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Cover art for this month's *Omni* is entitled *Broken Hearts*, a sculpture by American artist Nick Anisavlos. Created from polyester resin and various other objects, *Broken Hearts* was captured on film by photographer Shig Ikeda. Anisavlos works in New York City.

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BEN BOVA

● *Smallpox is a thing of the past. The scourge that has killed millions ... will never again threaten anyone. ... That's what scientists are supposed to do, right?* ●

It was only a small item, down in the corner of a page of the Sunday *New York Times*. "Smallpox has been eradicated."

The World Health Organization (WHO) officially announced that smallpox has been wiped out everywhere on Earth. One of the great killer diseases has itself been killed. No more need for smallpox vaccinations. No more need for international travelers to carry the yellow cards that prove they are not bearers of the dreaded disease as they cross national borders.

The rest of the news that same day was filled with the usual passions: riots, threats of war, terrorism, starvation, population problems in India and Latin America, inflation, unemployment, strikes . . . on and on and on.

Americans were in the streets, marching in memory of those who were killed in military service. It was Veterans Day, when we honor our dead and remember the wars we have fought.

Iranians were in the streets, too, in Tehran, where they held more than 60 American citizens hostage in the U.S. Embassy and were demanding the return of their deposed shah so that he could face the Ayatollah Ruhollah Khomeini's version of justice.

No public celebrations greeted the news from WHO. No one cheered from any rooftop. Smallpox is a thing of the past. The scourge that has killed millions and scared hundreds of millions will never again threaten any child or adult. No human. That's what scientists are supposed to do, right?

Well, yes, it is. But how often does the public stop to reflect that what scientists do is rather miraculous?

Perhaps I'm prejudiced. I started my writing career as a newspaper reporter back in the late 1940s. Every summer, in those days, newspapers carried a long, ugly running story about polio. It was like covering the baseball season. All summer long we ran box scores every day on the number of children who had died of polio, the number placed in iron lungs, the number crippled for life.

That's life. What can you do about it?

Then one springtime we carried one single story: Lots of human interest. Plenty of wonderful photographs. Children were being inoculated with the Salk vaccine.

Good front-page stuff: a kid screaming bloody murder as a doctor jabbed a needle into his arm and his anxious mother smiled bravely in the background.

That was a dull summer, polio-wise. And there has never been another summer

when any newspaper in the land has had to carry a running account of polio's ravages.

Now we've wiped out smallpox. We've eliminated another killer disease.

A curious doublethink takes place in most human minds on subjects such as this. Polio, smallpox, tuberculosis, for countless ages were regarded as inevitable natural disasters that humankind just had to bear, scourges sent by the gods to keep us in our place. Then science—the product of human thought—puts an end to these diseases, and people accept their absence as being in the natural order of things.

The same people who unthinkingly accept the gift of life from modern science, as if scientists are supposed to produce miracles the way chickens produce eggs, are quick to blame modern science for many of the problems that our society has not solved.

"No more nukes," they chant, holding science (and scientists) responsible for Three Mile Island.

"No DNA experiments," they shout, visions of horror movies dancing in their heads.

"No research on intelligence," they demand, being told that such studies are done by "elitists."

Such people form the shock troops for the armies of ignorance. In another place, or another time, they would be shouting, "Death to the Shah," or "Down with Balıyaz," or even "Sieg Heil!" Like Konrad Lorenz's ducklings, they will follow whatever or whoever moves across their field of vision at the critical moment when they are ready for imprinting.

Unwittingly, they are destroying our one true hope for a better future. Science, the most human activity that human beings engage in, the highest expression of rational human thought.

Yes, the work of scientists can lead to nuclear reactors or genetic engineering or computers that are smarter than we are. Scientific research and experimentation can also lead to the blanching of disease, hunger—and ignorance.

For, beyond all the controversy on the uses of scientific knowledge lies the fact that the ultimate goal of science was summed up beautifully by the English poet John Donne, nearly four centuries ago:

Death, be not proud, though some have called thee
Mighty and dreadful, for thou art not
so.
And Death shall be no more; Death,
thou shalt die! ☐

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BONESTELL



STURGEON



DUMONT

When the twentieth century began, artist Chesley Bonestell was twelve years old. He grew up in San Francisco and recalls vividly the earthquake of 1906. "We'd been carousing on the Barbary Coast, and I got home about two in the morning. At five-fifteen I was thrown out of bed. The whole room was shaking." Bonestell started drawing pictures when he was five and reading about astronomy at ten. When he was seventeen, he hiked to the Lick Observatory and was so enthralled by a view of Saturn that he rushed home and painted his first vision of the ringed planet. Throughout his long career he has painted this planet from hundreds of perspectives.

Trained as an architect, Bonestell quickly gained recognition for his mastery of detail. He was involved in the design of such great buildings as the Chrysler Building, in New York, and the Supreme Court Building, in Washington, D.C. He also drew early renderings of the Golden Gate Bridge. Growing restless with architecture, in 1939 Bonestell moved to Hollywood, where he became the most respected special-effects artist in town, designing backdrops for such films as *Citizen Kane*, *The War of the Worlds*, *The Hunchback of Notre Dame*, and many others. Today, at ninety-two, Bonestell paints daily—everything from extinct *Incinerators* to Chinese landscapes on silk. "The Chinese," he says, "ignore reality and use imagination to create scenes one

would like to see." This month, exclusively for *Omnib*, Frederick C. Durant, of the Air and Space Museum in Washington, D.C., has gathered a selection of some of Bonestell's greatest works. We invite you to gaze at the artistry of a man whose visions of the solar system have influenced generations. Our gallery begins on page 68.

