ever heard of a bug with delta wings and a three-piece tail?" they ask. So far there seems little evidence to support either interpretation.

For more information, the Ancient Astronaut Society can be reached at 600 Talcott Road, Park Ridge, Illinois 60068.

"I sometimes think that God in creating man somewhat overestimated His ability."
—Oscar Wilde

Ancient Astronaut Society

Colombian artifact: Ancient space shuttle . . . or just an insect?

VOLCANO WATCH

The decades-long search for ways to forecast volcanic eruptions is slowly beginning to pay off. "It will be a long time before we're as accurate as the weatherman, but I think monitoring stations can finally be used to predict eruptions near populated areas," says Dr. Gordon Eaton, associate chief geologist of the U.S. Geological Survey.

The volcanologist bases his claim on data from the Hawaiian Volcano Observatory, which has been watching the Kilauea and Mauna Loa calderas since 1912. "We have good data to show that certain changes always precede a volcanic outburst," he reports.

"The mountain itself tends to swell over a period of months. Minor earthquakes become progressively more common. Then there is a rapid deflation at the summit of the mountain, and the earthquakes migrate toward the eruption site. About 24 hours before the eruption, constant tremors begin to shake the site. At that point it's time to evacuate."

The predictions are not perfect, Dr. Eaton admits. One year, Mauna Loa repeated the pattern three times without erupting. But, he says, there has never been an eruption that arrived without that warning.

Volcano monitors won't come cheap. They require a broad array of seismometers, geodimeters, and devices to measure gravity, magnetic fields, and land slope. These are backed up by a complex radio system to transmit data to a safe work site. But most geologists feel that the benefits of forecasting will be worth the expense, because there have been several recent instances when faulty predictions have led to costly evacuations.

Georg Gerster/Photo Researchers, Inc.

Eruptions: First, a swelling

Most dramatic was the case of La Soufriere, on the island of Guadeloupe. In 1976, fears of a violent eruption led the French government to evacuate some 74,000 people from the area for more than three months—against the advice of trained volcanologists.

When the three eruptions finally came, they rained soot for a mile around but caused no serious damage.

"If the French government had been willing to listen to its own scientific advisors, they could have spared their people tremendous hardship," Dr. Eaton concludes.

"I am vitally interested in the future, because I am going to spend the rest of my life there." —Charles F. Kettering

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Black-hole theorist Stephen Hawking is perhaps the most brilliant physicist since Einstein

THE WIZARD OF SPACE AND TIME

BY DENNIS OVERBYE

There are equations—thin blue scrawls—scribbled and ground into the surface of the low white table where Stephen Hawking and his cohorts gather twice a day for tea 'When we want to save something we Xerox the table quips Hawking Emerging from dens scattered throughout an old engineering building to share a moment of relaxation, refreshment and communication Hawking's group at the University of Cambridge looks more like an English rock band on its day off—long hair, beards, T-shirts—than one of the world's outstanding collections of theoretical physicists

Hawking with his youngish looks and perpetually tousled hair might be mistaken for a bookish high-school student on a day tour of the university A hint of age shows only in the wrinkles around the eyes which are blue He is one of the outstanding scientists of our generation At 36 he has shaken the world with a discovery so weird and still so mysterious that even a statement of one of his findings sounds like a Zen koan "When is a black hole not black?" "When it explodes"

Black holes are regions of space so warped by powerful gravitational forces that it was long thought that nothing not even light could escape from them At least one way a black hole can be formed is by the collapse of a large star under the force of its own gravity after it has burned all its

PHOTOGRAPH BY J CALDER

thermonuclear fuel. In the past few years, astronomers have invoked black holes to explain everything from quasars to puzzles in the behavior of our own sun to the fate of the universe itself. Estimates of their number in our galaxy alone have ranged from the billions to the trillions.

Einstein's theory chillingly holds that at the center of a black hole, space and time themselves come to an end. An astronaut, or anything else that fell into a black hole, would be stretched like a noodle, then crushed smaller than a dust mote before he got to the bottom. There would be no question of escape, only annihilation so clean it would seem almost mythical.

In 1973, Hawking turned the theory of black holes inside out when he discovered that some black holes are not completely black: they can emit particles and eventually even explode, becoming "white" holes from which energy and particles gush.

Since then Hawking's breakthrough has dominated discussions of black holes, but its importance transcends the subject of black holes themselves. His work has revived one of the oldest dreams of science: the search for a single theory that will encompass all the laws of physics, the unified field theory that was an unrealized dream of Einstein's. What Hawking has uncovered suggests that a deep unity underlies three realms of physics that were previously thought entirely separate—gravitation, quantum theory, and thermodynamics. Already in his 30s, he is widely credited with having advanced the general theory of relativity more than anyone since Einstein. He also seems to have discovered that the universe is more unpredictable than anyone had previously recognized.

Hawking's puckish, youthful looks belie the struggle that it has been for him to have any career at all. Stricken with a slow, wasting neuromuscular disease, Hawking is confined to a wheelchair, where he can do little but sit and think. His mind is his blackboard. He memorizes the long strings of equations that give life to his ideas, then dictates the results to his colleagues or secretary—a feat that has been compared to Beethoven's writing an entire symphony in his head or Milton's dictating *Paradise Lost* to his daughter.

"I used to push him along in his wheelchair," recalls Martin Rees, a Cambridge University astrophysicist. "He would say he wanted a book on quantum electrodynamics and tell me what page to open to. Then he would just sit there for hours, motionless, reading this book."

When the black-hole equations that had taken Hawking months to set up finally unreeled across his mind in the fall of 1973, there were an infinite number of particles pouring out of the black hole. It was almost as if the hole had turned white.

"I didn't want the particles coming out," Hawking chuckles. "I wasn't looking for them at all. I merely tripped over them. I was very sorry because it destroyed my framework, and I did my best to get rid of them. I was rather annoyed."

Black holes were supposed to swallow things, not spit them out.

To talk to Hawking is to be barraged by a slow but steady stream of one-liners, good jokes and bad, as he fights to get each word past his partially paralyzed mouth. Teatime consists of writing on the table as the theorists exchange ideas and crack jokes with Hawking, who is always the first to pick up on somebody else's joke, his eyes lighting in anticipation of the punch line. He is too weak to write, feed himself, comb his hair, fix his glasses—all this must be done for him. Yet this most dependent of all men has escaped invalid status. His personality shines through the messy details of existence.

"I always wanted to know how everything worked," says Hawking, who was born in Oxford in 1942 and grew up in the London suburb of St. Albans, the oldest of four children. His father was a medical researcher who worked for the National Institute. "I would take things apart to see how they worked," he recalls, "but they didn't often go back together. I wasn't terribly good with my hands." By the time he was eight or nine, he had decided to be a scientist but chose not to follow his father into biology.

"I felt that the biological subjects were too inexact, too descriptive. They often seemed to consist of doing detailed drawings. I was never any good at drawing. Nowadays it is more exact, particularly molecular biology, but that didn't really exist when I was growing up.

"What I had against biology was that everything seemed to be rather hazy and hand waving. One felt that one wasn't dealing with a basic treatment but with a phenomenological treatment of the subject. It is only with molecular biology that the basic interactions have come to be studied.

"I went through a phase of being very interested in ESP at about the age of 15. A group of us even conducted dice-throwing experiments. Then we heard a lecture by someone who had gone through all the famous ESP experiments by Rhine at Duke University. He found that whenever they got results the experimental techniques were faulty, and whenever the experimental techniques were really good they did not get results. So that convinced me that it was all a fraud."

Today he remains skeptical of claims for psychic phenomena and suggests that the people studying it "are at the stage where I

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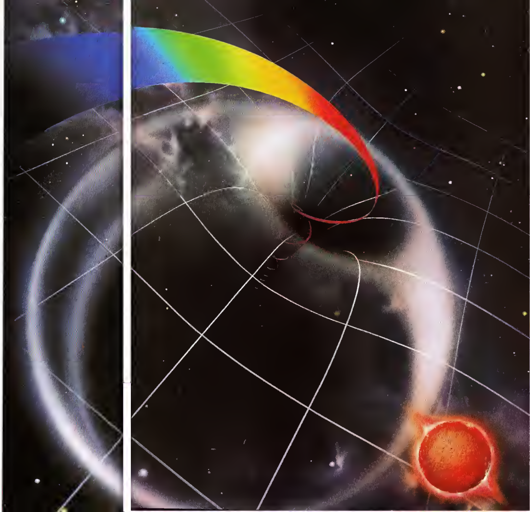

Stars may end their lives as black holes, objects so dense and with such massive gravitational fields that escaping their grip would require speeds faster than light. A black hole, as rendered here by artist Helmut K. Wimmer, may actually alter the very fabric of space, theorizes Stephen Hawking.

FICTION

Could all those ancient legends be true? Was a vampire stalking her?

The Ancient Mind at Work

BY SUZY MCKEE CHARNAS

On a Tuesday morning Katje discovered that Dr Weyland was a vampire, like the one in the movie she d seen last week

Jackson's friend on the night cleaning crew had left his umbrella hooked over the bike rack outside the lab building Since Katje liked to take a stroll in the dawn quiet before starting work, she went over to see if the umbrella was still there As she started back empty-handed through the heavy mist she heard the door of the lab building boom behind her, and she looked back.

Two men had come out One of them, clearly hurt or ill sank down on his knees and reached out a hand to steady himself on the damp and glistening surface of the parking lot The other a tall man with gray hair turned his head to look full at the kneeling figure—and continued walking without hesitation He didn't even take his hands out of his raincoat pockets until he stooped to unlock his shimmering, dark Mercedes He got inside and drove off

Katje started back toward the lot But the young man pushed himself upright looked around in a bewildered manner and making his way unsteadily to his own car also drove away

So, there was the vampire, sated and cruel and there was his victim, wilted pale and confused—although the movie vampire had swirled about in a black cloak not a trench coat, and had gone alter bosomy young females Walking over the lawn to the club, Katje smiled at her own fancy

What she had really seen, she knew, was the star of the Cayslin Center for the Study of Man Dr Weyland leaving the lab with one of his sleep-subjects after a debilitating all-night session Dr Weyland must have thought the young man was stooping to retrieve dropped car keys

The Cayslin Club was an old mansion donated years before to the college It served now as the faculty club Its grandeur had been severely challenged by the lab building and attendant parking lot constructed on half of the once spacious lawn but the club was still imposing within

This morning when she stepped inside Katje found a woman in a T-shirt shorts and red shoes running from the

PAINTING BY H R GIGER

dining area through the hall and down the length of the living room, making a turn of quick little steps at the fireplace and running back again. It was Miss Donelly's latest guest lecturer, who was surely old enough to have more dignity. Nothing could hurt the synthetic carpeting that had replaced the fine old rugs, but really, what a way for a grown woman to behave!

She glared. The runner waved cheerfully.

Jackson was in the green room, plugging leaks; it had begun to rain now. The green room was a glassed-in terrace, tile-floored and furnished with chairs of lacy wrought iron.

"Did you find it, Mrs. de Groot?" Jackson asked.

"No, I'm sorry." Katje never called him by his name because she didn't know whether he was Jackson Somebody or Somebody Jackson, and she had learned to be careful about everything to do with blacks in this country.

"Thanks for looking, anyway," Jackson said.

In the kitchen she stood by the sinks, staring out at the dreary day. She had never grown used to these chill, watery winters, though after so many years she couldn't quite recall the exact quality of the African sunlight in which she had grown up. It was no great wonder that Henrik had died here. The gray climate had finally quenched even his ardent nature six years ago.

Her savings from her own salary as housekeeper at the Cayslin Club would eventually finance her return home. She needed enough to buy not a farm but a house with a garden patch somewhere high and cool. She frowned, trying to picture the ideal site, but nothing clear came into her mind. She had been away so long.

While Katje was scrubbing out the sinks, Miss Donelly burst in, shrugging off her dripping coat. "Of all the high-handed, Goddamn—oh, hello, Mrs. de Groot; sorry for the language. Look, we won't be having the women's faculty lunch here tomorrow after all. Dr. Weyland is giving a special money pitch to a couple of fat-cat alumni, and he wants a nice, quiet setting—our lunch corner here at the club, as it turns out. Dean Wacker's already said yes, so that's that." She cocked her head to one side. "What in the world is that thumping noise?"

"Someone running," Katje said, thinking abstractedly of the alumni lunching with the vampire. Would he eat? The one in the movie hadn't.

Miss Donelly's face got red patches over the sharp cheekbones. "My God, is that my lecturer doing her jogging in here because of the weather? I'm so sorry, Mrs. de Groot—I did mean to find her someplace to run, but even in free periods the gyms are full of great hulking boys playing basketball—"

She smiled. "You know, Mrs. de Groot, I've been meaning to ask you to be my next guest lecturer. Would you come talk to my students?"

"Me? What about?"

"Oh, about colonial Africa, what it was like growing up there. These kids' experience is so narrow and protected. I look for every chance to expand their thinking."

Katje wrung out the rag. "My grandfather and Uncle Jan whipped the native boys to work like cattle and kicked them hard enough to break bones for not showing respect. Otherwise we would have been overrun and driven out. I used to go hunting. I shot rhino, elephant, leopard, and I was proud of doing it and doing it well. Your students don't want to know about such things. They have nothing to fear but tax collectors and nothing to do with nature except giving money for whales and seals."

"But that's what I mean," Miss Donelly said. "Different viewpoints."

"There are plenty of books about Africa."

"Okay, forget I asked," Miss Donelly gnawed at her thumbnail, frowning. "I guess I could get the women together over at Corrigan tomorrow instead of here if I spend an hour on the phone. We'll miss your cooking, Mrs. de Groot."

Katje said, "Will Dr. Weyland expect me to cook for his guests?"

"Not Weyland," Miss Donelly said drily. "It's nothing but the best for him, which means the most expensive. They'll probably have a banquet brought in from Borchard's."

She went to collect her guest.

Katje put on coffee and phoned Buildings and Grounds. Yes, Dr. Weyland and two companions were on at the club for tomorrow, no, Mrs. de Groot wouldn't have to do anything but tidy up afterward; yes, it was short notice, and please write it in on the club calendar; and yes, Jackson had been told to check the eaves over the east bedrooms before he left.

"Wandering raincoat," Miss Donelly said, darting in to snatch it up from the chair where she'd left it. "Just watch out for Weyland, Mrs. de Groot."

"What, an old woman of fifty, more gray than blond, with lines and bones in the face? I am not some slinky graduate student trying not only for an A but for the professor also."

"I don't mean romance," Miss Donelly grinned, "though God knows half the faculty—of both sexes—are in love with the man." Honestly, Katje thought, the things people talked about these days! "To no avail, alas, since he's a real loner. But he will try to get you into his expensive sleep lab and make your dreams part of the world-shaking, history-changing research that he stole off poor old Joel Milnes."

Milnes, Katje thought when she was alone again. Professor Milnes, who had gone away to some sunny place to die of cancer. Then Dr. Weyland had come from a small southern school and taken over Milnes's dream project, saving it from being junked—or stealing it, in Miss Donelly's version. A person who looked at a thing in too many ways was bound to get confused.

Jackson came in and poured coffee for himself. He leaned back in his chair and flipped the schedules where they hung on the wall by the phone. He was as slender as a Kikuyu youth—she could see his ribs arch under his shirt. He ate a lot of starch and junk food, but he was too nervous to fatten on it. By rights he belonged in a red blanket, skin gleaming with oil, hair plaited. This life pulled him out of his nature.

"Try and don't put nobody in that number-six bedroom till I get to it the end of the week," he said. "The rain drips in behind the casement. I laid out towels to soak up the water. I see you got Weyland in here tomorrow. My buddy Maurice on the cleaning crew says that guy got the best lab in the place."

"What is Dr. Weyland's research?" Katje asked.

"'Dream mapping,' they call it. Maurice says there's nothing interesting in his lab—just equipment, you know, recording machines and computers and like that. I'd like to see all that hardware sometime. Only you won't catch me laying out my dreams on tape!

"Well, I got to push along. There's some dripping faucets over at Jottey I got to look at. Hans Brinker, that's me. Thanks for the coffee."

Katje began pulling out the fridge racks for cleaning, listening to him whistle as he gathered up his tools in the green room.

The people from Borchard's left her very little to do. She was stacking the rinsed dishes in the washer when a man said from the doorway, "I am very obliged to you, Mrs. de Groot."

Dr. Weyland stood poised there, slightly stoop-shouldered, head thrust inquisitively forward as he examined the kitchen. She was surprised that he knew her name, for he did not frequent the club. She had seen his tall figure only once or twice in the dining room.

"There was just a bit remaining to do, Dr. Weyland," she said.

"Still, this is your territory," he said, advancing. "I'm sure you were helpful to the Borchard's people. I've never been back here. Are those freezers or refrigerators?"

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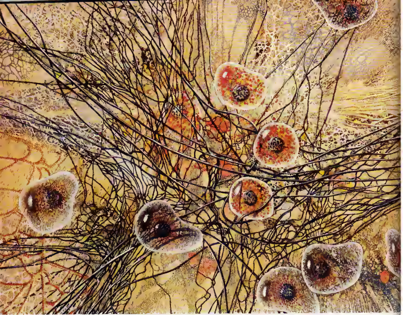
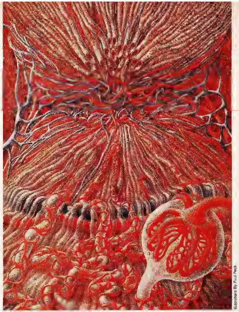
> "Dream mapping," they call it. Maurice says there's nothing interesting in his lab—recording machines and computers and like that. Only you won't catch me laying out my dreams on tape!





Illustrations By Paul Peck

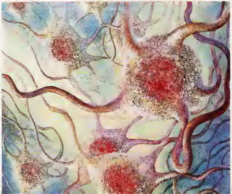
INNER LANDSCAPES

Uncharted regions of bone and sinew become fantastic art in the service of science

BY KATHLEEN STEIN

Early in my study of vertebrate structure, I became entranced by the aesthetic pleasure I derived from contemplating the organic form," says the renowned medical artist Paul Peck. Like his predecessors from Da Vinci to Andrew Wyeth, Peck contradicts the myth that the artist is at continual odds with the stringent discipline and accountability of the scientific method. To the contrary, the instant the artist records an observation—a leaf, sunlight falling on a pool of water, the complexities of a human face—he is participating in a scien-

Peck's three dimensional rendering of the various fibrous and netlike components of connective tissue (top). Inner structure of the kidney (top right) depicts thousands of glomeruli and tubules, neurons (below)



"I was determined," says Peck, "to create art that would reveal the harmony in living organisms"

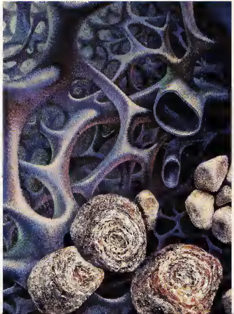
tific event Before the invention of the camera medical illustration was the only means—other than dissecting corpses—of learning anatomy Although photography has now replaced the illustrator's function in recording the appearance of objects, the camera is not able to dramatize important elements or simplify and clarify relationships That is the work of art. In the case of anatomy the arrangements of organs and their vessels and nerves are so intricate the relationships so hidden by overlying tissue, that a photograph tends to confuse rather than clarify Medical art captures the essence of life, a more subtle task In fact advancing photographic technology has done art a favor in

The structure of bone (above left) Right ventricle of the heart (above right) looking toward the bicuspid valve Gallstones (below right) Lung section (below) painted by Frank Armitage for a pharmaceuticals house

Dr Paul Peck

Frank Armitage

Frank Armitage



Dr Paul Peck

Illustrations By Frank Armitage

❛ I would reveal especially those microscopic structures —in a manner to fire the imagination. ❜

liberating the artist to create more exciting conceptual visions. "Artists must realize the creative potential inherent in the intricacies of science," comments Frank Armitage, who, as an art student, had to cajole his way into the dissecting rooms of medical schools. Once inside, the space-age Michelangelo made sketches and mental notes that would later become epic visions of the interior body. Armitage's inner landscapes have become the bases of numerous medical films. The SF movie *Fantastic Voyage* is an Armitage odyssey. So, in giving "the inward parts" a local habitation and a name, science has enlarged the artist's vocabulary: science in service to art. ◘◘

Armitage's conceptualization of the brain's optic system (above left). Nerve synapse (right). The exposed tendon sheaths of the hand, palm side facing up (below left); dorsal view (right). Acrylic on mat board.

FARMING THE PLANETS

Since our sister planets will not support life, we have but one choice—we must redesign them

BY JAMES OBERG

Paintings by Adolph Schaller

Earth is unique in this solar system—it is the only planet that supports life. Its hospitable ecosphere stands in stark contrast to the empty lifeless landscapes of the moon, Mars, Venus, Mercury and other worlds probed by our spacecraft.

But it doesn't have to be that way.

We can increase the number of life-supporting worlds in this solar system from one, as at present, to a dozen or more. Instead of just being a freak accident of biology, the earth could serve as a blueprint for the transformation of her sterile sister worlds into earthlike ecologies. We don't have to wait for this metamorphosis to come about through billions of years of random accidents. We can make it happen in just a few centuries of deliberate human manipulation.

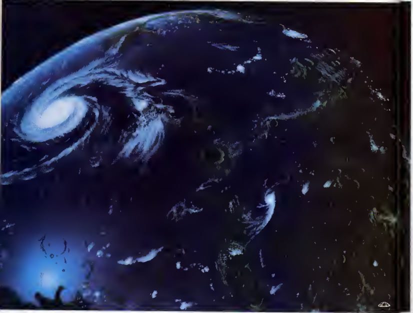
The word for this awesome concept is terraforming. It was coined 40 years ago in a science-fiction story, but the concept of world shaping goes back much further. How far it may still be ahead of its time is unknown.

Advocates of terraforming conjure up idyllic visions of reshaped planets made fit for human settlements. They ask incredulous listeners to imagine red-skied Mars watered and in bloom, to imagine choking Venus tamed and cooled, to imagine even the sterile, airless moon transformed into a smaller replica of earth.

And how could such remodeling be accomplished? The transformations, it turns out, do not really require magic but only extrapolation from what we know today. Colossal energies would be required, but in a century or two such forces should be available. Intimate knowledge of climatology would be required, but those lessons must be learned on earth in any case. Tricks of biology and ecology are still far beyond

Seen from approaching spaceship, terraformed moon (opposite page) would resemble a distant earth (at top). Above: Mars as seen from space port on its moon Phobos.

“The material to be transported would be primarily water for the dry inner planets”



An atmosphere and ocean have been added to a terraformed moon. A hurricane swirls at top left. Green forests and meadows grow abundantly along shores.

present scientific capabilities, but they are in the directions along which modern science is moving.

Each planet would require a different combination of these techniques, although many of the tools would be common from world to world. The major obstacle is not technological but conceptual. Humanity does not yet realize that it has the capability to transform whole planets, for worse (as we are often warned by the doomsday prophets) *and* for better.

A good first candidate is the planet Venus, once thought to be a twin of the earth but now known to be a closer analogue of medieval visions of hell. The planet gets too much sunlight, has too much carbon dioxide and sulfuric acid, and spins far too slowly.

Imagine what would happen to a human being placed on the surface of Venus. Immense atmospheric pressures would instantly crush the soft body tissues, while ovenlike temperatures would convert body water to steam. An expanding cloud of soot would surround a pile of crumbling bones as the acidic vapors of Venus turned a human body to dust.

Terraformers call for a physical assault on such conditions. Nuclear bombs could change the course of comets, which could be steered into off-center collisions with Venus. Besides providing the planet with water (in the form of cometary ice), their glancing blows would spin Venus into a more comfortable day-night cycle.

Carbon dioxide in the atmosphere of Venus would be transformed biologically by clouds of algae, suitably tailored in genetics laboratories to thrive under Venusian conditions. Artificial dust clouds would shade the planet, allowing oceans to form.

CONTINUED ON PAGE 106

Impacting comets would supply water and speed up Venus's spin, creating an equatorial ocean (poles are at left and right). Polar continents would be like Samoa.

She could control the sharks, but who controlled her?

LOBOTOMY SHOALS

BY JULEEN BRANTINGHAM

Sharks followed the school of fish, as sharks have been doing for millions of years. The new element was the submarine, an oversized coffin, within the shark pack, following the fish.

From time to time, sharks would dart out of the pack, to the right or the left, driving in stragglers. In the crannies of the rock piles on the bottom, moray eels watched this action as dogs might watch for crumbs to drop from the master's table. But there were no crumbs. These sharks were not feeding.

The morays also watched the submarine as it passed. Its shape was like that of a shark but, from its actions, the morays categorized it as not immediately dangerous. Its smell/taste was thin and bitter, not like that of the soft things on which the morays fed.

But the eels continued to watch until the school, pack, and intruder faded from sight. An ocean predator seldom knows where its next meal is coming from until the scent of blood spreads in the water.

Tinkertoy was nuzzling my submarine's rear stabilizer. Just before burn-out, old hammerheads get as friendly as puppies. A pony is designed to withstand abuse, that's the word from topside. But that's *topside*. Up there they don't have to worry about getting too close to playmates with lots of teeth.

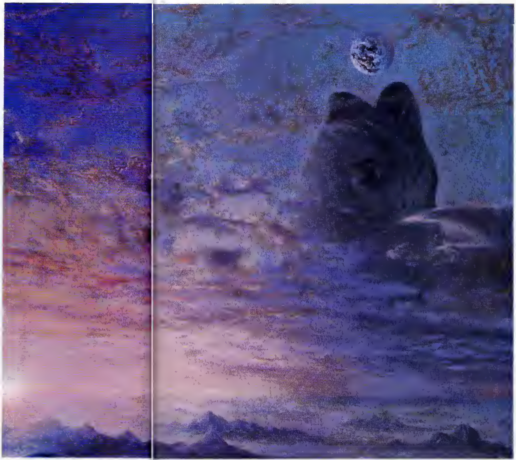
This promised to be a tough patrol. I'd relieved Tindall, my alternate, off the eastern tip of Cuba. I was sweeping a school of mackerel up the shelf to Atlantic Fisheries Corporation's Station Number Seven at Grand Abaco. Tindall had reported the school to be losing mass. Down an estimated 700 kilos since the spotters had tagged it out in the Deep. Something was slipping in under the noses of the pack and the scopes of the pony. Civilians seem to think a pack can protect the school against anything, but that just shows how little they know about conditions out here. Throwing a pack against healthy cetaceans or a good-sized great white would be mass murder. The pack's job is to herd the school into the catch pens before word gets around that a free lunch is in the neighborhood.

Besides losing mass in the school, the pack was down to 37. Tindall had reported four losses. Two, he said, had been rammed by porpoises. But Tindall's been my alternate for three years now and I know him. He likes to play with the pack. So his burn-out rate is way too high and he tries to hide it from the cost accountants. He probably burned all four plus Tinkertoy. There's no mistake, the way the old boy's acting. He's close.

I'll hate to see him go. I was running the pack a year and a half ago when the trainer delivered Tinkertoy and a couple of tigers. First thing he did was shimmy through the pack, wagging his head like it wasn't enough that he had an eye at each end of that ridiculous deformity and he was afraid of missing out on something.

There was a bump from amidships. Tinkertoy had seen me come out of the lock often enough to make a lie of its name on the parts list—Emergency Escape Chamber

PAINTING BY CLIFF McREYNOLDS



There's something about a hammerhead. I don't think any herder feels neutral about them. They look like a cross between a nightmare and an abortion, but they have brains that can be conditioned and programmed to herd fish, just like any other shark. Some herders would run all-hammerhead packs if they could. Others have threatened to torp the trainer if he ever delivers one.

I've had some minor troubles with hammerheads. And I've had some good experiences, mostly with Tinkertoy. He's always the first to go into action when I use the Voice. When there's a predator around, Tinkertoy seems impatient for my command to go at it.

I haven't named any of the others in the pack and Tindall wouldn't. We're warned not to do that, not to get emotionally attached. Sharks may not seem lovable to civilians, but when you work with them day after day you learn their little quirks. It's hard to see a friend nearing brain death.

There was another nudge from amidships. He was acting like a little boy. I could almost read his mind. "Can Petey come out and play?"

Cancel that. Erase. I could not read Tinkertoy's mind, did not know what he wanted. Could not. Did not. The Voice only works one way.

I steered the pony through the pack. Warned by the pressure wave, sharks scooted right and left, never crossing the invisible barrier that their conditioning set up between them and the school. I'd hoped Tinkertoy would turn his attention to one of the others, but a rasp along the hull testified to his loyalty.

"Please, Petey. Let's play."

Wrong. He wasn't thinking that. He wasn't thinking at all. He was just a big, dumb fish. Maybe he was horny and had mistaken me for a female hammerhead. How would *I* know?

The Voice only works one way.

I reached hesitantly for my mike switch. Tinkertoy was close to burn-out. One more command might trigger it, and the pack was understrength now. But I *did* reach for the switch. I'd been in the pony for over 24 hours and before that I'd had two weeks of the violence and filth of topside.

I *needed* to go out. I was carefully not thinking about the rumors. *My* brain was all right. I just needed to go out for a swim.

The bars in the ports are full of rumors and stories and things that have to be pure myth. God knows where they all come from. There's no such animal as an *old* fish herder.

Once in a while a wild shark will swim with the pack. Sharks aren't like dogs or wolves or even lions. They don't hunt cooperatively. But where the food supply is good they gather in groups, especially hammerheads.

When a wild shark joins a guard pack it never stays long. Even if the pack doesn't drive it away the wild one becomes more and more skittish and bad-tempered. The Voice hardware doesn't show on a shark's head, but apparently the wild ones can sense *something*.

It's the same with fish herders and civilians.

In every port city close to a harvesting station there are one or two special bars. There is no canned music, the voices are hushed, and the light is sort of green and peaceful. The customers move slowly and there's a blasted look in their eyes. Those are the fish herders' bars.

The owners of those places aren't going to get rich. The stuff they sell doesn't have much of an effect compared to the smoothed-out feeling we carry over from our jobs. The only reason we need the bars at all is as a retreat.

When a civilian wanders in by mistake, we don't chase him away. We'll talk about our jobs if he wants to listen, or about the happenings topside—though that's harder because most of us are deliberately out of

"There's something about hammerheads. They look like a cross between a nightmare and an abortion, but they have brains that can be conditioned and programmed to herd fish, just like any other shark."

touch. But the civilians don't stay long. They become more and more nervous, as if they can sense some kind of hardware in our heads, something that changes us.

There is no hardware. Our heads are as clean as theirs. But we're not sorry to see them go. Civilians are too loud, too tight, too scared.

When fish herders are alone we talk about the most important things in the world: the packs, the predators, the ocean. And sometimes we wonder why there are no old fish herders. Why is it that nearly every week at least one pony fails to meet its okay schedule?

Civilians pity us. They're always talking about the loneliness and the danger. They talk about the sacrifices we have to make to feed the millions topside. They ought to take a good look at *their* world: crowds, noise, shortages, tension, rules, ugliness, hostility and more rules. They can have it.

Pass through the surface of the ocean and you leave all that behind. Herders are the last of the free people. It's clean down here. It's peaceful. It's beautiful.

Sure, there's danger. Hulls crack, systems fail, and outside there's an ocean full of predators with an appetite for red meat. But that's just the way things even out. Maybe what topside needs is a little more danger, a few more predators.

The packs themselves are right at the top of the list of dangers. Oh, they've been conditioned to avoid a human body in the water, but conditioning works best with an animal that's at least semi-intelligent. You need the Voice to guarantee control, and you can't use it from outside. I guess the Atlantic Fisheries Corporation figures they'll lose fewer of us if they keep us in the ponies. Scared, like all topsiders.

Herders aren't the first to find the ocean more attractive than topside. Cetaceans used to be land animals, too.

There's no sacrifice involved in being a herder, in spite of the stuff they spout in the training sessions. We're down here because this is where we want to be. But sometimes we wonder why no one has ever beaten the odds. Sometimes, when too many of our friends have missed the okay schedule, we speculate in whispers about the Voice.

We're just herders, not scientists or trainers. We know that even sharks can be conditioned to avoid certain things, like the schools they're supposed to be guarding. We know that hardware can be planted in a shark's brain to stimulate certain areas. It's like pulling a puppet's strings. But they don't tell us too much about how it works. We're just supposed to give the orders and the Voice does the rest.

We do know about burn-out. The Voice is a clumsy tool. Repeated commands damage neural tissue, and sooner or later, usually within a year or two, the animal suffers brain death.

When the ocean ranges began to be managed and harvested intensively, when the big harvesting stations replaced the energy-hungry fishing fleets, herders used porpoises to steer the schools. Cetaceans are intelligent and can be trained. But they're also intelligent enough to resent being turned into slaves. Sometimes the whole pack would take off, leaving the herder with a scattering school and a hole in the harvesting plan.

So the scientists started cutting open the porpoises' heads and implanting their hardware. After all, there were quotas to meet.

Thank God that was stopped. It was like turning our brothers into zombies.

Sharks are just killing machines, ugly, vicious, unpredictable devourers, according to civilians. Yet there isn't a herder who doesn't wish there was another way.

Burn-out.

I've seen it happen a few times. It's nothing dramatic but I've happened to be looking in the right direction once in a while. Just after a command, one shark gives a little quiver. That's it. Most of a shark's systems are so primitive that it's a while after brain death before the body gives up. But that quiver is the end. Even if the body continues to move, there's nothing there.

I guess every herder has had nightmares of looking down and seeing his own body quiver like that.

There is no hardware in a herder's head. The Voice only works one way.

That's what they tell us.

Why are there no *old* herders? Why are bodies almost never recovered even when the ponies are intact?

I touched the switch on my mike and the box translated my words into a command for Tinkertoy to swim to the east and circle around the school. His appearance would keep it bunched up. And why was I thinking about waste? This school was a big one in spite of the loss of mass, so I should have plenty of time. I really needed a swim to wash off the stink of topside.

He swam away below the eyes of the pony giving me a good view of sinuous locomotion. He seemed regretful. 'Aw Petey, I wanted to play!'

Cancel that. Erase. I don't know what he was thinking.

When Tinkertoy faded into the distance I took a last look at the scopes and put the pony on automatic. I was slipping into the escape gear as I stepped down to the lock. The pony is home, but outside is heaven.

The touch of the water made me euphoric. I don't know what it is, but I feel more alive there than anywhere else. In a way it doesn't make sense because I'm completely dependent on the air packs. My senses are limited to vision—dim—and hearing—almost useless. I can't sense a pressure wave until it's too late to be any use. I can't taste/smell the odors in the water, probably the most important sense to fish. I can't swim very fast, and I have to depend on my suit to prevent dangerous loss of body heat. In the world under the surface I'm better prey than predator.

But I can move, glide, fly—effortlessly. I am part of the ocean, as it is a part of me.

I forgot about the air packs and the suit. I was alert and aware of the danger every second but it was unimportant. Every part of my body was functioning, not like being in the pony or topside, where I am mostly useless meat supporting a brain that in turn functions as a puppet of the Atlantic Fisheries Corporation.

I could fly. I was alive. I was whole.

I swam from the lock directly into the school, counting on the pack's avoidance conditioning to protect me there. It is possible to swim with the pack, even to play with them if they've been fed recently. I've done it often. But around the pack you have to be doubly alert, and on this first swim after my return, I didn't want to be alert. Not that way.

Why do they force us to go topside for R and R every two weeks? I'd stay on the job forever if they'd keep giving me air packs. I'd take my R and R outside if they'd give me air packs. Why won't they turn us loose? Why keep binding us with their own fears?

Maybe they're afraid we won't come back.

Change course. Think of something else. That's the way a shark would think.

Erase.

I soared through the school. It was like swimming through a shower of gigantic confetti that parted to make a path for me. They're even dumber than the sharks. If I'd been hungry I could have reached out and grabbed one.

I flew, trying to breathe shallowly, hoarding every breath in my pack.

Time was running out. I called my usual curse down on the heads of the Atlantic Fisheries Corporation and began my return to the pony. Thirty hours of air in a pack and one pack per pony. For emergency use only. I had to make this one last two weeks. Damn them. With this slender thread they hold me. Topsiders.

At the edge of the school I stopped dead in the water. Something had changed out there. The aura was different.

The pack was making its usual near-aimless sweeps, but they seemed nervous, their movements jerky. The school was calm, but then, the school is always calm until they approach the catch pens. I could see no predators. But something had changed. I could feel it.

Then I saw him. Gliding from the dimness at the edge of my vision. Tinkertoy.

He was returning from the east.

From the *east*. The shock raised my respiration rate but I no longer thought about hoarding the air in my pack. A shark cannot disobey a command. The puppet can't cut its own strings. Either a shark obeys or its brain is dead and it is not capable of initiating an action. But Tinkertoy was returning from the east. If he had finished his sweep, if my time sense could have been that far wrong, he would have returned from the northwest.

A shark could not disobey a command. But if something had changed since I gave Tinkertoy that last order he would expect a new order. He could not function without the correct order. If predators were attacking the school on the east side, Tinkertoy could not complete his sweep and he could not attack without my command.

There must be predators in the school. It was the only explanation. If I'd been in the pony I would have seen them on the scopes. Alarms must have been flashing all across the board as I indulged in that forbidden pleasure.

Tinkertoy circled the pony, caressed it with his hide, tasting. 'Here I am, Petey. What do you want me to do?'

My suit suddenly felt like a quilted overcoat. As long as I stayed where I was, Tinkertoy would not "see" me. His conditioning blinded him to the main body of the school to prevent him from lunching on the things he was supposed to protect. While I was hidden in the school I was safe, and the way he'd been acting, I needed that protection. Maybe he wouldn't attack me.