Orthomolecular therapy, the use of vitamins, minerals, and other nutrients to strengthen the body's own natural defenses, has been called the medicine of the future. Yet this idea that disease can be controlled by diet dates back to Hippocrates, some 2,500 years ago. In her article "Orthomolecular" (page 44), science writer Belinda Dumont visits with the proponents of orthomolecular medicine, whose claims that "modern medicine has backlaid" are driving traditional doctors up the wall.

Originally a newspaper reporter, Dumont has worked for several notable publications, including *Medical World News*, of which she was an editor for five years. Her interest in orthomolecular therapy derives from personal experience. "While traveling through the Soviet Union," she told us, "I was made ill by an unknown virus that had attacked my brain. I was hospitalized and given massive doses of vitamin C. The orthomolecular treatment was successful."

This month's lead Continuum essay, "The Science Brokers" (page 35), takes a hard look at how the National Science

Foundation funds research in America. The author, Carl Frederick, is a physicist who describes himself as being "greatly annoyed with American science and the NSF's part in it." Frederick, formerly with NASA, took a post at Cornell University because, he said, "I thought universities were places where great ideas were exchanged. Instead, I found a large amount of my time was spent seeking NSF grants and messaging data."

Ben Bova, formerly *Omnib*'s fiction editor, has replaced Frank Kendig as executive editor. Mr. Kendig has left *Omnib* to pursue a writing career. *Omnib* is also pleased to announce that writer Robert Sheckley has joined the staff as our new fiction editor. Mr. Sheckley is author of some 28 books, most notably *Mindswap* and *Immortality, Inc.* His novel *Tenth Victim* was made into a motion picture. His newest work is entitled *Crampton Divided*.

One of science fiction's most gifted and provocative writers, Theodore Sturgeon takes us on a journey to the planet Medea, a world of "irreconcilable hatreds" and "unpredictable situations." It's the story of an Earthman's attempt to divert an impending civil war. "Why Dolphins Don't Bile" (page 62) is part of a complete anthology about Medea, edited by Harlan Ellison, to be released later this year.

Joining Sturgeon in this month's issue are author Stephen Robinson ("The President's Image," page 88) and British writer/mathematician Ian Stewart ("Message from Earth," page 50). **DD**



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FEBRUARY

LETTERS

COMMUNICATIONS

Yetis on Pogo Sticks

For years I half-believed in the existence of yetis. I'm even working on a short story involving the big, ugly creatures. Yet after seeing the photo of yeti tracks on page 111 in *Omni's* October issue, I'm almost inclined to drop my half-beliefs and dead-file my story.

I can't think of a single bipedal creature off a pogo stick that moves in such a straight line, placing one foot directly in front of the other. Even uphill tracks in snow show a variance of movement from right to left to right off a central axis line. To walk placing one foot so directly in front of the other as the photo indicates requires considerable concentration and effort. The steps have to be very deliberately placed and executed to avoid a loss of balance. Lower pelvic and upper leg structure in any animal—including a human, and especially the adult male—is not really designed for this sort of rigidly linear locomotion.

Poor yetis! Fantastically well balanced, but hobbled, unable to run, and suffering from severe lower-back problems and horribly chafed thighs. Considering the possible damage to the male sex organs, it is little wonder that the yeti population is as scarce as it seems to be. I certainly hope these particular tracks are not typical.

Bill Taibt
New York, N.Y.

Available for the Asking

It may interest many *Omni* readers that NASA space photographs are available for purchase. Anyone wishing to buy NASA photographs should write to the National Aeronautics and Space Administration, Room 6035, 400 Maryland Avenue, S.W., Washington, D.C. 20546, or phone 202-755-2320 and ask for the recent NASA Photography Index. This Photography Index lists all photographs from the Vanguard mission in 1956 to the present. When our index arrived, we also received a free set of 11 color glossies of the recent photographs of Jupiter, which were outstanding.

However, I was very disheartened when

I received NASA's Information Sheet of July 1979, which states:

"1. Space settlements are no longer being studied by NASA. A workshop study was conducted in 1975 to explore the space settlement concept.

2. Establishing settlements in space would be very costly. Both the hardware required and the technology needed have not been developed. The number and background training of people to occupy a settlement is unknown.

3. There is within NASA no recognizable need for a space settlement project now or in the near future.

4. NASA has no plans at this time to establish a space station on the lunar surface."

More people ought to show their interest in, and support of, space technology and exploration, since this seems to be our ultimate destiny. Youths living today might live long enough to witness man's expansion into the universe.

Dennis and Victoria Lund
Maplewood, Mont.

Annoyed Pigeons

Your answer to Martin Gardner's question number 8, in *Omni's* November issue, was right when you concluded that the overall weight of the truck remains the same, but for the wrong reasons. The question clearly stated that the truck compartment was airtight. If that were the case, the pigeons would not be flying, they would be lying on the floor of the truck, dying of asoxia.

Robert Mackey
New York, N.Y.

Green Hair Update

I read your Continuum item on green hair in the October issue, and I wish to provide this update. The Fenzels have withdrawn their lawsuit. Blood screening of the water-system consumers indicates that all tests are normal and that there is no health risk. Water testing confirms this finding. Their drinking water is safe to consume.

Ray E. Anderson
Environmental Health Administration
Baltimore, Md. **OO**

DIALOGUE

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, N.Y. 10022.

Free Enterprise

I had just picked up the November 1979 issue of *Omni* and hadn't even passed your editorial when I was prompted to write.

Creeping collectivization, which has been a hallmark of "civilization" these last 20 years (indeed these last 60 years), is now threatening not only our entire planet but our future in space as well. J. Anderson Dorman's First Word made that clear.

How sad it is that the last frontier is to be smothered in the web of those who want something for nothing—and before we even get there!

I'm not anti-humanitarian. The moon, and indeed all of space, is our common heritage as human beings. But killing exploration and development by private individuals and/or companies is not the way to guarantee each person his "just" share in that heritage.

True, space belongs to us all, and so all of us, from whatever country, should be free to invest in it as we choose, and according to the means at our disposal. Those not part of the actual team would be free to buy whatever resource, product, or development was the result.

The Communists and the Third World countries, which have sponsored this disgusting space treaty, should ask themselves where the capital will come from to operate these "free-for-everyone-except-the-provider" systems.

Perhaps a more intelligent treaty would be one in which any interested nation or individual could participate, exchanging skills, sharing both the financial investment and the results obtained. Exploration teams could easily be

international in composition, through some voluntary cooperation among nations, eschewing the absurd theory of borrowing from Peter to pay Paul.

As a Canadian, it would do little good for me to write to a U.S. congressman, but I hope *Omni*'s American readers will answer the call sounded in your editorial. Americans, beg your representatives not to give away your heritage in space and your rights as individuals to a free interplanetary future.

Beverly S. Pirneger
Toronto, Ont., Canada

After I read J. Anderson Dorman's editorial in *Omni*'s November issue, I became concerned enough to write. American free enterprise is about to be handcuffed. Socialist treaties, such as the one concerning outer space, must be stopped. As *Omni* states, our only key to space is free enterprise. Since our government doesn't find it necessary to spend money on NASA or scientific exploration, industry is our only key to open the door to space technology.

Many new and exciting discoveries are being made that directly affect our future. Space technology is only one of many—but one of the most important. We must encourage our elected representatives to vote against such treaties and to increase funding for NASA and scientific experimentation for the

benefit of all. My hope and yours is quickly being wrested from our grasp; immediate action must be taken. Stop the U.N. outer space treaty now.

John A. McDonough
Kokomo, Ind.

Appealing Experiments

I have read the article "So That Others May Live" [December 1979], and it frightens me. I believe scientists need the rhesus monkey the way a drug addict needs his daily fix. I am also appalled that *Omni* seems to condone human experimentation. Is it your magazine's intention to keep letting the scientists play and give them human beings as toys after they've run out of monkeys? Where is it all going to end?

John Ruzzo
New York, N.Y.

It is true that scientists sometimes have trouble demonstrating the legitimacy of their experiments. But it must be remembered that countless diseases have been eradicated by techniques developed in experiments on animals and man. This often makes it hard to draw the line between what should and should not be done. Omni's goal in publishing the article was to inform the public of the uses and abuses of scientific experimentation so that people can decide for themselves what is and is not proper — Ed.

Risky Business

In response to a quotation of Ray Bradbury in *Omni* [October 1979], these "knuckleheads running around protesting nuclear power" happen to be, on the average, well-educated and intelligent political participants. The fact that they get up and protest proves they care about the human race. One can be wrong about something one protests, but one cannot "pretend" one cares about humanity by protesting—bad logic. Also, as a group, opponents of nuclear power, and environmentalists in general, probably own the fewest cars and, I'm willing to bet, use them the least.

John L. Jordan
Eugene, Oreg.



HEARTLAND SPIKE

EARTH

By Kenneth Brower

If nature abhors a vacuum, then so does industry.

"The Kaiparowits Plateau of southern Utah is so vast that you could drop Manhattan Island in the middle of it and never notice," says Calvin Rampton, an industry scout. "Besides, nobody ever goes there anyway."

Rampton, a former governor of Utah, is now consultant to seven companies that hold coal leases on the Kaiparowits Plateau, which contains the richest undeveloped coal deposits in the United States. He and his employers would like to improve the vacuum of the plateau by dropping a coal mine and a railroad into the middle of it. The railroad, necessary for bringing coal out of southern Utah's present tracklessness, would be the largest rail project in 50 years—more than 300 miles of new track and three years of labor—costing \$350 million. The mine and railway, called the Allen-Warner Valley Energy System, would be one of the biggest energy projects ever undertaken in the Southwest.

One hundred years ago, or even 50, no

one would have minded. The Calvin Rampton Vow of the Desert went unchallenged, then. Our appreciation of the aesthetic virtues of the Southwest has developed slowly. Before the southwestern terrain could look like anything but wasteland to us, we had to teach ourselves to see again.

"The lover of nature, whose perceptions have been trained in the Alps, in Italy, Germany, or New England, in the Appalachians or Cordilleras, in Scotland or Colorado, would enter this strange region with a shock, and dwell there for a time with a sense of oppression," wrote Clarence Dutton, one of southern Utah's first white visitors. "Whatever things he had learned to regard as beautiful and noble, he would seldom or never see. The colors would be the very ones he had learned to shun as tawdry and bizarre. But time would bring a gradual change. Some day he would suddenly become conscious that outlines which at first seemed harsh and trivial have grace and meaning, that forms which seemed grotesque are full of dignity, that

magnitudes which had added enormity to coarseness have become replete with strength and even majesty."