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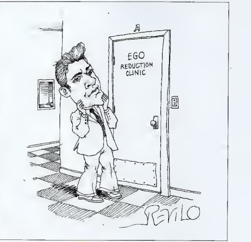

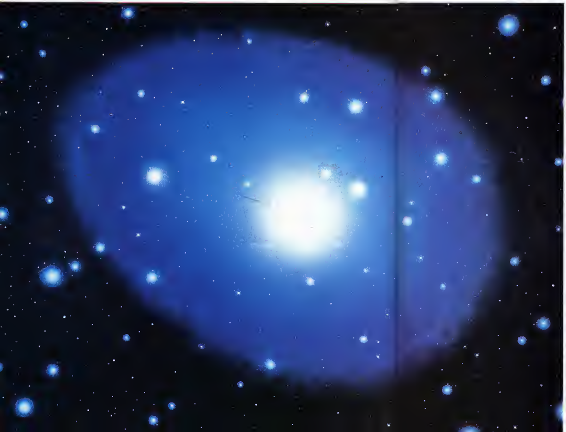

Life, says Britain's leading cosmologists, may well have begun in the vast dust clouds between the stars

LIFECLOUD

BY SIR FRED HOYLE AND CHANDRA WICKRAMASINGHE

The precise moment of our emergence on this planet, the emergence of *homo sapiens*, is still a matter of dispute. On a geological time scale it must surely be very recent, no more than a few hundred thousand years ago. Yet our biogenetic and chemical links extend to a very remote past, and probably to distant regions of the universe. How far into the past and how far away in space can our origins, and indeed the origins of all life, be traced? How did life reach our own planet, and possibly others?

Darwin proposed that higher life forms must necessarily evolve from the lower. We shall take the basic concept of Darwinism still further back and come to the conclusion that a pre-Darwinian chemical evolution preceded the emergence of the first living species.

Darwin's theory is the cornerstone of modern biology. Our own links with the simplest forms of microbial life are well-nigh proven. From a biochemical point of view, the difference between man and microbe is comparatively trivial. At a most rudimentary chemical level, life in all its varied shapes and forms simply involves the interaction between two groups of biochemical substances, the nucleic acids and proteins. The nucleic acids are themselves constructed from just one sugar, four bases—adenine, guanine, thymine, and cytosine—and a phosphate, while proteins contain about 21 separate amino acids. The myriad possible arrangements and rearrangements of these 27 or so basic substructures make up the wide diversity of life forms on our planet. Once these fewer than 30 biochemical building blocks have formed and become assembled to make up a primitive life system, Darwinian evolution takes over

PAINTING BY CHING HO CHANG

and everything else follows. But what of our ultimate chemical and biochemical genesis? And how is this genesis connected with the universe at large? It is now clear that a long heritage of pre-Darwinian molecular evolution occurred in space, predating by many billions of years the formation of the first organisms on earth.

Emissaries of our biochemical heritage still arrive on our planet in the form of meteorites. Some 100 or so metric tons of matter plunge daily into the earth's atmosphere. Much of this material is in the form of fine particles, many of which burn up before they ever reach the ground. There are also larger objects, which apart from a scouring off of their outer layers arrive on the ground more or less intact. For instance, a certain class of meteorite known as the carbonaceous is rich in organic chemicals.

Where do the fine particles that enter our atmosphere come from? Most of them come at well-defined times of the year in meteor showers, which almost certainly originated in comets. Comets are probably derived from a reservoir of bodies that surrounds our planetary system out to a distance of one tenth of a light-year. Kilometer-sized cometary nuclei with an icy composition are thought to plunge from time to time into the inner regions of the solar system.

An example was comet Kohoutek, which passed through the inner solar system in 1973. Its present orbit is estimated to carry it round the sun every 75,000 years. As it passes close to the sun, heat causes volatile gases and solid particles to spray out from the cometary nucleus. It is this spray of matter directed radially outward from the sun by solar pressure that makes the spectacular display of a comet.

Although Kohoutek's visual display was a disappointment to most observers, the discovery of organic molecules in the cometary "spray" has bearing on our story. In comets such as Kohoutek we are witnessing an exchange of material between the outer and inner parts of the solar system, an interchange that may well connect us with still more distant parts of the galaxy.

In the youth of our planet, about 4.5 billion years ago, the rate of capture of cometary and meteoritic matter must have been much greater than it is today. The outermost planets in the solar system were then still being formed from billions of comet-type objects, of which some would have crossed the earth's orbit, while others would have plunged to the earth's surface. We consider it almost certain that the earth acquired all of its volatiles, including water, carbon dioxide, ammonia, rare gases, and complex biochemicals, by this process.

THE STARS CONDENSE

It is interesting to trace the history of a single cloud of interstellar matter, one that is on the verge of collapse to form stars. The total mass of a typical interstellar cloud is several thousand times the mass of the sun. About two percent of this total mass consists of interstellar dust. The gaseous component at first consists mainly of single atoms with a density of about 100 atoms per cubic centimeter and a temperature of 10 to 100 degrees above absolute zero.

When the cloud has collapsed and its density has increased tenfold to about 1000 atoms per cubic centimeter, molecules begin to be formed. The first molecules are hydrogen and carbon monoxide. Simple molecules like hydrogen can form efficiently when individual atoms stick on to dust-particle surfaces, waiting there until an appropriate "mate" arrives on the surface, and then bouncing back as molecules into the gas.

Radio astronomers have recently discovered a wide range of molecular species in clouds that are probably just about at the stage of prestellar collapse. Formaldehyde, a basic molecular unit from which sugars and polysaccharides could form, is abundant and widespread in the galaxy. Furthermore, a molecule of formic acid and a molecule of methanimine could react to create the simplest amino acid, glycine, and there is every reason to believe that this will happen very extensively.

"From a chemical view the gap from microbe to man is relatively trivial. Life involves two substances, nucleic acid and protein. The building blocks for both formed in deep space many billions of years ago."

When the collapsing cloud becomes sufficiently dense, yet still far removed from a truly prestellar state, complex molecules are deposited as tarlike sticky coatings on the dust grains. The grains themselves now collide sufficiently often to stick together to produce larger grains 10 to 30 times their original radii. Such composite dust grains contain a hybrid mixture of many organic materials. This could provide an important source of solid particles with a complex organic-chemical composition.

The next stage is for cloud fragments, many hundreds of them, to break apart and collapse separately to form individual stars. It is difficult to determine what fraction of the original cloud ends up as stars, but one third would seem a likely upper limit, though it could be appreciably less.

Biochemical substances form in high-density clouds like the Orion Nebula, and only a small fraction of these molecules is engulfed by the newborn stars or suffers breakup by radiation from hot stars. Most of the molecules are thrown back into the space between stars. An individual clump of grains containing organic molecules can be shuttled back and forth between the denser star-forming regions and the less dense interstellar clouds many times before being finally destroyed by direct incorporation into a star.

During this long process of movement to and fro between widely different physical conditions in different regions, it seems inevitable that a Darwinian-style molecular evolution would occur, probably leading to a widespread emergence of those molecular structures that can best withstand the most hostile conditions encountered. A molecular species strongly resistant to breakup by the various disruptive agencies in interstellar space would finally be most widespread in the galaxy.

It is therefore only a part of the gas in space that goes toward the formation of stars, the rest of the gas being subject to a complex process of prebiotic chemistry in which the basic materials of life are formed.

STELLAR BIOCHEMISTRY

Our search for the origins of life brings us to the materials of the interstellar dust clouds. These materials emit and absorb radiation at ultraviolet, visual, and infrared wavelengths. By studying the emission and absorption patterns, particularly for the dust, and by comparing them with patterns found for substances in the laboratory, we can hope to determine the chemical nature of the interstellar material itself.

A difficulty intervenes, however. The way in which a material system emits radiation depends on two factors, its temperature and the quantity of material comprising the system. When the quantity of material is large, in effect, distinctive properties of individual atoms and molecules are hidden. The chemical nature of the material becomes suppressed, with emerging radiation dependent only on the temperature. The system's radiation is then said to be of the "black body" type.

Early in 1977 we became convinced that it would be best if a single chemical substance could be found to explain all the main features of infrared radiation from astronomical sources. What single substance, we asked, has absorptions in the 2- to 4-micron band (1 micron = 1 millionth of a meter), the 8- to 12-micron band, and also a feature centered on 18 microns in the deeper infrared? What substance could also serve to explain the trend toward black-body emission over remaining portions of the total wavelength range? We felt that the answer to these questions must turn on an organic or biochemical material, since it should be composed predominantly of atoms of carbon, nitrogen, and oxygen.

It was only then, somewhat belatedly, that we asked a crucial question. What are the infrared properties of the *most abundant* terrestrial organic substance, cel-

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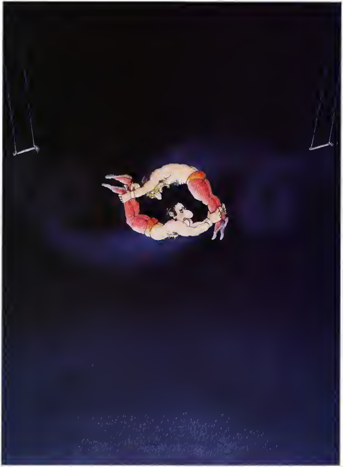


FICTION

THE SINGING DIAMOND

The prospector was searching for valuable ores among the asteroids. No one expected to find diamonds—and fireflies!

BY DR. ROBERT L. FORWARD

PAINTING BY BOB VENOSA

My asteroid was singing. Alone, but safe in my ship, I heard the multitude of voices coming through the rock. They were an angel chorus in a fluid tongue, strange but beautiful.

I followed the source of the sound, stereo headphones connected to a pair of sonar microphones buried in the crust. The voices were moving slowly through the solid stone. They suddenly stopped, cut off in the middle of a tremulous crescendo. I took off the earphones, looked up from the sonar screen, and peered out the port at the black void around me. I could see nothing. I would have thought my ears were playing tricks on me if I had not seen the unusual fuzzy ball on the three-dimensional display of the sonar mapper.

I stopped the pinger that was sending short bursts of sound down into the asteroid I had captured and waited while the last few pulses echoed back from within the body of almost pure metallic ore. This find would bring me a fortune once I surveyed it and got it back to the processing plant.

Most rock-hoppers are content to set up the sonar mapper on a potential claim and let the computer do the job of determining whether there is enough metal in the rock to justify dragging it in. But I always liked to work along with the computer, watching the reflections on the screen and listening to the quality of the echoes. By now my ears were so well trained I could almost tell the nickel content of an inclusion by the "accent" it put on the returning sound. But this time my ears had heard something coming from the solid rock that had not been put there by the pinger.

I had the computer play back its memory, and again I heard the eerie voices, like a chorus of sirens calling me to leave my ship and penetrate into their dense home. I was sure now that the music was real, since the computer had heard it too. I replayed the data again and found that the sound had started on one side of the asteroid, traveled right through the center in a straight line, and then had gone out the other side. I had a hunch, and 90 minutes later was waiting, earphones on, when the singing started again. This time the voices started at a different position on the surface of the asteroid, but as before, they slowly traveled in a straight line, right through the exact center of the rock and out the other side. A quick session with the computer verified my hunch. Whatever was doing the singing was orbiting the asteroid, but instead of circling about it like a moon, the orbit went back and forth right through the dense nickel-iron core!

My first thought was that the weak gravity field of the asteroid had trapped a miniature black hole. The singing would be caused by stresses in the metal ore from the intense gravitational field of the moving point of warped space. But then I realized the asteroid was too tiny, only a few hundred meters across, to have captured a black hole.

The computer did more work. It determined the orbital parameters and predicted where the singers would next intersect the surface of my slowly revolving rock. I was outside, waiting at that point, when it came.

For a long time I could see nothing. Then, high above me, there was a cloud of little sun specks—falling toward me. The glittering spots in the cloud moved in rapid swirls that were too fast to follow, and the cloud seemed to pulsate, changing in size and shape. Sometimes it collapsed into an intense concentration that was almost too small to see, only to expand later into a glittering ball as big as my helmet. Inexorably the gravity of the asteroid pulled the swarm of star-midges down toward me. They were getting close. I tried to move back out of their path, but in my excitement I had floated upward in the weak gravity, and my magnetic boots were useless. Twisting my body around, I tried to dodge, but the cloud of light spots expanded just as it passed me. I screamed and blanked out as my right leg burst into pain. I felt as if I had stepped into a swarm of army ants.

I woke the emergency beeper shouting in my ear. My leg ached, and my air was low. Detached, I looked down at the agony below my knee to see fine jets of vapor shooting out from hundreds of tiny holes in my boot. Fortunately most of the holes seemed to be clogged with frozen balls of reddish stuff. My numbed brain refused to recognize the substance.

Using my hands, I dragged myself across the surface to my ship and carefully pulled my suit off. Insult was added to injury as the suit's Sani-Seal extracted a few red hairs as I peeled it off. I looked carefully

> *"It was a diamond—with a flaw. Right in the center of the crystal was a thick sheet of highly reflecting metal. 'What is that?' I asked. 'The original asteroid,' he replied. 'All four million tons of it.'"*

at my leg. The tiny holes had stopped bleeding, so I was in no immediate danger. I just hurt a lot.

For the next few days I let my leg heal while I listened to the music. I know that I was imagining it, but the beautiful voices now seemed to have a tinge of menace to them. The computer carefully monitored the motion of the swarm. It returned every 93 minutes, the normal time of close orbit around an asteroid with such a high density. Once, I had to move the ship to keep it away from the singing swarm as it came up out of the rock underneath.

After I could move around again, I experimented. Tracking the swarm as it went upward away from the surface, I used the mass detector on it at the top of its trajectory. The collection of nearly invisible specks weighed 80 kilos—as much as I did in my space suit!

I put a thin sheet of foil underneath the swarm as it fell and later examined the myriad tiny holes under a microscope. The aluminum had been penetrated many hundreds of times by each of the specks as they swirled about in the slowly falling cloud. Whatever they were, they were about the size of a speck of dust. I finally counted the midges by tracing the streaks on a print made with my instacamera. There were over one thousand of them.

I was stumped. What was I going to do? No matter how valuable the asteroid was to me, I could not drag it back to the processing plant with its deadly hornet's nest swirling about it.

I thought about pushing the asteroid out from under the cloud, but my small ship was not going to move a 20-million-ton chunk of rock at anything like the acceleration needed. I would have to get rid of the stinging swarm in some way, but how do you trap something that travels through solid iron like it isn't there? Besides, it could be that the tiny star specks themselves were worth more than the ball of ore that they orbited.

I finally gave up and called for help. "Belt Traffic Control, this is Red Vengeance in The Billionaire. I have a problem. Would you please patch the following message to Belt Science Authority?" I then gave a detailed description of what I had been able to learn about my tiny pests. I signed off and started lunch. It was nearly 20 light-minutes to the Belt Traffic Control station.

In two weeks a few of the small cadre of scientists who were allowed to live out in the Belt were there, cluttering up my rock with their instruments. They couldn't learn much more with their gadgets than I did with my camera and aluminum foil. The specks were tiny and very dense. No one could think of any way to trap them.

I was ready to abandon my claim and leave a fortune and its buzzing poltergeist to the scientists when I remembered the Belt Facility for Dangerous Experiments. The major activity was a high-current particle accelerator designed to produce the antihydrogen that filled the "water torch" engines used in deep space. At each refueling I would watch apprehensively as electric fields and laser beams carefully shepherded a few grams of frozen antimatter into my engine room. There, each grain annihilated would heat many tons of water into a blazing exhaust.

However, antimatter has other uses, and nearby a group made exotic materials by explosive-forming. I went to them with my problem. Soon I had a bemused entourage of high-powered brains trying to think of ways to stop my irresistible objects. We were relaxing with drink squeezers in the facetiously named BOOM! room, which overlooked the distant explosive-forming test site. I dressed for the occasion in an emerald-green bodysuit that I had chosen to match my eyes, and a diaphanous skirt that required dexterity to keep it looking properly arranged in free fall. I wore my one luxury, an uncirculated solid-gold Spanish doubloon.

While the discussions were going on, news arrived from the contingent still observing my find. The specks were still moving too fast to fake close-up pictures with the cameras available but at least the size and density of the specks had been determined. They were dense, but not of nuclear density only about a million times greater than the density of water.

Our bodies are one thousand times more dense than air and we can move through that with ease," I said. "So, at a density ratio of a million to one my leg was like a vacuum to them! No wonder they can go through solid iron like it isn't even there!"

"Although the asteroid's iron can't stop the swarm, its gravity does hold them," said one scientist. He pulled out a card computer and started scratching with his fingernail on the pliable input-output surface. We clustered around, holding position by whatever handhold was available, and watched as his crude scratchings were replaced by a computer generated picture of a flat disc with curved arrows pointing smoothly in toward its two faces.

"What is it?" I asked.

"Flypaper," he said, looking up at me floating above him. "Or, for your problem, Red—gnat paper."

His thick fingers scratched some more calculations, this time in pure math. I followed them without too much trouble. There were no pictures to give me any clues, but it was obvious from the symbols that he was merely applying Newton's Law of Gravity to a disc instead of to the usual sphere.

"We can make the flypaper with the explosive-forming techniques we have developed," he said, "but to keep it from decomposing, we are going to have to contain it in a pressure capsule."

The process looks deceptively simple when one looks out through the eyes of an auto-robot. You merely take a large rotating asteroid as big as an office building and hit it from all sides with a spray of antimatter. When the shock wave passes, you have a small, rapidly spinning plate of glowing decomposed matter that is trying desperately to regain its former bulk. Before it does, you hit it from 12 sides with a carefully arranged set of accurately cut chunks of nickel-iron lined with pure carbon. In the split-nanosecond that the configuration is compressed together into an elastically-rebounding supersolid, you coat it heavily with another layer of antimatter and let it cool for a week.

The auto-robots brought it to us—still warm. It was a diamond—with a flaw. Right in the center of the barrel-size crystal was a thick sheet of highly reflecting metal.

"What is that?" I asked the one who had arranged the fireworks display.

"The original asteroid, Miss Vengeance," he replied. "All four million tons of it. It has been compressed into a thin disc of ultradense matter and surrounded by diamond to keep it from expanding back into normal matter. There is your flypaper, let's go use it."

The disc was 360 centimeters across and only a centimeter thick, but it took a large space-tug to heave that ultraheavy pancake griddle into an orbit that would reach my claim and its singing hangers-on. Once it was there, it was delicate work getting the sluggish plate placed in the path of the glittering cloud that still bounced back and forth through my property every 93 minutes. Finally the task was accomplished. Passing slowly through the diamond casing as if it were not there, the scintillating sparks floated upward toward the metal disc—and stuck.

"They stopped!" I shouted in amazement.

"Of course," said a metallic voice over my suit speaker. "They ran into something that was denser than they are, and its gravitational field is strong enough to hold them on its surface."

"Something that dense must be a billion g's," I said.

"I wish it were," said the voice. I would have liked to have made the gravity stronger so I could be sure we would hold

"The gravity of the asteroid pulled the star-midges toward me. I tried to move out of their path . . . but the cloud of light spots expanded just as it passed me. I screamed and blanked out."

on to the specks once we had stopped them. With the limited facilities we have at the test site, the most matter we can compress at one time is four million tons. That disc has a gravitational field of only one g on each side."

After watching for a while, I saw that the tiny specks were not going to be able to leave the surface of their flat world prison. I conquered my fear and let my helmet rest against the outside of the diamond casing that encapsulated the shiny disc and its prisoners.

The diamond was singing.

The voices I remembered were there, but they were different from the wild, free swirling chorus that still haunted me from our first meeting. The singing now seemed constrained and flat.

I laughed at my subconscious double pun and pulled back to let the scientists have their prize. They hauled the crystalline cask away with the space tug, and I returned to the difficult months-long task of getting my asteroid back to the processing station.

I made a fortune. Even my trained ear had underestimated the nickel content. When payoff time came, I knew that from then on every expedition I made out into the belt was for fun and gravy for all the money I would ever need for a decent retirement nest egg was in solid credits in the Bank of Outer Belt.

With no more financial worries, I began to take an interest in my little beasties—for that is what they were. The high-speed cameras had been able to determine that their complex motion was not due to random natural laws but was caused by the deliberate motion of each of the spots with respect to the others. A few frames had even shown some of the tiny specks in the process of emitting a little jet of gamma-ray exhaust in order to change its course to meet with another speck for a fraction of a microsecond. Then many revolutions and many milliseconds later, each of the two specks that had previously met would release another tiny speck, which joined the great swarm in its seemingly random motion.

The most significant frame from the high-speed cameras, however, is the one that I have blown up into a holopicture over the head of my bunk. I didn't think that you could create a decent three-dimensional likeness of someone using only 1000 points of light, but it is me, all right. Everyone recognizes it instantly—aristocratic nose, bobbed hair, helmet, mike, freckles and all the rest.

But that is all the beasties have ever done in the way of communication. For years the scientists have tried to get some other response from them, but the specks just ignore their efforts. I guess that when you live a trillion times faster than someone else, even a short dialogue seems to drag on forever and just isn't worth the effort. The scientists even took the diamond down to Earth and tried to build a superfast robot as a translator. Now, after years of examination and fruitless attempts to communicate, we finally were able to place the diamond in the San-San Zoo.

The specks, which used to be plastered to one side of the dense disc, are free now that they are on Earth. The one-g upward pull of the underside of the disc is exactly canceled by the one-g downward pull of the Earth. The specks seem to be perfectly happy. They could easily leave the gravity-free region under the disc, but they don't seem to want to. Their cloud stays a compact sphere just below their antigravity ceiling. They continue with their complex intermingling, swirling behavior, passing easily through the ultrahard diamond that holds up their four-million-ton roof.

When I was a young girl at Space Polytech, I dreamed that when I got rich I would spend my latter years reveling in the vacation spots around the world and throughout the solar system, but now I don't want to. Sometimes I can stand it for a whole month—but then I just have to go back and hear my diamond sing. ◘

SPACESHIPS

BY ARTHUR C. CLARKE

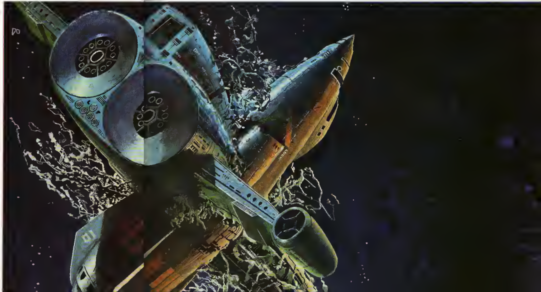
Cosmic toys to propel mankind from its cloistered nursery out into the playground of the stars

Illustrations by David Jackson

As the stately sailing ships of an earlier age of exploration crossed the oceans of earth, today ships of metal and flame are heading outward from our home world to explore the solar system. In this essay, written more than 20 years ago, the prophetic Arthur C. Clarke shows how every great achievement of the human race began as an idea, a dream, a vision, in the minds of individual human beings.

A historian of the twenty-first century, looking back past our own age to the beginnings of human civilization, will be conscious of four great turning points that mark the end of one era and the dawn of a new and totally different mode of life. Two of these events are lost, probably forever, in the primeval night before history began. The invention of agriculture led to the founding of settled communities and gave men the leisure and social intercourse without which progress is impossible. The taming of fire made him virtually independent of climate and, most important of all, led to the working of metals and so set him upon the road of technological

Illustrations by Bob Layzell



❝The dynamism of astronautics is in tune with the expansive spirit of our age.❞

development—the road that was to lead, centuries later, to the steam engine, the Industrial Revolution, and the age of steel and gasoline and surface transportation through which we are now passing

The third revolution began, as all the world knows, in a squash court in Chicago on December 2, 1942, with the first man-made self-sustaining nuclear reaction. We are still too close to that cataclysmic event to see it in its true perspective, but we know that it will change our world, for better or for worse, almost beyond recognition. And we know too that it is linked with the fourth and in some ways greatest change of all—the crossing of space and the exploration of other planets. For though the first space vehicles were chemically fueled, only atomic energy is adequate to lift really large payloads out of the earth's gravitational field—that invisible maelstrom whose tug can still be felt a million kilometers away.

There are still some scientists who consider that there is no point in sending men into space, even when it becomes technically possible,

Tony Roberts

Peter Knifton

machines, they argue, can do all that is necessary. Such an outlook is incredibly shortsighted; worse than that it is stupid, for it completely ignores human nature. Though the specific ideals of astronautics are new, the motives and impulses underlying them are as old as the race—and, in the ultimate analysis, they owe as much to emotion as to reason. Even if we could learn nothing in space that our instruments would not already tell us, we should go there just the same.

Some men compose music or spend their lives trying to catch and hold forever the last colors of the dying day or a pattern of clouds that through all eternity will never come again. Others make voyages of exploration across the world, while some make equally momentous journeys in quiet studies with no more equipment than pencil and paper. If you asked these men the purpose of their music, their painting, their exploring, or their mathematics, they would probably say that they hoped to increase the beauty or knowledge in the world. That answer would be true and yet misleading. Very few indeed would give the

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❛ Humankind can scarcely undertake the challenge of space while still earthbound ❜

Alan Daniels

Bob Layzell

The crossing of space may turn our minds away from present tribal squabbles

simpler, more fundamental reason that they had no choice in the matter—that what they did they did simply because they had to do it.

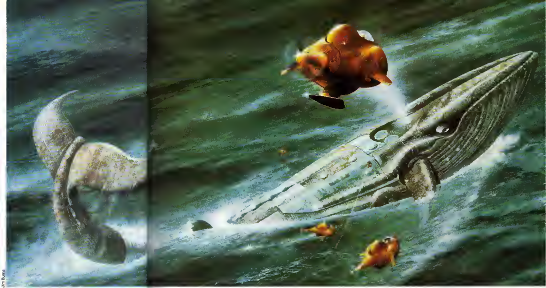
The urge to explore, to discover to "follow knowledge like a sinking star" is a primary human impulse, which needs and can receive no further justification than its own existence. The search for knowledge, said a modern Chinese philosopher, is a form of play. If this is true, then the spaceship, when it comes, will be the ultimate toy that may lead mankind from its cloistered nursery out into the playground of the stars.

The crossing of space—even the sense of its imminent achievement in the years before it comes—may do much to turn men's minds outward and away from their present tribal squabbles. In this sense the rocket, far from being one of the destroyers of civilization, may provide the safety valve that is needed to preserve it. By providing an outlet for man's exuberant and adolescent energies, astronautics may make a truly vital contribution to the problems of the present world. In many ways, astronautics is in tune with the expansive spirit of our age.

Bob Layzell

Robin Hidden

Colin Hay



Jim Burns

Alan Daniels

Bob Layzell

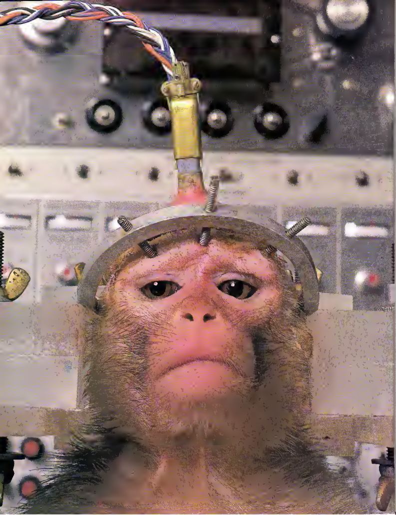
The future development of mankind, on the spiritual no less than the material plane, is bound up with the conquest of space

The future of which I have spoken is now being shaped by men working in quiet offices and by men taking instrument readings amid the savage roar of harnessed jets Some are engineers, some are dreamers—but many are both The time will come when they can say with T E Lawrence "All men dream; but not equally Those who dream by night in the dusty recesses of their minds wake in the day to find that it was vanity but the dreamers of the day are dangerous men, for they may act their dream with open eyes, to make it possible "

Thus it has always been in the past, for our civilization is no more than the sum of all the dreams that earlier ages have brought to fulfillment And so it must always be, for if men cease to dream, if they turn their backs upon the universe the story of our race will end

From *The Challenge of the Spaceship* by Arthur C Clarke Harper & Brothers (New York) 1959

“The future development of mankind is bound up with the conquest of space”



The body's internal opiates may hold the key to abolishing our worst enemy

AN END TO PAIN

BY JONATHAN B TUCKER

A brutal car accident left Barbara Loew with excruciating pain in her neck and back At first her doctor thought it was severe whiplash Months passed but the pain never lessened She tried sleeping tablets Valium, hundreds of painkillers None could relieve the agony that had become a daily part of her existence Like 20 million other American victims of chronic pain Barbara undertook a frustrating search for relief

Several years after the accident, her doctor told her of a revolutionary new drug "I haven't prescribed it to any of my other patients yet" he said hesitantly, 'but the drug appears to be totally safe—it's nonaddictive, there's no buildup of tolerance and it doesn't put you to sleep Furthermore you become desensitized only to the pain that bothers you For instance, you'd still feel a burn if you placed your hand on a hot stove Since your back pains have been unresponsive to any other medications why not give it a try?"

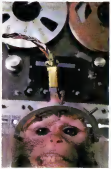
To Barbara's astonishment, there were only two pills in the glass container given her by the pharmacist—a prescription that was supposed to last a month The directions read, "Take one tablet every 24 hours' By the end of the second day, she was discouraged—nothing had happened But on the morning of the third day the aching pain that had plagued her for so long was gone Even more startling the relief lasted for a whole month

'How does it work?' Barbara asked her doctor

"It's really your body that does the work," he explained "The body has its own defense against pain—an opiatelike substance naturally produced in the brain that controls the amount of pain you feel The drug I gave you gradually increased the levels of this brain chemical to provide long-lasting relief"

Although Barbara Loew's story is fictitious, preliminary tests conducted on a group of chronic-pain patients last year indicate that the wonder drug in this story may already exist The potent analgesic properties of this drug were not discovered accidentally Rather the finding was precipitated by rapid developments in our understanding of pain only during the last decade—advances that promise to provide powerful new tools for treating chronic pain by exploiting the body's own pain-inhibitory system But before we can discuss these exciting developments, we first need to know more about pain itself

Pain physiologists have long debated whether specific pain sensors exist or whether pain results from the excessive stimulation of sensory cells that respond to touch temperature and pressure This question was only recently resolved when physiology professor Edward R Perl of the



Stimulating animal brains through implanted electrodes aids in the identification of pain centers in the brain

PHOTOGRAPHS BY DAN McCOY/RAINBOW

University of North Carolina School of Medicine identified nerve endings that are activated only if the stimulus is of sufficient intensity to be painful. These nerve endings have fine interwoven branches and are located in the deep layers of the skin, the internal organs, the membrane covering the bones, the cornea of the eyes, and the pulp of the teeth.

When a region of the skin is injured, the death of the cells in that area is believed to cause the liberation of chemicals associated with inflammation, such as histamine and bradykinin; these substances in turn trigger volleys of nerve impulses in the pain sensors. One of the actions of aspirin is to inhibit the manufacture of bradykinin, so that the generation of pain is blocked at the wound site.

The impulses generated in the pain fibers enter the spinal cord and travel through it to the cerebral cortex, where the location of the painful stimulus is pinpointed on the body surface. The limbic system—a doughnut-shaped region surrounding the core of the brain—appears to mediate the emotional component of pain. The prefrontal cortex located just behind the forehead may also participate in this aspect of the pain experience. Frontal lobotomy, a type of psychosurgery formerly used to treat chronic pain, involved severing the connections between the prefrontal cortex and the rest of the brain. After the operation patients reported that the pain was still there but that it didn't bother them; they simply no longer cared about it and often forgot that it was there. But the personality changes resulting from lobotomy—loss of spontaneity, reduced intelligence, and lowered responsiveness—often made the cure more terrible than the disease.

Surprisingly the brain itself is totally insensitive to pain. Although it interprets pain signals from the rest of the body, the brain can be cut or burned without any conscious sensation, and most brain operations are performed with the patient fully awake. Headaches do not originate in the brain itself but rather from a tightening of the muscles of the scalp owing to nervous tension or, in the case of migraine, from the pressure of swollen blood vessels within the skull against the sensitive membrane that sheathes the brain.

A major breakthrough in the understanding of the physiology of pain came in 1973 with the discovery in the central nervous system of specific receptors, or attachment sites, for morphine and other drugs of the opiate family. These "opiate receptors" were highly concentrated in regions of the brain and spinal cord traditionally associated with the perception of pain, such as the central gray matter of the brain stem and the limbic system.

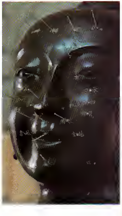
As it typically happens in science, the answer to one puzzling question—how an age-old drug exerts its influence—soon presented a more baffling mystery. Why did the brains of human beings and other mammals evolve with receptors for a chemical in the sap of the opium poppy? A rapid series of discoveries soon revealed that the brain manufactures its own opiates. The unparalleled painkilling properties of morphine (the active ingredient of opium) are made possible because the drug mimics the natural opiates produced in the brain. As Stanford University pharmacologist Avram Goldstein points out, it is "one of nature's most bizarre coincidences" that the configuration of a natural chemical in the brain should match that of a substance found in the opium poppy.

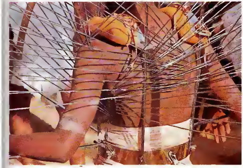
The first of the brain's opiates to be discovered was termed enkephalin (from the Greek, meaning "in the head") and consists of a chain of five amino acids—the building blocks of protein. Although enkephalin chains are destroyed very rapidly by enzymes in the brain, chemical analogues of enkephalin have been prepared in the laboratory that are resistant to enzymatic breakdown. These analogues stimulate pain suppression when injected into the brain or the bloodstream of experimental animals. They are about three times as potent as morphine.

Another potent morphinelike substance, dubbed beta-endorphin ("the morphine within"), has been found in the pituitary gland at the base of the brain. Beta-endorphin appears to be a hormone that is released directly into the bloodstream, which carries it to specific target organs. Because beta-endorphin is released at the same time as the "stress hormone" ACTH, it is thought to play an important role in the body's defensive reactions to physical trauma and stress.

Pharmacology professor Solomon H. Snyder and his colleagues at the Johns Hopkins University School of Medicine recently investigated yet another brain chemical with painkilling properties. Called neurotensin, it is a chain of 13 amino acids. Like enkephalin, neurotensin is localized in brain regions that integrate information about pain and emotion. Although its precise function in modulating pain has yet to be determined, a recent study by the Merck pharmaceuticals company has shown neurotensin to be 1000 times more potent than enkephalin in relieving pain.

The discovery of natural opiate substances in the brain has provided new clues to how some very old pain remedies—from acupuncture to the witch doctor's craft—may actually work. If the wisdom of the ancient Chinese was ever in doubt, certainly their methods of exploiting the brain's natural opiates in the treatment of pain and suffering were highly advanced. The first method the Chinese introduced was, of course, the smoking of opium, which no doubt became popular initially more for its euphoric properties than as a painkiller. The other method—acupuncture—has long aroused the suspicions of Western skeptics. Now, 2300 years after the ancient art was first developed, a link has been found between its anesthetic action and the opiates the brain produces.





By inserting needles at specific points on the skin, the acupuncturist (top) induces anesthesia in remote parts of the body. A physiological basis to the art was suspected when acupuncture points (see model, left, and atlas, top) were found to be located at nerve-cluster centers. Both acupuncture anesthesia and extraordinary feats of pain endurance, such as the Singapore religious ritual of impaling spikes in skin (bottom), are now thought to be linked to the body's ability to produce opiates.

Photo Researchers Inc /Brian Brake

Photo Researchers Inc /Robert Garner

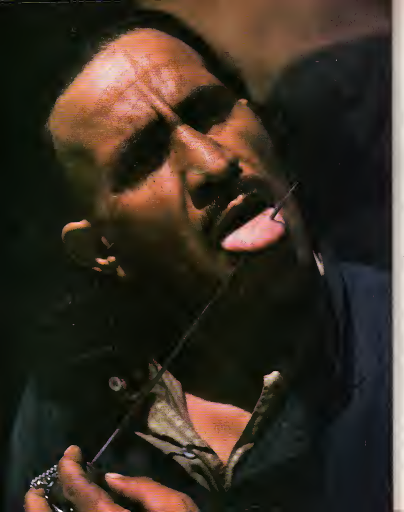
David Mayer of the Medical College of Virginia subjected normal people to experimental pain caused by electrical stimulation of their teeth and found that acupuncture effectively raised the pain threshold. He then gave the subjects naloxone (a drug that blocks the action of enkephalin) and found that it significantly reduced the analgesic effects of acupuncture. This finding suggests that the stimulation of nerve endings by acupuncture needles triggers the release of enkephalin in the brain or spinal cord, thereby raising the pain threshold.

Nonetheless, faith in acupuncture may be an additional factor in its success. It has long been known that a patient's expectations may affect his response to treatment. The success of the witch doctor, often the most highly esteemed member of primitive tribes, may be largely attributable to the patient's belief in the cure. Modern researchers call this phenomenon the "placebo effect." Nearly one third of all patients recuperating from severe postsurgical pain report marked relief after being given a placebo—an inert compound such as a sugar pill or saline solution that the patient genuinely believes is a potent analgesic. ("Placebo" comes from the Latin "I shall please.")

Evidence now suggests that the placebo effect is not just in the mind but also in the physical brain. Again, the natural opiates produced by the brain seem to be involved. Researchers at the University of California at San Francisco gave placebos to patients who suffered pain after wisdom-tooth extractions. As expected, the placebo brought about a significant reduction of pain in one third of the patients. When these patients were subsequently given a drug that inhibits the actions of beta-endorphin, their pain increased back to almost the same level reported by patients who had not responded to the placebo in the first place.