"It is lovely and terrible wilderness," writes Wallace Stegner. "...harshly and beautifully colored, broken and worn until its bones are exposed, its great sky without a smudge or taint from technocracy and in hidden corners and pockets under the cliffs the sudden poetry of springs. Save a piece of country like that intact, and it does not matter in the slightest that only a few people every year will go into it. That is precisely its value."

It was the air that Willa Cather remembered. Of her fictional Father Labret, returning to this desert as an old archbishop, she wrote, "He always awoke a young man, not until he rose and began to shave did he realize that he was growing older. His first consciousness was a sense of the light dry wind blowing in through the windows, with the fragrance of hot sun and sage-brush and sweet clover, a wind that made one's body feel light and one's heart cry 'To-day-to-day,' like a child's."

"Beautiful surroundings, the society of learned men, the charm of noble women, the graces of art, could not make up to him for the loss of those light-hearted mornings of the desert, for that wind that made one a boy again. He had noticed that this peculiar quality in the air of new countries vanished after they were tamed by man and made to bear harvests."

It has taken the Duttons and Stegner and Cather, the Georgia O'Keeffes, Eliot Porters, and John Hustons to teach us to see this country, but at last we do see it. Even our government has got the message, and much of this country's land is protected by law. Within a 250-mile radius of the Kaiparowits Plateau are 26 national monuments, 13 national forests, 8 national parks, 5 Bureau of Land Management natural areas, 3 primitive areas, 3 national recreation areas, 2 national historical sites, and 1 national memorial. Twelve Indian reservations lie within the circle, and these in turn contain their own tribal parks and sacred landmarks.

CONTINUED ON PAGE 96



Bryce Canyon's delicate towers may come tumbling down in the wake of active strip mining.

He created some of the world's most passionate music.

Yet he died whispering the name of a woman he had never met.

She was his patroness...his confessor...his "Beloved Friend" in an intimate 14-year correspondence. She was the inspiration for his most romantic works. And yet he shrank from meeting her even when she invited it, replying that one should never meet a guardian angel face to face.

Finally, she withdrew her support from him. Yet years later, on his deathbed, he whispered her name. In gratitude? In love? In anger? The secret died with Tchaikovsky. But the passion that Nadezhda von Meck inspired lives on in some of the most soaringly romantic melody ever penned, as you will discover in TIME-LIFE RECORDS' magnificent four-stereo-record album, *Tchaikovsky*—your introduction to an outstanding record series called GREAT MEN OF MUSIC.

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STAR CLUSTERS

SPACE

By Mark R. Chartrand III

The star clusters must be regions of incredible beauty. Imagine living on a planet inside a star cluster. Your night sky would be densely spangled with bright points of light. Glowing bands of cosmic gas might arch overhead. The spectacle could make Earth's clearest winter skies seem dull.

For terrestrial astronomers, star clusters also have a practical side. They are enormous astrophysical laboratories in which we verify our theories of how stars are born, live, and die. The largest, densest, and most symmetrical are globular clusters. Many are nearly spherical. Others are distorted into ellipsoids by the motion of the hundreds of thousands of stars swirling within them. Globular clusters surround our galaxy, most of them far above or below the disc that contains nearly all of the Milky Way's stars. In these clusters we find the oldest stars—stars that condensed from primordial gas before most of the rest of the galaxy had formed.

Open, or galactic, clusters lie within the Milky Way's disc and are less dense than

the globular variety. Their forms are irregular, with few symmetrical features. Open clusters contain younger stars, often entangled in a web of cosmic gas and dust left over from their formation. Such a cluster may have a few dozen stars or a few thousand.

The loosest groups of all are the "associations," swarms of very young, hot stars, still evolving and often flying slowly away from one another. They are subdivided according to their characteristic stars. T associations contain the low-mass, still-forming T-Tauri stars, named after the first star of their type that astronomers recognized. OB associations harbor the extremely luminous OB stars, among the most brilliant in the universe. R associations show much gas and dust—the afterbirth of stellar formation.

A good example of a globular cluster can be seen on very clear nights as a small, fuzzy patch in the constellation Hercules. The Pleiades, an open cluster in the constellation Taurus, are the most famous of this type, celebrated in poetry by writers from Sappho to Tennyson. An

association of very young stars lies within the Orion Nebula, found in Orion's sword. You can locate any of these clusters on a star map.

To see why clusters are so important, consider what astronomers cannot do in studying stars. They can't breed them, feed them, or run them through mazes to see how they behave. For the most part, they can't even watch an individual star age. Stellar astronomy is strictly a hands-off affair. But by examining a star cluster, we can find the answers to many significant questions.

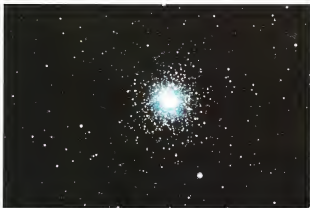
We can't tell how old a star is just by looking at it, but we can usually say that it is no older than a given maximum. We know that a star behaves normally as long as it is still "burning" hydrogen to form helium and energy—most of its life. Such stars, like our sun, are said to be on the main sequence.