Why placebos trigger the brain to release internal opiates in some patients but not in others remains a mystery. Researchers following this line of investigation speculate that stress may be the crucial factor. Indeed, two related observations—that patients under extreme stress often respond best to placebos, and that beta-endorphin is released from the pituitary simultaneously with the stress hormone ACTH—certainly lend plausibility to this theory. The role of beta-endorphin in stress may also explain peculiar aspects of pain tolerance, such as how athletes in the midst of competition and soldiers in battle can sustain severe injuries without becoming aware until later that they have been hurt. "One feels a single cut from a surgeon's scalpel," wrote Montaigne in the seventeenth century, "more than ten strokes of the sword in the heat of battle."

Could individuals learn to consciously control the release of opiates within their



DPA may be the long-sought wonder drug for chronic pain—two days' treatment can bring relief for up to a month.

own bodies? Followers of Eastern religions who practice self-discipline and meditation in order to achieve inner awareness have long known how to control involuntary responses such as heart rate, respiration, and body temperature. It would not be surprising to discover that the trancelike state Oriental mystics enter before walking over beds of burning hot coals or passing needles through their flesh somehow enables them to regulate the release of internal opiates. For less mystically oriented Westerners, biofeedback training may someday provide the key to gaining control over this seemingly involuntary response.

Man from the beginning has sought to conquer pain. Prehistoric skulls found in Britain, France, and Peru possess gaping holes drilled by Stone Age surgeons in an effort to purge the evil spirits held responsible for headache, and Egyptian mummies over 4000 years old show evidence of painful kidney abscesses and tooth decay. Our word *pain* comes from the Latin *poena*, meaning punishment, for the ancients believed that pain was a penalty inflicted by the gods on any mortal who incurred their wrath.

Despite a more rational basis for treatment today, the quest for pain relief still remains a major endeavor. In the U.S. alone, $10 billion is spent on analgesic drugs and surgical procedures each year.

Until very recently, the only effective treatment of chronic pain involved cutting pain pathways in the brain or spinal cord, or severing the peripheral nerves where they enter the cord. But the cost for such relief was terribly high: a useless, endangered limb or, in the case of psychosurgery, reduced intelligence and adverse personality changes.

In the last decade, however, approaches to pain therapy have changed radically owing to our new knowledge of the body's own pain-suppressing system. There has been a move away from the surgical treatment of pain to the electrical stimulation of peripheral nerves and parts of the brain involved in the pain-inhibitory system. This is not altogether a new method. In the first century A.D. the Roman physician Scribonium Largus relieved the pain of headache and gout by applying a live electric fish to the aching spot until the part became numb.

(left) Photo Researchers, Inc./William Carter

Today, current is applied with electrodes taped to the skin or implanted directly in the spinal cord or the brain so that the patient can intermittently activate them when the pain becomes too severe. Although the technique has proved effective in relieving chronic pain unresponsive to other therapies, it is not yet known whether excessive stimulation will lead to a reduction in the analgesic response over time or whether the presence of permanent metal electrodes in the brain tissue will have adverse long-term effects.

A second development in the treatment of chronic pain has been to devise new drugs possessing the beneficial qualities of morphine without the bad ones. In 1680 the English physician Thomas Sydenham wrote: "Among the remedies which it has pleased Almighty God to give men to relieve his sufferings, none is so universal and efficacious as opium." Even today in spite of all the thousands of painkillers available, the opiates remain the only class of analgesic drug powerful enough to treat severe pain.

Unfortunately, the toxicity and addictiveness of opium and its derivatives have greatly tempered much of the medical community's initial enthusiasm toward this class of drugs. The isolation of morphine from dried-opium powder in 1803 was followed shortly by the invention of the hypodermic syringe, greatly facilitating the administration of pure morphine to large numbers of wounded soldiers during the Civil War. This made opiate addiction a significant social problem in the U.S., and as is well known, the situation has now reached epidemic proportions.

Over the years, the continuing search for a nonaddicting synthetic opiate has been frustrated time and time again. In the 1890s, a German pharmaceuticals house introduced heroin, a semisynthetic form of morphine, as a nonaddicting opiate. It soon proved to be more addictive than the drug it was designed to replace, probably because it enters the brain more rapidly from the bloodstream. Similarly, in the 1940s Demerol became the most popular opiate analgesic in America, because it was thought to be nonaddicting. The growing number of Demerol addicts soon convinced the Bureau of Narcotics otherwise.

The recent discovery of the brain's own opiates naturally raised hopes that modified forms of these chemicals might provide the long-sought nonaddicting analgesics. Enkephalin was chosen for the preparation of analogues because it is only five amino acids long. But to produce a medically useful enkephalin, it first had to be stabilized so that it would not be immediately destroyed and chemically modified so that it would pass through the "blood-brain barrier" into the brain. Chemists at the Sandoz drug company in Basel, Switzerland, overcame these formidable obstacles. They managed to stabilize the molecule and enhance its activity so that one enkephalin analogue, designated FK-33824, is 30,000 times more potent than enkephalin.

Excitement about enkephalin analogues was quickly dampened when it was found that they too, are addictive. When rats are regularly treated with enkephalin or beta-endorphin, they develop many of the symptoms of morphine addiction. Nonetheless, the recent discovery of the analgesic properties of neurotensin has

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Surgery for chronic pain (above) may duplicate what mystics achieve through body control (left)

FICTION

When he built the best snow-going racer, he had no idea that it would be too good.

THE BLIZZARD MACHINE

BY DEAN ING

Sam's sudden blizzard is history now, and like all motor racing disasters its memory is rusting out in a junkyard of legends. Some claim Sam's design was faulty. Others say the fault was mine for listening to him. Smythe, our sports car club archivist, warns that we all orbit too closely around Sam, like moths around a rally car spotlight—but Smythe's a poly sci professor so that's got to be wrong.

I blame it on the weather. The snow came a month early and all at once and froze out our plans for late fall competition.

"Tee-boned yer slalom event, did it?" Sam grunted happily as we slumped at his fireplace.

"Black-flagged us," I admitted. I sat watching flames as Sam arranged blazing chunks of hardwood. Now anybody can poke at a fire with a Bugatti dipstick, but Sam was feeding his fire with old trophy bases. Pretty expensive way to heat a hangar, from the standpoint of effort expended. Actually, Sam only had to heat the living quarters in his surplus hangar, which is the only structure on his property. The rest of the place is crammed with machine tools, surplus aerospace materials, his vehicles, and his clean room, where he doesn't build racing cars. I mean, he doesn't anymore. That is, he does, but not as a business

PAINTING BY FRIEDRICH HECHELMANN

now Sam was with Lockheed s skunk works until after the U-2 and SR-71 were public knowledge and then he turned to designing racing cars

His series of fabled cars might have gone on forever had he not stolen computer time from Lockheed to make a study of racing trends Sam took one hard scan at the printout and quit serious competition in mingled disgust and fear In 1990, he predicts, go-carts will outgun Indy cars and dune buggies won t need wheels Something to do with new power units, he says with a glint in those gray granite eyes

With all his engineering know-how and all his stolen hardware and both of his magician s hands in that hangar Sam is roughly as important and predictable as the weather His sudden blizzard was inevitable from the moment Sam softly rasped as if to the fire, You don t really have to hole up all winter y'know

I glared at him. "No. I could get me a sled and name it *Rosebud* I grumped Great sport

Sled mm, yeah Brief pregnant pause then breech delivery You remember the old quarry course?"

I shivered, and not from the cold The quarry racecourse had been outlawed after our first competition event there We had had 73 entrants, and 21 didn t finish, and 52 canny dudes found excuses not to start Any idiot could add that up It was a week before we got the last car hauled out of there I reminded Sam of this

Yup and if you remember, I told you not to touch it with or without gloves, Sam countered 'But with a few ah *minor* changes I just might give it a try

This *winter*?

He nodded

In thirty inches of *snow*?

He hummed a snatch of "White Christmas

"You re weird" I said "We'd kill somebody

"Quoth the craven, he said 'Shut up and let me think

I m convinced now that Sam cheated he must've been plotting the idea for a long time He cupped his big stubby hands over one knee and smiled to himself Ever do any sledding?

"Exactly once

"Me, too Never got used to the lack of power on the uphill straights

But what s that gottadowith

Sam raised a restraining hand Just listen he soothed Take the old quarry course and run *down* it instead of *up* Build your own frame Use—heh, heh—any power plant you please add steering, put a windscreen on and be a hero at the quarry

I gnawed my lip a moment Sounds simple, I hedged, 'but if anybody goes off the edge—

He ll hit a nice cushy snowdrift instead of a bale of hay I figure you hay raisers might find that a welcome change Choice of power train is up to you Wheels chains, propeller spikes ducted fan or a team of oxen if that's yer karma Use any brake system that works at tech inspection Sky s the limit

Sam had something there And it was catching I tingled at the vision of sledding specials specially built racers midwifed in our garages It would be fun hell it could become a winter revolution Speed Week in Springville! "Sam? Ah would you—

Propose it to your club? I just did Sam s smile seemed open guileless Maybe it was a leer In any event, no pun intended, Sam s recommendation was as good as a direct order Twenty-seven members of the club swore to build specials and oddly enough many of us did The rest including me, gave help I wanted to help Sam when he announced that he was building a surprise entry I should ve saved my breath

The appointed Saturday dawned with a knifing chill in the clear sky Snowballs flurried between early arrivals at the quarry I

God only knows how any driver would dare to hunker down kneeling, his fanny up to tempt those cleats, and guide that flailing juggernaut over patches of glare ice on a twisty trail . . at the quarry

checked off the conical pylons fire extinguishers, doctor, and timing equipment wishing we had attracted some racing journalists The man from the local *Bugle* was worse than nothing but him we had, like it or not I fought the temptation to steal his hat for a pylon It was already the right shape

Scanning the entry list I could see our first mistake was the lack of ground rules Several guys used open propellers, one of em a front-mounted rig that nearly blew the driver off while it was idling He got chilblains and became an instant spectator Another the onist put six little tires across the rear axle to get more adhesion It worked fine on firm snow but at the technical inspection he gunned it and his wheels hungrily chewed a hole two feet deep Of course, it dropped backward into the hole like a sounding whale and killed the engine and caught fire with the usual result We buried the hulk under a pile of slush and went on with tech inspection

Sam s pickup eased up the access road with a towering, tarp-shrouded lump looming over its cab Everything got very quiet Sam had refused us even the slightest peek at his secretive entry Small wonder

With his usual stolid care Sam flipped back the tarpaulin and revealed most of his special One of the tech inspectors screamed saving me the trouble

To begin with the—thing—broke all the rules or, rather, the assumptions Everybody but Sam used heavy frames sand-filled tubes bags of birdshot, or Corvette body parts to add weight Sam had a gossamer birdcage frame of aluminum wrapped with quartz fiber tape For a maniacal moment I wondered if he d crocheted it

Everybody with wheels used fat little studded tires but Sam s wheel was two and a half meters high Towering between a rear pair of ski runners was a single viciously cleated monstrosity of magnesium, like a kulak s ferris wheel a half a meter wide It was mounted on an axle held by that spidery tubing frame

Nearly everybody had cart engines mounted near the wheels Sam used a turbine powered by a liquid that he handled with something very like terror—and Sam crimps dynamite caps with his teeth The turbine wasn t near the wheel it was inside! Sam had bolted it to the nonrotating axle within his hellish great wheel

If I forgot the gear teeth around the inside of the wheel, forgive me A simple drive gear transmitted the turbine's torque to the big wheel Studying the gear ratio I calculated that the monster wouldn't be very quick To be competitive the turbine would have to run at over 50,000 rpm Later, Sam told me his little aerospace fugitive didn t run well at 50,000 It ran much better at 500 *Thousand* Which partly explains—but I m getting ahead of myself

The steering mechanism was a disappointment at first (and to me, a revelation at last) a forward pair of skis pivoted from a box on the frame ahead of the driver s location God only knows how any driver would dare to hunker down kneeling his fanny up to tempt those cleats and guide that flailing juggernaut over patches of glare ice on a twisty trail near sheer drops at the quarry To any sane driver that rig was a case of shove at first sight

A murmur from the crowd drew me back to the course High on the trail a propeller-driven sled had just started when its brakes failed Worse the driver was a first-timer, our only woman entrant wife of an inept mechanic darling daughter of a city councilman She had never learned to drive and thought it entertaining to start with something little and cute I exchanged nervous tics with our club treasurer Bernie Feinbaum, but everything was fine until Turn One It always is

When I first spotted it the sled was spitting snow slowly rotating down a short straight until it was directly bass-ackwards and aimed off the cliff face That's when Bernie crossed himself

And down she came idling the prop on downslopes to build up speed A surge of backward thrust nearly stopped her at

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WELCOM
SEVILO

Do our genes control our destiny?
Are we programmed to behave?
Harvard sociobiologist
E. O. Wilson explores the controversial
nature of our genetic heritage

INTERVIEW

E.O. WILSON

The publication of E. O. Wilson's *Sociobiology* in 1975 was—to use a cliché—a landmark event in the history of biology. This enormous volume (697 oversize pages) is a truly remarkable compendium of a vast, widely dispersed literature on the relationship between biology and social behavior throughout the animal kingdom. It ranges from *Homo sapiens* to the social insects (Wilson is by trade an entomologist, his speciality—he calls them his "totem animal"—is ants). He intended it to be a scientifically respectable, thorough review, so it is full of tables and charts and extensively referenced. On the other hand, it is well written and handsomely illustrated.

The message *Sociobiology* carries was a startling one: that various kinds of social behavior are genetically programmed into many species, including our own, and that this programming is particularly true of the social behavior human beings label "altruism," which Wilson defines as "self-destructive behavior performed for the benefit of others."

The elegant theoretical construct that underlies this assertion is the notion of kin selection. Darwin's theory of natural selection argued that the organism that possesses traits that help it to cope successfully with its environment is the one that survives and passes its genes on to its offspring. But the altruistic organism, by definition, dies, usually leaving comparatively few offspring. This means, in Darwinian terms, that genes for altruism, if they exist, will continually be wiped out before they can be passed on. The kin-selection theory provides an explanation for this apparent paradox by pointing out that altruistic behavior which protects people with whom you have genes in common—your relatives or kin—is equivalent to saving pieces of yourself, and that those pieces will continue to persist in *their* children, even though you yourself may have died childless.

Sociobiology also argues strongly in favor of the genetic basis for behavior differences between men and women and also for aggressive behavior. This, too, is not a new debate, but the reiteration of these ideas certainly rekindled the fire. It is of course the century-old nature-nurture argument. Which is more important in the making of human beings, heredity or environment?

One criticism leveled at Wilson is that, as an expert on human nature, he is a fine entomologist. That criticism has not, however, prevented him from writing *On Human Nature*, his newest book, out this fall. It is, Wilson says, "not a work of science; it is a work about science and how far the natural sciences can penetrate into human behavior before they will be transformed into something new." Its core is a speculative essay about the profound consequences that will follow as social theory at long last meets that part of the natural sciences most relevant to it.

Edward Osborn Wilson, an only child, was born in Birmingham, Alabama in 1929, and was raised and educated in Alabama until he went to Harvard to work on his doctorate. He has been in Cambridge ever since and now holds the positions of Frank B. Baird, Jr. Professor of Science and curator of entomology at the Museum of Comparative Zoology. He is tall and rather thin, an enthusiastic and unabashed talker. Like most of the country, he jogs. The people he admires most are "the ones who have great goals they persevere toward over long periods of time in a controlled and fully rational way . . . particularly where they involve discipline and endurance." Dr. Wilson was interviewed for *Omni* by Tabitha M. Powledge, associate for biosocial studies at The Hastings Center, Institute of Society, Ethics, and the Life Sciences, Hastings-on-Hudson, New York.

Omni: One of the conclusions in *On Human Nature* is that there are what you call "modest" differences between the sexes that are genetic; these then become hypertrophied, that is, emphasized by culture, in most places. You then go on to say that those innate differences between men and women could probably be canceled through careful training. Should they be?

Wilson: That's the question I raise.

Omni: Answer it.

Wilson: I'll leave the question open. I say there are three things we could do. We could decide to exaggerate the differences. But that would exacerbate the current circumstances. Domination and injustice would continue, and individual development would be stunted. It would deprive the person who might want to move into roles not ordinarily associated with his or her sex.

The second alternative would be to erase the differences. As the evidence appears to me, they are so slight they could be erased with only a little bit of tinkering. You could probably get statistical equivalence in roles, so that you would have approximately the same percentage of women doctors as men doctors or women senators as men senators or men nurses as women nurses, etc., and approximately the same amount of time being spent by each sex in the home in domestic chores and in raising children and so forth. The evidence seems to suggest that predispositions are modest enough that they could be erased without a great deal of difficulty but it would require more knowledge than we have.

The third alternative would be laissez-taire, which essentially is what this society has been exploring: equal access, equal opportunity rigidly enforced, but then letting the chips fall where they may. However, if those genetic predispositions that appear to exist do in fact exist, then you probably would get, even with rigidly enforced equal access, some statistical difference in the outcome.

Omni: One of the examples you cite is the second generation of the kibbutz.

Wilson: Yes. I started off feeling that the Israeli kibbutz was a good piece of evidence of the stubbornness of sex differences, but that has been compromised in my opinion by the evidence of powerful influences from the outside of Jewish patriarchal ideology. However, the evidence there is still very suggestive. It is interesting to see the regression of women toward more traditional roles even in a culture that explicitly calls for egalitarianism and equality. And the second generation of daughters has gone further than their mothers. They demand and receive a longer period of time each day with their children, time that is significantly entitled "the hour of love." Some of the most gifted have resisted recruitment into higher levels of commercial and political leadership.

Laissez-faire, on first thought, might seem to be the most congenial to personal liberty and development. But that's not necessarily true. With identical education for men and women and equal access to all professions, men are more likely than not to continue to be disproportionally represented in political life, business, and science. Many would fail to participate fully in the formative aspects of child rearing. The result might legitimately be viewed as restrictive on the complete emotional development of individuals.

I should add that this last note entered into my thinking as a result of a discussion with a feminist. It was pointed out to me that males especially in our society tend to think of the professions as being the *summum bonum*, that the purpose of everyone in society is to move toward the professions, and that the entire women's-liberation movement consists of women demanding or getting access to the professions.

But it cuts the other way, too. The more balanced feminists tend to see that the dichotomization of society according to sex also prevents men from taking part in many activities and many emotional involvements. I had to concede the point.

I don't feel at this stage there is any basis for suggesting what should be done, only I'd point out that there is a cost connected with each one of these alternatives. I use the sex-role problem as the paradigm in this book for discussing a new kind of calculus for social design that we will have to begin to develop. The fact is that we do have to consider the cost of certain moral standards, or certain societal goals as opposed to others.

Omni: Relate what you just said about sex roles to your discussion of homosexuality, which, it seems to me, also has a lot of policy implications.

Wilson: I want to make that a paradigm too. I'm arguing for a whole different view of homosexuals.

Omni: You base it on an intriguing argument describing what you think sexual relationships are all about. Though your interest is in genetics, you present the fascinating argument that it's not procreation which is the terribly important function of sexual relationships, but rather—

Wilson: It's bonding. And once you appreciate that what sexual behavior is all about is primarily bonding—the establishment of particular kinds of human relationships that are needed for the rearing of offspring, for the maintenance of human society, and not for procreation alone—once you appreciate that, then you suddenly get a completely new view. For one thing, it suddenly makes sense why sex and sex relationships and sexual imagery pervade almost all of our social existence. We—

Omni: It's not just a creation of Madison Avenue?

Wilson: [Laugh] No. Certainly not. And I don't think it's just a creation of Western culture either. Sex is pervasive and it's important in *all* cultures, though more in some than others, obviously. In cultures that have been sexually repressive and are going through sexual liberation, of course, it probably commands an abnormal amount of attention. But it's pervasive in most aspects of life in all cultures. In subtle and difficult ways sexuality has confounded psychologists; it's been the source of endlessly complicated psychoanalytic theory, such as why it pervades the relationship with one's father, or why sexual images can be transferred so easily to automobiles, and so on. I think the general answer is that sexual behavior in human beings as primarily a bonding mechanism transcends even direct heterosexual, man-wife relations. And we need to explore the possibility that homosexual bonding might be a biological mechanism. In presenting this rather radical hypothesis—I didn't want to defend it too strongly because I don't think the evidence is overpowering—I did want to stress that the Judeo-Christian view, that sex exists for procreation, and the particular customs and particular attitudes toward sex which are embodied therein, is a view that is optimal for an expanding, rapidly growing population but inappropriate for stable, steady-state populations.

Omni: But in your discussion of homosexuality you tend to be much more prescriptive than you are in your discussions of sex roles

Wilson: That's quite true. I felt the need to be more emphatic. Also, it may be that the strength of the predisposition is different.

Omni: You mean that homosexual proclivities are somehow more genetic than sex roles?

Wilson: That may well be the case. It may be harder to erase homosexuality than to erase sex-role differences. But whether it is true or not, that's the kind of thing we ought to be considering when we add biological dimensions to social science: the "hardness" of the various predispositions.

I believe the immediate benefit of the sociobiological approach is to put on a much firmer basis what is natural and what is not natural. Sociobiology then can aid us in making moral judgments and also in the process of evaluating cost.

Take the case of homosexuality. There is a lot of evidence to support my hypothesis, and furthermore, it should be *explored*: biology has not been explored properly in the case of homosexuality. One of the great deficits of the social sciences is that they simply do not know how to explore these hypotheses, or at least they haven't up to now. The hypothesis should be explored, and if it turns out that the evidence favors it, then suddenly we would see that the benefits from suppressing homosexuality, from trying to cure homosexuals, from depriving them of their rights so they cannot teach at school, the benefits would shrink enormously and we would simultaneously see the cost expand. The results would be—and I believe should be—*toleration*, a completely different view of homosexuals, acceptance.

Omni: Okay. Then that leads into what seems to me to be an interesting point and certainly a source of some worry over sociobiology, and that is the use of genetic explanations to excuse some forms of behavior. Let's take aggression as an example. You argue fairly strongly for aggression's being innate. Why can't you use the same line of reasoning to argue for toleration of aggression as well as of homosexuality?

Wilson: If I am going to say what I am saying about homosexuals, why can't the same argument be used to save a war? But that is why I refuse to commit the naturalistic fallacy, that is, to say that what is natural is good.

In the case of homosexuality, what I am saying is that you cannot condemn homosexuality on the ground that it is biologically unnatural. I hope I demolish that argument. And then I say that we will have to recognize that there are some things that represent biological predispositions that are extremely difficult to eradicate. Some of them are absurd legacies of the hunter-gatherer society. It's just one of those crazy things we got stuck with, like hair on the backs of our hands, or the difficulty blue-eyed people have when they go to the tropics. There are certain things we've inherited that are inconvenient. Sex-role differentiation may well be one of those. Homosexuality may be one of those. The readiness to switch into violent aggressive behavior surely is one of those. And all I can suggest is the cost-benefit analysis made possible by sociobiology and other biological studies, and then an open discussion of what we want to do about it.

You know, aggression, even violent aggression by itself, is not necessarily an evil thing. All I'm saying is that with the present

"Religion has not been examined by biologists or sociobiologists or evolutionists. One of the main reasons is that it's so uniquely human. This is one subject, one area of behavior, where you can't draw from ants or baboons."

global situation, it clearly is to be proscribed because it is harmful to everyone, including ourselves. We need to study it more and find ways of getting around it. This cost-benefit analysis I'm talking about, deciding what we want in societies—stabilization, rapid technological progress, whatever—are things which are not going to be decided by reference to our crazy-quilt biological heritage.

Omni: I find those three examples particularly interesting because it seems to me the implications of what you're saying are quite different in each case. One is that as far as sex roles are concerned, we might want to choose a route that tended to eliminate the differences. As far as homosexuality is concerned, we might want to do the opposite: grant homosexuals a lot more recognition than we have. And as for aggression, we might sometimes want to curb it and sometimes not, which seems to me to be the hardest possible sort of thing.

Wilson: I would say that on the earth as it is today, we would always want to curb violent aggression.

Omni: But you and I would not have wanted to curb violent aggression in 1941. You think it is possible to choose to suppress a behavior or not to suppress it or to treat it variably, depending on the circumstances?

Wilson: Exactly. I think it depends on what the circumstances are and what we really want society to move toward. All that sociobiology can do, in my opinion, is to tell us more about where we came from, what we've got, what our predispositions are, as an aid in the cost-benefit analysis that goes into any discussion of our future goals. That's what a large part of politics and social planning is all about: what our goals are, what we want to achieve beyond mere survival.

Omni: You make some suggestions about channeling aggression. One of the suggestions you appear to be making is that sports, particularly organized sports—professional sports, I think, is the phrase you use—serve part of that function.

Wilson: Well, that was Konrad Lorenz's idea.

Omni: How do you differ?

Wilson: I don't differ. I think that's a correct argument. Except that I do dispute his basic model, on the basis of new information over the last ten years. He had in his mind his old hydraulic model, the idea that pressure to engage in aggressive behavior was always building up, that you have to find a release for it in one way or another, and that the best way to release it is through sports.

The evidence now seems to go strongly against the building up of the drive, but Lorenz was correct in believing that there is a biological predisposition there. I think there is a strong tendency to engage in competitive sports and to identify chauvinistically with them. You see nationalism at its worst in world soccer meets. Good, kindly Americans can develop a real hatred toward Cincinnati or Seattle at the height of the championship play-offs. It's so strong that we can identify with it and do it even though the team members are being traded back and forth and come from all over the country. It's interesting to listen to interviews with athletes who have just been traded into a local franchise. They may come from Texas or have played for UCLA, but now they're joining the Celtics, and what they say is predictable: "Boston's a lovely town. I feel a sense of community here. The thing I really like about the Celtics is the feeling of team play I can identify with this place." And the hearts of people go out. They are just dying to make this guy a member of the family. So we have an overpowering predisposition to do that. The question is: How good is it? Lorenz's original argument is probably wrong. We don't *have* to do it. Indeed, if anything, it can exacerbate the tendency to develop regional rivalries and perhaps even our propensity for violent aggression, but it seems to provide great emotional rewards for human beings.

Omni: Do the rewards have to do with its xenophobic aspects?

Wilson: That's right. Yes, we have a predisposition to be xenophobic, to be chauvinistic, to identify with a familylike group that occupies a particular territory. This is all quite naked and open, and it's not harmful unless it exacerbates nationalistic feelings or racial or ethnic feelings, which can then become deadly.

Another example is what I call biophilia. I am inclined to think of that as a very strong natural predisposition. That's the desire to be surrounded by other living things, like

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NUTRITION HYPE

The "fortification war" may end only when we all starve

BY DANIEL GREENBERG

Sometime within the next few years, a food manufacturing company will announce the development of a new snack food. It might be a chocolate-covered cupcake or a milk shake or a candy bar—it could come in almost any form. But the feature the food company will advertise most prominently is that this snack, though composed mostly of refined sugar, will be *nutritious*. That is, by eating just one cupcake, milk shake, or whatever, you will be meeting the U.S. Recommended Daily Allowances (RDAs) for every nutrient considered vital to good health by the Food and Drug Administration (FDA).

It's not such a farfetched idea. We're currently in the middle of a "fortification war" in which the widely touted U.S. RDAs for protein and 19 vitamins and minerals have become major weapons in the hands of the food company giants. Any foods that can proudly display on the sides of their glossy packages that they meet 100 percent of any or all of the RDAs instantly gain a tremendous advantage over their competition on supermarket shelves.

The future implications of the fortification wars are far from optimistic, however. True,

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the promise of getting all of one's Recommended Daily Allowances from a single snack is indeed inviting. But the cruel reality is that it's possible to consume 100 percent of every one of the 20 RDAs and still starve to death. Or at least be seriously malnourished.

The RDA standard may be one of the single largest obstacles to the future of healthful nutrition in this country. It is outdated, vulnerable to exploitation, and basically useless in guiding Americans toward a healthy diet. What's worse, it can be misleading. Consumers are convinced that the RDAs reflect scientific knowledge of sound nutrition and dine under the illusion that eating a full share of RDAs is the key to health.

It's simply not true. Despite advertising claims to the contrary, adding up RDA percentages on the labels of processed foods until you reach 100 percent for every nutrient (protein, iron, calcium, copper, iodine, magnesium, phosphorus, zinc, biotin, niacin, thiamin, riboflavin, folic acid, pantothenic acid, and vitamins A, C, D, E, B_6, and B_{12}) is just not the way to eat.

Here, then, are the unfortified and unappetizing facts on our U.S. RDA system and why it doesn't work.

AN IDEA WHOSE TIME HAS GONE

The RDAs may have been useful back in the 1940s for combating deficiency diseases such as rickets, pellagra, and scurvy, but these problems are almost nonexistent in present-day America. Instead, we are faced with the problem of excess, particularly in regard to sugar, fats, and salt, all of which can be detrimental to health when ingested in large quantities. The RDA system not only remains oblivious of the harm these substances may cause but, ironically, tends to encourage their consumption. For example, many popular cereals are heavily fortified so as to provide 100 percent or more of many RDAs. But they are also heavily laced or coated with sugar to make them more palatable. The consumer gets the impression that he's eating well, when in fact his excess intake of sugar is subjecting him to many health hazards.

And recently in a government-supported food program for women, children, and infants, a cereal containing 68 percent sugar was allowed while more healthful cereals—those that were whole grain and lower in sugar content, such as oatmeal and shredded wheat—were not allowed, simply because they contained less than 45 percent of the RDA for iron.

Where do the RDAs come from? Like so much else in the scientific realm, the RDA system can be traced back to military considerations. At the beginning of World War II, concern over the adequacy of the national food supply turned government attention to the question of what the nutritional requirements of the American people are. In 1943, the nation's most prestigious scientific society, the National Academy of Sciences (NAS), agreed to take on the job. Today, as they did then, the RDA ratings originate in the academy's Food and Nutrition Board, composed of learned figures in the nutritional sciences. Every five years the board reviews the latest scientific literature and produces a publication, *Recommended Dietary Allowances*. This, plus other sources, is in turn used by the FDA to calculate the U.S. Recommended *Daily* Allowances that show up on your food packages.

But despite the elaborate procedures set up to create the RDAs, there are still many holes in the system. For example, it ignores many nutrients, at least 20, that have been identified as essential to good health.

This policy can have far-reaching effects on the public health. Bonnie F. Liebman, a consumer representative on the Food and Nutrition Board, recently told a congressional inquiry about some of the abuses. Ms. Liebman explained that hospital dietitians as well as many other institutional

"The RDAs may have been useful back during World War II for combating deficiency diseases such as rickets, pellagra, and scurvy, but these problems have long since disappeared from the land."

food planners are often so obsessed with the RDA system that they tend to disregard other nutritional factors just so long as they can pack those RDAs into their meal planning. "Because of the availability of highly processed, highly fortified food products," she said, "they [the dietitians] can easily overlook the presence or absence of other dietary constituents, such as fat, saturated fat, trace elements, and fiber, which now pose far greater public-health problems than those nutrients included in the RDA."

The problem is twofold: The RDA system ignores the modern need for more fiber, trace elements, and other nutrients in the diet while it indirectly encourages unhealthy intakes of sugars and fats.

So what kind of diet *should* the NAS and FDA be encouraging? That, we'll soon see, is yet another problem.

WHO KNOWS?

Nobody knows what a good diet is. Two years ago, the General Accounting Office (GAO), which conducts investigations for the U.S. Congress, made an extensive survey of the nutritional sciences. They went so far as to interview 32 leading nutrition researchers. The results? The GAO dourly concluded: "Given the present state of nutrition knowledge, it is not possible to say what constitutes an adequate diet."

And then there's the expert and gloomy appraisal of the nutrition sciences offered by Ross H. Hall, professor of biochemistry at McMaster University, Ontario, Canada: "The science of nutrition has essentially stagnated since the early 1950s, when the last vitamin to be discovered was announced." Yet during this time, Hall points out, monumental changes have occurred in the American food supply to the point where factory-processed foods dominate the nation's diet. Whether this is good or bad, Hall insists, is unknown, because the nutritional sciences are hooked on the obsolete notion that by identifying RDA requirements, they are pointing the way to good nutrition.

THOSE MAGIC NUMBERS

Despite the credentials of the NAS and the FDA, there's nothing scientific about the RDA's magic numbers. On what basis, for example, does the FDA list six micrograms as the RDA for Vitamin B_{12} or 400 international units (IUs) as the RDA for Vitamin D? Also curious is that only one number is ever given for a particular nutrient on food-package labels, regardless of whether the consumer is a growing adolescent, a sedentary senior citizen, or a hardworking manual laborer. Surely requirements must differ among individuals according to age, activity, and sex. As a matter of fact, the academy's tables recognize these differences by establishing five age groups of males, females, and pregnant and lactating women. And each group is further divided by weight, height, and daily energy expenditure. But the version the public gets—the FDA's RDAs—gives only one amount for each nutrient. And this is for "adults," defined by the FDA as anyone over age four! (To be fair, the FDA does prescribe different amounts for infants, children under age four, and pregnant and lactating women, in its public—but rarely seen—literature.)

Finally, if the RDAs are based on scientific study, why is it that other nations have come out with different numbers? In the U.S., for example, the adult RDA for Vitamin C is 45 milligrams, whereas in Canada and Britain it's 30, in West Germany it's 75.

ENOUGH IS TOO MUCH

The RDAs are much too high. Since they originated because of wartime concern over nutritional adequacy and at a time when the nutrition sciences were most concerned with deficiency diseases, the whole thrust was toward making sure the American population as a whole would get essential nutrients. Since the focus was on the masses, the single figure for each RDA had to be set high above the average requirement to make sure *everyone* got enough.

What the NAS and FDA strive for, then,

are RDAs set above the average requirements by twice the standard deviation. Which means that approximately 97.5 percent of our population needs less than the specified RDA for any particular nutrient.

Stated otherwise, the system deems it better for most of us to have too much than for some to have too little. Once again, this reflects the antiquated obsession with deficiency diseases, even though for the most part they've long since disappeared from the land.

FAULTY TESTS

RDA tests are suspect. Strangely enough, the academy committee that periodically reissues the RDA tables admits that the scientific underpinnings for its recommendations are often pretty wobbly.

"Unfortunately," states the committee, "experiments on man are costly; they must often be of long duration; certain types of experiments are not possible for ethical reasons; and even under the best conditions only a small number of subjects can be studied in a single experiment. Thus, requirement estimates must often be derived from limited information."

Even when the RDAs are based on extensive experimentation, one of the most common techniques used—called "balance studies"—has been the subject of skepticism. Based on the assumption that when the body has enough of a nutrient, the surplus will be excreted, these studies are simply feed-and-measure exercises. What researchers look for is the amount that must be ingested to produce a surplus, from which, presumably, the minimum required for good nutrition can be calculated.

But these retention rates may have no significance so far as nutritional requirements are concerned, according to D. M. Hegsted, who recently left the Harvard School of Public Health to head the Department of Agriculture's newly established Human Nutrition Center. The rates he observed in an article in the *Journal of Nutrition*, appear to vary without explanation when such factors as temperature and dosage are changed. Hegsted concluded that new analytical techniques are needed, and "until such methods are available, the results obtained with balance methods must be viewed with skepticism."

PROMOTING HUCKSTERISM

Besides creating an atmosphere of scientific certainty, when in fact much of the scientific basis behind it is pretty shaky, the RDA system also lends itself to hucksterism.

In their early days the RDA ratings were mainly of interest only to government planners and various technocrats. But as the vitamin craze developed in postwar America, food manufacturers began to realize that RDAs could be a potent marketing tool. And in 1974, when the FDA instituted a requirement for nutritional labeling on most packaged foods, the fortification wars began in earnest, with manufacturers competing to outdo each other in providing—and even exceeding—the government-certified Recommended Daily Allowances. Toward this goal, they were prodded on by manufacturers of vitamin and mineral supplements, who heavily advertised in the trade press about the marketing wallop to be had with high RDAs.

It is interesting to note that a possible by-product of the fortification war is that Americans are eating less fresh fruit and vegetables than ever before. While fruits and vegetables are valuable sources of a majority of the nutrients on the RDA list, RDAs are listed on packaged foods only. Which gives Kellogg's cornflakes a distinct advertising edge over corn on the cob.

LABEL OF THE FUTURE

The problem of what to do about the system has been rumbling around government circles and the food industry for years. RDA ratings *can* be defended on the ground that poor as they are they represent the best available knowledge and are therefore valuable guides, if properly used. In response to the argument that label information is too sparse to be meaningful to the average consumer, the industry counters that it would take a label the size of a newspaper page to provide full details about nutrient content and requirements.

Yet some have proposed that the present labeling be replaced with simple charts that would concentrate on such basics as roughage, salt, sugar, fats, proteins, and carbohydrates—leaving out the currently listed RDA items on the assumption that any reasonably diversified diet will probably provide all of them.

It is very likely that we will see major changes in food-product labeling within five years, if not sooner—because one of the advocates of more comprehensible labeling is Donald Kennedy himself, commissioner of the FDA. One possibility might be a pie-shaped graph, which would quickly show how much of a product was made up of sugar, protein, salt, and so on. Another chart might spell out daily nutritional needs based on weight and height, as opposed to the current system of a single standard for everyone.

And perhaps the FDA may break its fixation with minimum requirements for "good" nutrients and concentrate more on *maximum* allowances for potentially harmful substances like sugar and fat. In which case we may see a new "anti-fortification war" in which food companies scramble to get their products in *under* these new requirements.

Meanwhile, for a public that's increasingly befuddled by a wildly conflicting nutritional clamor, the best advice is to eat sparingly from a wide variety of foods—particularly fresh ones—and don't pay too much attention to RDAs. In any sensible diet it's hard to avoid them. **OO**

NUTRITION FADS AND FALLACIES

The mere fact that no one knows what good nutrition really is hasn't kept enthusiasts, faddists, and outright quacks from spreading ill-founded diets among the American public.

One of the country's most influential faddists was the Reverend Sylvester W. Graham, who claimed that meats and fats inflame sexual desires—and were therefore to be avoided. Mustard, catsup, and pepper, he said, cause insanity.

One of his prominent followers was Dr. John Harvey Kellogg, manager of the Battle Creek (Michigan) Sanitarium, which treated almost any illness with diets Graham had prescribed.

Dr. Kellogg invented a cereal called Granose which sold 100,000 pounds its first year. His company now accounts for over 40 percent of the breakfast-food business in the U.S. One of its major competitors was founded by C. W. Post after a nine-month stay at the sanitarium.

A less successful "nutritionist" was Adolphus Hohensee, who set himself up as a physician and nutrition expert in the 1940s. His professional qualifications were one semester of high school and a carnival barker's sense of salesmanship.

The average American diet, Hohensee declared, could ruin the kidneys, blood, veins, and intestines. His diet, he claimed, could restore all bodily organs except the kidneys, dissolving "incrustations" in the brain and eyes that block clear thinking and clear vision, and helping its followers live to be 180.

In 1948, Hohensee was arrested in Phoenix and fined $1800 for his fraud. He was convicted again six years later, in Scranton, Pennsylvania. While his case was pending appeal, news photographers caught him in a Houston restaurant, pouring down beer and eating both fried red snapper and white bread.

Then there was Gayelord Hauser, who claimed that most people over 40 suffer malnutrition, a cause of "premature aging." The cure for this, he said, lay in such wonder foods as brewer's yeast, powdered skim milk, and blackstrap molasses.

Hauser's brand of dietary mythology sold well. His book *Look Younger, Live Longer* was third on the nonfiction bestseller list in 1950, first in 1951.

It's tempting to try to draw some profound conclusion from all this. Frankly, we haven't thought of any. As P. T. Barnum observed when the population was much smaller, there's a sucker born every minute. Claiming sure knowledge in the uncertain world of nutrition is one of the most reliable ways to part him from his money.

WIZARD OF SPACE

CONTINUED FROM PAGE 47

was at 15. Perhaps people distrust modern physics because they don't understand it. That's why they welcome ESP because that's a way of reasserting their control over the laws of physics. If you think you believe in something strongly enough to make it happen, then why bother with modern physics?"

He attended college at Oxford University, where, he claims, he did not work too hard. One of his colleagues comments that "he did a lot of work in physics, but he never liked doing practical work." When it came time to graduate, he was reportedly on the border line for graduating with first-class honors and had to take a special oral exam. On the basis of the oral exam, he was accepted for graduate study at Oxford's ancient rival, Cambridge.

At Oxford he had checked out a career in astronomy but the observatory there had no telescopes, just a spectrohelioscope for looking at sunspots. "I was not impressed by observational astronomy," he chuckles drily, "and, anyway, I was always more interested in theory than in observation. I decided I'd better go to Cambridge, where they did have work on theoretical astronomy."

So Hawking installed himself under the tutelage of Dennis Sciama, who had come to Cambridge a year earlier to set up a group to do research on general relativity. At that time, Sciama was the only one in England teaching general relativity.

What Sciama calls "that terrible thing" hit Hawking during his first year at Cambridge. He began to stumble and have trouble controlling finer movements of his limbs. It was diagnosed as amyotrophic lateral sclerosis, a progressive disease that wastes the voluntary nerves and muscles. It was ALS, as doctors call it, that killed the famed Yankee ballplayer Lou Gehrig. The disease is incurable. Hawking was given a couple of years to live.

"When it first set on, it progressed very rapidly," says Hawking. "I was very depressed because I thought I would be dead in a few years. There didn't seem to be any point in carrying on." One story has it that he turned to spending a good deal of time reading science fiction and listening to Wagner while halfheartedly pursuing his studies. But after a couple of years his nose dive seemed to flatten into a glide. Hawking was still alive, although he had to walk with a cane. Sciama suggested that since Hawking was going to live, he'd better finish his thesis.

At about the same time, in 1965, an equally important event occurred. Stephen Hawking married Jane Wilde, another native of St. Albans, whom he had met two years earlier, shortly after his illness was diagnosed. "The turning point was my marriage," Hawking says. "That made me determined to live. It gave me a reason for continuing on, striving. Without the help that Jane has given I would not have been able to carry on, nor have the will to do so."

On a warm June day Jane and I sat in her Victorian living room, light-years from the nearest black hole, and drank orange juice. Their daughter, Lucy, wandered in and out. Late-afternoon light billowed through the tall south windows behind a piano.

Of her decision to marry a man in Hawking's dire circumstances, Jane, a freckled redhead, says, "I decided what I was going to do, so I did." She remembers that he was "very, very determined, very ambitious. Much the same as now. He already had the beginnings of the condition when I first knew him, so I've never known a fit, able-bodied Stephen."

Today the Hawkings have two children, Robert, ten, and Lucy, seven. They live on the ground floor of a large Victorian mansion owned by Cambridge University, about a ten-minute walk from Hawking's office. Although the burden of coping with Stephen's slowly deteriorating condition has fallen largely on Jane, she does not feel particularly martyred. "I can imagine how frustrating it must be for some physicists' wives when they expect help from able-bodied husbands that is not forthcoming," she comments. "I have no illusions on that score, so it doesn't trouble me unduly.

"I think Stephen has achieved an important ambition: to extend the bounds of human knowledge by just one step. Not many of us are in a position to do it. When we look at what he's done, I find it very satisfying, though I can't understand it. I feel he has been a success in the sense that he has used his talents to the fullest. He hasn't wasted any of his talents at all. In fact, he's intensified them."

As Hawking himself puts it, "It seems very lucky that I chose such an out-of-the-way subject. Theoretical physics is one of the few areas in which my disability is not really a handicap at all. In a way it's helped," he says deadpan, "because it means I haven't been obligated to teaching duties, which would have taken time.

"I think I am happier now than I was before I started. Before the illness set on I was very bored with life. I drank a fair amount, I guess, didn't do any work. It was really a rather pointless existence. When one's expectations are reduced to zero, one really appreciates everything that one does have."

There is a bumper sticker that says, "Black holes are out of sight," pasted to the door of the cavernous office that Stephen Hawking shares with former student Gary Gibbons. Hawking's end of the office is crammed with gadgets like page turners and computer terminals equipped with special controls so that he can use them. The display of his computer terminal functions as a sort of blackboard, since he can't use the real blackboard there. His desk is stacked high with papers of every sort, from preprints of technical articles to fan mail. "Being famous is really rather a nuisance," he comments.

His speech has been so badly affected by the disease that only those who know him well can understand what he is saying. An outsider needs an interpreter. My own conversations were conducted with the help of Don Page, a California Institute of Technology graduate who is doing research at Cambridge on a NATO fellowship and who lives with the Hawkings. Often I thought Hawking had spoken an entire sentence only to find out he had just finished a single word.

None of this has slowed him scientifically. "Stephen puts things very succinctly and gets to the point. In a five-minute conversation he can probably give you more insight into a problem, more benefits than most people would in months," says Hawking's former student Bernard Carr. And Hawking remains the best articulator of his own ideas. Parts of his scientific papers can often be read by laymen. Once he has the germ of an idea, it can take Hawking a month or two to write a paper, dictating an hour or so a day to Judy Fella, his secretary.

Hawking's papers are spiked with his own wry brand of humor. He has a sharp tongue, slow but sharp, and his humor can be technical and sarcastic. Apropos of this he reports, "The *Physical Review* does its best to keep out any humor. In one paper I said, 'Suppose you have a little race of gnomes . . .' They changed it to 'Suppose you have observers . . .'"

A star is a long thermonuclear explosion held together and fed by gravity. The star's size is a continual negotiation between the crush of gravity seeking to collapse it and the heat blowing it apart. Eventually, though, the fires inside must die.

The first one to realize what might happen if gravity won was the French scientist Pierre Simon Laplace. In 1796 Laplace did not predict that gravity would shrink the star he just reasoned, from Newton's theory that light was composed of particles with mass, that a massive-enough star would recapture all the light that left its surface. It is therefore possible, he concluded, "that the largest luminous bodies in the universe may . . . be invisible."

In 1939, J. Robert Oppenheimer and his graduate student Hartland Snyder repeated Laplace's investigation, but in the language of general relativity, and got an even stranger result. If a star was heavy enough, no force—not nuclear forces, quark forces, or electrostatic repulsion—could resist gravity and the star would collapse indefinitely. Once shrinking started, it would go on forever. In a short time, the star would shrink to the point at which the velocity needed to escape its surface would pass the speed of light. Since nothing can exceed the speed of light, the star would be cut off from communication with the rest of the universe.

An outside observer would see it shrink and then just fade away. Its gravitational field would remain ghostlike surrounding empty crushed space The calculation was a prescription for a black hole although it would be 30 years before John Wheeler the Princeton cosmologist, coined the term.

There seemed nothing to stop a gravitational collapse from proceeding to such an absurdity A star would shrink to an infinitely small point its density would become infinite and space would become infinitely curved The result would be a *singularity*, a cosmic dead end, where particles and energy simply went out of existence

Singularities appear to be defined mainly by our ignorance of them. At a singularity Hawking once explained the traditional notions of space and time break down 'Because all known laws of physics are formulated on a classical space time background, they will all break down at a singularity" he wrote This is a great crisis for physics because it means one cannot predict the future. One does not know what will come out of a singularity '

Are there truly regions of the universe outside the domain of physical law cosmic free-fire zones where anything goes? The very idea makes physicists queasy

It had long been thought—and hoped—that the singularities in gravitational collapse would turn out to be only mathematical artifacts but in 1965 Roger Penrose was able to prove that a collapsed star would result in a real physical, unpredictable singularity Penrose proved, in effect that space-time could have an end

A year later Hawking applied Penrose's techniques to the universe as a whole "The big question was" he says "Was there a beginning or not? Roger Penrose and I discovered that, if general relativity is correct, there did have to be a beginning '

After receiving his degree, Hawking stayed on at Cambridge as a researcher, splitting his time between the Department of Applied Math and Theoretical Physics, in town and the new, low-slung Institute of Astronomy, sprawled across a wooded country hillside, to which he commuted in a little three-wheeled 'invalid' car

In the next few years he and Penrose produced a number of theorems about singularities, the structure of space-time, and the fate of matter caught in its dark path A famous theorem by Penrose predicted that the collapsing matter (or anything that fell into a black hole) either would hit the singularity or (if the black hole, having formed from a rotating star, was rotating) would miss it and escape through a "wormhole" to another point in space-time or even another universe There it would gush forth as a "white" hole the opposite of a black hole

To deal with these kinds of problems, Penrose and Brandon Carter another of Sciama's students, developed a sort of geometric pictorial shorthand in which, by mathematical transformations the entire universe, past and future, was represented in a triangle. The vertices and two of the sides denote various kinds of infinity, while the third side is a time axis Singularities appear as heavy jagged lines either perpendicular or parallel to the time axis In the former case which applies to nonrotating black holes or the collapse of the universe the singularity exists at a particular time and trying to dodge it is like trying to avoid your 30th birthday.

In a spinning black hole though space and time switch roles, and the singularity is in a particular place, like a pothole in the road One could, in principle steer around it. The price of avoidance though since you can't come back out of the black hole, is finding yourself in a new triangle representing a new space-time Theorists soon learned to string these triangles called Penrose diagrams, together in long repeating chains like the pattern on some kind of cosmic wallpaper, and chart the paths of astronauts into black holes and out white holes from universe to imaginary universe

But it turned out that the wormholes would have to have been built into the fabric of space-time at the beginning of the universe preceding the formation of the black holes themselves The prospect was viewed unfavorably by physicists who like to believe in cause and effect. Early last year English physicists N D Birrell and Paul Davies showed that if such wormholes did exist, fluctuations in the fields around them would slam them shut

That left the uncomfortable alternative of meeting the singularity Fortunately the same laws that predicted singularities seemed to say that they would always be imprisoned in black holes preventing word of the breakdown of law and order from ever getting to an outside observer Whatever came out of a singularity would never escape the black hole surrounding it

Penrose wondered whether there was a 'cosmic censor' that forbade the appearance of a "naked" singularity that is one that could be seen from the outside world. The cosmic-censorship hypothesis enjoys almost the status of a divine commandment among black-hole theorists today, even though it has never been proved. "Physicists have to believe that the universe makes sense in order to work" says Hawking

Hawking was fond of pointing out that there was one singularity that could never be clothed, the big bang in which the universe began This naked singularity has been known for a long time to theoreticians but until radio astronomy found evidence of its existence it was widely regarded as a mathematical artifact with no physical meaning Another naked singularity is the one in which the universe might some day end if it should gradually stop expanding and then collapse

In 1971, Hawking proposed an alternative way to create black holes by the enormous forces operant during the big bang creation of the universe Although objects with less than three times the mass of the

'Guess what happened today'

sun could not collapse to black holes of their own accord, they could be squeezed to that state. Hawking realized that during the big bang such a squeeze might have taken place. If so, our galaxy could now be sprinkled with trillions upon trillions of tiny primordial black holes. The typical mass of a primordial black hole would be a billion tons (10^{15} grams), about as much as a mountain, but it would only be the size of a proton (10^{-13} centimeters), barely a pinprick in the fabric of space-time.

These mini black-holes were a big hit with astronomers. It seemed there was hardly a problem that could not be explained by the judicious postulation of a mini black-hole. When an experiment to detect neutrinos from nuclear reactions in the center of the sun unexpectedly came up empty-handed, one scientist suggested that a tiny black hole in the sun could explain the finding.

Meanwhile, the search for their larger relatives was heating up. Astronomers had opened yet another window on the universe, with x-ray telescopes mounted in satellites orbiting high above the earth's atmosphere.

In the constellation Cygnus, about 6000 light-years away, astronomers had discovered a giant blue star with an invisible companion, Cygnus X-1. The companion was about ten times as massive as the sun and shrouded by x rays, the signature of matter heated beyond incandescence as it swirled tightly packed around the outside of the cosmic drain. "In a way today a black hole is the most conventional explanation for Cygnus X-1," says Hawking. "If it isn't a black hole, it really has to be something even more exotic."

Hawking has hedged his emotional involvement with black holes by betting Kip Thorne, a Caltech physicist, one of Wheeler's students and a longtime friend, that Cygnus X-1 is *not* a black hole. "It would really be easier for me to win than for Kip to win. There are a number of observations that could disprove that it's a black hole—for example, if they found that it was emitting absolutely regular pulses." Should that happen, Hawking would win a four-year subscription to *Private Eye*, a British combination investigative-humor magazine. Thorne, on the other hand, would win a year of *Penthouse*.

In the summer of 1973, Hawking started to think about small black holes again. Something the size of an elementary particle would have its properties defined not only by general relativity but also by quantum mechanics, the laws that govern the fuzzy world of subatomic physics. A tiny black hole might force some sort of a marriage between the laws that govern the two realms—the very great and the very small. "One ought to look at the quantum aspects of gravitation," he told Sciama one day.

Quantum gravity—if there is a magic phrase, a dream, in physics those two words are it. The goal was and is to describe gravity the way physics describes other forces—as an interaction between two particles. In electromagnetism, for example, photons of light communicate the electrical force between two charged particles.

Quantum theory had rescued physics from its last previous encounter with singularities, at the turn of the century. Theory then predicted that two opposite charges, an electron and a proton, for example, would fall together with infinite energy. That this did not happen—atoms did not spontaneously collapse—was obvious. Nature, it turned out, had other rules.

While astronomers were discovering the expanding universe, a whole raft of physicists was discovering the strange world inside the atom. As puzzles poured out of the laboratories of Europe, a generation of distinguished physicists struggled to unlearn a lifetime of assumptions. It seemed that everything they knew was wrong.

The new findings were consolidated and reformulated in 1927 by a young German physicist, Werner Heisenberg, whose uncertainty principle became the symbol of a new age. He stated that it was impossible *even in principle* to know exactly both the velocity and the position of a particle at a given time.

If relativity had been strange, quantum theory was outrageous. It was such a rude concept that Einstein himself refused to accept it, arguing that the quantum fuzziness of nature was only the screen of our own ignorance. "God does not play dice," he said.

Princeton's John Wheeler likes to compare the quantum principle to a game of 20 Questions he once played in which his fellow players tricked him by not agreeing on an answer beforehand but decided to be led by his questions. "The word would be brought into being by my questions." Each question took them longer and longer to answer as the players struggled to be consistent, until he finally guessed the word he had helped create.

Wheeler was among those who hoped that quantum gravity, when it came about—as everyone believed it must—would incorporate a similar rule change to prevent the dreaded unruly gravitational singularity, which he called the greatest crisis and the greatest hope in the history of physics.

In the early 1970s Hawking turned to the task of applying quantum mechanics to black holes. "I had an idea about small black holes forming atoms with electrons in orbit around them, and I wanted to have a proper framework to describe these atoms."

In September 1973, I went to Moscow where I talked to people about the quantum mechanics of these black-hole atoms. A. A. Starbinsky there told me that rotating black holes ought to emit particles. This idea seemed reasonable to me, but I didn't like the way it had been derived. So I tried to get my own derivation. What I expected was that black holes would emit particles if, and only if, they were rotating. I found out otherwise."

Hawking decided to work out the relatively simple case of a nonrotating black hole first. To his surprise, he discovered that even they appear to create and emit elementary particles such as photons, electrons, or neutrinos.

His abstract calculations didn't even tell him how the particles got out of the black hole, only that somehow they apparently did. Hawking spent a lonely month running and rerunning the equations through his head before he told anyone about his results. "I worried about this all over Christmas, but I couldn't find any convincing way to get rid of them. In a way it was one of those accidental discoveries, like the discovery of penicillin."

Two things helped convince Hawking that particles really would come out of a black hole. One was that he figured out a way for it to happen, something his calculations couldn't tell him. The Heisenberg uncertainty principle taught that space never was really empty but was a fountain of creation, of birth and death, if you looked closely enough. Elementary particles such as electrons and their opposites, positrons, were continually being created out of borrowed energy in complementary pairs, strutting their fraction of a microsecond in space-time, then meeting and annihilating each other, paying back the borrowed energy which could come, say, from a strong gravitational field.

Near a black hole, one of the temporary particles could drift over the edge, however, and leave its mate behind. The latter would then be free to wander away from the black hole. To a faraway observer, it would appear to have just popped out of the black hole. The energy for the particle's existence, its mass, borrowed and not paid back, would have to come out of the mass-energy of the black hole, so this process would slowly reduce the mass of the black hole.

Hawking showed that the loss of energy owing to radiation would eventually deflate or "evaporate" a black hole. Someday it could explode, depending on the details of

"Space and time themselves come to their end in the center of a black hole. There may be billions of these cosmic free-fire zones in our galaxy alone, formed in the big bang that started the universe."

the structure of matter like a 100-million-megaton bomb in a shower of gamma rays and high-energy particles.

For ordinary—if that adjective applies to anything about black holes—stellar-mass black holes, the Hawking radiation process, as it came to be called, would be less than negligible. A hole the size of the sun would have a temperature of one ten-millionth of a degree above absolute zero and take 10^{66} years to evaporate, far longer than the age of the universe.

As black holes get smaller, though, the surface gravity and temperature skyrocket and the lifetime shortens. One of Hawking's primordial mini black holes, with a mass of a billion tons would be more than white hot, 120 million degrees hot, and spewing hard gamma rays. Any that formed at the beginning of the universe should be popping off about now.

Small black holes would in fact be indistinguishable from white holes, their time-reversed cousins. "White holes," he said, "will emit radiation at the same rate as black holes. I think there's only one entity. There are only holes. They appear black when they're big and white when they're small."

The most important thing about the Hawking radiation process is that it shows the black hole is not cut off from the rest of the universe. Hawking notes that it has many suggestive similarities with the big bang. You can regard the particles coming out of the black hole as coming from the singularity at the center. The singularity in the big bang might have behaved as ordinary black holes seem to.

Does an evaporating black hole leave behind a naked singularity? "That's what we all wonder, but my view is that a black hole completely evaporates, leaving behind just empty space."

It turns out that the radiation from a black, or white, hole has a special flavor of disorder about it, an unpredictability that goes one degree beyond the grudging uncertainty specified by quantum theory. Neither the velocity nor the position of outgoing particles could be predicted, because of the information that has been lost down the black hole. Any pattern of radiation consistent with our limited knowledge of what is in the hole—its mass, charge, and angular momentum—stands an equal chance of being emitted.

Black holes, it seems, are perfect entropy machines, perfect generators of chaos. Hawking attributes this to the singularity, and with characteristic style has named it the *principle of ignorance*. "God not only plays with dice, He sometimes throws them where they can't be seen."

Life has taken a strange turn for the man who rejected biology as too fuzzy and inexact. But he contends, "At least physics is inexact in a precisely defined way."

In another calculation, Hawking and Gibbons extended the Hawking radiation process to the case of an observer accelerating through a vacuum and found that reality began to diverge for differently accelerated observers or in very strong gravitational fields.

"Two different observers might even encounter different histories of the universe," they wrote in 1977. Hawking has hinted that the laws of physics themselves may be somewhat observer-dependent, a thought guaranteed to make Einstein wish he had taken up biology.

"I don't think there's one unique real universe," Hawking said when I asked him about this. "When you do quantum mechanics for the whole universe you encounter conceptual problems about what is meant by measurement. One possible viewpoint is what's called the Everett-Wheeler interpretation. According to quantum mechanics, if you make a measurement there are various possible results you can get, and each has a different probability. The Everett-Wheeler picture says that there are different branches of the universe, and each branch corresponds to a different possible result—parallel universes.

"Calling these things black holes was a masterstroke by Wheeler, because it does make a connection, or conjure up a lot of human neuroses," Hawking comments. "There is a psychological connection between the naming of black holes and not the mathematical or physical idea but the popularization. They're named black holes because they do relate to human fears of being destroyed or gobbled up. They have played an important part in my career but they don't have any psychological connection for me. I don't have fears of being thrown into them. I understand them. I feel in a sense that I'm their master." Hawking is not ready to be eaten.

In January of 1974, Sciama was back at Cambridge to organize a symposium. Rees came up to him, trembling and pale. "Have you heard? Stephen's changed everything!"

When is a black hole not black?

When it explodes.

Hawking's announcement at an Oxford symposium the next month that black holes would explode confounded and amazed his colleagues. Sciama called it one of the most beautiful papers in the history of physics. Hawking had found the first fragile link between the gravity that bends the universe and the quantum chaos that lives inside it. It might be the first step—even just a candle to light the first step—toward a unified theory of all the forces of nature.

In 1978, Hawking was given the Albert Einstein Award by the Lewis and Rosa Strauss Memorial Fund, in Washington, D.C. The award, given infrequently, is the highest honor for physicists given in the United States. The press release sent out by the memorial fund to announce the decision noted that the Einstein award has often provided current recognition for scientists who later go on to win the Nobel Prize. ◘◘

AN END TO PAIN

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aroused interest in its possible drug applications. According to Solomon Snyder, "Merck has made over 300 analogues of neurotensin."

Snyder personally believes that a different approach may ultimately prove more fruitful. "Making enkephalin analogues is just like making morphine," he says. "My own prejudice is that if we can find the enzyme in the brain that specifically destroys enkephalin and isolate it, then we could develop a drug that would inhibit this enzyme and thereby indirectly raise enkephalin levels. This would be a different way of juicing up the system, perhaps in a more gentle fashion than by having something that just mimics enkephalin."

Snyder's "prejudice" must have been well founded. Two months after our interview, this past September, Seymour Ehrenpreis of the Chicago Medical School reported the development of a drug, D-phenylalanine (DPA), that inhibits the enzyme that rapidly breaks down enkephalin. In 9 out of 11 chronic-pain patients, DPA brought about marked or complete relief from pain without causing sedation, a buildup of tolerance, or withdrawal symptoms after treatment was stopped. Furthermore, as in the fictional case of Barbara Loew, the patients who responded to DPA usually required only two days of treatment in order to obtain relief from pain for as long as a month. Ehrenpreis believes that this prolonged analgesia is the result of a long-term buildup of enkephalin levels in the brain. Laboratory tests with 200 mice have also found DPA to be nonaddictive, giving support to Snyder's contention that this method would prove to be a gentler way of "juicing up the system."

From these preliminary tests, DPA seems a likely candidate in the running for a miracle drug in the fight against pain. Indeed, for the nine patients who suffered from low-back pain, arthritis, nerve injuries, and other debilitating forms of chronic pain, DPA has significantly changed their lives.

While DPA research continues, the medical community is watching warily to see if adverse reactions to the drug occur—especially those telltale signs of withdrawal. Past history of tampering with the brain's opiate system necessarily dictates a cautiously optimistic response to this new development. But today there is really good cause for optimism. The enormous growth in our understanding of the body's natural mechanism for coping with pain has not only revealed a scientific explanation behind esoteric methods for treating pain, but it has also suggested a cure that comes from within the body and the brain itself, especially through drugs that enhance the pain-suppression system without disrupting it to the point of addiction. Never before have the prospects of conquering man's oldest and most relentless enemy looked so promising. ◘◘

FARMING

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The new spin rate would "power up" the planet's internal dynamo, generating a magnetic field which would help ward off solar radiation.

A century or two after this transformation, human beings would walk the surface of Venus without backpack refrigerators and perhaps even find it pleasant. The centrifugal force of the new spin would probably drive the seawater into an equatorial globe-girdling ocean, leaving the dry land at the Northern and Southern hemispheres along those newly formed coasts, the climate could resemble that of Samoa or Curaçao or the Côte d'Azur.

Mars offers different problems. A human body placed on Mars would exhale all of its internal gases in a great rush out body orifices. Consciousness would fade through anoxia as the thin Martian air provided no breath. The cold of the sand would freeze the fallen body within minutes. But it might take centuries for the mummified flesh to erode. In the end, one patch of red sand might have a lighter coloration for a few thousand years beyond that, the visitor would leave no trace.

Mars has neither enough air nor enough sunlight, although its day is nearly earthlike. To attract more sunlight, dark soot could be mined from the two small moonlets in Mars's orbit and spread on the surface of the planet. If permafrosts (giant dust-covered glaciers) exist, they might melt, flooding the surface after a billion years of drought; in cases where such planetary water does not exist, cometary water would have to be imported. Biological activities could be instigated, perhaps in miles-deep oasis valleys gouged out of the landscape by the ice melt. Additional heating could be provided by giant space mirrors, a thousand kilometers on a side, concentrating sunlight onto the planet.

As the Martian air thickens to breathable levels, and as temperatures rise to above the freezing point of water, a new climate could be formed that would approximate that of the Andes or the Caucasus or Kashmir. If such conditions on the new planet seem unattractive, recall the persistent stories of longevity and happiness among mountain people here on earth.

The earth's own moon need not remain forever barren. Even as human mining activities bring it a measure of life in the coming decades, it too could hold an atmosphere, either baked from its own rocks or imported from Saturn and beyond. Other rocky worlds such as Mercury and various moons of the outer planets such as Ganymede, Titan, and Triton could similarly be engineered into habitable home worlds.

But it is the earth that will be the first planet humanity will terraform, as humanity already has been modifying it for millennia. Forests were cleared, hostile animals eradicated and useful crops and domestic animals developed, rivers dammed, deserts created from overgrazing and salinization, rainfall patterns disrupted by pollution. Now consideration is being given to altering the Sahara or Baffin Island or the entire Mediterranean, in grandiose dreams of planetary engineering. If humanity develops the wisdom to go with the know-how and survives the lesson, other planets will then become feasible targets. And when and if this happens, what criteria will be used for "comfort"? What are the features of a planet ideal for human settlement? Should it necessarily be a carbon copy of earth?

Naturally, these questions cannot be answered today but terraformers say it is about time they were asked.

First, human beings need an atmosphere with a partial pressure of oxygen of about 1.4 kilograms per 6.5 square centimeters (maybe half as much will suffice, but no more than twice as much can be tolerated). The fraction of the air consisting

When terraformers finish with Venus, it could resemble Samoa or Curaçao or the Côte d'Azur. Mars will be like the Andes, the Caucasus, or Kashmir. Even Mercury could be a habitable planet.

of carbon dioxide, carbon monoxide, and other noxious gases such as methane and ammonia must be very low. The bulk of the atmosphere can be made up of nitrogen or inert gases such as argon or xenon.

On earth, air pressure (7 kilograms per 6.5 square centimeters at sea level, of which only 1.4 kilograms is oxygen) is maintained by the weight of the overlying atmosphere pulled down by gravity. In spaceships and on space colonies, pressure is maintained by airtight hulls.

Atmospheres are nice to have for other reasons besides breathing. They support clouds and dust, which contribute to worldwide irrigation via rainfall. Atmospheres play a vital role in transporting heat from sunlit areas to the dimmer regions.

Temperatures of a planet should range between limits determined by the freezing and boiling points of water, since our biology is based on that substance. Open oceans are a desirable feature. This is not purely for aesthetic reasons or to aid in transportation. Oceans protect and support complex ecologies of plant and animal life, which might thrive for centuries before life appeared on dry land. Such organisms could become the food chain of the first human settlers.

Gravity is another factor that will transform a hostile planet into a habitable, productive ecosphere. There are no stony planets with stronger gravity than the earth's, and it would not be a good idea to build any. Many stony planets have gravity much less than the earth's, down to the moon's one-sixth earth gravity, and these might actually be more comfortable environments. The major problem is in holding on to an atmosphere, but that can be solved by periodic replenishments of the atmosphere from the same sources that provided the gases in the first place.

Magnetic fields are desirable. They interact with incoming charged particles from the sun, forming a protective radiation belt over the planet's middle latitudes. Additionally, biologists are today still studying the biological effects of magnetic fields (and the absence of magnetic fields) on living organisms. Experimental data suggest that a weak magnetic field is essential to the longevity of biological processes and biochemical reactions.

Beyond these physical criteria lies a greater difficulty: introduction of a self-sustaining ecological chain. A 1975 NASA study about terraforming coined the word "ecosynthesis" to mean the creation of a stable biological system on a new world. The establishment of a long food chain introduces problems of soil chemistry, bacteria, manufacture of usable nitrogen compounds (via biological and electrical means), prey-predator cycles and other topics.

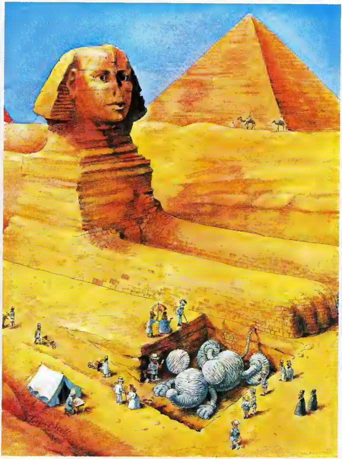
We can safely say that no biologist in the world today knows how to design a self-correcting ecology such as is needed on a new planet. Some observers believe it never will be possible and that a trial-and-error approach is the only way to do it. Yet it is also undeniable that such ecological knowledge, even if never applied beyond the confines of earth, could be extremely important to our survival on this planet.

What are the techniques and tools of terraforming? Initially the tasks demanded seem far beyond even the wildest imaginations of science fiction. However, many of the techniques of terraforming could be extensions of tools and theories already in use today.

The key concept is the generation and application of energy, both for moving material across a solar system, for changing its state from liquid to solid or back, and for converting it into powder or gravel or solid projectiles. The energies of the sun need to be concentrated at some times and dissipated at other times.

Consider the terraforming tool kit of the 23rd century along with candidate applications for these tools. Don't think of these scenarios as descriptions of how it *really* will be done. Rather, treat them as what mathematicians call an *existence proof*, a demonstration that, simply, it *can* be done.

Nuclear power and solar power are al-



ready familiar, and they can be applied to terraforming as well. Nuclear power could be used for rocket propulsion, for a heat source, or for explosions. The solar power could be used purely as heat or converted to electricity for propulsion.

Fusion rockets, to move personnel and equipment between "construction sites," remain a science-fiction concoction, although engineers have recently been formulating clever new ideas for harnessing such power for space propulsion. An ideal system would use water as a propellant, since it is plentiful in many areas of the solar system. The engine would maintain a constant acceleration of one g, equivalent to the force of gravity on the earth's surface. With continuous thrusting, such a spacecraft could reach the moon in hours, Mars or Venus in days, and the outer reaches of the solar system in weeks.

For moving large cargoes around when you get there, consider using thermonuclear bombs. Although the notion of blowing up the solar system with H-bombs might seem abhorrent and destructive, there are some terraforming requirements that could easily be satisfied by a well-placed detonation of a 1000-megaton explosive. That's almost a hundred times as powerful as bombs built today, but the limitations are imposed only by practicality, not by engineering.

A large nuclear bomb deposits massive amounts of energy into nearby material, causing it to expand suddenly and reradiate the energy. Placed in the center of a solid body, a bomb could shatter it. Lying on the surface of an asteroid, a bomb would cause a small fraction of the asteroid to be flung out to one side, resulting in a net push in the other direction and a consequent change in course.

Moving a ten-mile-wide hunk of ice or other material from orbits near Saturn could require such blasts. The "ice-teroid" would be shoved by a series of blasts onto a new path aimed toward the inner planets. Impact trajectories to Venus, Mars, the moon, or Mercury could be plotted by computer-navigation systems.

One sophisticated improvement of such a scheme would call for aiming the cargo only toward Jupiter, which would require far less energy. Delicate midcourse corrections to the asteroid could result in a close flyby of Jupiter, during which the giant planet's massive gravity could twist the asteroid's flight path onto any new course desired.

The material to be transported would be primarily water for the dry inner planets. Additionally, rocky material could be obtained for mining into metals needed for giant mirrors (to be described shortly) or artificial dust clouds.

It may not be necessary to go to the outer solar system for such resources. There are small asteroids and burned-out comets that already pass through the inner solar system. They may be easier to reach and steer to new destinations.

Already, plans exist to reach these asteroids and push them back to earth for mining. These plans are based on the application of a revolutionary device for space transportation called a "mass driver."

Mass driver is only the current name for this concept, which has also been called an electromagnetic slingshot and a space catapult. Its principle of operation is simple. A "bucket brigade" of open containers is loaded bucket by bucket with reaction mass (which means, in practice, nearly anything handy). The buckets are sped down a track by a series of electromagnets. At the end of the track the contents of each bucket are flung off into space, and the empty buckets are cycled around to be filled again.

When the mass driver is installed on the moon, the net result is a stream of moon rock being flung deep into space, where it can be caught, processed, and turned into construction material. But the other side of the coin also works: When a mass driver is

> "Nuclear bombs could change the course of comets, steering them into off-center collisions with Venus. Their glancing blows would spin the planet into a more comfortable day-night cycle."

set up on an asteroid, and pieces of the asteroid itself are thrown off into space, the asteroid is gently but inexorably pushed off in a new direction.

Ex-astronaut Brian O'Leary, now working for the Space Sciences Institute in Princeton, New Jersey, claims that a mass-driver device could push a near-earth asteroid back to earth for use as metal ore. O'Leary's computations show that the round trip of the mass driver from earth to the asteroid and then back to earth could take several years, using up about two thirds of the asteroid as reaction mass.

The remaining one third of the asteroid, at today's prices for iron and nickel ore, would be worth in excess of a hundred billion dollars. The cost of retrieval would have to be subtracted. O'Leary estimates that these expenses would be on the order of ten billion dollars.

Mass drivers get their energy from the sun, in the form of solar panels converting sunlight to electricity to power the electromagnets. If it were attached to any piece of space rock, they would be able to push it around the solar system to support terraforming activities, if needed.

These driven asteroids would be used to import water and other compounds to planets that need those materials. Asteroids could also be pulverized into dust clouds to provide rain. And others could be steered violently into planets to gouge out giant oasis valleys—five miles deep in which air density and temperatures are far more benign than over the rest of the planet.

Imported foreign materials could also be added to planetary atmospheres to create the so-called greenhouse effect. On earth, our atmosphere contributes a "bonus" heat of several tens of degrees. On outer planets, a healthy greenhouse effect could make the difference between an ice age and a comfortable climate.

The greenhouse effect, as it applies to planetary atmospheres, involves the trapping of infrared radiation. Incoming sunlight warms the ground, which then reradiates the energy as infrared, or heat, radiation. But since the atmospheres of planets are much less transparent to outgoing infrared than to incoming visible light, the energy is trapped, and the planet remains stable at a temperature higher than that expected if it had no atmosphere at all.

The components of the atmosphere responsible for this effect do not have to be particularly plentiful. On earth, carbon dioxide and water vapor play a prominent role; the components on other planets are often not as easily identified.

Since these key components form only a small fraction of the mass of the atmosphere, they can have their proportions significantly altered by the importation of material from space. This may be one of the earliest forms of terraforming, since the total mass of transported material is not terribly high.

The major driver of planetary temperatures is, of course, the sun. Terraformers will leave actual manipulation of the sun itself to future generations to dream about. It is more feasible to simply work on the radiation levels which arrive at planets being engineered.

On earth, sunbathers have used several basic techniques to control sunlight, either concentrating it or dissipating it. These same theories can be applied on a planetary scale. Sunlight can be shaded with parasols, reflected with mirrors and light-colored clothing, or filtered with lotions and other materials.

Mercury and Venus need to have their natural levels of sunlight (in scientific terms, *insolation*) reduced. There are a number of ways to imagine this done. Reflectivity of the planet's surface could be increased. Dust clouds could be spread between the planet and the sun. Giant umbrellas a thousand miles across but only a few molecules thick could be orbited over the planet. Artificial rings of debris could be placed around the planet. The net effect of any combination of these techniques would be to reduce the amount of insolation on the surface and to allow the temperatures to drop.