When the hydrogen in a star's central furnace is exhausted, the star swells and becomes red. Eventually this red giant ends its days as a white dwarf star, a neutron star, or even a black hole—if such a thing exists.

Computer studies tell us that mass determines how long a star remains on the main sequence. The larger the star, the shorter its life. In the main sequence, a star's mass also determines its color. So if we see a yellow star, like our sun, we know that it must be less than 10 billion years old. A hot blue star must be less than 1 billion years old. And a main-sequence red star could be as old as the universe, a red dwarf's lifetime is longer than the 15 billion or so years the universe has been around.

But any single star could be much younger than its maximum possible age. There is no way we can be sure just by looking at it.

In a cluster, however, we can safely assume that all the stars were formed at about the same time. We can tell how old the cluster is by examining the color of the stars just leaving the main sequence, just beginning to bloat and cool. It is roughly as old as the number of years it takes those stars to begin turning into red giants,



Red giants are the brightest stars in M3, a typical globular cluster about 10 billion years old.

LISTENING TO LIFE

LIFE

By Dr. Bernard Dixon

Scientists have begun listening to plant leaves and human skin. Lumps of cells and other biological specimens are being monitored for low-frequency sounds in several pioneering laboratories around the world. A more unlikely idea is difficult to conceive: Leaf and skin cells are scarcely noted for their habit of making noise. Yet the technique used for this bizarre preoccupation—photoacoustic spectroscopy—is attracting intense interest among biologists. The first machines for the purpose have recently gone on the market.

The experimenter who wants to listen to a piece of tissue first seals a sample inside a tiny transparent chamber. He then shines a light on the specimen. The beam is interrupted by a "chopper wheel," like that in a film projector, which rotates at a speed corresponding to the frequency of audible sound. In a typical setup, the specimen receives flashes of light 150 times a second. Although the light pulses at the same frequency as sound waves, the tissue is bombarded not with noise but

with rapidly flashing illumination.

What happens next is the interesting part. If the cells absorb the light, they warm up—very, very slightly—and expand the gas around them in the chamber. This increases the pressure momentarily, until the chopper wheel once again interrupts the beam of light. Then the tissue cools and the pressure falls. Because the cycle of heating and cooling is so rapid, the result is an audible sound wave. This is picked up through a small microphone inside the chamber. By varying the wavelength of light and listening to the sounds produced, which become louder as more light is absorbed, a great deal can be learned about the makeup of the material in the chamber.

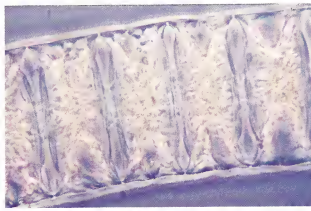
Photoacoustic spectroscopy is being developed particularly energetically by Dr. David Cahen, at the Weizmann Institute of Science, in Rehovot, Israel, and by Dr. Gordon Kirkbright, at Imperial College, London. The method has only begun to be explored, so its full range of applications is far from obvious. But two typical uses so far suggest that the scope is enormous. Dr.

Kirkbright, for example, has been experimenting with wavelengths of light that penetrate a vanishingly tiny distance into the specimen, so that only the thinnest outer shell is examined. This has proved to be an excellent way of finding out how much of a laser beam is absorbed by a mirror. In another recent investigation the method provided information about the lens of the human eye, thereby enhancing our knowledge of how cataracts develop.

Writing in *Trends in Biochemical Sciences*, Dr. Cahen speculates on other applications of this technology. If suitable chambers could be made that are open on one side, allowing them to be placed over the tissue being examined, they might yield new insights into the function and malfunction of living cells in the body. For example, by using ultraviolet light, it may be possible to gain insights into how a lengthy exposure to sunlight causes sunburn and skin cancer.

What excites me about listening to cells, rather than analyzing them chemically or taking detailed pictures of them, is the possibilities this technique opens up. Throughout the development of medical science, ways of doing things have been as influential as the brightest of ideas in fostering radical change. Historians often overlook this. But think, for example, of the revolution in medicine triggered by Sappone Riva Rocci in 1896, when he invented the first modern device for measuring blood pressure. That followed a century of misguided and often fatal attempts to measure blood pressure by inserting small glass tubes into patients' arteries. Consider how greatly the electron microscope has benefited medicine, agriculture, and other fields by permitting the intimate structures of cells to be scrutinized. More recently, computerized axial tomography—a technique for peering inside the brain—has opened up exciting new frontiers in neurology.

Listening to the tissues of animals and plants is an extraordinary research tool still in its infancy. But its practical repercussions could turn out to be as startling as those that have transformed those other areas. **DD**



Cells have long remained silent, but scientists have discovered a way to "sound out" their structure.

FILM

THE ARTS

By James Nelson

In front of you the screen projects an image so vast that you become part of the movie. Suddenly you're free-falling through space in a flying sequence. Minutes later you're submerged in water, gazing up toward the surface.

This is Omnimax, the world's most advanced projection system. A dome-like screen framed by speaker clusters creates a hemisphere of sight and sound that physically pulls its audience into the picture. Heads must turn to capture the whole effect.

Omnimax is the second generation of Imax, the largest film format in existence for flat-screen projection. Whereas the former is shown on a dome surface, Imax can be thrown onto a screen nine stories high and six wide. Though both are limited by budget, audience size, and the number of theaters available to show them, these systems are expanding the boundaries of motion-picture technology.