Reflectivity of a planet can be a function of cloud cover which requires an atmosphere. If water clouds can be generated, nuclear-fusion power plants may generate steam at a few points on the surface, creating cloud cover over vast regions, much the same effect could be accomplished by sunlight-concentrating mirrors in space heating small areas of an open ocean. Dust storms also could serve this purpose, and they could be set in motion by artificially generated temperature extremes. Clouds of ions could be suspended in a planet's magnetosphere as well.

Dust clouds deep in space, perhaps a million miles on the sunward side of the planet, would also dissipate sunlight. These clouds could be manufactured from pulverized cometary material towed to those points by mass drivers. Since sunlight and gravitational instabilities would tend to clear the dust away from that location, the cloud would have to be periodically replenished.

The concept of giant space mirrors and parasols, measuring in the thousands of kilometers, is not as mind-boggling as it may seem at first glance. As a matter of fact, they have been described in space literature for decades. Smaller versions may be among the first practical payloads carried into orbit by the Space Shuttle.

Space-mirror advocate Dr. Krafft Ehricke envisages launching mirrors a few hundred meters across, at first. He calls these devices "lunettas," since their illumination on the ground would approximate that of moonlight. They could be used for search and rescue illumination, or even for ordinary lighting of city streets.

Larger mirrors (Ehricke calls them "soletas") could raise local temperatures by several degrees, saving crops from sudden frosts. By the time they are built, soletas might also be used to steer hurricanes away from populated coasts. These mirrors, thousands of kilometers from earth, would be kilometers on a side.

Eventually, mirrors rivaling the sun in brightness (when measured over a small region of the ground, of course) could provide balmy climates for polar regions on earth, or could provide winter-long illumination of industrial regions beyond the Arctic and Antarctic circles. These same mirrors could provide the same concentration of sunlight for the outer planets, or, if turned away from a planet, could cast giant shadows on its surface, reducing its temperature.

After the grosser characteristics of a planet's surface have been altered by manipulations of matter and energy the activity of biology becomes important. On Venus, a traditional terraforming approach has called for the use of blue green algae to break down the carbon dioxide (it turned out that there is not enough local water for that approach to work without substantial importation of ice). On all new planets, the formation of organic materials in the soil will be a crucial step. Ground-plant cover also affects the land's reflectivity as well as its propensity for raising obscuring dust storms. Indeed, ground-vegetation alteration may well have played a crucial role in the history of the Sahara Desert, right down to the Sahelian drought of today.

Many forms of life already existent on earth may be useful on new planets as well, since the range of conditions under which terrestrial life forms can thrive is truly astounding. Some lichens, when air dried, can still function at about half their normal rate above the boiling point of water. Methanogens, the so-called "third branch of life," live only in oxygen-free environments such as in Yellowstone Park hot springs and in the mud at the bottom of San Francisco Bay; they digest hydrogen and carbon and excrete methane, and may have had a crucial role in the formation of the earth's present atmosphere. Two miles deep in the Pacific Ocean, a breed of sulfide-oxidizing bacteria thrive in total darkness and unimaginable pressures, happily digesting hydrogen sulfide gas bubbling up from volcanic vents. Other forms of bacteria live in the stratosphere and in airplane fuel tanks.

But the use of artificially engineered organisms, created or modified in genetics laboratories, is more plausible. Genetic engineering is a hot topic today. Already, biologists have developed new strains of bacteria to eat oil spills or to produce human insulin. Botanists believe that they will be able to construct a new strain of bacteria that can fix atmospheric nitrogen for a much wider range of crops than is possible today. New goals defined by terraforming needs would be approached in a similar manner.

For terraforming, special life forms would be needed that could survive temperature extremes and unique chemical poisons, living on bare rock (or burrowing within the rock), in tainted water (or in ice), and in midair. The bacteria, which could pave the way for higher plants and animals, would produce oxygen from carbon dioxide, producing usable nutrients, without in turn needing to use oxygen for respiration.

These forms of life will likely come from the biological laboratories of the future, probably located in deep space for reasons of efficiency and quarantine. When the time comes for such creations to appear on new planets, they will be ready.

This, then, is the vision of terraforming other worlds as portrayed by futurists and science forecasters. Scenarios of world changing have been proposed, while notes of caution have been sounded. The study of terraforming tools is useful today even if the application is a century or more off. Both the target planetary conditions and possible tools needed to remold derelict planets into such conditions are already within the range of human imagination and understanding.

Terraforming is possible. ∞

Ancient Mind

CONTINUED FROM PAGE 50

She showed him around the kitchen and the pantries. He seemed impressed. He was, she realized, unexpectedly personable: lean and grizzled, but with the hint of vulnerability common among rangy men. You couldn't look at him without imagining the gawky scarecrow he must have been as a boy. His striking features—craggy nose and brow, strong mouth, lank jaw—no doubt outsize and homely then, were now impressively united by the long creases of experience on his cheeks and forehead.

"No more scullions cranking the spit," he remarked over the rotisserie. "You come originally from East Africa, Mrs. de Groot? Things must have been very different there."

"Yes. I left a long time ago."

"Surely not so very long," he said, and his eyes flicked over her from head to foot.

Relaxing in the warmth of his interest she said, "Are you from elsewhere also?"

A mistake: he frosted up at once. "Why do you ask?"

"Excuse me. I thought I heard just the trace of an accent."

"My family were Europeans. We spoke German at home. May I sit down?" His big hands, capable- and strong-looking, graced the back of a chair. He smiled briefly. "Would you mind sharing your coffee with an institutional fortune hunter? That is my job—persuading rich men and the guardians of foundations to spend a little of their money in support of work that offers no immediate result. I don't enjoy dealing with these shortsighted men."

"Everyone says you do it well." Katje filled a cup for him.

"It takes up my time," he said. "It wearies me." His large and brilliant eyes, in sockets darkened with fatigue, had a withdrawn, somber aspect. How old was he? Katje wondered.

Suddenly he gazed at her and said, "Didn't I see you over by the lab the other morning? There was mist on my windshield; I couldn't be sure."

She told him about Jackson's friend's umbrella, thinking now he'll explain this is what he came to say. But he added nothing and she found herself hesitant to ask about the student in the parking lot. "Is there anything else I can do for you, Dr. Weyland?"

"I don't mean to keep you from your work. One thing. Would you come over and do a session for me in the sleep lab?"

She shook her head.

"All the information goes on tapes under coded I.D. numbers, Mrs. de Groot. Your privacy would be strictly guarded."

"I would prefer not to."

"Excuse me then. It was a pleasure to talk with you," he said, rising. "If you find a reason to change your mind, my extension is one sixty-three."

She was close to tears, but Uncle Jan made her strip down the gun again—her first gun, her own gun—and then the lion coughed, and she saw with the wide gaze of fear his golden form crouched, tail lashing, in the thornbush. As her pony shied she threw up her gun and fired, and the dust boiled up from the thrashings of the wounded cat.

Then Scotty's patient voice said, "Do it again," and she was tearing down the rifle once more by lamplight at the worn wooden table while her mother sewed with angry stabs of the needle and spoke words Katje didn't bother hearing because she knew the gist by heart: "If only Jan had children of his own! Sons, preferably, to take out hunting with Scotty. Because he has no sons, he takes Katje out shooting instead so he can show how tough Boer youngsters are, even a girl. For whites to kill for sport, as Jan and Scotty do, is to go backward into the barbaric past of Africa. Now the farm is producing, there is no need to kill for hides to get cash for coffee, salt, and tobacco. And to train a *girl* to go stalking and killing animals like scarcely more than an animal herself!"

> *"Uncle Jan made her strip down the gun again—her first gun, her own gun—and then the lion coughed, and she saw with the wide gaze of fear his golden form crouched, tail lashing, in the thornbush."*

"Again," said Scotty, and the lion coughed, making the pony shiver under her. Katje woke.

She was sitting in front of the tv, blinking at the sharp, knowing face of the talk-show host. The sound had gone off again, and she had dozed.

She didn't often dream, hardly ever of Africa. Why now? Because, she thought, Dr. Weyland had roused her memory. She thought he looked a bit like Scotty, the neighboring farmer whom Uncle Jan had begun by calling a damned *rooinek* and ended treating like a brother.

She got up and hit the tv to make it speak again and sat down to watch with an apple in her hand. Lately she ate too much, out of boredom. Would she grow stout like her mother? It was Dr. Weyland who had brought this worry to the surface of her mind, no proper concern of a middle-aged widow. It was Dr. Weyland who had stirred up that long-ago girlhood spent prowling for game in the bright, dissolving landscape of tan grass.

"Under the bed, do you think?" Miss Donelly dropped on her knees to look. The guest lecturer had left her hairbrush behind. Katje forbore to point out that this was the sort of thing to be expected of someone who put on track clothes and ran inside the house.

A student flung open the bedroom door and leaned in. "Is it too late to hand in my paper, Miss Donelly?"

"For God's sake, Mickey!" Miss Donelly burst out. "Where did you get that?"

Across the chest of the girl's T-shirt where her coat gapped open were emblazoned the words SLEEP WITH WEYLAND: HE'S A DREAM. She grinned. "Some hustler is selling them right outside the co-op. Better hurry if you want one—Security's already been sent for." She giggled, put a sheaf of dog-eared pages down on the chair by the door, added "Thanks, Miss Donelly," and clattered away down the stairs.

Miss Donelly sat back on her heels and laughed. "Well. I never, as my grandma used to say. That man is turning this school into a circus!"

"These young people have no respect for anything," Katje said. "What will Dr. Weyland say seeing his name used like that? He should have her expelled."

"Him? He'll barely notice. But Wacker will throw fits." Miss Donelly got up, dusting her hands. She ran a finger over the blistered paint on the windowsill. "Pity they can't use some of the loot Weyland brings in to really fix this old place up. But I guess we can't complain. Without Weyland this would be just another expensive little backwater school for the not so bright children of the upper middle class. And it isn't all roses even for him: this T-shirt thing will bring on a fresh bout of backbiting among his colleagues, you watch. This kind of incident brings out the jungle beast in even the mildest academics."

Katje snorted. She didn't think much of academic infighting.

"I know we must seem pretty tame to you," Miss Donelly said wryly, "but there are some real ambushes and even killings here, in terms of careers. It's not the cushy life it sometimes seems, and not so secure either.

"Even you may be in a little trouble, Mrs. de Groot. I hope not. Only a few weeks ago there was a complaint from a faculty member that you upset his guests by something you said—"

"I said they couldn't set up a dart board in here," Katje responded crisply.

"There are others who don't like your politics—"

"I never speak about politics," Katje said, offended. That was the first thing Henrik had demanded of her here. She had acquiesced like a good wife, not that she was ashamed of her political beliefs. She had loved and married Henrik not because but in spite of his radical politics.

"From your silence they assume you're some kind of reactionary racist," Miss Donelly said. "And because you're a Boer and don't carry on your husband's crusade. Then there are the ones who say you're just too old and stuffy for the job, meaning you scare them a little, and they'd rather have a giggly cocktail waitress or a downtrodden mouse of a working student. But you've got plenty of partisans too, and even Wacker knows you give this place tone and dignity. They ought to double your salary. You're solid and dependable, even if you are a little, well, old-fashioned. And you lived a real life in the world, whatever your values, which is more than most of our faculty has ever done." She stopped, blushing, and moved toward the door. "Well, when that hairbrush turns up just put it aside for me, will you? Thank you, Mrs. de Groot."

Katje said, "Thank you, too." That girl was as softheaded as everyone around here, but she had a good heart.

Many of the staff had already left for vacation during intersession, now that new scheduling had freed everyone from doing special intensive courses between semesters. The last cocktail hour at the club was thinly attended. Katje moved among the drinkers, gathering loaded ashtrays, used glasses, rumpled napkins. A few people greeted her as she passed.

There were two major topics of conversation: the bio student who had been raped last night as she left the library, and the Weyland T-shirt or, rather, Weyland himself.

They said he was a disgrace, encouraging commercial exploitation of his name. He was probably getting a cut of the profits, no he wasn't, didn't need to, he was a superstar with plenty of income, no dependents, and no tastes except for study and work. And that beautiful Mercedes-Benz of his, don't forget. No doubt that was where he was this evening—not off on a holiday or drinking cheap club booze but tearing around the countryside in his beloved car.

Better a ride in the country than burying himself in the library and feeding his insatiable appetite for books. But what can a workaholic do if he's also an insomniac? The two conditions reinforce each other. It was unhealthy for him to push so hard. Just look at him, so haggard and preoccupied, so lean and lonely-looking. The man deserved a prize for his shy-bachelor-hopelessly-hooked-on-the-pursuit-of-knowledge act.

How many students were in the sleep project now? More than were in his classes. They called his course in ethnography "The Ancient Mind at Work," but the girls found his formality charming, and his absent-mindedness, too—did you hear how he wore two vests one on top of the other to class and never knew it? He wasn't formal, he was rigid and too old-fashioned in his thinking to make a first-rate contribution to anthropology. So he'd simply appropriated poor Milnes's beautiful adaptation of the Richman-Steinmolle recording system to the documentation of dreams, throwing in some "cross-cultural" terminology to bring the project into his own field. And there was doubt that Weyland fully understood the computer end of the process. No wonder he couldn't keep an assistant for long.

Here was Petersen leaving him because of some brouhaha over a computer run. Charming, yes, but Weyland could also be a sarcastic bastard. He was apt to be testy, yes, the great are often quarrelsome, nothing new in that. Remember how he almost came to blows with young Denton over that scratch Denton put on the Mercedes' fender? When Denton lost his temper and threw a punch, Weyland jumped into the car and tried to run him down. Well, that's how Denton told it, but was it likely, considering that Weyland was big enough to flatten Denton with a slap? Denton should have been given a medal for trying to get Weyland off the street. Have you seen him drive? Roars along just barely in control of that great big machine—

Weyland himself wasn't there. Of course not. Weyland was a disdainful, snobbish son-of-a-bitch, Weyland was a shy, socially maladroit scholar absorbed in his great work. Weyland had a secret sorrow too painful to share. Weyland was a charlatan. Weyland was a genius working himself to death to keep alive the Cayslin Center for the Study of Man.

Dean Wacker brooded by the huge, empty fireplace and said several times in a carrying voice that he had talked with Weyland and that the students involved in the T-shirt scandal would face firm disciplinary action.

Miss Donelly came in late with a woman from Economics. They talked heatedly in the window bay, and the two other women in the room drifted over to join them. Katje followed.

"... from off-campus, but that's what they always say," one of them snapped. Miss Donelly caught Katje's eye, smiled a strained smile, and plunged back into the discussion. They were talking about the rape. Katje wasn't interested. A woman who used her sense and carried herself with self-respect didn't get raped, but saying so to these intellectual women wasted breath. They didn't understand real life. Katje headed back toward the kitchen.

Buildings and Grounds had sent Nettie Ledyard over from the student cafeteria to help out. She was rinsing glasses and squinting at them through the smoke of her cigarette. She wore a T-shirt bearing a bulbous fish shape across the front and the words SAVE OUR WHALES. These "environmental" messages vexed Katje; only naive citified people could think of wild animals as pets. The shirt undoubtedly belonged to one of Nettie's long-haired, bleeding-heart boyfriends. Nettie herself smoked too much to pretend to an environmental conscience. She was no hypocrite, at least. But she should come properly dressed to do a job at the club, just in case a professor came wandering back here for more ice or whatever.

"I'll be helping you with the club inventory again during intersession," Nettie said. "Good thing too. You'll be spending a lot of time over here until school starts again, and the campus is really emptying out. Now there's this sex maniac cruising around—though what I could do but run like hell and scream my head off I can't tell you."

"Listen, what's this about Jackson sending you on errands for him?" she added irritably. She flicked ash off her bosom, which was high like a shelf, pushed up by her too tight brassiere. "His pal Maurice can pick up his own umbrella, he's no cripple. Having you wandering around out there alone at some godforsaken hour—"

"Neither of us knew about the rapist," Katje said, wiping out the last of the ashtrays.

"Just don't let Jackson take advantage of you, that's all."

Katje grunted. She had been raised not to let herself be taken advantage of by blacks. At home they had all practiced that art.

Later, helping to dig out a fur hat from under the pile of coats in the foyer, Katje heard someone saying, "... other people's work, glomming on and taking all the credit, a real bloodsucker."

Into her mind came the image of Dr Weyland's tall figure moving without a break in stride past the stricken student.

Jackson came down from the roof with watering eyes. A damp wind was rising.

"That leak is fixed for a while," he said, hunching to blow on his chapped hands. "But the big shots at Buildings and Grounds got to do something better before the next snow piles up and soaks through again."

Katje polished the silver plate with a gray flannel. "What do you know about vampires?" she said.

"How bad you want to know?"

He had no right to joke with her like that, he whose ancestors had been heathen savages. "What do you know about vampires?" she repeated firmly.

"Not a thing," He grinned. "But you just keep on going to the movies with Nettie, and you'll find out all about that kind of stuff. She got to have the dumbest taste in movies there ever was. Horrible stuff!"

Katje looked down from the landing at Nettie, who had just let herself in to the club. Nettie's hair was all in tight little rings like pigs' tails. She called, "Guess what I went and did?"

"Your hair," Katje said. "You got it done curly."

Nettie hung her coat crookedly on the rack and peered into the foyer mirror. "I've been wanting to try a permanent for months, but I couldn't find the money. So the other night I went over to the sleep lab." She came upstairs.

"What was it like?" Katje said, looking more closely at Nettie's face. Was she paler than usual? Yes, Katje thought with sudden apprehension.

"It's nothing much. You just lie down on this couch, and they plug you in to their machines, and you sleep. Next morning you unplug and go collect your pay. That's all there is to it."

"You slept well?"

"I felt pretty dragged out yesterday. Dr. Weyland gave me a list of stuff I'm supposed to eat to fix that, and he got me the day off too. Wait a minute, I need a smoke before we go into the linens."

They stood together on the upper landing. From down in the living room rose the murmur of quiet conservation.

Nettie said, "I'd go back for another sleep session in a minute if they'd have me. Good money for no work, not like this." She blew a stream of smoke contemptuously toward the closet door.

Katje said, "Someone has to do what we do."

"Yeah, but why us?" Nettie lowered her voice. "We ought to get old Grauer and Rhine in there with the bedding and the inventory lists, and us two go sit in their big leather chairs and drink coffee like ladies."

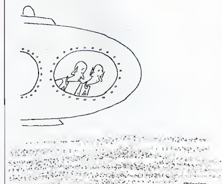
Katje had already done that as Henrik's wife. What she wanted now was to sit on the *stoep* after a day's hunting, sipping drinks and trading stories of the kill in the pungent dusk away from the smoky, noisy hole of a kitchen: a life that Henrik had rebelled against as parasitical, narrow, and dull. His grandfather, like Katje's, had trekked right out of the Transvaal when it became too staid for him and had started over, and what was wrong with that kind of courage and strength? Henrik had carried on the tradition. He had the guts to fight Uncle Jan and everybody else over the future of the land, the government, the natives—that courage had drawn her to him, and had lost her that fine old life and landed her here, now.

Nettie, still hanging back from the linen closet, grudgingly ground out her cigarette on the sole of her shoe. "Coming to the meeting Friday?"

"No. I told you, they're all Reds in those unions. I do all right for myself." Besides, Dr Weyland was giving a lecture that same Friday night. Katje opened the closet.

"Okay, if you think it's fine to make what we make doing this stuff. Me, I'm glad there's something like a gig in the sleep lab now and then so I can make a little extra and live like a person once in a while. You ought to go over there, you know? There's hardly anything doing during intersession with almost everybody gone. They could take you right away. You get extra pay and time off, and besides, Dr. Weyland's kind of cute, in a gloomy, old sort of a way. He leaned over me to plug something into the wall, and I said, Go ahead, you can bite my neck any time."

Katje gave her a startled glance, but Nettie, not noticing, moved past her into the closet and pulled out the step stool. Katje said in a neutral voice, "What did he say to that?"



"Of course they're civilized! Just look at that smog!"

"Nothing, but he smiled." Nettie climbed onto the step stool. "We'll start up top, all right? I bet all the guys who work nights at the labs get those kind of jokes all the time. Later he said he was hoping you'd come by, and I said he just likes his blood in different flavors."

Taking a deep breath of the sweet sunshine smell of the clean linens, Katje said, "He asked you to ask me to come?"

"He said to remind you."

The first pile of blankets was handed down from the top shelf. Katje said, "He really accepts anyone into this project?"

"Unless you're sick, or if you've got a funny metabolism or whatever. They do a blood test on you, like at the doctor's."

That was when Katje noticed the little round Band-Aid on the inside of Nettie's elbow, right over the vein.

Miss Donelly was sharing a jug of cheap wine with three other faculty women in the front lounge. Katje made sure the coffee machine was filled for them and then slipped outside.

She still walked alone on campus when she chose. She wasn't afraid of the rapist, who hadn't been heard from in several days. A pleasurable tension drove her toward the lighted windows of the labs. This was like moving through the sharp air of the bushveldt at dusk.

The lab blinds, tilted down, let out only threads of light. She could see nothing. She hovered a moment, then turned back, hurrying now. The mood was broken, and she felt silly. Daniel from Security would be furious to find her alone out here, and what could she tell him? That she felt herself to be on the track of something wild and it made her feel young?

Miss Donelly and the others were still talking. Katje was glad to hear their wry voices and gusts of laughter equally glad not to have to sit with them. At first she had been hurt by the social exclusions that had followed her hiring on at the club; now she was grateful.

She had more on her mind than school gossip, and she needed to think. Her own impulsive act excited and appalled her: sallying forth at dusk at some risk (her mind swerved neatly around the other, the imaginary danger), and for what? To sniff the breeze and search the ground for tracks?

The thought of Dr. Weyland haunted her. Dr. Weyland as the restless visitor to the club kitchen, Dr. Weyland as the enigma of faculty gossip, Dr. Weyland as she had first thought of him the other morning in the lab-building parking lot.

She was walking to the bus stop when Jackson drove up and offered her a lift. She was glad to accept. The lonesomeness of the campus was accentuated by darkness and the empty circles of light around the lamp posts.

Jackson pulled aside a jumble of equipment on the front seat—radio parts, speakers, and wires—to make room for her. Two books were on the floor by her feet. He said, "The voodoo book is left over from my brother Paul. He went through a thing, you know, trying to trace back our family down in Louisiana. The other one was just lying around."

The other one was *Dracula*. Katje felt the gummy spot where the price sticker had been peeled off. Jackson must have bought it for her at the discount bookstore downtown. She didn't know how to thank him easily so she said nothing.

"It's a long walk out to the bus stop," Jackson said, scowling as he drove out of the stone gates of the college drive. "They should've let you stay on in faculty housing after your husband died."

"They needed the space for another teacher," Katje said. She missed the cottage on the east side of campus, but her present rooming-house lodgings away from school offered more privacy.

He shook his head. "Well, I think it's a shame, you being a foreign visitor and all."

Katje laughed. "After twenty-five years in this country a visitor?"

He laughed too. "Yeah. Well, you sure have moved around in our society more than most while you been here, from lady of leisure to, well, maid work." She saw the flash of his grin. "Just like my old auntie that used to do for white women up the hill. Don't you mind?"

She minded when she thought working at the club would never end. Sometimes the Africa she remembered seemed too vague a place to go back to now and the only future she could see was keeling over at the end while vacuuming the club, like a farmer worn to death at his plow.

None of this was Jackson's business. "Did your auntie mind her work?" she snapped.

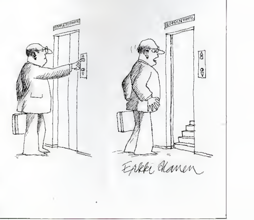
Jackson pulled up opposite the bus stop. "She said you just do what it comes to you to do and thank God for it."

"I say the same."

He sighed. "You're a lot like her, you know? Someday I got a bunch of questions to ask you about how it was when you lived in Africa. I mean, was it like they show in the movies, you know, *King Solomon's Mines* and like that?"

Katje had never seen that movie, but she knew that nothing on film could be like her Africa. "No," she said. "You should go to Africa sometime and see for yourself."

"I'm working on it. There's your bus coming. Wait a minute, listen—no more walking alone out here after dark. There's not enough people around now. You got to arrange to be picked up. Didn't you hear? That guy jumped another girl last night. She got away, but still. Daniel says he found one of the back doors to the club unlocked. You be careful, will you? I don't want to have to come busting in there to save you from some deranged, six-foot pre-med on the rampage, know what I mean? Skinny dude like me could get real ruined that way."



"Oh, I will take care of myself," Katje said, touched and annoyed and amused all at once by his solicitude.

"Sure. Only I wish you were about fifteen years younger and studying karate, you know?"

As she climbed out of the car with the books on her arm he added, "You do any shooting in Africa? Hunting and stuff?"

"Yes, quite a lot."

"Okay, take this." He pulled metal out of his pocket and put it in her hand. It was a gun. "Just in case. You know how to use it, right?"

She closed her fingers on the compact weight of it. "But where did you get this? Do you have papers for it? The laws here are very strict—"

He tugged the door shut and said through the open window, "I live in a rough neighborhood, and I got friends. Hurry up, you'll miss your bus."

Dracula was a silly book. She had to force herself to read on in spite of the phony Dutchman Ven Helsing, an insult to anyone of Dutch descent. The voodoo book was impenetrable, and she soon gave it up in disgust.

The handgun was another matter. She sat at the formica-topped table in her kitchenette and turned the shiny little automatic in the light, thinking. How had Jackson come by such a thing, or for that matter, how did he afford his fancy sports car and all that equipment he carried in it from time to time—where did it all come from and where did it go? He was up to something, probably lots of things—what they called "hustling" nowadays. A good thing he had given her the gun. It could only get him into trouble to carry it around with him. She knew how to handle weapons, and surely with a rapist at large the authorities would be understanding about her lack of a license for it.

The gun needed cleaning. She worked on it as best she could without the right tools. It was a cheap .25-caliber gun. Back home your gun was a fine rifle made to drop a charging rhino in his tracks, not a stubby little nickel toy like this for scaring off muggers and rapists.

Yet she wasn't sorry to have it. Her own hunting gun that she had brought from Africa years ago was in storage with the extra things from the cottage. She realized now that she had missed its presence lately—since the beginning of the secret stalking of Dr. Weyland.

She went to sleep with the gun on the night table next to her bed.

She woke listening for the roar so she would know in what direction to look tomorrow for the lion's spoor. There was a hot, rank odor of African dust in the air, and she sat up in bed thinking, he's been here.

It was a dream. But it had been so clear! She went to look out the front window without turning on the light, and it was the ordinary street below that seemed unreal. Her heart drummed in her chest. Not that he would come after her here on Dewer Street, but he had sent Nettie to the club, and now he had sent this dream into her sleep. Creatures stalking one another over time grew a bond from mind to mind. But that was in another life.

Was she losing her sanity? She read for a little in the Afrikaans Bible she had brought with her from home but so seldom opened in recent years. What gave comfort in the end was to put Jackson's automatic into her purse to carry with her. A gun was supposedly of no use against a vampire—you needed a wooden stake, she remembered reading, or you had to cut off his head to kill him—but the weight of the weapon in her handbag reassured her.

The lecture hall was full in spite of the scarcity of students on campus this time of year. These special talks were open to the town as well.

Dr. Weyland read his lecture in a stiff, abrupt manner. He stood cramped slightly over the lectern, which was low for his height, and rapped out his sentences, rarely raising his eyes from his notes. In his tweeds and heavy-rimmed glasses he was the picture of the scholarly recluse drawn out of the study into the limelight. His lecture was brief; he fulfilled with unmistakable impatience the duty set every member of the faculty to give one public address per year on an aspect of his work.

"The . . . vampire, if it existed, would be by definition the greatest of all predators, living as he would off the top of the food chain. Man is the most dangerous animal . . . and the vampire preys on man."

The audience didn't mind. They had come prepared to be spellbound by the great Dr. Weyland speaking on the demonology of dreams. At the end there were questions, most of them obviously designed to show the questioner's cleverness rather than to elicit information. The discussions after these lectures were usually the real show. Katje, lulled by the abstract talk, came fully to attention when a young woman asked, "Professor, have you considered whether the legends of such supernatural creatures as werewolves, vampires, and dragons are not distortions out of nightmares, as many think, that maybe the legends reflect the existence of real, though rare, prodigies of evolution?"

Dr. Weyland hesitated, coughed, sipped water. "The forces of evolution are capable of prodigies, certainly," he said. "You have chosen an excellent word. But we must understand that we are not speaking—in the case of the vampire, for example—of a blood-sipping phantom who cringes from a clove of garlic. How could nature design such a being?

"The corporeal vampire, if it existed, would be by definition the greatest of all predators, living as he would off the top of the food chain. Man is the most dangerous animal, the devourer or destroyer of all others, and the vampire preys on man. Now any sensible vampire would choose to avoid the risks of attacking humans by tapping the blood of lower animals if he could, so we must assume that our vampire cannot. Perhaps animal blood can tide him over a lean patch, as seawater can sustain a castaway for a few miserable days but can't permanently replace fresh water to drink. Humanity would remain the vampire's livestock, albeit fractious and dangerous to deal with, and where they live, so must he.

"In the sparsely settled early world he would be bound to a town or village to assure his food supply. He would learn to live on little—perhaps a half-liter of blood per day—since he could hardly leave a trail of drained corpses and hope to go unnoticed. Periodically he would withdraw for his own safety and to give the villagers time to recover from his depredations. A sleep several generations long would provide him with an untouched, ignorant population in the same location. He would have to be able to slow his metabolism, to induce in himself naturally a state of suspended animation, mobility in time would become his alternative to mobility in space."

Katje listened intently, thinking yes, he is the sort of animal that lies in wait for the prey to come his way. His daring in speaking this way stirred her; she could see he was beginning to enjoy the game, growing more at ease at the podium as he warmed to his subject.

"The vampire's slowed body functions during these long rest periods might help extend his lifetime, so might living for long periods, waking or sleeping, on the edge of starvation. We know that minimal feeding produces striking longevity in some other species. Long life would be a highly desirable alternative to reproduction, since a vampire would flourish best with the least competition. The great predator would not wish to sire his own rivals. It could not be true that his bite would turn his victims into vampires like himself—"

"Or we'd be up to our necks in fangs," whispered someone in the audience rather loudly.

"Fangs are too noticeable and not efficient for blood sucking," observed Dr. Weyland. "Large, sharp canine teeth are designed to tear meat. Polish versions of the vampire legend would be closer to the mark. They tell of some sort of puncturing device perhaps a needle in the tongue like a sting that would secrete an anticlotting substance That way the vampire could seal his lips around the wound and draw the blood freely without having to rip great spouting wasteful holes in his unfortunate prey" Dr Weyland smiled

The younger members of the audience produced appropriate retching noises

Would a vampire sleep in a coffin? Someone asked

"Certainly not," Dr Weyland retorted "Would you, given a choice? The corporeal vampire would require physical access to the world which is something that burial customs generally prevent He might retire to a cave or take his rest in a tree like Merlin or Ariel in the cloven pine, provided he could find either tree or cave safe from wilderness freaks and developers bulldozers

"Finding a secure resting place is one obvious problem for our vampire in modern times" he continued "There are others Upon each waking he must quickly adapt to his new surroundings, a task that we may imagine has grown progressively more difficult with the rapid acceleration of cultural change since the Industrial Revolution In the past century and a half he has no doubt had to limit his sleeps to shorter and shorter periods for fear of completely losing touch This curtailment of his rest might be expected to wear him down and render him increasingly irritable "

He paused to adjust his glasses now as visibly relaxed as Katje had seen him in her kitchen at the club Someone called out, "Could a corporeal vampire get a toothache?"

"Assuredly" replied Dr Weyland "He is, after all, a stage of humanity real though hard to come by He would no doubt also need a haircut now and then and could only put his pants on, as humorists have said since the widespread adoption of trousers, one leg at a time

"Since we posit a natural rather than a supernatural being he grows older but slowly Meanwhile each updating of himself is more challenging and demands more from him—more imagination, more energy more cunning While he must adapt sufficiently to disguise his anomalous existence he must not succumb to current ideologies of Right or Left—that is to the cant of individual license or to the cant of the infallibility of the masses—lest either allegiance interfere with the exercise of his predatory survival skill "

Meaning Katje thought grimly he can't afford scruples about drinking our blood

Emrys Williams raised a giggle by commenting that a lazy vampire could always take home a pretty young instructor to show him the new developments in interpersonal relations

Dr Weyland fixed him with a cold glance "You are mixing up dinner with sex" he remarked "and not I gather, for the first time "

They roared Williams—the "tame Wild Welshman of the Lit Department" to his less admiring colleagues—turned a gratified pink

One of Dr Weyland's associates in Anthropology pointed out at boring length that the vampire, born in an earlier age would become dangerously conspicuous for his diminutive height as the human race grew taller

"Not necessarily" commented Dr Weyland "Remember that we speak of a highly specialized physical form It may be that during his waking periods his metabolism is so sensitive that he responds to the stimuli in the environment by growing in his body as well as in his mind Perhaps while he's awake his entire being exists at an intense inner level of activity and change The stress of these great rushes to catch up all at once with physical mental, and cultural evolution must be enormous No wonder he needs his long sleeps."

He glanced at the clock on the wall "As you can see by the application of a little logic and imagination we come up with a creature bearing superficial resemblances to the vampire of legend but at base one quite different from your standard strolling corpse with an aversion to crosses Next question?"

They weren't willing to end this flight of fancy Someone asked how he accounted for the superstitions about crosses and garlic and so on

Dr Weyland sipped water from the glass at hand while contemplating the audience He said finally, "Primitive men first encountering the vampire would be unaware that they themselves were products of evolution They would have no way of knowing that he was a still higher product of the same process They would make up stories to account for him and to try to control him In early times the vampire himself might even believe in some of these legends—the silver bullet, the oaken stake

"But waking at length in a more rational age, he would abandon these notions just as everyone else did A clever vampire might even make use of the folklore For instance, it is generally supposed that Bram Stoker was inspired to write *Dracula* by his meeting with a Rumanian professor of Oriental languages from Pest University, I refer you to a recent biography of Stoker by Daniel Farson Why was this Professor Arminius Vambery in London at just the right time a guest at a certain eating club along with Stoker on a certain night? How did Vambery come to have a wealth of tantalizing detail about the vampire superstition at his fingertips? Ladies and gentlemen, take note There is a research paper in it somewhere "

He didn't wait for their laughter to die away but continued "Any intelligent vampire sensitive to the questing spirit of those times would have developed a passionate interest in his own origin and evolution Now, who was Arminius Vambery and why his ceaseless exploration of that same subject?

"Eventually our vampire prudently retires. Imagine his delight upon waking half a century later to find vampire legends a common currency of the popular culture and *Dracula* a classic."

"Wouldn't he be lonely?" sighed a girl standing in the side aisle, her posture eloquent of the desire to comfort that loneliness.

"The young lady will forgive me," Dr. Weyland responded, "if I observe that this is a question born of a sheltered life. Predators in nature do not indulge in the sort of romantic moonings that humans impute to them. As for our vampire, even if he had the inclination he wouldn't have the time. On each waking he has more to learn. Perhaps someday the world will return to a reasonable rate of change, permitting him some leisure in which to feel lonely or whatever suits him."

A nervous girl ventured the opinion that a perpetually self-educating vampire would always have to find himself a place in a center of learning in order to have access to the information he would need.

"Naturally," agreed Dr. Weyland drily. "Perhaps a university, where strenuous study and other eccentricities of the living intellect would be accepted behavior in a grown man. Possibly even a modest institution like Cayslin College would serve."

Under the chuckling following this came a question too faint for Katje to hear. Dr. Weyland, having bent to listen, straightened up and announced sardonically, "The lady desires me to comment upon the vampire's 'Satanic pride.' Madam, here you enter the area of the literary imagination and its devices, where I dare not tread under the eyes of my colleagues from the English Department. Perhaps they will pardon me if I merely point out that a tiger who falls asleep in a jungle and on waking finds a thriving city overgrowing his lair has no energy to spare for displays of Satanic pride."

That's nerve, Katje thought. Dr. Weyland expounding on a vampire's pride—what an exercise in arrogance!

Williams, intent on having the last word as always, spoke up once more: "The vampire as time traveler—you ought to be writing science fiction, Weyland," which provoked a growing patter of applause. It was evident that the evening was ending.

Katje went out with the crowd, but withdrew to stand outside under the portico of the Union Building. She saw Dr. Weyland's car across the street, gleaming in the lamplight: his access to physical mobility and a modern mechanical necessity that he had mastered. No wonder he loved it.

With the outwash of departing audience came Miss Donelly. She asked if Katje needed a lift. "There's my car, the rusty, trusty Volks." Katje explained that a group of women from the staff cafeteria went bowling together each Friday night and had promised to come by and pick her up.

"I'll wait with you just in case," Miss Donelly said. "You know, Wild Man Williams is a twerp, but he was right. Weyland's vampire would be a time traveler. He could only go forward, of course, never back, and only by long, unpredictable leaps—this time, say, into our age of what we like to think of as technological marvels, maybe next time into an age of interstellar travel. Who knows, he might get to taste Martian blood, if there are Martians, and if they have blood."

"Frankly, I wouldn't have thought Weyland could come up with anything so imaginative as that—the vampire as a sort of living saber-toothed tiger prowling the pavements, a truly endangered species. That's next term's T-shirt: SAVE THE VAMPIRE."

Miss Donelly might banter, but she would never believe. It was all a joke to her, a clever mental game invented by Dr. Weyland for his audience. No point consulting her.