Designed and built by filmmakers for their own use, Imax and Omnimax are simply oversized renditions of traditional equipment with modifications built in to

stabilize them. Both involve a gigantic strip of film nine times the size of standard 35mm stock and three times the size of 70mm, the widest format currently in general use. But footage runs through the projector at the same fast 24 frames per second, requiring a horizontal feed instead of the traditional vertical arrangement. A patented "rolling loop" mechanism isolates each frame individually. The entire combination of gears, air pressure, film compression, and rock-solid machinery presents the largest and richest picture in the world.

Colin Low's *Weather* is a big-budget Omnimax film currently in production. As director and producer of documentaries for the National Film Board of Canada, Low, through his use of futuristic movie-making techniques, has achieved the distinction of a cinematic visionary.

Universe, a black-and-white documentary about the cosmos, which Low made in 1960, featured special effects of such sophistication that even today, 20 years and a couple of generations of improvements later, they

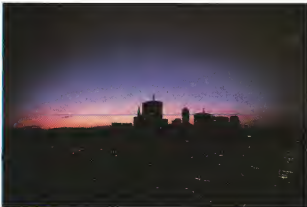
are still impressive. The most popular film ever made by the film board, *Universe* has been in constant demand since its release, with more than 300 prints sold to the U.S. government alone.

The influence of *Universe* on subsequent cinematic productions is underscored by its contribution to Stanley Kubrick's 2001: *A Space Odyssey*. Not only did Kubrick borrow the film's overpowering imagery of the sun rising behind a planet, but he also duplicated technical methods of creating special effects and used Douglas Rain, *Universe's* narrator as the voice of HAL. "After seeing our film, Stanley asked me to work on *Space Odyssey*," Low recollected, "but I had already committed myself to making *Labyrinth* for Expo Sixty-seven in Montreal. Besides, I knew that if I worked with him, I'd be a very small fish in a very big pond."

Low doesn't seek publicity, but he has had a fair share of the limelight, stemming from his work on *Labyrinth*: a multimillion-dollar multimedia pavilion for Montreal's World's Fair in 1967. "There was a lot of interest in creating multiscreen movies after the success of the IBM and KLM [Royal Dutch Airlines] pavilions at New York's 1964-65 World's Fair," Low said. "That was the first time audiences seemed genuinely interested in seeing several images projected onto abnormally shaped screens, though Abel Gance had done it in his pictures in the silent days."

"When Roman Kroitor and I put *Labyrinth* together, we played with all sorts of ideas about the use of space and the manipulation of the audience's reactions to given images. What we ended up with was a three-chamber setup that people moved through, watching separate films that tied together in overall feeling. We had to make certain compromises because of time, budget, and physical limitations, but the pavilion was a huge success."

Kroitor and two other filmmakers, Graeme Ferguson and Robert Kerr, went on to start a film company which they called Multiscreen Corporation, Ltd. For Expo '67 Ferguson and Kerr had created a multi-image film called *Polar Life*, and all three saw the future in a series of



This frame of Imax/Omnimax film is nine times the size of 35mm, three times the size of 70mm.

MUSIC

THE ARTS

By Sam Bruskin

In 1619 the Bavarian astronomer Johannes Kepler published *Harmonices Mundi* ("Harmony of the Universe"). Although astronomers since then generally consider Kepler's greatest contributions to have been his deduction of planetary laws and the ray theory of light to explain vision, Kepler himself considered this 1619 treatise on the music of the spheres to be his crowning achievement.

Three and a half centuries later, by adapting Kepler's astronomical data and synthesizing them on an array of computers and electrical devices, two Yale professors have succeeded in creating 40 minutes of "celestial music" audible to mortal ears.

"Kepler sent us a definite challenge," said Yale geologist John Rodgers, "and we think we've met it." Rodgers and his partner, associate professor of music Wilfrid Ruff, have recorded this music on a stereo LP entitled *The Harmony of the Worlds: A Realization for the Ear of Johannes Kepler's Astronomical Data from Harmonices Mundi in 1619*.

The idea that planets "sing" as they move in their orbits has fascinated people for centuries. Kepler was not the first

Celestial polyphony was virtually a department of mathematics for the Greek philosopher Pythagoras, who laid the foundations of acoustics. Pythagoras conceived the heavens as a grand scheme of concentric spheres whose ordered rotations through the kosmos produced music made pleasing through numerical relationships. He speculated that as planets moved through space, the proportional distances between them, like the divisions of the strings of a lyre, produced spatial harmonies. Moving at a constant speed, each planet emitted a characteristic tone; the combination of these tones created one eternal chord audible to the divine ear.

This idea was unquestioningly accepted until Kepler permanently shattered its astronomical basis by discovering that the planets have elliptical rather than circular orbits, the angular velocity of each planet changing as it moves nearer to or farther from the sun.

For Kepler, however, the astronomical importance of his discovery was secondary to its musical implications. Because of the planets' changing velocities, Kepler thought, the celestial music would not be a single chord but an

ever-changing symphony that demonstrated the awesome beauty of God's compositional powers. "The music that God made during the Creation," he writes, "He taught Nature to play, indeed she repeats what He played to her."

Professor Ruff explains it further. "Kepler reasoned that God had chosen to give the planets eccentric and variable motion precisely in order to create six-part harmony."

Ruff first encountered Kepler's work when he was an undergraduate at Yale. In 1952 Ruff (fresh out of the air force's then all-black jazz band) attended composer Paul Hindemith's classes on music theory. Hindemith introduced the young musician to the musical theories of Kepler, on whose life he was basing his opera *Die Harmonie der Welt*. Ruff inherited Hindemith's fascination with Kepler and developed a compelling desire to prove that the astronomer's musical theories were fundamentally inseparable from his scientific work.

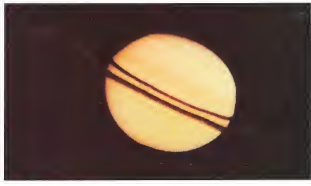
"We were listening to Hindemith's opera on Kepler when we decided to do it," recalls John Rodgers, Silliman Professor of Geology at Yale and Ruff's downstairs neighbor. Rodgers is also a musician, mathematician, and astronomer.

"We had dinner together every night here at the dining commons," Ruff said "and we were jotting down formulas on napkins and envelopes."

Rodgers and Ruff applied the calculations Kepler had made for the six planets known to him. Kepler had assigned a pitch to each planet, derived from its angular velocity; the pitch modulated according to the eccentricity of each orbit. In the modulation of this pitch, Kepler represented the changes in the planet's speed as its orbit approached or got farther away from the sun. In this way he described a six-part motet.

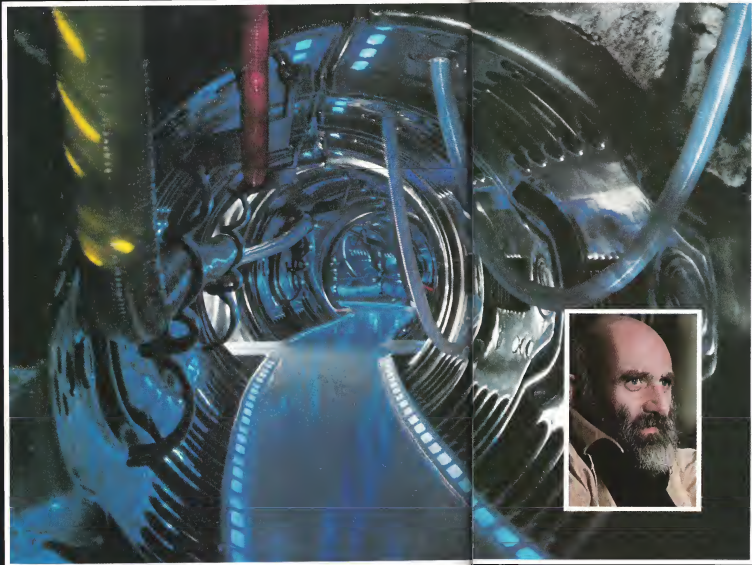
Ruff and Rodgers used the pitches Kepler had chosen for each planet, starting with the G next below the piano keyboard to represent Saturn, with Mercury being placed the highest, reaching to the E next above the keyboard.

CONTINUED ON PAGE 118



Kepler assigned a musical pitch to each planet according to its angular velocity — Saturn, a low G

The Final Vision Of John Barry



THE ARTIST WHO DESIGNED "STAR WARS" AND "SUPERMAN" TAKES US TO A FUTURE WORLD — WITH A SEXUALLY PSYCHOPATHIC ANDROID — IN "SATURN 3"

It is some three hundred years from today.

At a hydroponic laboratory on Saturn's third ring, two scientists work in idyllic isolation, searching for new forms of protein to feed a polluted Earth. Their world is a cocoon of fluorescent blue corridors, tunneled into volcanic rock, ending in a sudden oasis of advanced technology.

They have a visitor, a disturbingly intense young scientist from Earth who has come to deliver, assemble and program the ultimate robot. The first in the Demi-God series, the android is an eight foot mass of gleaming metal, simulated brain tissue and plastic tubing through which vital fluids pulse.

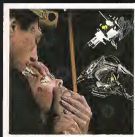
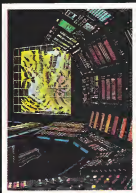
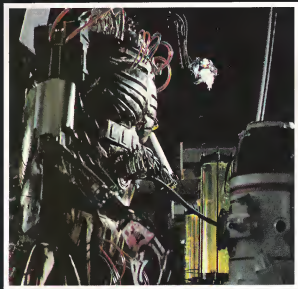
Christened Hector, he is programmed through "direct brain drain" from his creator. And since his creator — as it turns out — is a sexual psychopath with a taste for murder, Hector is not only the most practical robot ever designed, he is also congenitally insane.

The movie is titled "Saturn 3." Starring Kirk Douglas, Farrah Fawcett, Harvey Keitel and the indomitable Hector, it is a dazzling, deftly researched portrait of the future, studded with some \$3 million worth of special effects.

It is also the final vision of the movies' most brilliant seer, the late John Barry.



The Final Vision Of John Barry



As a production designer — the artist responsible for imagining, then creating, a film's environment — Barry specialized in science fiction. In Stanley Kubrick's "A Clockwork Orange," he painted a crimson portrait of a future-shocked society that thrived on violence. In "Star Wars," he whisked us to a distant corner of the universe where a galactic civil war was waged with medieval bravado and light-speed spacecraft.

For "Superman," he created the exploding planet, Krypton, the glacial Fortress of Solitude and the subterranean lair where arch-fiend Lex Luther dwelt — and plotted — beneath the lower level of Grand Central Station.