Miss Donelly added ruefully, "You've got to hand it to the man. He's got a tremendous stage presence, and he sure knows how to turn on the charm when he feels like it. Nothing too smooth, mind you, just enough unbending, enough slightly caustic graciousness, to set susceptible hearts a-beating. You could almost forget what a ruthless, self-centered bastard he can be. Did you notice that most of the comments came from women? Is that your lift?"

"She was sure that he had attacked that girl, drunk her blood, and then killed her. He was using the rapist's activities as cover. When subjects did not come to him . . . hunger drove him out to hunt."

It was. While the women in the station wagon shuffled themselves around to make room, Katje stood with her hand on the door and watched Dr. Weyland emerge from the building with admiring students at either hand. He loomed above them, his hair silver under the lamplight. For over-civilized people to experience the approach of such a predator as sexually attractive was not strange. She remembered Scotty saying once that the great cats were all beautiful, and maybe beauty helped them to capture their prey.

He turned his head, and she thought for a moment that he was looking at her as she got into the station wagon.

What could she do that wouldn't arouse total disbelief and a suspicion that she herself was crazy? She couldn't think amid the tired, satisfied ramblings of her bowling friends, and she declined to stay up socializing with them. They didn't press her. She was not one of their regular group.

Sitting alone at home, Katje had a cup of hot milk to calm herself for sleep. To her perplexity, her mind kept wandering from thoughts of Dr. Weyland to memories of drinking cocoa at night with Henrik and the African students he used to bring to dinner. They had been native boys to her, dressed up in suits and talking politics like white men, flashing photographs of black babies playing with toy trucks and walkie-talkie sets. Sometimes they had gone to see documentary films of an Africa full of cities and traffic and black professionals exhorting, explaining, running things, as these students expected to do in their turn when they went home.

She thought about home now. She recalled clearly all those indicators of irrevocable change in Africa, and she saw suddenly that the old life there had gone. She would return to an Africa largely as foreign to her as America had been at first. Reluctantly, she admitted one of her feelings when listening to Dr. Weyland talk had been an unwilling empathy with him. If he was a one-way time traveler, so was she.

As the vampire could not return to simpler times, so Katje saw herself cut off from the life of raw vigor the rivers of game, the smoky village air all viewed from the lofty heights of white privilege. One did not have to sleep half a century to lose one's world these days; one had only to grow older.

Next morning she found Dr. Weyland leaning hands in pockets against one of the columns flanking the entrance to the club. She stopped some yards from him, her purse hanging heavily on her arm. The hour was early the campus deserted-looking. Stand still, she thought; show no fear.

He looked at her. "I saw you after the lecture last night and earlier in the week, outside the lab one evening. You must know better than to wander alone at night, the campus empty, no one around—anything might happen. If you are curious, Mrs. de Groot, come do a session for me. All your questions will be answered. Come over tonight. I could stop by here for you in my car on the way back to the lab after dinner. There is no problem with scheduling, and I would welcome your company. I sit alone over there these nights hoping some impoverished youngster unable to afford a trip home at intersession, will be moved by an uncontrollable itch for travel to come to my lab and earn his fare."

She felt fear knocking heavily in her body. She shook her head, no.

"My work would interest you, I think," he went on, watching her. "You are an alert, fine-looking woman; they waste your qualities here. Couldn't the college find you something better than to be a housekeeper for them after your husband died? You might consider coming over regularly to help me with some clerical chores until I get a new assistant. I pay well.'

Astonished out of her fear at the offer of work in the vampire's lair she found her voice. "I am a country woman, Dr Weyland, a daughter of farmers. I have no proper education. We never read books at home, except the Bible. My husband didn't want me to work. I have spent my time in this country learning English and cooking and how to shop for the right things. I have no skills, no knowledge but the little that I remember of the crops and weather and customs of another country—and even that is probably out of date. I would be no use in work like yours."

Hunched in his coat with the collar up-turned, looking at her slightly askance, his tousled hair gleaming with the damp, he had the aspect of an old hawk, intent but aloof. He broke the pose, yawned behind his large-knuckled hand, and straightened up.

"As you like. Here comes your friend Nellie."

"Nettie," Katje corrected, suddenly outraged: he'd drunk Nettie's blood; the least he could do was remember her name properly. But he was vanishing over the lawn toward the lab.

Nettie came panting up. "Who was that? Did he try to attack you?"

"It was Dr Weyland," Katje said. She hoped Nettie didn't notice her trembling, which Katje tried to conceal.

Nettie laughed. "What is this, a secret romance?"

Miss Donelly came into the kitchen toward the end of the luncheon for the departing Emeritus. She plumped herself down between Nettie and Katje, who were taking a break and preparing desert, respectively. Katje spooned whipped cream carefully into each glass dish of fruit.

Miss Donelly said, "In case I get too smashed to say this later, thanks. On the budget I gave you, you did just great. The Department will put on something official with Beef Wellington and trimmings, over at Borchard's, but it was really important for some of us lowly types to give Sylvia our own alcoholic farewell feast, which we couldn't have done without your help."

Nettie nodded and stubbed out her cigarette.

"Our pleasure," Katje said, preoccupied. Dr Weyland had come for her would come back again; he was hers to deal with, but how? She no longer thought of sharing her fear, not with Nettie with her money worries or with Miss Donelly whose eyes were just now faintly swimmy-looking with drink. Weyland the vampire was not for a committee to deal with. Only fools left it to committees to handle life and death.

"The latest word," Miss Donelly added bitterly, "is that the Department plans to fill Sylvia's place with some guy from Oregon, which means the salary goes up half as much again or more inside of six months."

"Them's the breaks," Nettie said, not very pleasantly. She caught Katje's eye with a look that said, Look who makes all the money and look who does all the complaining.

"Them is," Miss Donelly agreed glumly. "As for me, the word is no tenure, so I'll be moving on in the fall. Me and my big mouth. Wacker nearly fainted at my prescription for stopping the rapes. You trap the guy, disembowel him, and hang his balls over the front gate. Our good dean doesn't know me well enough to realize it's all front. On my own I'd be too petrified to try anything but talking the bastard out of it. You know. Now you just let me get my dress back on and I'll make us each a cup of coffee, and you tell me all about why you hate women.'"

She stood up, groaning.

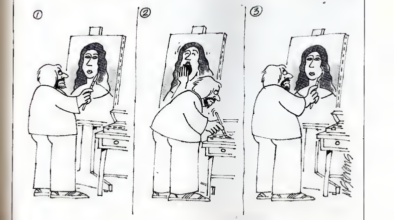
"Did you hear what happened to that girl last night, the latest victim? He cut her throat. Ripped her pants off but didn't even bother raping her, that's how desperate for sex he is."

Katje said, "Jackson told us about the killing this morning."

"Jackson? Oh, the maintenance man. Look out, it could even be him. Any of them, damn them," she muttered savagely as she turned away, "living off us, kicking our bodies out of the way when they're through—"

She stumbled out of the kitchen.

Nettie snorted. "She's always been one of those libbers. No wonder Wacker's getting rid of her. Some men act like hogs, but



you can't let yourself be turned into a man-hater. A man's the only chance a girl has of getting up in the world, you know?' She pulled on a pair of acid-yellow gloves and headed for the sink. "If I want out of these rubber gloves I have to marry a guy who can afford to pay a maid."

Katje sat looking at the fruit dishes with their plump cream caps. It was just as the Bible said. She felt it happen. The scales fell from her eyes. She saw clearly and thought, I am a fool.

Bad pay is real, rape is real, killing is real. The real world worries about real dangers, not childish fancies of a night prowler who drinks blood. Dr. Weyland took the trouble to be concerned, to offer extra work, while I was thinking idiot things about him. Where does it come from, this nonsense of mine? My life is dull since Henrik died, so I make up drama in my head, and that way I get to think about Dr. Weyland, a distinguished and learned gentleman, being interested in me.

She resolved to go to the lab building later and leave a note for Dr. Weyland, an apology for her reluctance, an offer to stop by soon and make an appointment at the sleep lab.

Nettie looked at the clock and said over her shoulder, "Time to take the ladies their dessert."

At last the women had dispersed, leaving the usual fog of smoke behind. Katje and Nettie had finished the cleaning up. Katje said, "I'm going for some air."

Nettie, wreathed by smoke of her own making, drowsed in one of the big living-room chairs. She shook her head. "Not me. I'm pooped." She sat up. "Unless you want me along. It's still light out, so you're safe from the Cayslin Ripper."

"Don't disturb yourself," Katje said.

Away on the far edge of the lawn three students danced under the sailing shape of a Frisbee. Katje looked up at the sun, a silver disc behind a thin place in the clouds; more rain coming, probably. The campus still wore a deserted look. Katje wasn't worried; there was no vampire, and the gun in her purse would suffice for anything else.

The sleep lab was locked. She tucked her note of apology between the lab door and the jamb and left.

As she started back across the lawn, someone stepped behind her, and long fingers closed on her arm. It was Dr. Weyland. Firmly and without a word he bent her course back toward the lab.

"What are you doing?" she said, astonished.

"I almost drove off without seeing you. Come sit in my car. I want to talk to you." She held back, alarmed, and he gave her a sharp little shake. "Making a fuss is pointless. No one is here to notice. No one would believe."

There was only his car in the parking lot, even the Frisbee players had gone. Dr. Weyland opened the door of his Mercedes and pushed Katje into the front passenger seat with a deft, powerful thrust of his arm. He got in on the driver's side, snapped down the automatic door locks, and sat back. He looked up at the gray sky, then at his watch.

Katje said, "You wanted to say something to me?"

He didn't answer.

She said, "What are we waiting for?"

"For the day man to leave and lock up the lab. I don't like to be interrupted."

This is what it's like, Katje thought, feeling lethargic detachment stealing through her, paralyzing her. No hypnotic power out of a novelist's imagination held her, but the spell cast on the prey of the hunting cat: the shock of being seized in the deadly jaws, though not a drop of blood was yet spilled.

"Interrupted," she whispered.

"Yes," he said, turning toward her. She saw the naked craving in his gaze. "Interrupted at whatever it pleases me to do with you. You are on my turf now, Mrs. de Groot, where you have persisted in coming time after time. I can't wait any longer for you to make up your mind. You are healthy—I looked up your records—and I am hungry. You may live to walk away after. I don't know yet—who would listen to a mad old woman? I can tell you this much: Your chances are better if you don't speak."

The car smelled of cold metal, leather, and tweed. At length a man came out of the lab building and bent to unlock the chain from the only bicycle in the bike rack. By the way Dr. Weyland shifted in his seat, Katje saw that this was the departure he had been awaiting.

"Look at that idiot," he muttered. "Is he going to take all night?" She saw him turn restlessly toward the lab windows. That would be the place, after a bloodless blow to stun her—he wouldn't want any mess in his Mercedes.

In her lassitude she was sure that he had attacked that girl, drunk her blood, and then killed her. He was using the rapist's activities as cover. When subjects did not come to him at the sleep lab, hunger drove him out to hunt. Perhaps he was glad then to put aside his civilized disguise.

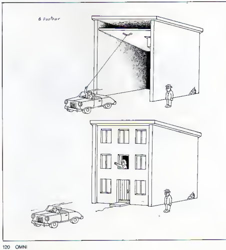
She thought, *But I am myself a hunter!*

Cold anger coursed through her. Her thoughts flew. She needed time, a moment out of his reach to plan her survival. She had to get out of the car—any subterfuge would do.

She gulped and turned toward him, croaking, "I'm going to be sick."

He swore furiously. The locks clicked; he reached roughly past her and shoved open the door on her side. "Out!"

She stumbled out into the drizzling, chilly air and backed several hasty paces, hugging her purse to her body like a shield, looking quickly around. The man on the bike had gone. The upper story of the Cayslin Club across the lawn showed a light—Nettie would be missing her now. Maybe

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Jackson would be just arriving to pick them up. But no help could come in time.

Dr. Weyland had gotten out of the car. He stood with his arms folded on the roof of the Mercedes, looking across at her with a mixture of annoyance and contempt. "Mrs. de Groot, do you think you can outrun me?"

He started around the front of his car toward her.

Scotty's voice sounded quietly in her ear: "Yours," he said, as the leopard tensed to charge. Weyland too was an animal, not an immortal monster out of legend—just a wild beast, however smart and strong and hungry. He had said so himself.

She jerked out the automatic, readying it to fire as she brought it swiftly up to eye level in both hands while her mind told her calmly that a head shot would be best but that a hit was surer if she aimed for the torso.

She shot him twice, two slugs in quick succession, one in the chest and one in the abdomen. He did not fall but bent to clutch at his torn body, and he screamed and screamed so that she was too shaken to steady her hands for the head shot afterward. She cried out also, involuntarily. His screams were dreadful. It was long since she had killed anything.

Footsteps rushed behind her, arms flung round her, pinning her hands to her sides so that the gun pointed at the ground and she couldn't fire at Weyland again. Jackson's voice gasped in her ear: "Jesus Creeping Christ!"

His car stood where he had braked it unheard by Katje. Nettie jumped out and rushed toward Katje, crying, "My God, he's shot, she shot him!"

Breaking off his screaming, Weyland tottered away from them around his car and fetched up leaning on the front. His face, a hollow-cheeked, starving mask, gaped at them.

"It's him?" Jackson said incredulously. "*He* tried to rape you?"

Katje shook her head. "He's a vampire."

"Vampire, hell!" Jackson exploded in a breathless laugh. "He's a Goddamn dead rapist, that's what he is! Jesus!"

Weyland panted, "Stop staring, cattle!"

He wedged himself heavily into the driver's seat of his car. They could see him slumped there, his forehead against the curve of the steering wheel. Blood spotted the Mercedes where he had leaned.

"Mrs. de Groot, give me the gun," Jackson said.

Katje clenched her fingers around the grip. "No."

She could tell by the way Jackson's arms tightened that he was afraid to let go of her and grab for the gun. He said, "Nettie, take my car and go get Daniel!"

Nettie moaned, "My God, look! What's he doing?"

Weyland had lifted his red-smeared hands to his face, and he was licking the blood from his fingers. Katje could see his throat working as he strained to swallow his food. His life

A siren sounded. Nettie cried in wild relief, "That's Daniel's car coming!"

Weyland raised his head. His gray face was rigid with determination. He snarled, "I won't be put on show!" The door—one of you shut the door!" He started the engine.

His glaring face commanded them. Nettie darted forward, slammed the door, and recoiled, wiping her hand on her sweater.

Eyes blind to them now, Weyland drove the Mercedes waveringly past them out of the parking lot toward the gateway road. Rain swept down in heavy gusts. Katje heard the siren again and woke to her failure. She had not made a clean kill. The vampire was getting away.

She lunged toward Jackson's car. He held her back, shouting, "Nothing doing, come on, you done *enough*!"

The Mercedes crawled haltingly down the middle of the road, turned at the stone gates, and was gone.

Jackson said, "*Now* will you give me that gun?"

"Weyland had lifted his red-smeared hands to his face, and he was licking the blood from his fingers. Katje could see his throat working as he strained to swallow his food. . . . A siren sounded."

Katje snapped on the safety and dropped the automatic on the wet paving at their feet.

Nettie was pointing toward the club. "There's people coming. They must have heard the shooting and called Daniel. Listen, Jackson, we're in trouble. Nobody's going to believe that Dr. Weyland is the rapist—or the other thing either." Her glance flickered nervously over Katje. "Whatever we say, they'll think we're crazy."

"Oh, shit," said Jackson tiredly, letting Katje go at last. He stooped to retrieve the gun. Katje saw the apprehension in his face as he weighed Nettie's assessment of their situation: a wild story from some cleaning people about the eminent professor—

"We've got to say something," Nettie went on desperately. "All that blood—" She fell silent, staring.

There was no blood. The rain had washed the tarmac clean.

Jackson faced Katje and said urgently, "Listen, Mrs. de Groot, we don't know a thing about any shooting, you hear?" He slipped the gun into an inside pocket of his jacket. "You came over to make an appointment at the sleep lab, only Dr. Weyland wasn't around. You waited for him, and Nettie got worried when you didn't come back, so she called me, and we drove over here looking for you. We all heard shooting, but nobody saw anything. There was nothing to see. Like now."

Katje was furious with him and herself. She should have chanced the head shot; she shouldn't have let Jackson hold her back.

She could see Daniel's car now, wheeling into the parking lot.

Jackson said quietly, "I got accepted to computer school in Rochester for next semester. You can bet they don't do vampires down there. Mrs. de Groot and they don't do black guys who can get hold of guns, either. Me and Nettie got to live here; we don't get to go away to Africa."

She grew calmer; he was right. The connection had been between herself and the vampire all along, and what had happened here was her own affair. It had nothing to do with these young people.

"All right, Jackson," she said. "There was nothing to see."

"Not a thing," he said in his old, easy manner, and he turned toward Daniel's car.

He would do all right, maybe someday he would come visit her in Africa, in a smart suit and carrying an attaché case, on business. Surely they had computers there now too.

Daniel stepped out of his car into the rain, one hand on the butt of his pistol. Katje saw the disappointment sour his florid face as Nettie put a hand on his arm and began to talk quietly.

Katje picked up her purse from where she had dropped it—how light it felt now, without the gun in it. She fished out her plastic rain hood, though her hair was already wet. Tying the hood on, she thought about her old Winchester 270, her lion gun. About taking it from storage, putting it in working order, tucking it well back into the broom closet at the club. In case Weyland didn't die, in case he couldn't sleep with two bullets in him and came limping back to hunt on familiar ground, to look for her. He would come next week, when the students returned, or never. She didn't think he would come, but she would be ready just in case.

And then, as she had planned, she would go home to Africa. Her mind flashed a new life, whatever life she could make for herself there these days. If Weyland could fit himself to new futures, so could she.

But if he did sleep, and woke again 50 years from now? Each generation must look out for itself. She had done her part, although perhaps not well enough to boast about. Still, what a tale it would make some evening over the smoke of a campfire on the veldt, beginning with the tall form of Dr. Weyland seen striding across the parking lot past a kneeling student in the heavy mist of morning. . . .

Katje walked toward Daniel's car to tell the story that Buildings and Grounds would understand. **DO**

SCIENCE'S KIND OF TOWN

EXPLORATIONS

By Nancy and Paul Condylis

When Mrs. O'Leary's cow kicked over the lantern that ignited the Great Chicago Fire of 1871, she officially laid the foundation for what was to become a city of architectural inspiration. Faced with four square miles of leveled metropolis, architects were given a rare opportunity to redesign an entire city center. From the ashes of Chicago's fiery immolation rose, among other major innovations of modern architecture, the first skyscraper. Similar structures soon took shape along the magnificent downtown lakeside strip known as Michigan Avenue, so that by mid-century a gleaming skyline (containing some of the world's tallest buildings) framed this sprawling industrial jewel of the Midwest. "Here is a tall bold slugger set vivid against little soft cities," wrote Carl Sandburg of Chicago.

Science has long been a factor in shaping the cultural and economic output of the windy city. Chicago and its immediate vicinity abound in museums, research-and-development centers, pioneering power plants, and other science-oriented tourist attractions. Some of these institutions are at the forefront of scientific investigation and development: subatomic-particle research, alternative energy sources, biomedical and environmental research, water purification, astronomy and astrophysical studies, and medical sciences.

The huge, rambling **Museum of Science and Industry** presents an overwhelming array of large exhibits designed to illustrate key scientific principles and to demonstrate how those principles are applied throughout society and industry. The exhibits, which emphasize present-day knowledge, are often three-dimensional and directly involve the visitor. Participants view sophisticated films and displays on computers, examine photographic processes ranging from primitive daguerreotypes to amazing holograms, test their knowledge about energy in an "energy game," walk through a simulated steel-making plant, and explore the microworld of one-celled and multicelled animals. Visitors can also tour a captured World War II submarine, explore a reconstructed coal mine, crowd into a picture-phone booth to talk to a friend across the hall, gaze up at historic airplanes hanging from the ceiling, frustrate themselves with mathematical puzzles, hear a friend's every word whispered from across a special acoustic room, traverse a giant model of a human heart, watch a circus film on a nine-meter-high vertical screen, and peer into a two-man space vehicle.

The Museum of Science and Industry is only one of many science museums that dot the shore of Lake Michigan. Animal and natural-history lovers will enjoy the **Shedd Aquarium**, with its more than 5000 freshwater and saltwater fish watching the people watching them. The aquarium features a diver who gives underwater commentary while feeding some 50 different species of fish in a coral-reef exhibit tank.

The **Field Museum of Natural History** is another must, a large Grecian temple of artifacts and skeletons; its purpose is to outline the evolution of man, the animal world, the plant world, and the earth itself. Don't pass by the **Chicago Academy of Sciences**; it is a compact but remarkable museum, recently renovated, that shows the natural habitats of various animals around the world.

Those with an interest in medicine will appreciate Chicago's status as a major medical-science center. Some of its hospitals and medical schools are landmarks. In addition, the **International Museum of Surgical Science**, also on the shore of Lake Michigan, traces the story of healing from ancient times to the present with 32 rooms of exhibits profiling the history of surgery in different countries.

Those excited by black holes and the possibility of extraterrestrial life will find an exceptional astronomical institution, also on the lakefront, in the **Adler Planetarium**, one of the great planetariums of the world. As the first major planetarium constructed in the U.S., it was completed shortly before the planet Pluto was discovered in 1930. A mural inside depicts the planets only up

Hedrich-Blessing

Fermi National Accelerator Laboratory is one of many science tourist attractions near Chicago through Neptune The major attractions under this dome-topped building are the Kroc Universe Theatre—a multimedia/multiscreen theater the Sky Theatre, with its huge ant-shaped Zeiss star projector that simulates the night sky in regularly scheduled programs, and the new Doane Observatory, with its 40 centimeter reflecting telescope and electronic eyepiece that captures "live" views ot astronomical objects and displays them on a television monitor In addition there are displays ranging from antique astronomical instruments to artifacts of space-age exploration

Tourists with a technological bent might prefer a different installation on Lake Michigan the world's largest water-purification plant While not a museum the **Jardine Water Purification Plant** conducts free tours that tell the fascinating story of how this concrete mass of mechanical logic operates The "monster" treats more than four million liters (one million gallons) of water per minute—tap water for three million people in and around Chicago

Another unusual installation, on Chicago's South Side, is the new **Supplementary Fuel Processing Facility**, which converts common garbage into electrical energy It is a city-owned $16 million plant that processes solid residential waste and sells it to the Commonwealth Edison Company the local electric utility The plant handles 1000 tons of household refuse per day and Chicago realizes $1 million a year from its sale and the sale of recycled metals Efficient and economical the facility embodies the very future of domestic waste disposal

Visitors to the new plant observe an operation wherein coal is added to the refuse that is burnt in Commonwealth Edison furnaces to generate electricity This mixture substitutes for 100,000 tons of raw coal each year Sightseers at the facility are shown a color film of the entire process

Commonwealth Edison also generates electric power from nuclear fuels Public visitor centers at its Dresden and Quad-Cities nuclear power stations outside of Chicago feature tours movies lectures exhibits models and demonstrations on the history and operation of the plants (See Explorations, November 1978)

Outside the main city are several research-and-development centers worth an extra trip In the town of Argonne, Illinois, 44 kilometers southwest of Chicago, is the **Argonne National Laboratory**, one of the nation's largest federally funded research centers Its history is as long as the history of organized atomic research in the U S , it grew out of its predecessor the Metallurgical Laboratory, where on December 2, 1942, Enrico Fermi and his colleagues achieved the world's first controlled nuclear chain reaction A striking nuclear-energy sculpture by Henry Moore now marks this historic spot Argonne carries out fundamental research in radiobiology (the effects of radiation on living systems and its use in medicine), the causes and effects of air, water, and land pollution and the technology of alternative energy sources Some of the fascinating work in alternative energy sources includes research and development of high-performance batteries to store electrical energy during off-peak times by electric utilities and for propelling automobiles major coal research leading to more efficient coal combustion and less pollution thermonuclear (fusion) reactors the practical use of solar energy and magnetohydrodynamics (MHD) a relatively new method of converting heat into electricity The broad range of studies and equipment at Argonne can be explored in tours *by appointment only*

While one of the largest components of Argonne's physical-sciences program is its high-energy research into the behavior of subatomic particles, it is overshadowed quantitatively by the nearby **Fermi National Accelerator Laboratory** which houses the world's largest particle accelerator Located about 48 kilometers west of Chicago near Batavia, Illinois, Fermilab is another midwestern tourist attraction open daily to the public for guided tours and self guided tours Each month thousands of visitors get a close look at portions of the accelerator, which is, in a sense a giant microscope that permits scientists to study the world of the very small including the basic building blocks of nature Besides tours and audiovisual programs Fermilab's extraordinary architecture (which houses one of the largest atriums in the world) is well worth the visit The beautiful countryside surrounding the facility includes the rare sight of a roaming herd of buffalo

What makes a tour of Chicago's science sites particularly satisfying is that in addition to being first rate tourist attractions they offer each visitor the special thrill of experiencing activities of international significance to the scientific community and to the public at large **OO**

Nancy and Paul Condylis are a husband-wife writing team and producers of "Chicago Odyssey" a six-year old tourist-oriented multimedia show

CHICAGO IS A LABORATORY

The Adler Planetarium
1300 S Lake Shore Dr Chicago IL 60605 Call (312) 322-0300 or 322-0304 for information on exhibits, classes, shows, schedules and hours and show prices

Argonne National Laboratory
9700 S Cass Ave Argonne IL 60439 Tours are arranged through the Office of Public Affairs, (312) 972-2773

Chicago Academy of Sciences
2001 N Clark St Chicago IL 60614, (312) 549-0606 Admission is free

City of Chicago Southwest Supplementary Fuel Processing Facility
3757 W 34th St at S Hamlin Ave (northwest corner), Chicago IL 60623 Admission is free For tour and visitor information (312) 744-3181

Commonwealth Edison Company/Nuclear-Power Stations

- Quad-Cities Nuclear Information Center, (319) 326-7360 Offers tours exhibits
- Dresden Nuclear Station Visitors Center (815) 942-2920, Ext 225 Tours are by appointment

Fermi National Accelerator Laboratory
PO Box 500, Batavia IL 60510 For information and tour arrangements call the Public Information Office, (312) 840-3351 There are 1½-hour guided group tours Monday through Friday and self guided tours daily

Field Museum of Natural History
Lake Shore Dr at E Roosevelt Rd , Chicago IL (312) 922-9410 An admission fee is charged

International Museum of Surgical Science
1524 Lake Shore Dr Chicago IL 60614 (312) 642-3632 Museum is open Sundays from 10 to 4 Admission is free

Jardine Water Purification Plant
1000 E Ohio St (between Lake Shore Dr and Navy Pier), Chicago, IL (312) 744-3701 Tours are free

Museum of Science and Industry
57th and S Lake Shore Dr Chicago, IL 60637 (312) 684-1414 Admission is free to building and most exhibits

Shedd Aquarium
1200 S Lake Shore Dr Chicago, IL 60605 (312) 939-2426 An admission fee is charged

Henry Moore Nuclear Energy Sculpture,
University of Chicago Office of Public Information (312) 753-4420 Call or write for brochures maps directions tour information, and admission charges

For more attractions, contact **The Chicago Convention and Tourism Bureau,** 332 S Michigan Ave Chicago IL 60604, (312) 922-3530

LIFECLOUD

CONTINUED FROM PAGE 68

lulose? A dash to the library and we found to our amazement that laboratory measurements for cellulose over the wavelength range from 2 to 30 microns showed just the absorption bands we were seeking. Moreover cellulose was free of unwanted bands. It took only a half-hour's calculation to verify that cellulose can account both for the 8- to 12-micron emission feature and for the 18-micron band in the observed spectrum of the Trapezium Nebula.

Other spectral data can be explained by a substance with a C_4N_2 ring bonded to a subsidiary carbon ring, giving an empirical chemical formula (with H atom attachments) of $C_8H_8N_2$. The ultraviolet observations are explained by a mixture of $C_8H_8N_2$ together with some graphite particles, which are still required to account for the overall breadth of the observed hump.

The second requirement for nitrogen-bearing rings comes from the observed spectra of highly reddened stars, stars whose light penetrates a great deal of dust on its journey to earth. Such stars have some 30 diffuse absorption features at well-defined wavelengths between 4400 and 7000 angstroms (1 angstrom=1 ten billionth of a meter).

Although these features have been studied for more than four decades, their origin has remained obscure. A few years ago, however, F. M. Johnson suggested that porphyrins could explain many of these mysterious features. Porphyrins form the basic structure of chlorophyll which, in turn, is one of the most essential of all biochemical substances. Although Johnson's suggestion has hitherto been considered implausible, in the light of the present discussion it no longer seems so.

We have argued that there is evidence for an astrophysical origin of several basic biochemical units. These include polysaccharides, nitrogen-bearing rings that could form the purine and pyrimidene bases in nucleic acids, and nitrogen-bearing rings assembled into porphyrins. It is with the formation of these materials that the foundations of biochemistry appear to have been laid.

EVOLUTION BEGINS

If interstellar space is full of prebiotic molecules, it is almost self-evident that the origin of life on earth involved merely a piecing together of interstellar prebiotics. It is easy to understand why all life turns on basic molecular combinations of hydrogen, carbon, oxygen, nitrogen, sulphur, and phosphorus, from the billions of possible combinations that might have been equally workable. It is also easy to understand why the same molecular configurations are deployed for a multitude of different functions and do not always make the best use of available energy resources.

A case in point is chlorophyll. The sunlight-chlorophyll connection drives the whole of biology. It comes as a surprise to find that chlorophyll does not have its absorption bands where the sun emits most of its energy. In other words, chlorophyll does not make the best use of sunlight. If life had free choice to pick the best pigment-battery system, it would quite likely find a substance better related to the sun, our particular star. That it did not do so is significant. Life simply used what was available to it from the interstellar warehouse.

Some people argue that all interstellar organics were destroyed in the processes that led to the formation of the earth, but we know that comets do carry organic compounds. Some meteorites bring such molecules to earth entirely preserved. Recent investigations have shown that chondrites have optical properties inconsistent with an origin in the asteroidal belt. Chondrites resemble more closely objects such as Icarus, which lie in orbits crossing that of Mars. They are therefore more likely to be of cometary origin.

Primitive life forms may even have evolved on comets. Heat released below the surface of a comet could have melted a fraction of the underlying ice, the heat being released by chemical reactions between the organic molecules. Once some ice was melted, there would have been further heat-releasing chemical reactions between the organic molecules and liquid water. Such a situation, adequately insulated against heat loss by overlying surface layers, could well have provided the most favorable conditions for the emergence of life, the best location of all for a primeval soup.

Prebiotic molecules, including polysaccharides, amino acids, porphyrins, and the component substructures of nucleic acids could all have been concentrated in the melted ice. Indeed, the concentrations of these substances would have been far higher in such a mixture than in any terrestrial location. According to our point of view all the essential building blocks of life would have been there, without any need for further energizing events. We suspect that the first living organisms (prokaryotes), those that could live anaerobically (without free oxygen), were put together in such cometary situations from preexisting macromolecules.

The best explanation, therefore, of the known facts relating to the origin of life on the earth is that comets brought about the spread of water and other volatiles over the earth's surface. Then, about 4 billion years ago, life also arrived from a comet. By that time, conditions on earth had become sufficiently similar to those on the cometary home for life to persist here. The long evolution of life on the earth could begin.

TALKING TO THE STARS

While space travel would demand the

"I think it's time we told him he's adopted."

technology of a superintellect space communication lies within the compass of present-day human technology. Careful calculations, such as those made in a project studied by NASA Project Cyclops have shown that with radio transmitters and receivers we could build and with aerials no larger than the radio telescope at Bonn West Germany intelligible communication could be established across a distance of 500 light-years.

Either by dropping the requirement of being fully steerable or by stacking an array of many such telescopes we could increase the communication range for the resulting aerial system at least tenfold, to 5000 light-years. With the technical improvements even a very modest superintellect would surely have achieved, communication across the entire galactic system should be readily attainable.

Let us assume that a superintellect is steadily beaming a radio message toward the solar system. Somewhere in the sky and somewhere in the radio band, a great discovery awaits us.

If instead of steerable telescopes fixed telescopes like the big one at Arecibo Puerto Rico, were built, each of them would be equipped with a large bank of detection horns provided with radio amplification. The combined display from many such detection horns would be similar in principle to a photograph taken by an optical telescope.

The radio "photograph" could be made to cover a square in the sky with a side of about two degrees. Ninety such telescopes placed at equal intervals along a line from the North Pole to the South Pole would cover a strip in the sky two degrees wide. As the earth rotated, the strip would sweep across the whole sky. For one part in 180 or two in 360 of each day the message from our hypothetical superintellect would lie within one or another of 90 "photographs" being taken by our telescopes.

Next we must ask what form of "message" we would be likely to recognize. The sequence of digits 3 1 4 1 5 9 2 could not fail to attract our immediate attention since this is the beginning of the famous number π, the ratio of the circumference of a circle to its diameter.

The digits would not necessarily be sent in the above decimal notation, however, because the superintellect would probably not know that we used the decimal system. The best notational choice for our communicator would be the binary scale, in which case the same number would take the form 10111111101111111011000. The digit 1 would be represented by a radio pulse and the digit 0 by the absence of a pulse.

At a reasonable transmission rate of a digit per second, only 22 seconds would be needed to receive this particular series of digits. The source lies within the detection strip established by our radio telescopes 480 seconds per day. If constantly repeated, the number could therefore be received about 20 times every day provided we knew the radio frequency on which to look for it, but this is the problem.

The trouble arises because the transmission must be very finely tuned. Otherwise the signal would be swamped by the general cosmic background of radio waves and by the "noise" generated within our own terrestrial radio receivers. To minimize background interference, the frequency chosen by our communicator would probably lie within a range from a billion Hz up to 30 billion Hz, with a variation of not more than 10 Hz from the chosen frequency.

Finding such a sharply defined frequency by random search would be rather like looking for a needle in a haystack. A random choice of frequency would have only one chance in a thousand million of being right. If we made a new choice of frequency every 22 seconds, thus leaving sufficient time for each choice to recognize the starting digits of π, we could only make about 20 choices per day. Fifty million days would go by before we had a good chance of landing on the right frequency. Nearly 150 000 years of search would be required.

Fortunately the relevant waveband has several precisely determined frequencies that are astronomically significant. An outstandingly important frequency occurs at 1.662 billion Hz, for example. This is a frequency emitted by hydroxyl radical molecules within the interstellar gas clouds. Our communicator would be manifestly unwise to transmit at exactly this frequency, because there would then be competition from the molecules themselves. However a choice not far away from this frequency, or from one of the other several astronomically important frequencies would be very sensible. The 150 000 years of search would then be greatly shortened to a century or two.

Nevertheless, when viewed against the immediate urgency of world events, even a search time of only a century might seem unconscionably long. No government or international organization is going to rush in to set up such a longitudinal chain of big radio telescopes. Nor would it really be sensible to do so. We can well afford to think about the matter for a few more decades before committing ourselves to any particular system. It is generally agreed that a radio system in the frequency band described above would be better than an optical laser, but the fact that the optical laser presents itself for serious discussion at all shows that techniques unthinkable before 1960 will perhaps be used to tackle the problem.

The important thing about space communication systems is to show that they can be achieved. The system described above, for instance, is certainly feasible. It may be cumbersome in comparison with what the future holds, but it demonstrates that if a potential correspondent exists in the galaxy space communication can be

established in a time scale no longer than would in any case be necessary for an interchange of messages

The time scale required for space communication is very much less than the many millions of years needed for space travel through the galaxy. Stay-at-homes will have received excellent television pictures of other creatures and planetary systems long before adventurous space travelers manage to get anywhere. This may be another reason why other beings have never come here. Space communication is so much quicker than space travel.

Some scientists have suggested that space communication could be as devastating as actual physical invasion. Here we are back at the predator-prey relationship but in a new guise. Instead of being consumed physically the prey is now to be overwhelmed intellectually. The game of chess is no game at all when played at a high enough level. It is a means of reducing an opponent to a groveling wreck, which is what Bobby Fischer meant by the remark "The weakie has made a lemon and is busted."

The human species would be a pushover for an intellect even a few centuries ahead of us, let alone millions or billions of years ahead. The fears sometimes expressed are by no means without foundation. Yet there are salutary protections. The long time scale involved in the interchange of messages would permit recovery from intellectual defeat. New generations untainted by previous defeats would be prepared to pit their wits against an outsider.

An intellect millions of years ahead of us would hardly take much pleasure in "busting" us, as Bobby Fischer would hardly have taken much pleasure in "busting" a five-year-old child. The human instinct is to be helpful whenever there is no real challenge. The same is likely to be the case with superior beings.

Where else, one might ask the critic, is there for the human species to go? Nuclear bombs have essentially ruled out serious interhuman competition, even though we have not yet really grasped this fact. The land surface of the earth is now fully explored. The moon has been visited. A few centuries hence space travel will reach its natural limitations. What then? Degeneracy or a determined effort to climb to the first galactic division?

To move from the analogy of chess to English soccer the achievement of space communication would put us in the position of a new club. There would be an enormous way to go before we could hope to climb up among the big boys of the first division.

The choice hardly needs serious discussion. Our long evolutionary experience as the earth's outstanding predator will inevitably force us to make the attempt. It is equally inevitable that the attempt will supply a much needed unifying influence within our species, a unifying influence that has been so sadly lacking throughout recorded history. ◘

LOBOTOMY

CONTINUED FROM PAGE 65

Maybe But a friendly shark is no better than a hungry one A flick of his tail could break my spine A caress from that hide would rip away my suit and half my skin Blood in the water would bring the rest of the pack down on me

I had to get back to the pony I had to find out what was hitting the school If it was a few small sharks I could send the pack to attack If it was more than the pack could handle I might be able to save part of the school by turning it with the pony

Tinkertoy rounded the pony's stern and started up the other side I swam out of the school, trying to reach the lock before he made a complete circuit No good I threw out my arms to stop myself He was soaring over the top, almost as if he d planned this maneuver to trick me out of hiding

"Petey! I've been looking all over for you!"

Erase He just seemed a little excited, that s all I didn t know what he was thinking I swam back into the school and Tinkertoy lost interest again

I felt dizzy Hyperventilation I had to slow down I had to *think*

I couldn t get back to the pony but I could swim *through* the school At least get to the east and check out the situation for myself I had no weapons, but if it was a small shark or a single porpoise— fat chance—I might be able to chase it away

That still left the problem of getting back to the pony But save that for later

If I lost an entire school because I was outside, against regulations, I could get fired Exiled topside for the rest of my life

Forget that Breathe slowly

I couldn t go straight through the school or I'd lose my sense of direction Fish all look alike and sections of the school are always changing orientation, though the school as a whole was heading north

If I swam over the school and there were any wild sharks around, they might be drawn to attack Even a careful diver makes some jerky movements and the closer these are to the surface, the more exciting to sharks

I went under the school gliding like a ray inches from the bottom

Swimming like that gives a diver a dangerous sense of power It's not narcosis Biochemistry has taken care of that But the movement is almost effortless You look down and you see the bottom passing so rapidly you feel jet propelled The light is confusing

The world was small enough to clasp in my arms

I hadn t solved my problem, I was running away from it And not from any sense of duty to the Atlantic Fisheries Corporation My brain was a prisoner in an organism that had returned to its natural element

Cancel that Erase

It wouldn t erase I d been a herder for years using the Voice almost daily If there *was* feedback if the experts were wrong my brain must be riddled with holes Maybe I was as much a puppet as Tinkertoy Who was pulling my strings? The Atlantic Fisheries Corporation? Or something older more primitive?

I remembered what a sculptor said when asked about a piece of his work "Why I just took a block of marble and cut away everything that wasn t lion"

Cancel Cancel Cancel

I was swimming to the east of the school to see if it was being attacked and by what Cut off from my pony I still had an obligation to my employer I was protecting a vital food crop for millions of topsiders

Oh hell That wasn t any better Cancel

I was trying to save my job my life My only opportunity to live where I belonged

Why bother? I didn't care about the topsiders the Atlantic Fisheries Corporation or my job Why not let it all slip away? I didn t *have* to go back to the pony

Swimming was no longer effortless I was moving fast, pushed by adrenalin Thinking like a shark again I didn t even bother to cancel that one

When the school started to thin out I rose just inside the curve of its flank, hoping it would cover me from whatever it was that had disturbed Tinkertoy I could see nothing but the bottom the fish and the blue-green curtain at the edge of my vision

Nothing No sharks No cetaceans

I pushed out of the school and let my body drift north The ocean was calm as if nothing existed but the fish and me suspended in the quiet I decided I was still suffering from the effects of hyperventilation I was seeing spots

Or rather one spot I shook my head and looked straight at it It didn t go away It was a man-shaped thing hanging so deep within the curtain that I could hardly see it But man-shaped No air pack

My breath went in and out, the school drifted away from me I stared at the dark spot in the curtain while the world turned over and crushed something

Maybe after years on the job the Voice riddles a herder's brain with pinholes Maybe we start to see things imagine impossibilities

Humans can t breathe water like fish We can t survive underwater without complicated support systems air packs We have the word of the experts on that That couldn t be a man out there, waving at me No air packs Impossible

Cetaceans used to be land animals too Maybe something has been working on me like that sculptor cutting away everything that isn t—what? I wanted to find out I wanted to believe it was possible

But there was my job The world I knew, the packs and the pony and a fresh air pack every month

The man shaped thing beckoned

I think I'm going to miss Tinkertoy

"Aside from the painting, what else bothers you?"

UFO

CONTINUED FROM PAGE 32

artificial satellites. Astronomers on such projects are not concerned with dim and distant galaxies. They want to find—and track—light in the night sky anywhere in the sky.

Since most UFO sightings occur at night, they should theoretically be visible to full-sky searches. Better yet, such UFOs should have been recorded on the scientists' calibrated photographic film. Here, expert opinion is divided. Some insist that unidentified objects *have been* photographed by such projects, with the results stashed away quietly, or burned. Other pro-UFO specialists argue that UFOs, which tend to be localized and low-level manifestations, could not have been on such photographs in the first place.

Scientists connected with full-sky searches dispute both these points of view and invite their pro-UFO colleagues to examine the photographic file and produce their own hard evidence (a challenge that so far has been declined, since the effort could be extremely expensive and time-consuming). Arguments that UFOs would not show up on astronomical scans are dismissed as after-the-fact rationalizations, since many UFO groups have for years urged the funding of just such sky surveys in an effort to obtain reliable documentation of the UFO phenomenon.

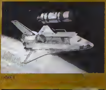
The negative opinion of most astronomers is summarized by noted skywatcher Dr. Carl Sagan. Writing on UFOs for the *Encyclopaedia Americana*, Sagan described a sky survey conducted at the Harvard observatory in the mid-1950s: "These observations by professional astronomers were made in a locale and period characterized by extensive reports of unidentified flying objects. No unexplained objects were detected, despite the fact that rapidly moving objects were being sought in the study of meteors. Similar negative results, obtained by large numbers of astronomers, help to explain the general skepticism of astronomers toward flying saucers."

Dr. J. Allen Hynek disputes this conclusion. Referring to the Moonwatch sky-survey project (with which he was personally affiliated in the late '50s), Hynek claimed in 1973: "I know that during the satellite-tracking mission we picked up a number of things that appeared on the films but were never tracked down. A person who says that the Baker-Nunn cameras never spotted anything is just dead wrong, because I know they did. We just didn't bother about it. It would have been too much work to investigate some strange lights."

But were these strange lights UFOs? If someone *had* bothered to investigate, would the "strange lights" have been explained?

Other astronomers from the same satellite-tracking project dispute Hynek's recollection of mysterious objects 15 years be-

NEXT OMNI



EINSTEIN

TICKET TO SPACE [illegible] d of vacation? [illegible] rocket ship wit[illegible] arth sliding past your window. Then an overnight stay [illegible] and your wife, lover, [illegible] and family—can per[illegible] e privacy of your own room. Science fiction? Pe[illegible] Space expert G. Harry Stine, in the March *Omni*, dates [illegible] rism a mere twenty years down the road. Stine exa[illegible] e needed for space tourism, but the economics as wel[illegible] ence that NASA—or somebody else in the rocket bus[illegible] space by the late 1990s.

EXCLUSIVE INTERVIEW [illegible] RKE—"There's a tremendous amount of traffic going o[illegible] m quite sure that when one vehicle arrives here we[illegible] se is so huge it's hard to believe that there can be so[illegible] From his villa atop a mountain on the island Valhalla of S[illegible] ence fiction writers, Arthur C. Clarke, provides *Omni* wi[illegible] restrials, space colonization, underwater exploration a[illegible] al and real. *Omni* readers will be able to slip into the worl[illegible] perhaps than anyone else, the future.

THE CLONE DOC[illegible] news story of 1978 was science writer David Ro[illegible] n being had actually been cloned. The scientific c[illegible] story a hoax, claiming that the necessary tech[illegible] available. To find out the truth, *Omni* [illegible] Bill Stucke[illegible] medicine man Lardrum Sheitles. [illegible] cording to hi[illegible] easy.

EINSTEIN'S LEGACY [illegible] the 100th anniversary of the birth of Albert Einstein. To[illegible] ent, *Omni* profiles the brilliant physicist who brought us nu[illegible] ack holes, measured the atom, explained [illegible] solar cell, des[illegible] senses, and nearly invented the laser.

THE WORLD'S HARDEST TEST—Designed to measure the top 2 percent of the top 2 percent[illegible] test of intelligence yet devised. That's the [illegible] news. The [illegible] requires no supervision, and you can take [illegible] long with it as[illegible] Langdon Adult Intelligence Test," appears in its entirety in the ne[illegible] your pencils.

DELPHIC POLL RE[illegible] ober *Omni*, we asked our readers to look into their crystal ba[illegible] ur first Delphic Poll. The response was overwhelming, and the tab[illegible] complete. See the results in the next *Omni*.

While reaping wheat fields near Tooligee Hills, Australia, farmer Robert Habner discovered a UFO trace, or crater measuring three meters in diameter. Later analysis of the trace proved inconclusive.

fore. "We never saw anything that couldn't be identified as aircraft," claimed a colleague of Hynek's from Northwestern University. Another scientist went further: "Early in the program there were occasional contrails, film problems, mechanical failures, jarred or loose optics, and other occurrences. But these declined almost to zero as the professionalism of the camera crews grew."

Hynek was mistaken, his colleagues insist, in claiming that these anomalies "were never tracked down." There was in fact an unofficial program "to seek explanation for occasional blips noticed on the Baker-Nunn frames." The professional conclusion was that they were "Eastman objects," or flaws in the film or developing process.

Dr. Frederick Whipple, former director of the Smithsonian Astrophysical Laboratory (SAO) and Hynek's boss on the Moonwatch project, also flatly disputes Hynek's claims of UFOs on the Baker-Nunn camera exposures. Wrote Whipple: "The files and photographs of the SAO programs for satellites and meteors are and have been completely available anytime for an investigation of Dr. Hynek's imagined hidden UFOs. He of course has known this all these years. The reason that he has done nothing about it is obvious. He knows that he would find nothing."

Dr. Whipple's interpretation of Hynek's motives may appear harsh. There are, after all, literally square kilometers of film in the Smithsonian vaults, and a comprehensive search and evaluation could take thousands of man-hours. UFO researchers have to date been unable to afford this effort; despite the promise of scientifically documented UFO evidence, Full-sky search photographs are still waiting and, perhaps as yet unrecognized by the skeptical world, may reveal crucial evidence for the reality of unidentified flying objects.

Or perhaps not. UFO theorist Jacques Vallee claims to have pointed out a problem: "Many astronomers must have known what I knew from my days at the Paris observatory, namely that we were tracking unidentified objects and even photographing them. There were films too." And what happened to all this UFO evidence? French scientists allegedly destroyed it all, in Vallee's estimation, out of fear of the unknown.

But perhaps UFO buffs would believe the assurances of another astronomer who had served on the satellite-survey project. In 1959 he was asked about any flying saucers that the Smithsonian Astrophysical Observatory might have picked up on their Baker-Nunn cameras, and he dismissed that idea as nonsense. "I can quite safely say that we have no record of ever receiving from our Moonwatch teams any reports of sightings of unidentified objects which had any characteristics different from those of an orbiting satellite, a slow meteor, or of a suspected plane mistaken for a satellite."

That astronomer's name was Dr. J. Allen Hynek. The statement appeared in a section of Edward Ruppelt's book *The Report on Unidentified Flying Objects* (Doubleday, 1959), which was later dropped from reprints because of its skeptical conclusions. Hynek's statement was rescued from oblivion by St. Louis UFO researcher David Schroth, who found the change in Hynek's opinion over the years quite puzzling.

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A tenet of faith among UFO buffs is that the government is holding secret files, perhaps even conducting a secret study project regarding UFOs. Despite numerous government denials, many buffs are insistent that Uncle Sam knows something they don't, particularly in light of recent lurid allegations concerning federal secrets and cover-ups. Perhaps there really could be important files with secret UFO information stashed away somewhere.

Others caution that even if such information may have been classified, lost, or destroyed by the government, there still is no reason to suppose that any unique or conclusive data have been kept from civilian UFO researchers. "An example of how data can become innocently unavailable is the current state of the Blue Book files. They have been so badly scrambled by years of research visits, without necessary refiling and sequencing, that a large portion of the folders are hopelessly lost somewhere among the hundreds of boxes of documents—and no one knows how to find them."

Under statutes of the Freedom of Information Act, UFO specialists have been attempting to extract UFO-related documents from the CIA, the air force and navy, the FBI, the State Department, and other agencies. Representatives of the Phoenix-based "Ground Saucer Watch" UFO group filed legal suits last year to seek out such documents; their inquiries have been taken over by another group, founded for the specific purpose of declassifying government UFO material. This group is "Citizens Against UFO Secrecy" (CAUS), based in New York.

The main goal of CAUS investigators is to uncover anything the government may not have told the public about UFO activities and to determine whether the government is continuing UFO research a decade after the air force's Project Blue Book was terminated (and the government publicly washed its hands of the whole UFO question).

So far much of this hitherto secret information is intriguing but not spectacular or earthshaking. No "smoking gun" (or "stashed saucer") has been found. Top officials in government appear to have been as baffled by the UFO phenomenon as anyone else, all the while issuing bland assurances to the public that the situation was well in hand. Internally, however, government attitudes ranged from naive credulity to paranoid suspicion to knee-jerk hostility. The government was evidently working with no better data than that possessed by the general public.

Even today, according to CAUS Director W. Todd Zechel, reports of unidentified aerial activity from government sensors and from foreign sources continue to be routinely distributed among numerous government agencies. Zechel also admitted that there is so far no evidence of ongoing investigations regarding civilian UFO sightings, or any evidence of the existence today of a special office devoted exclusively to UFOs.

Instead, realizing that most UFO incidents do have prosaic explanations and that many of these explanations are definitely of interest to specific government agencies (unidentified aircraft, as an example, would be pertinent to the missions of the air force, the FBI, and possibly the Drug Enforcement Administration), the reports appear to be routinely circulated to a standard mailing list just in case any particular agency might find something of unique interest

Zechel who has recently become a leading figure in UFO research because of his role in these Freedom of Information suits has been pleased with the results so far even though at least another thousand pages of data are still being cleared for release "The government said it had no further secret UFO files, and that it was no longer interested in UFOs What we ve dug up so far contradicts these assertions says Zechel

The question remains Despite what these secret UFO files reveal about the government s eagerness to classify its own confusion what do they contribute to the understanding of the UFO phenomenon itself? Thousands of cases are already on public record finding a few more will not really help (and indeed many of the secret government files may actually concern legitimately classified military operations which led to some public UFO flaps)

UFO experts realize that there is as yet no hard government evidence that could substantially revise the publicly available body of UFO data Still, if only to satisfy curiosity and nagging doubts the CAUS efforts appear useful Helpful information whose utility might not have been recognized in the narrow considerations that led to its classification may still be found A more accurate, if less flattering, image of government-sponsored UFO research may also emerge And one more open question in the still-baffling UFO phenomenon may be answered

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Another key issue in the question of "government UFO secrets" is the threat of federal prosecution to those who disclose UFO data Although UFO buffs refer ominously to a number of tough-sounding government regulations in actual fact there is no record of any individual s ever having been prosecuted for talking about UFO sightings Still many people who claim privately to have "startling UFO stories" will not allow their names to be used or will assure UFO researchers that they know a lot more but cannot tell

UFO investigators are generally skeptical of such claims Some of these stories when checked out for corroboration prove to be frauds or honest memory mistakes The stories as a body are generally contradictory and are often third- or fourth-hand

An aspect of this issue also deals with the question of whether all UFO reports sent to the air force actually ended up in the Blue Book files (files that have been available to researchers for years with names of most witnesses deleted to conform to federal privacy laws) Some UFO researchers have collected a series of cases that were officially reported in the '50s but never seem to have made the Blue Book registry

One such story is told by former astronaut Gordon Cooper While at Edwards AFB in the mid '50s Cooper relates, he led a team of observers who photographed a landed UFO in the desert Their films were sent to Washington for study and mysteriously vanished

Skeptics point out that there could be entirely reasonable (and nonextraterrestrial) explanations for such disappearances of data The government knew exactly what the sightings were about Far from describing alien spaceships these theories suggest the UFO reports were based on misperceptions of legitimately classified top-secret military maneuvers or aircraft tests

To resolve this ambiguity UFO researchers last year called on President Carter to fulfill his campaign pledge of full disclosure of government UFO files by issuing an executive order waiving any federal prosecution of citizens who claim to have UFO information but are afraid to publicly disclose it Such a presidential "pardon" of would-be UFO witnesses could go a long way toward opening up new sources of data observers believe

As of early 1979 there had been no reply from the White House

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Although some groups notably Ground Saucer Watch and Citizens Against UFO Secrecy, have been attempting to extract UFO documents from the U S government for publication they too have been criticized for keeping documents to themselves that do not support conspiratorial theories of government UFO cover-ups In other words some UFO groups themselves may be guilty of covering up hitherto unreleased information

In a news release issued last October top UFO skeptic Philip J Klass blasted CAUS for selective release of material obtained from their Freedom of Information suits CAUS s director wrote Klass was guilty of withholding crucial information from other UFO groups when he continued to insist that he had evidence of a "crashed saucer" which the government had allegedly hidden away in 1948 In fact Klass continued CIA documents declassified in April 1977 and in the possession of CAUS officials show that no such incident was known to top officials of the U S government as of January 1953 In other words CAUS allegedly had documents contradicting its public statements but didn t inform other researchers or the public at large

Todd Zechel speaking for CAUS rejected Klass s allegations We are not committed to any preconceived ideas about what is in these files he said in an interview a few months ago "If the documents convince us that there is no crashed saucer we ll say so"

And so the controversy continues The crashed saucer has not yet been shot down and thus still flies high in the hearts of UFO enthusiasts everywhere

MACHINE

CONTINUED FROM PAGE 94

each bend She paddled around the course in just over seven minutes

Three more stalwarts made their runs The converted garden tractor managed to convert a patch of ice into hot water half way down and did not finish My money was on a twin-tread rig until its driver saw the short straight beyond Turn Two and tromped on it The thing did a tread-stand just long enough to barf him out, crashed down, ruptured an oil line that made weewee under one tread, and hi-hoed away overland as a free and driverless spirit until it bisected a chickenhouse a kilometer away

The guy on skis sporting five little bitty model engines with propellers on each ski was protested but he tried anyhow In deference to Sam the printed rules slated, The sky's the limit—prophetically—and the sitzmark artist was judged within his rights He made his mark, all right just past Turn Four

During all this, Sam completed tech inspection and only once was seen actually driving his special He had to fire it up for his braking test and by the time the crowd leaped around to see what the ruckus was it was over The great thing accelerated for 60 meters on a thimbleful of fuel, with the wail of a lost soul in a sausage grinder then reversed power in a geyser of snow But it stopped like a Christmas tachymeter

Sam suggested that the course be walked again, to be sure it was still open Very few people could testify one way or the other He also asked if he could make the tour afoot, and some fool said he could After all Sam wasn t competing for a trophy His was to be a demonstration run like a dragster at the soapbox derby One more advantage wouldn t matter So we thought

Sam spent a few minutes dallying with a black box that evidently plugged into his special Finally content he ambled up the gentle back slope of the hill, carrying the little box I followed at a distance

Striding away from the start line Sam pushed something on the box and tucked it under his arm I watched him pace down the course absently positioning himself for a fast approach to the first turn, and then I got involved with the *Bugle* reporter

The scribbler is the sort who sniffs a story with gore potential from any distance and will end up manufacturing most of the story if he feels like it "I got a list of entrants" he mused "but durn if I recognize anybody important"

"You might as well go home" I urged "This is just a local fun-type event no big prizes"

"Yeah? He gloomed after Sam jerked his head in Sam's direction Who's the tough old curmudgeon walking down The Last Mile?

I told him about the former rocket man Pause Waitaminnit Don't I know that name from someplace?

I was casual Possibly Indy Atlanta 500 Le Mans—but Sam doesn t crave publicity these days

"He s public property" the pencil pusher snorted "But he musta turned chicken in his old age, he s registered as the owner of that Rube Goldberg waterwheel but the driver s some lunatic named Botts"

While I fought myself to keep from feeding this guy a few knuckles a nagging doubt clung to me Why *wasn't* Sam driving? Had he finally lost his nerve on a measly small-time event?

The reporter wheedled more information He had faucet charm and turned it on and off as it suited him "You a good ol friend of good ol Sam?"

"That pleasure is mine," I said

"Maybe you can gimme some details on his, uh, whatchamacallit The *Bugle* prides itself on accuracy" His look dared me to

When physicists learn to chrome plate the equator, or any other imaginary line, the same will be able to put chrome on a roll center, which is also an imaginary line My twinge of guilt evaporated

disbelieve it.

"Sure Kinda hard fo know where to start," I hedged wondering if I could get away with wild inaccuracies I invented quickly "You could mention the desmodromic valves" I began

"I intended to Uh. how d you spell it?"

"Like the inventor, I lied warming to the game "Herr Desmond Droemik" I spelled it out "And you'll notice the hydrodynamic spoilers"

He was writing like mad "Come again?"

"To spoil the hydrodynamics" I frowned with a wisp of scorn "And the outer-space frame, obviously With unlimited-slip differential and and a chromed roll center"

When physicists learn to chrome plate the equator or any other imaginary line then Sam will be able to put chrome on a roll center which is also an imaginary line My twinge of guilt evaporated in a warm rush of fresh fantasy And of course it has computer-designed steering" I concluded reaching wildly enough to grasp a great truth by the tail But how could I know? I shrugged "Otherwise, Sam s rig is pretty ordinary"

He cranked his spigot on for me "Hey, you were lotsa help fella Maybe I could mention your name Immortality in print!"

Gaston Martin I perjured and shook his hand Then I sloped off down the hill, whistling an innocent medley

Sam had finished his trek before I reached bottom and was fiddling with something under his tarp The word was spreading that Sam had lost his nerve Nobody could locate Botts his driver Sam drove up the hill by the easy back way and parked near the start line The start official was in brief conversation with him, and we watched them wrestle a ramp from the pickup to the ice Presently, the last serious entrant made his run it was a conventional go-cart and expired conventionally in a deep snowdrift By the time the driver was exhumed from his own personal avalanche Sam had his vehicle fueled and waiting at the start line Sure enough Sam wasn t driving

A chubby stranger in a sleek black coverall was strapped in place, inhumanly calm under the circumstances During his last-minute checks, Sam was in a lively dialogue with the official I was heartbroken that Sam could accept another driver in his place and through my misting eyes it seemed that Sam and the official were actually arguing I heard the muted buzz around me everybody had a theory because nobody knew anything

The PA system crackled THE SAM-BOTT SPECIAL it boomed, DRIVER R O BOTTS Then like everybody else it fell silent

High above us the tiny figure of Sam made an adjustment at his power unit A spurt of steam billowed like an omen in the frosty air A moment later its harsh tooth-loosening wail reached us and Sam was fooling around near the steering I could swear the little black box was nestled there

Sam knelt clear of the great machine intent on the steering The official stamping and yelling with hands over his ears, slipped on the ice and caught himself on the controls And engaged the drive gear and was flung into Sam and Botts didn t bother to hit the reverse As a matter of cold fact Botts had no brakes

In an instant, Sam was on his feet, running after the special, an exercise in pure loserism The machine keened its air-raid siren song, the big wheel churning down the slope a roostertail of snow lofting up up and away behind The gasp from the crowd must ve lowered ambient air pressure by five pounds we all expected a god-awful smash at Turn One

But the special simply laid over at an angle and disappeared around the bend When it reappeared near Turn Three a cheer went up and Sam went down having blindly run through the roostertail into banked snow Next came a twisty uphill stretch, and judging by the noise, the turbine was revving harder than ever Sam abandoned his direct chase and half clambered half-fell straight down the embankment It was a maneuver that would bring him to the course just past the last turn, before the timer at the finish line. I wondered if he intended to trip the damned thing, intimidate Botts, or signal him—assuming they both survived that long.

The special was surviving, but only by inches. Turn Six was a fiendish right-hander of decreasing radius, bounded by the bluff on the outside and thin air on the inside. Botts would *have* to shut down his power long before he reached it, but Botts was not shutting down at all. Before our bulging eyes the machine angled toward the outside and, running flat-out, swept up the side of the bluff that followed the curve of the course. Like a trick cyclist at a carnival, Botts and the machine shrieked around the curving wall while absolutely horizontal, then shot out of the curve onto the course again.

Still accelerating.

The scream of the turbine grew nearer, higher-pitched, impossibly abrasive on the ears. Sam scrambled to his feet just as the special slued around the last turn. Now there was nothing ahead of it but a straight path and a gaggle of timing people flanking the finish line. This group got one glimpse of the thundering wheel, saw it gaining speed and trailing a seven-story roostertail of snow, and abandoned ship like cats on polished linoleum. All, that is, except for the girl at the timer who had earmuffs on and wasn't looking and will always describe the passage of Sam's special as the Sudden Blizzard of Seventy-Nine.

Sam had his windbreaker off as the thing howled past him, and in one deft swoop he threw it into the blur of the great wheel. It was, he told me later, his only hope of jamming something because there was lots more fuel to be burned and he did not own an antitank gun.

The wadded cloth was effective in its way. For an instant the wheel skipped a beat, digested the offering, then belched shreds of nylon in all directions. Something, probably a sleeve, caught in a cleat and started to beat Botts rhythmically. The special accelerated down the straight at something over 160 kilometers an hour. Sam wiped slush from his eyes and watched, now helpless. The pounding was too much for Botts and suddenly the driver was ejected.

The Botts trajectory was simply unbelievable if you didn't know what you were watching. From the driving position of a praying Moslem, Botts rose majestically toward heaven and began to pirouette in the air to one side. Tiring of this, Botts jerked, seemed to shrug, then fell in a series of falling leaf aerobatics before hitting flat in the snow. Flatter than we knew.

The special was bumping hard now. Every bump caused a higher bounce, and as it headed toward our parked cars the wheel steadied a few inches above the surface. Then the errant sleeve sailed away carrying the cleat with it, and the big machine arrowed upward. It was airborne, and more so every second. The course physician sprinted after Botts, aspirin jouncing from his open bag.

The rest of us gaped at the special darting and swooping above us in a pattern that seemed vaguely familiar. Half a minute later it rocketed away again, still higher, and began the same routine. It was then that Sam reached us.

The doctor returned flinty-eyed, holding up a rubber suit. "Where'd you hide the body?" he accused.

Sam nodded at the suit. "That's him. I just took an old scuba suit, sealed it, stuck a helmet on it, and pumped it up. I'll give it two hot patches and call you in the morning."

"You can't run a race without a driver," someone said.

"That's what the start official kept hollering," Sam responded, "and I kept explaining that my driver was really in the programming box." He squinted toward the sky. "But I wasn't finished programming it when the idiot hit the controls. The box was

But the special simply laid over at an angle and disappeared around the bend. When it reappeared near Turn Three, a cheer went up and Sam went down . . . through the roostertail into banked snow.

set to go where I had taken it before, but I didn't get a chance to program a stop."

The facts interlocked in my head. "Sam! Your driver was a robot?"

"Welcome to the machine age," Sam said drily. "I didn't figure on my driver springing a leak, though; thought I had ol' Botts strapped in pretty well."

The reporter huffed up, looking grimly pleased. "What about that—that thing up there?" He pointed on high, where a contrail of steam followed a flashing silver streak. At that height it sounded like a sex-crazed mosquito. "Who's to say that iron windmill won't chew up a satellite or something?"

"I am," Sam said quietly. "I knew there'd be a low-pressure area over the wheel, but that piece of nylon created a higher differential when it bent the cleats. More lift. Now the special will go as high as thin air will let it, and then it'll run out of peroxide. And it'll keep running the same damn course I programmed until then—only skewed upwards."

The doctor, a nice guy but a bit out of his element, now shambled off, dragging the punctured scuba suit and muttering about an autopsy with Cousteau. A group of rescuers dug out the girl at the finish line. She was still at her post and only a little stunned under her mound of powder-snow. She swore that Sam's machine had clocked the course in 27 seconds, roughly a 112-kilometer-an-hour average. That figured.

The reporter, still trying to promote fireworks, drew a crowd with the old citizen's arrest gambit. "You stand accused of reckless driving," he began.

"Only I wasn't driving," Sam reminded him.

"Unauthorized flying of unlicensed aircraft," he ployed. God knows, that much was true.

"If you can prove it," Sam murmured, glancing up.

"I'll impound it when it comes down. Ah, it *will* come down." It was a statement, but it was a question too.

"How very right you are," Sam said, glancing at his chronometer. "And it should be out of fuel shortly."

"Good." The reporter folded his arms, Fletcher Christian on the *Bounty's* deck, and glared into the sky. "And you should be jailed for improper construction. I know a few things, mister."

"Front page news," Sam replied. "Name one."

"You can embrittle something if you don't put the chrome on right. I read it somewhere. Right?"

Sam chewed an ebony cuticle reflectively. "It happens," he conceded.

"I thought so," snarled the reporter. "And you went and embrittled your roll center!"

Sam blinked, shook his head as if to clear it. I drew him aside and whispered how I'd had some sport with the *Bugle*boy, who didn't know an imaginary reference line from a breadline. Sam tried to hide the smile that was growing as he listened.

Then he called to the reporter. "You were right. Guess you'll have to write me up for that." Course workers stopped to listen. "And one other thing: the special is your impounded property, but barring wind drift I'd say you have a problem." Sam headed for his pickup truck, cheerily shouting, "When it comes down, it will be doing roughly Mach two. Your problem is not being anywhere near *where* it hits *when* it hits." He made a quick one-fingered obeisance from his pickup. "Wear it in good health."

The quarry was innocent of human life in two minutes flat.

Sam never recovered the special, though we found a new sinkhole near the quarry later. It was too cold to dig, and anyway Sam and I were too busy. The *Bugle's* coverage was everything we'd hoped, and the writer of the best sarcastic letter to the editor won a place on Sam's pit crew. True to his resolve against serious competition, Sam was preparing his old Nash Metropolitan for that race where—but everybody's heard about that. ꝏ

INTERVIEW

CONTINUED FROM PAGE 99

plants and pets. Pets are not just child surrogates, you know.

Omni: No, I quite agree. I feel very struck by that idea, in fact.

Wilson: Yes. And I think that all these things we've been talking about—sports, sexual bonding, biophilia, the things that occupy our existence and make us uniquely human—ultimately have a pragmatic basis. That's the whole point of my book, that human beings are unique. Their behavior is much more narrowly circumscribed than most people realize. But when you start comparing us with other kinds of animal societies, you realize we are really peculiar, and that these peculiarities are based to a large extent on early pragmatic adaptations. Those adaptations are not the simple-minded gene-to-behavior pattern that some people think I mean. That would be true in the case of an ant or a mosquito; but for us, they are the learning rules, the predispositions to learn one thing as opposed to another: to seek immediate and large rewards from doing one thing instead of the other. In other words, we are much more predisposed to learn to play soccer, or to watch soccer than we are to, shall we say, cumulate prime numbers.

Omni: Well, the emotional reward might be the immediate reason why we do something, but you're saying there's an underlying functional reason *which gave rise* to the emotion that promotes the behavior.

Wilson: And which doesn't come completely clear unless you consider that valuation in the genetic coinage, particularly in early human history. This is kind of a crazy thing, but it really is at the root of the absurdity of human existence.

Omni: Let's not get too existential! But while we're on the subject, just as another example of this, one of the things that's likely to provoke the most discussion and most controversy around the new book is what you say about religion. You make a case for the genetic origins of religion, including why it has been maintained and what its future is.

Wilson: That's possibly the most original chapter in the book.

Omni: I found it original and striking. It may end up overshadowing what you say about sex as far as public discussion is concerned.

Wilson: I think you're right. There's a rule about dinner conversation: that you don't discuss sex or religion, and, I might add, aggression.

Omni: The biological origins of both sex and aggression are subjects that have now been discussed an awful lot in the last ten years or so, but a biological origin of religion really has not.

Wilson: I agree with you and think you've put your finger on something very important. I have tussled with people critics and others in endless reviews and seminars and so on on sex and aggression. I really think I understand virtually all the concerns that people have about these: the people who think that talking about aggression as a natural predisposition is dangerous or the ultrafeminists who think that talking about any difference in biological predisposition is sinful.

But in the case of religion there is a yawning pit. Religion's really the pivot of *all* that we do and *all* that we really fight about, particularly when you incorporate ideology into it, the propensity people have to identify with a particular ideology, with a world view which becomes absolute in their minds. In my view such identification is tribalistic, so I have looked at it that way.

Religion has not been examined by biologists or sociobiologists or evolutionists at all carefully. One of the main reasons is that it's so uniquely human. This is one subject, one area of behavior where you *can't* draw any principles from ants or baboons. But that doesn't lower the value of taking a more biological approach to religion. One can look through all the animal kingdom and plant kingdom and see case after case of unique structures or unique behavior patterns that have developed. They make sense only when you study the particular biology of that species.

❝The greatest scientists have always looked on scientific materialism as a kind of religion ... as a mythology. They are impelled by a great desire to celebrate mystery, to open it up, to read the stars, to find deeper meaning❞

Along with our productive, semantic language, I think religion is the unique human trait, *sui generis*. It has to be studied on its own terms, but it has to be looked at as a biological phenomenon, not just a cultural phenomenon, nor as an aberration, nor, as some would like to have it, the conduit for divine guidance to man.

So with that proposition in mind, I then explored in that chapter an interesting hypothesis: that religion is essentially an extension of tribalism and of the need for human beings to be able to subordinate themselves, at least temporarily, to concerted, irrational, and even frenzied group activity.

This view has forerunners in some of the anthropological studies of religion, where the students of the subject, like Anthony Wallace and even going back all the way to Durkheim, have looked for functional explanations of religion: the group-activity hypothesis is *one* of the primary functions they see in it. There are also other explanations, such as the psychoanalytic one, which is, to me, just an intermediate-function explanation, like looking for why we eat in terms of metabolism and digestive enzymes. Sure, those are important, and I'm sure psychoanalytic explanations are important for understanding the full range of religious behavior, but we are interested in the ultimate understanding—where did it come from and why is it so powerful? What the chapter attempts to do is to examine the main features of religious behavior, from magic to witchcraft to ritual to mythology in light of the hypothesis that among our learning predispositions are almost certainly strong predispositions to xenophobia, to attention to charismatic leadership, to subordination, to group sacralization, to the ability to regard a covenant and a set of dogmas and rituals as beyond question. These may be unique human behavioral properties that have to be studied on their own, but genetic predispositions nonetheless. I'm thinking of the ability to go through an epiphany toward religious conversion. Or the powerful tendency to identify with a religious group you think has the absolute truth, especially embodied by the utterances of a principal leader in it.

I think these capabilities can be related back to the behavior in prehistory of human beings who were required to develop a covenant, a social contract, such that they followed certain rules absolutely even though many of the rules were arbitrary. They had the ability to subordinate themselves temporarily to the unity of the group they belonged to for the welfare of the tribe. And this, of course, redounded to their own ultimate genetic welfare.

In many cases you can see the evidence of benefits to the votaries, but even that isn't necessary as long as the family, the genetic allies within the tribe, are being benefited in the long term through the devotion of the votary. That's kind of a stark, and perhaps to some people even an unpleasant, way of viewing religion. Yet I find it fascinating. To me, it explains an enormous amount about religious belief, the phenomenon of the true believer, the ease with which people use ideologies for tribalism and for self-seeking, and the capacity, the endless capacity human beings have for hypocrisy and self-deception when they give a religious reason for selfish or group-centered behavior.

Omni: Assuming that's the reason for the origin of religious practices, do those reasons still apply? What's the future?

Wilson: I was just reading Anthony Wallace's book *Religion: An Anthropological View* last night. He addressed exactly the same question. In 1966, when it was written, he came up with that very unsatisfactory answer that others, going back to Auguste Comte, had come up with, namely, that we need a secularized religion. We have to recognize the power of religion, but we need to have ritual without God. That, to me is very unsatisfactory We need a real myth The one I adopted is scientific materialism as a mythology and whatever we can make of it. You must realize that most scientists think about the world about as much as bank clerks do They get pleasure from working on neutrinos or polyglycosides, but as far as the rest of the world is concerned, they have very little knowledge and very little interest Most scientists think of science as being a kind of purifying intellectual machinery that leads to honesty to the withering away of ignorance and wrong ideas, including, providing they are of the atheistic persuasion, those of religion They see the scientific method as a mechanism for getting at certain kinds of truth

But the greatest scientists have always looked on scientific materialism as a kind of religion, as a mythology They are impelled by a great desire to explore mystery to celebrate mystery in the universe, to open it up, to read the stars, to find the deeper meaning Many of them have found total philosophical satisfaction in this conception, particularly when it can be harnessed to humanism, to the viewing of the human species as central

What I've done in this book is to simply make all this much more explicit That is I've said the religious impulse is a uniquely human impulse, but it is biological nonetheless But the religious faith, in the hundred thousand forms it has taken, is almost always linked to imaginary scenarios and false mythology false stories It's a part of the predisposition to make *complete* stories about the universe and about the tribe But they are almost always false, they are arguments of convenience to achieve another ultimate purpose Science tends to wipe them out, one after the other Whenever science comes into contact with these more traditional mythologies they are destroyed, but science itself has not been the appropriate substitute for the mythologies it's been destroying It is not true that scientific methodology the scientific viewpoint the desire to be discovering truth, is a sufficient substitute, because the thing it is supposed to be substituting for is one of the most powerful forces in the human mind, this tribalistic, myth-producing force We have to recognize that the most dedicated and inspired of all scientists have been the people who are entertaining, explicitly or implicitly a mythology of their own, a belief that the world is thus and so, and that there are unchanging laws, and that they are exploring them

The trick is to capture religious energies This is where I think the natural sciences and the humanities will really come together at last We can t abolish those energies They are overpowering, they are magnificent; they are the source of many wondrous parts of our own culture, they can t be abolished But they can be captured, and science itself can be transformed in its intention and in its philosophy by recognizing that it can serve this function But how far can it go?

Omni: Give me an example of how you think one might do science differently to make it more mythical

Wilson: Well, I wouldn t do science differently I would simply be more explicit about the employment of the scientific method in exploring the labyrinths of the human mind and in providing additional explanations and new depth and understanding to subjects that have hitherto been the provinces of the humanities

Omni: One of the arguments you make in the book is that the "big bang" cosmology theory is really a lot more interesting and exciting than any biblical or other religious theory of the origin of the universe

Wilson: There are a lot of those things You know the way a cell is put together is more intricate and wondrous than any preliterate or early religious conception of what life is all about I felt that science should be addressing these more humanistic subjects

"Biology has not been explored properly in the case of homosexuality. One great deficit of the social sciences is that they simply do not know how to explore these hypotheses, or at least they haven't up to now"

directly—or shall we say in order not to seem imperialistic, that humanistic scholars and social scientists should be utilizing the natural sciences more fully and efficiently to account for the phenomena they are most interested in

Omni: Yet you predict a long and happy future for traditional forms of religion

Wilson: Not theology but for religion I did that because I am not at all certain that the emotional rewards from scientific materialism would be sufficient for most people I don't envision the ritualization of scientific materialism or science What I envision is a secular development where the drive for knowledge and the enrichment of the humanities by the natural sciences, and of the natural sciences by the humanities, can become a much more compelling and exciting endeavor This is the great challenge for scholars and for writers But I just don't see this as being formalized or ritualized in any way that would be as completely emotionally satisfying as the traditional religions I foresee many people maintaining, as an emotional refuge, belief in God and ties with formal religion because the final readout of Deism is something that scientific materialism cannot, at least as I see it, touch, the belief in the original, creative God

Omni: Even a "big bang" needs somebody to light the fire?

Wilson: You might go further than that You might want to argue in the way of process theology and think of a more personal God who has actually set the clockwork going with the whole thing developing toward an ultimate expression of some transcendental mind set or goal

Omni: For me the ritual is by far the most appealing part of religion The ritual and the *rites de passage* ceremonies, which I think are terribly important and which culturally we just don t have any substitutes for

Wilson: I think those things will endure, even though there will be increasing uncertainty in cold, rational moments, about the explicit claims that these rituals make about the nature of God and the nature of a particular church

Omni: At one point I think you argue that Marxism is likely to fail because its biological base was not explored—which presumably you would not argue *vis-à-vis* Roman Catholicism Maybe you can make that distinction?

Wilson: Yes I think that the secular ideologies like Marxism are more vulnerable than the traditional religions because the traditional religions depend upon a transcendental explanation of human existence, whereas Marxism in particular which is now the all-encompassing secular ideology, depends upon historicism and materialism and is meant to be a scientific explanation of human history

Omni: You say it's sociobiology without the biology

Wilson: Yes well that's what I meant It was trying to explain the way societies are and the way they are going in entirely materialist ways But it increasingly has neglected the substructure of biology, to its own peril

Omni: One of the things that really struck me about this book was the way it proceeds from some ideas you have expressed before to become more and more sweeping And in that last chapter, which you nicely entitle "Hope," you talk about these ideas you have just talked about and then you also talk as if sociobiology will eventually lead us to reliable laws of history

Wilson: That is, of course, my most extended speculation That is to say I wanted to toy with the idea and—

Omni: I don't think you really explore it much

Wilson: No I wanted to toy with it and then leave it at that because I knew the intense interest that humanists and others have about prediction of history

You know sociobiology is not an easy subject to understand, and so it's perhaps not surprising that a full and sensible discussion of it has not, in spite of articles like the one in *Time*, entered into the public domain It takes a little bit of thinking and learning about genetics and what the evolutionary process is before you can really start applying ideas like these systematically Most people are much more prone to respond with gut feelings about it They say, "Oh, sociobiology says we're programmed by instinct to do that and do this, but I know I'm not that way, I'm a human being with free choice" But, of course, that's a completely erroneous way of talking about it

Omni You have an extensive discussion in the book about your definitions of free will and determinism

Wilson Three chapters, yes I worked a lot on that I didn't want to get into that philosophical discussion but was forced to because of the sort of criticism that has been mounted against sociobiology It goes right to the heart of free will and determinism. But even people who are favorably inclined really haven't thought it through either They don't really understand what's being said I'm hoping that subjects like homosexuality and religion, and maybe altruism, which are the gut issues that people worry a lot about, will cause them to think more about the basic ideas

Omni One thing growing out of your discussion of religion but which you've also talked about in other places, is your belief that ethics has to be biologized

Wilson Yes I have a go at what I think might be cardinal values I didn't want to go too far with that because you start getting on very slippery ground but I did want to discuss some primary values that I thought we might arrive at right now My point in taking on what I call the cardinal values in the last chapter was to show, by taking perhaps the safest and hardest cases, that biological knowledge really will help us arrive at a firmly based moral code

One of the values is diversity that's one of the most controversial If you take an elitist's or extreme eugenicist's point of view, what we should be doing is looking for the ideal human type If the whole world could be made up of that type of person then we'd be far more intelligent and far more moral far better off That would be the eugenicist's ideal

What I am suggesting, however, is that modern biology seems pretty strongly to indicate that we ought to want to go, at least temporarily in the *opposite* direction, that is, that we ought to want to preserve genetic diversity The reason for that is that the very process of sexual reproduction tears down and rebuilds genotypes each generation We are being torn apart and reassembled in such a terrific and unpredictable manner with each generation that it would be extremely dangerous to narrow the genetic basis for humanity as a whole If we had some great world congress of politicians scientists, philosophers, and so on, it is very likely that we would arrive at the position I am suggesting namely that for the time being we would want to preserve genetic diversity and even cherish it until such time as we can come to a better understanding of human heredity Then we might talk about eugenics, but that will not be within our generation

Omni Yes, but what you're saying is that even diversity might not necessarily be anything like a permanent value that ultimately our state of knowledge might be such that we might want to practice eugenics It's exactly the sort of statement which leads your critics to charge that you are serving conservative racist interests When you imply that in the 23rd century, or even in the 28th century, we may know enough genetics to practice eugenics, that's going to offend a lot of people

Wilson Yes That's not saying that I believe we should that our great-grand-to-the-eighth-power descendants should do that I'm just stating what may well be a fact, which is that our knowledge may be sufficient then to make that choice We won't make it not in our lifetime But it's there to be made And I think it's worth saying, or worth extrapolating, just as a part of our understanding of what we are If you refuse to think about it, then I think you are closing your mind to an important part of what the human species really is

You know that reaction does occur from the most extreme of the critics And they make the same argument about recombinant DNA That may be the reason they want to close off debate Their ace card always seems to be that if we let people go ahead with their research or we let them go ahead with a discussion of these subjects, then the next thing you know they're going to be redesigning the human species controlling humanity through genetics That seems to be the real fear in the back of their minds

Omni I think that fear is also central to the recombinant DNA argument

Wilson Yes They weren't really worried so much about monsters or runaway viruses, although they had that in mind as they were about one more step toward genetic control of the human species So one has to put them at ease by simply saying that we have to think these things through We're not talking about anything that *could* be done for generations And even then it will be done I hope, by free choice, by an electorate with careful thought and preparation I closed my last chapter by saying I think it's very likely there's something in our nature which will make us decide we'll never change even though we're lumbering along on a jerry-built Pleistocene vehicle

I think the scientists themselves need to be more explicit in addressing what they are doing to the effects it will have on human emotion I don't know whether you noticed it but I did try to tie those things together throughout the book To the best of my ability I made allusions to literature, I have used quotes from Yeats and Joyce and so forth I was saying, in effect, that science now addresses the sources of human nature and *that's* where the two cultures come together Science and the humanities can enormously enrich each other

"At last! Now we can make educated guesses"

FORUM

CONTINUED FROM PAGE 14

send out will be few and far between, last ing as they do for very short time spans

However an alien race as little evolved as ours sends out a continuous, if weak, signal consisting of tv radio and various other methods of broadcasting from which any race would be sure to learn

Already our signal has gone out to stars that will be receiving noises from our distant past, highlighting us as a beacon to any relatively advanced civilization with reflectors large enough to collect the weak signal

This is the area we should be exploring—not the wavelength least used but the one easiest to use Normal wavelengths of communication are where the first contact will come—not in short sharp binary bleeps but in a continuous stream of science art and poetry from civilizations light-years away broadcasting perhaps to each other but more likely to themselves

Tim Caves
Wheathamptonstead
England

Fish Map Alternative

James Oberg cites four interpretations of the Betty Hill map, "at last count all very convincing One interpretation of course is the Fish map and another evidently is my own

Marjorie Fish and I arrived independently at our interpretations and we agreed on one point that the alleged UFO map was based on some removed point of view in interstellar space

Beyond that our assumptions differed Ms Fish concentrated her search on a "finite" point of view in space I mine on an "indefinite" view, similar to the way our own mapmakers do it Road maps for example represent an indefinite view and are resolvable to the useful *x*, *y* rectangular coordinates

Why shouldn t a space map be similarly plotted in the useful three-dimensional *x*, *y*, *z* coordinates and conveniently set in some larger cosmic frame of reference?

Including the two larger "circles" as Betty Hill describes them, there are 28 "points" in the sketch—12 along connected routes and another 16 "background" stars Ms Hill was instructed, while under hypnosis to draw *only* what she could remember As Mr Oberg suggested we simply cannot dismiss the background stars as "decoration" To the extent possible they too must be identified

Of the stars in the densest areas of Betty Hill's map an overall number of about 50 could reasonably fill out the map More than 50 stars and there would have been too much clutter for Betty Hill to have discerned and recalled the distinctive subpatterns of background stars and lone-star positions that she did The limiting nature of travel routes in the map place a strict upper limit on the number of stars and volume of space to be remembered

My interpretation of the map, then is based on all the 45 star systems including the sun, in the Van de Kamp list of nearest stars plus the two slightly more distant stars Eta Cassiopeiae and Sigma Draconis At 18 2 light-years Sigma Draconis the terminal star of the topmost "expeditionary" route is the star in the map most distant from us

Corresponding to the two large circles the UFOnauts' home stars those connected by heavy solid parallel lines are Epsilon Eridani and Epsilon Indi Another apparently heavy solid line leads from Epsilon Eridani to Tau Ceti Such lines were described as "trade routes" The solid lines described as places where the visitors "occasionally go" lead separately from Epsilon Eridani to Groombridge 34, Ross 248, and our own sun

The three broken lines were described as "expeditionary routes" Two of these branch out from our own solar system to Groombridge 1618 and the tiny dwarf Ross 128

To offer some "incomprehension" of the distances involved, though the map is based on the necessarily smallest scale possible, it would take our astronauts an incredible half-million years to travel the 15 light-years to Groombridge 1618—at the speed they whirl around the earth in their space capsules

That raises an interesting question Are the alien space voyagers racing through the solar system to and from these distant expeditionary points? Or have they not yet returned from their expeditions having left only surveillance probes behind to keep an eye on us?

Charles W Atterberg
Hanover Park IL

More or Less Split-Brain?

Thomas Hoover is quite correct in his article in the October *Omni*, that intuition is a vital factor in scientific creativity as well as in creativity in other fields However his identification of creativity with the right hemisphere—and some sort of slavish noncreative mode of thought with the left hemisphere—is a prime example of the naive hemispherizing that has recently become so common in popular writing In fact there is not one bit of evidence that the left hemisphere is any less (or more) creative than is the right Even the evidence that the two hemispheres have different modes of thought or cognitive styles is equivocal

Left-hemisphere specialization for speech production probably arose from the rather mundane need to have one and only one center for the exceedingly complex commands to the vocal apparatus Interference would take place if both the left and the right hemispheres had the capability to control speech output In terms of motor control needed to realize it

"The Pterodactyl brought you"

bird song is almost as complex as human speech and in studies of several species of songbirds song has been lateralized to the left half of the avian brain. Happily however no one has (yet) suggested that the left half of the avian brain is some sort of bird-brained IBM 360

One final thought on Hoover's holistic education We are told that drawing is a right-hemisphere phenomenon (a statement flatly contradicted by numerous studies of hemispheric differences) Does Hoover seriously believe that Da Vinci could have produced his masterpieces or that Beethoven could have written the Ninth Symphony had the left side of their brains been cut out?

Terence Hines Ph D
Boston MA

TV Revolt

I ask the American Broadcasting Company to televise the following episode on *Battlestar Ponderosa* in an effort to improve the programming

1 The Cylons rip off Boxie s arms

2 Adama accidentally runs Daggit through a powerful magnetic field and changes him into a Wookie

3 The Wookie rips off Adama s arms

4 The Cylons learn how to control their eye tremors long enough to shoot down Starbuck s Viper

5 Daggit captures a Cylon, rips off his loincloth and forces him to perform various unnatural acts

6 Hoss and Little Joe rip off Boxie s arms

7 Adama captures a Cylon and forces him to watch old *Bonanza* reruns

8 Starbuck captures Boxie and tortures him by making him watch old *Battlestar Galactica* reruns

9 The crew of the *Galactica* uncover a Cylon plot to dissolve their entire fleet

10 The crew of the *Galactica* uncover a plot—any plot

Elaine Lovitt
Detroit MI

Master of Moleculegraphy

In reference to Future Drugs by Gene Bylinsky in the October *Omni* I find an interesting corollary to Alexander Shulgin's new type of antidepressant I believe the new unnamed drug to be Nabilone the only candidate I know of that may qualify as this forthcoming class of commercial psychopharmacological activant In recent publicized reports Nabilone has been described as a THC derivative with similar beneficial potential to glaucoma patients having none of the undesirable side effects (i e, high) of the cannabis derivative

Currently an endeavor of Eli Lilly & Co subjective reports indicate that Nabilone elicits a functional high similar to that obtained from marijuana and light doses of stronger hallucinogens The article claims this new compound to be a variant of mescaline which is in some respects true though I would demonstrate more symmetry with the THC derivatives even if it is not a proper tetrahydrocannabinol

The attempt to relate such homologues to the key receptor site theory of drug effect is similar to the pattern demonstrated for LSD and for psilocybin Nabilone is administered in doses from one to five mg average two mg and is useful to the treatment of glaucoma The drug is, we hope a substitute for less desirable compounds such as prochloroperazine and compazine and effects differentiate from placebo

Obviously Shulgin is the master of intuitive moleculegraphy situating hypothetical probability resonances within complex specific microcellular receptor combinations to derive an intended functional translation I find great satisfaction in the opportunity to make a logical inference and comment on the work of this most highly respected sage of the acid tradition This man is no stoned relic from the 60s

Stan K Stephenson
Vice President R & D
PTK Industries Inc
Houston TX

Alexander Shulgin replies *I wish to extend my appreciation for these kind comments but it is misleading to refer to Nabilone as one of my compounds It is a 9-keto analogue of the cannabinoids, and my psychopharmacological studies in this chemical area have been limited to the 9-aza analogues I will agree, however that it is gratifying to note the increased interest in this area of research being shown by the pharmaceuticals industries It can only be through their participation that potentially valuable psychotropic agents can ever be made broadly available*

Vive le Virus

This letter is to inform you that viruses do not conjugate Furthermore there are biologists who do not consider viruses to be alive in the strict sense of being able to replicate with their own machinery As Mr Asimov points out in Found (October *Omni*) they need machinery created elsewhere

Eric Lois Erica Eileen
Wickstrom
Denver CO

Dr Asimov replies *Viruses include self replicating molecules of nucleic acid and are therefore alive I know of no biologists who deny this Viruses may need the help of other life forms but so do we We couldn t live without food*

Leaky Cosmos

In contemplating the astronomers steady state proposal that matter is leaking constantly into the universe it occurred to me that the speed of light can be compared to the surface of a liquid exposed to an atmosphere In this simile the liquid represents pure energy or whatever Our outer space represents the atmosphere at the surface of a liquid molecules are vaporizing and condensing with a net loss to the lower density of the air Molecules of vapor tend to disperse at a predictable rate to fill the available space This tendency has been cited as support for the theory that time is directional as we know it a theory that seems self evident

Is it possible that at the interface between energy and matter (the speed of light?) matter vaporizes or condenses into our universe in the lower density of interstellar space?

If this is true it seems to me that a so-called black hole could result when a concentration of mass creates a density so great that radiation within the mass would exceed the speed of light and boil into energy Matter in such a mass would be converted into energy until sufficient reduction of radiation stopped the event Or concentration of the mass could occur to the point that a large portion would sublimate all at once creating a big bang in reverse and a supernova on our side of the barrier

One possibility of a black hole condensation could be that the angular velocity of the atomic particles involved accelerates and becomes coherent Radiation would be inward and opposite to the direction of time as we observe it

Mass involved in the creation of a black hole I propose disappears from our perception just as a bubble in a boiling liquid is not of that liquid Mass is in the process of transcending our physical universe that exists for us only on this side of the speed of light

If it is possible that a duplicate universe exists on the other side humans age-old beliefs would take on a new mantle of respectability Not that we can know but awareness of such a thing is not totally without basis

W Michael Joyce
Certified Public Accountant
Redwood City CA

Sunless Solar Cell

I would like to know if anyone has invented a solar cell that continues to produce electricity after the sun goes down

Annozie Ommaya
Lagos Nigeria

Such cells have been developed and produced independently by Israeli scientists at the Weizmann Institute by researchers at the Bell Laboratories in New Jersey and by investigators at M I T These cells are the outgrowth of the photoelectrochemical solar cell and they contain their own internal storage system They need no backup power for sunless periods Consequently they are a viable alternative to the standard solid-state photovoltaic cell which requires high-purity single crystal materials that have been specially treated and coated —Ed DO

THE ARTS

Carla Bley has always been ahead of her time As a teenager, uneducated and untrained she wandered onto New York s jazz scene in the seminal late fifties wrote a few tunes and immediately impressed such avant garde heavies as Ornette Coleman and Cecil Taylor with her inventions She s been charting unbeaten paths ever since Her spare, often witty compositions have been recorded by a wide range of innovative musicians including Gary Burton Art Farmer Tony Williams Jan Garbarek, and George Russell All her work, like her wildly ambitious opera, *Escalator Over the Hill*, is at the least unorthodox—and visionary at its best

Just back from a whirl around Europe with the ten-piece Carla Bley band she is sketching in the final notes on the group s second album *Musique Mechanique* which she tells us is "concerned with nonhuman elements in music, up to but not including electronic I tried to make at least half the tracks sound as if they re being played by anything from dummies to machines—but just the kind you crank by hand or," she smiles "by treadmill " As usual humor is the keynote "One of the pieces gets stuck Another piece starts out very slowly because the musicians have to be oiled, and finally the machines break down completely Actually the record will have a huge chunk out of it It will get stuck artificially as well as by humans "

Don t count on it Bley's well-known penchant for hyperbole strikes with dizzying frequency, but she's serious when she objects to being labeled a jazz composer despite the fact that all her work embodies the improvisational elements of jazz And she s even more serious when she claims that "the most avant-garde interesting music in the world at this moment is punk rock

Even at 40 even with her solid reputation Carla Bley is a perfectly credible punk queen Tall thin with long frizzled yellow hair that all but hides her eyes she's never outgrown the enormous restlessness that she claims drove her out of school after three tries at tenth grade "My mother tried to teach me to play piano and I bit her very hard, on the arm," she shamelessly recalls "My father gave up on me when I was six because I was bored with fingering Anything that stood in my way, that was boring I got rid of "

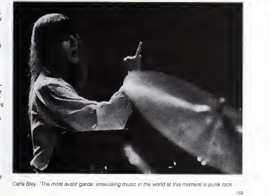
Even after she had earned considerable respect in the jazz community, musically Bley remained "a reject" from conventional commercial routes undaunted, she has excavated channels of her own and wouldn't have it any other way "Things are snowballing for me now If I were in the roster of a commercial record company, I wouldn't be allowed to change I d have to do my old music ad infinitum "

With her husband trumpeter-composer Michael Mantler Bley has established a record label (WATT Works) a recording studio a publishing company and the nonprofit New Music Distribution Service which handles the independently produced records of hundreds of avant-garde and experimental artists We catch her there at New Music s Manhattan base with a gin and tonic in one hand and a cigarette in the other perched cross-legged atop a desk

Bley is alternately ecstatic and concerned over plans for an American tour that may alienate her fans and turn on strangers The material as always will be hers alone yet, Bley tells us, the band will come on a great deal louder and somewhat more outrageous than jazz audiences may expect—thanks to her brief stint with a legendary group known as Penny Cillin and The Burning Sensation Bley a k a Penny, was attracted by the punk/new wave sound because in it she heard a chance to solve some problems

"I m unable to play fast, slick, quick music It takes me years to write something good Then, all of a sudden I heard people playing and thinking more slowly and in a little more basic way It took me very very far back, to very simple forms "

Although The Burning Sensation self



Carla Bley "The most avant garde interesting music in the world at this moment is punk rock destructed almost instantly "for perverse reasons." Bley had already created for them a body of work that she hopes to weave into the more sophisticated repertoire of her own big band.

"Things seem to happen for me in three stages," she reflects. "First I do something safe. Then I do something disastrously adventurous, like frying to take a punk band on the road. And then, in stage three, I find myself modifying the adventurousness. I'm coming back to my big band with everything I've learned from working in the new wave, and everything I'm still learning from listening to punk groups.

"Playing difficult music is like driving on a mountain road. You can't relax. You're always looking out for what comes next. New wave showed me a stretch of broad, flat highway where I could pick up a little speed and enjoy the ride.

"My new tunes have only one or two chord changes. And every single bar is in 4/4. My old stuff has hundreds of changes, and I've written in 13/7, 4½/11—you name it, every possible combination, even within a single piece."

Another new element Bley wants to keep is Penny Cillins C-melody saxophone, an instrument seldom used by professionals because, among its other drawbacks, it's hard to play in tune. Bley whose tormented music lessons began when she was just past infancy and stopped in grade school, insists that she plays it "very much in tune but very badly. Of course," she adds after a moment's thought, "I play notes so loud you can't really tell if they're in tune. And I hum through it, which thickens the texture a bit."

Enfant terrible? Definitely. Bley has the at times infuriating ability to do very serious work without seeming to take herself seriously at all. In the music as well as what she says about it, ambiguities abound. One message, however, is clear. She's always reaching toward the future, in her own music and in her work with the New Music Distribution Service.

"I love the strange in music. If I hear something I've never heard before, I just go crazy," she says, "but I don't like things that are too obscure, like microtones, something that is not tempered, something that is not on the piano. Human ears have always been attracted to a certain set of intervals. I think this is going to change so slowly that we may have to reach an evolutionary stage beyond anything we can dream of before the human ear loves anything as desperately as it loves an octave, a tenth, a third, a fifth, a fourth. We won't live to see many people relating to an interval so small you can hardly discern it, like on the microtone scale where an octave is divided into 85 parts. Now Harry Partch has done this, and I do love Harry Partch. But he's the only one who's original in it. He's kept a beautiful rhythm going underneath. It's corporeal music for dancing, for watching."

Bley is proud, however, that neither her tastes nor anyone else's influence what is distributed by NMDS, which has several microtone composers and at least one punk band on its current list. It is the only such service that turns no one away.

"We know through personal experience that some of the rejects have been incredibly talented but not obviously talented," says Bley. "The important thing is to keep alive what doesn't instantly grab us. Phil Glass, for instance, whom people are just beginning to know, has been around for years and years. His work will be the popular music of the eighties.

"But by the nineties," she speculates, "we're going to amalgamate. We're already amalgamating. There's probably a McDonald's in Sri Lanka. At first, maybe it will be junk music, like junk food. But it would be very sad to think the common denominator will keep getting lower and lower. It would be much better to think it will start rising."

She describes a music with multiple layers and levels, containing nourishment for a variety of musical appetites within a single bar. It's roughly parallel to the taste treats Roald Dahl imagines in his children's classic *Charlie and the Chocolate Factory*: the successive gustatory pleasures of a full-course meal within a single stick of Willy Wonka's magic gum.

"Although there will be a steady overall tempo and you can hear the four beats, you can also hear the counter-rhythm that's a little more intricate. You can go a little further and hear something that's almost not audible if you're the person who needs to pick up on that, or if you're someone who has dog's ears and has got to hear something strange for it to get through to you, then you'll hear that.

"Instead of subcultures, instead of folk music for the folkie and hard rock for the acidheads and punk for the punkers and jazz for the sophisticates and dixieland, it will all exist in one musical culture that will pretty much appeal to everyone. The weirdest stuff, instead of lying in some godforsaken cobweb niche in some cellar, can exist on the same level as the most accessible tune. We may all be listening to the same music, and I'm not against that. I hope it's true."

She takes a deep breath. "Wow," she says. "Nice piece." She says, "I like the ending," and walks out of the room.

—*Bibi Wein*

Recommended Listening

Escalator Over the Hill. Music by Carla Bley, words by Paul Haines. JCOA Records.
Tropic Appetites. Carla Bley. WATT Records #1.
13/ 3/4. Carla Bley and Michael Mantler. WATT Records. #3.
Dinner Music. Carla Bley. WATT Records. #6.
European Tour/77. The Carla Bley Band, WATT Records. #8.
Musique Mechanique. Carla Bley. WATT Records. #9.
The above albums can be obtained through Jazz Composers Orchestra, 6 West 95th Street, New York, NY 10025.

BOOKS

CONTINUED FROM PAGE 28

was able to author so many books.

Finally, there's Asimov the private man.

Isaac came to America as an infant and was raised in Brooklyn, where he spent his school years helping his parents in their candy store. He read his first science-fiction magazine from the store rack, and got to read it only because his father saw the word *science* on the cover and figured that it would improve his son's mind. Smart man!

No matter how famous or wealthy he has become, Asimov has never really left that candy store. He works the same long hours his parents did, and he is happy in his work. He can travel the world (by ocean liner; he will not willingly fly), live in the best hotels, and still feel that somehow none of this really belongs to him.

Beneath the brash public persona is a thoughtful, humble man, and a great and true friend. He has been unswervingly helpful to every writer who has ever asked for his assistance, and he performs as a sort of international data bank for any writer who needs information about the sciences.

As for his success, his fame, his prolific output of books, he says modestly, "I realized long ago that I couldn't write good, so I write a lot."

A cruel canard.

Asimov has many talents as a writer, but his special genius—when it comes to nonfiction—is his ability to approach the most complex of subjects, dissect them neatly, and present them to his readers in terms of such precise clarity that anyone can understand them.

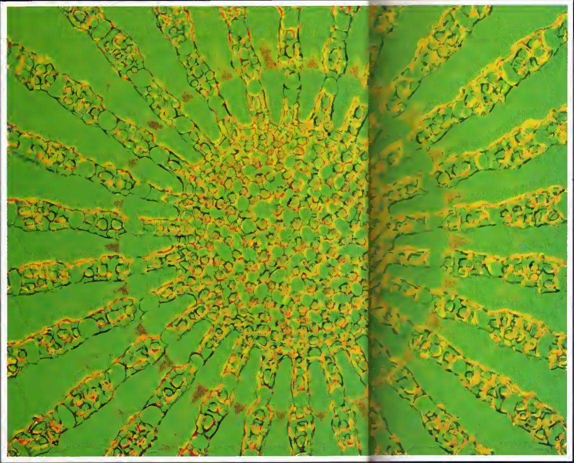
He is an apostle of rationality, a firm believer that our minds are what is important and that the universe is understandable. We have the intellect to survive and prosper in the Asimovian view. The only question about the future of the human race is whether or not we will use our intellect well.

There is a memorable canard about writers in general and Asimov in particular: the idea that if you write fast, you can't be writing well.

True, most writers produce only a few good books in their lifetime, but that is often because they spend most of their lives not writing. Almost every one of the great masterworks was produced over a very short period of time.

Asimov's pace of virtually a book every month is certainly extraordinary, but the literary critics who sniff haughtily at the idea of producing books in such quantity should cast their thoughts in the direction of a playwright named Shakespeare. At his peak, the Bard of Avon was knocking out masterpieces at a rate of at least two per year.

Speed and quality are not mutually exclusive. Asimov has written two hundred books and is merrily working on his next hundred. Thank God for that!—*Ben Bova*



PHENOMENA

Repetition is the cornerstone of nature's structures. When something is successful in its purpose, it is endlessly adapted and repeated in diverse forms. Here, a cross-sectional photograph of a sea urchin spine dramatically illustrates this tenet.

The ubiquitous sea urchin is radially symmetrical, that is, all of its parts are arranged around a central axis (like spokes on a wheel). Parts of its internal structure mimic the overall shape of the creature—each individual spine has many "arms," made of alternating plates of calcium carbonate that diverge from the center to provide mechanical support for the spine.

In this striking representation of radial symmetry, Mortimer Abramowitz used a Leica camera and kodachrome 40 positive transparency film. He was able to contrast the different structures of the spine through the Rheinberg illumination technique. By using two separate color filters, one within the other, and sending light through a condenser lens beneath his vintage Zeiss microscope, Abramowitz was able to distinguish the framework of the spine (here seen in yellow) and the matrix surrounding it (in green). ΩΩ

Non-verbal signs speak louder than words

GAMES

By Scot Morris

When we announced our first competition in the October issue, we were, frankly, not sure that we would receive ten drawings worth reproducing. After sifting through more than 2000 entries, we began wondering how to narrow the field down to *just* ten winners!

The majority of entries were designs for one of the sample messages we suggested, such as "No Marijuana Smoking" or "Caution: Loud Noises." This resulted in a lot of repetition—a diagonal slash across a marijuana leaf, for example, or sound waves radiating toward an ear. Many excellent drawings never ended up in the running because of heavy competition with almost identical drawings.

What caught our eye were the fresh ideas—signs to communicate messages we hadn't even thought of: "No Hovering," "This Way to the Next Galaxy," and so on. Unfortunately, many times when the concept was good, the art did not quite fulfill the thought. So we ended up choosing ideas and art that were compatible and original and will probably be found somewhere fairly soon.

While thanks are extended to all of you who helped make this competition such a success, special mention should be made of the school classes that entered 30 or 40 drawings apiece. More often than not, all 30 or so were completely different, original, and quite good. Whether they were done as a class project or simply for the fun of it, we wish to thank you.

For the record, the standardized "NO" symbol is a diagonal that slants from the upper left to the lower right, from the viewer's perspective. This is the "bar dexter," or right-handed stripe, that slants in the same direction as the stripes on most men's ties and coats-of-arms. In addition, this direction mimics the cross-body slant of a right-handed warrior reaching for a sword carried at the left hip. The opposite stripe is a "bar sinister," and in the tradition of English heraldry it denotes "bastard," and was used on the coats-of-arms of a ruler's illegitimate sons.

Next month we will once again present a wide variety of games and puzzles to delight and confound you.

NO RESTRICTIONS ALLOWED
James F. Palmer
Lake Forest, Illinois
First Place Winner

CAUTION: WATER POLLUTION
Alan Steele
New York, New York
Runner-up

CASH NOT ACCEPTED HERE
Robert Boulay
Verdun, Quebec
Runner-up

ANDROID SERVICE STATION
Bill Grewe
River Grove, Illinois
Runner-up

CAUTION: NUCLEAR WASTE
Michelle Mirkay
Oakville, Missouri
Runner-up

REDUCED-GRAVITY AREA
Tony Boatright
Douglasville, Georgia
Runner-up

CAUTION LOUD NOISE
Bruce Giacoppo
Woodhaven, New York
Runner-up

NO-CLONE ZONE
Ed Morykwas
San Francisco California
Runner-up

CAUTION AIR POLLUTION
Frank R Dennis
New York, New York
Runner-up

ELECTRIC AUTOMOBILES ONLY
Boyd Evans
Salt Lake City Utah
Honorable Mention

REDUCED VISIBILITY AHEAD
Jon P Dowling
Houston, Texas
Runner-up

NO SHOOTING AT SIGNS
John E Stith
Colorado Springs Colorado
Honorable Mention

OMNI Competition #4

While some scientists write expansive lyric poetry and occasionally publish it most scientists confine their poetic forays to the familiar terrain of the limerick The limerick is basically a four part story outline with an exact meter a pleasing balance and a sassy rhythm The fifth and final line is a punch line completing the idea of the other four For example

Relativity Theory

There was a young lady named Bright
Who traveled much faster than light
She went off one day
In a relative way
And returned the previous night

—*A Reginald Buller FR S*
University of Manitoba

It s Greek to Me

An astronomer said What s the use?
Our classical knowledge is loose
There can be nothing stupider
Than to call that thing Jupiter
When we all know it should be named Zeus

—*Isaac Asimov*

Topology

A mathematician confided
That a Moebius band is one sided
And you ll get quite a laugh
If you cut one in half
For it stays in one piece when divided

—*Author unknown*

Fitzgerald Contraction

There once was a young man named Fisk
Whose fencing was agile and brisk
So fast was his action
The Fitz-Gerald contraction
Diminished his sword to a disc

—*Author unknown*

The Competition Create an original limerick with an *Omni* flavor—scientific futuristic informed colorful and playful Make sure that it follows the form of the limerick as described above All entries on postcards please with one entry per postcard, postmarked no later than March 1, 1979

The first-prize winner will receive $100 Runners-up (2–10) will receive $25 each All entries become the property of OMNI and will not be returned Send entries to OMNI Competition #4, 909 Third Ave New York, NY 10022

LAST WORD

By Bruce Wallace

The limits to growth, economists tell the United Nations, are not physical, rather, they are economic and political. Garrett Hardin, author of *The Tragedy of the Commons* and proponent of "lifeboat ethics," is roundly booed by conference audiences. Worldwide nutrition is a question of distribution, not of production, still another expert tells us.

Sorry! I am not convinced.

Simple calculations show that feeding the four billion human beings on earth in the fashion to which affluent North Americans are accustomed would require an amount of energy equal to that budgeted for all the purposes—domestic, industrial, transportational, and agricultural—of the entire United States. The world has neither the sources of this needed energy nor a physical base large enough for releasing it safely if such sources were to be found.

But I am being carried away. My intent is not to bicker but to join. To cooperate. Distribution is indeed a problem: we must distribute our manufactured goods and agricultural produce more efficiently. We must pack and stack. Even those who oppose zero population growth often recognize that unlimited urban sprawl and the concomitant desecration of productive land cannot be tolerated.

These persons are then led to propose high-density living arrangements of one sort or another: high-rise apartments, medieval-type cities, or some other human anthill. In the eyes of these persons, packing is essentially a physical problem. None of them, to my knowledge, has seen a second possibility: packing in time.

To correct this oversight, I now generously share with them a preliminary model for time packing: the 31-hour day—10 hours for work, 10 hours for play, 10 hours for sleep, and an hour for lunch.

The 31-hour day that I propose should under no circumstance be confused with the effort to adapt our current time system to the decimal system. This effort, the revival of an attempt made during the French Revolution, would divide the day into 10 hours, the hour into 100 minutes, and the minute into 100 seconds. The simplicity of the decimal system appeals enormously to physicists and engineers. The thought of handling all time calculations from milliseconds to days according to the same rules (4 + 3 = 6 carry 1—such a nuisance!) brings joy to the hearts of those who manufacture pocket calculators. Such joy, however, is trivial. It has no social significance. Furthermore, it is parochial because the length of the earth's day remains a local accident in the cosmic view. Let's then forget the convenience of the few for the better life of the many.

Do not tamper, please, with my 31 hours! The new day cannot be shortened to 30 hours or lengthened to 36 and still fulfill its packing function. The number 31 is a prime number. That is the secret. The numbers 24 and 31 share no common divisor; consequently, 24 31-hour days coincide in total length of time with 31 24-hour days. Furthermore, each of the 24 31-hour days begins at a different one of the 24 hours of the normal day today's day.

The world currently operates on essentially a single shift. Most persons arise in the morning and retire sometime during the evening. The night and graveyard shifts involve many fewer persons than does the daytime shift. Night-shift workers suffer when they try to sleep while the majority of their neighbors go about their daytime activities.

The 31-hour day would enable the entire population to function normally on 31 shifts, not just on three. The basis for this flexibility is the manner in which successive days move about in reference to daytime and nighttime. In the proposed day there would be no "night" shift, that is, a shift that condemns one to work by night and sleep by day. On the contrary, a shift beginning at any hour would, during the 24 "long" days, report for work on the traditional hours of the 24-hour day.

The division of the population into 31 shifts packs people timewise. A 500-seat theater might now entertain 1000 persons during two evening performances. Because "evening" would arrive at a different hour for each of the 31 shifts, the movie house would remain open continuously; somewhat more than 60 seats would be required in order that 1000 persons could see a two-hour show.

Restaurants would also benefit enormously from the switch to the new day. Restaurants, especially excellent ones, are deserted wastelands throughout most of each day. Starting at about five or six o'clock in the evening, patrons drop in, drink, order, relax, and then leave after two or three hours. Here again, the tremendous packing in time offered by the 31-hour day is apparent. A restaurant of 200 tables offering dinners only and serving some 600 customers each evening could serve as many persons equally well under the new system with no more than five or six tables.

Restaurants, in fact, provide evidence that people are prepared to accept changes the 31-hour day would demand. Reservations at good restaurants are becoming increasingly difficult to obtain. On the other hand, a multitude of fast-food outlets—with, generally, a mere handful of tables—are routinely serving customers 24 hours each day. The 31-hour day would merely legitimize round-the-clock service on the part of gourmet establishments.

Others are welcome—more than that, encouraged—to extend these calculations to the operation of highways, bridges, tollbooths, factories, schools, and other facilities whose designs now include provision for overusage interspersed with long periods of idleness and desertion. Standpipes in high-rise buildings, as discontented students proved in college dormitories throughout the nation during the 1960s, can withstand only so much simultaneous use. The dispersal of human activities and basic human functions over all daytime and nighttime hours would permit either the construction of higher rises or, conversely, the use of more modest standpipes.

The proposal made here has, as I said at the outset, been presented in a spirit of cooperation with those who see no physical limits to the earth's resources, and as an aid to those who actively encourage (as a leader of the Gaullist party in France only recently did) the continued growth of the human population. **OO**

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