Trained as an architect, the Academy Award winning designer drew this revealing comparison between "Star Wars" and "Superman": "In 'Star Wars,' we set out to achieve a 'used' look, as if the picture had been shot on location in outer space. 'Superman' demanded a more poetic tone. We were dealing with a universal wish fulfillment and you had to believe, if only for a few hours, that Superman was really up there, in a red cape and blue uniform, soaring over the streets of the city."

For Barry, who began his career as the "seventeenth draftsman from the left" during the production of "Cleopatra," "Saturn 3" was different from any previous project. It was his concept... his story... his dream. He first described the idea to producer-director Stanley Donan while the two men were involved in "Lucky Lady," the comedy-adventure about bootlegging off the California coast which starred Liza Minnelli, Burt Reynolds and Gene Hackman.

Finally, some four years later, with the financial backing of international impresario Lord Grade and executive producer Martin Starger, "Saturn 3" went before the cameras in a massive network of futuristic sets, outside of London. Included were a communications room, crammed with whirling, oscillating, computer-controlled gadgets... a garage for the scientists' lunarbuggies... a hydroponics laboratory where some 600 varieties of plant mutations were bathed in artificial daylight, amidst a clutter of electronic "nutrient chambers"... "modular living quarters paneled in fibre-glass and suede... and miles of tubular scaffolding.

It was the perfect playground in which the ultimate robot would run amok.

But Barry never saw his vision come to life on the screen. Tragically, he passed away shortly after the start of production, leaving behind what producer-director Donan described as "the most fitting tribute" any creative artist could possibly have... a world that once existed only in his mind, brought wonderfully to life... the world of Saturn 3."

An A.F.D. release, "Saturn 3" is a Lord Grade Presentation, starring Kirk Douglas, Fannah Fawcett and Harvey Kalital. Stanley Donan produced and directed the screenplay by Martin Amis from a story by the late John Barry. Martin Starger was executive producer.

ALONE AGAIN

UFO UPDATE

By James Oberg

When astronomers began to point their high-powered radiotelescopes toward the stars in search of intelligent life, their hopes ran high. In Earth's neighborhood alone, half a dozen stars showed the slightly wobbling motion that should reveal orbiting planets. And if planets were quite common, surely life, even civilization, could not be rare. That was almost 20 years ago. Today the chances of locating extraterrestrial civilizations appear much poorer.

The idea that life abounds in the galaxy seems to be almost universal, at least among laymen, and some astronomers still claim that the best way to detect life out there is to search for the radio transmissions of distant technological societies. Many UFO buffs are equally convinced that extraterrestrial civilizations have already found us and are now paying visits here.

Neither group questions the existence of extraterrestrial intelligence (ETI). Author and researcher Robert K. G. Temple in 1976 said, "An attitude which asserts that

man is the only intelligent life form in the universe is intolerably arrogant. Anyone holding such an opinion today is an intellectual freak."

UFO lecturer Stanton Friedman is just as positive. "I consider the term UFOs a copout," he once declared. "They're not unidentified flying objects, they're flying saucers." The evidence is overwhelming that we are being visited by intelligently controlled vehicles from off planet Earth. In other words, somebody's UFOs are somebody else's spacecraft. The majority of the public concurs, according to numerous opinion polls conducted throughout the past decade.

Astronomers involved in the search for extraterrestrial intelligence (SETI) remain almost universally hostile to claims of alien visitation. In 1976 a poll found most astronomers willing to concede that UFOs might be worthy of study but unwilling to bother doing the research themselves. UFO proponents, however, have been interpreting — astronomical research to provide scientific respectability for their

belief in the existence of alien cultures.

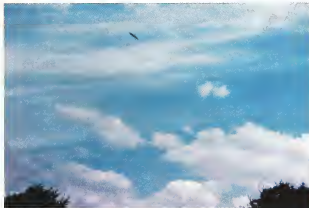
Recently a third point of view has forced its way into this bitter standoff. Humankind, it is suggested, may actually be alone in the universe. This notion enrages UFO buffs for obvious reasons, and SETI astronomers are understandably upset by the idea that their search is a waste of time and money (as Senator William Proxmire has declared).

Late in 1978 proponents of this third force in the ETI controversy gathered at the University of Maryland for a two-day symposium. Their topic, "Implications of Our Failure to Observe Extraterrestrials," was bound to be provocative. For most of those attending, the implications were clear. Since we haven't seen any trace of them, either they aren't there or there is something fundamentally wrong with our comprehension of the universe.

The consensus that emerged from the colloquium was heresy itself. "If we extrapolate ourselves into the foreseeable future, and then generalize our type of civilization across the galaxy, then we should not exist," declared Dr. Sebastian von Hoerner, of the Green Bank Radio Observatory. "If anyone is out there at all," insisted cochairman Michael Hart, a Texas astronomer, "then Earth should have been colonized millions of years ago, and 'us natives' wouldn't be standing here now."

The idea that life has arisen on millions of planets and that many developed high-technology civilizations raises a question originally attributed to nuclear physicist Enrico Fermi: "Well, then, where are they?" ETI advocates argue that such civilizations either refrain from, or are incapable of, interstellar flight. UFO proponents argue that some such civilizations do visit this planet but avoid detectable contact for any of several reasons.

The Maryland conference considered both arguments and found them wanting. Papers by such eminent space scientists as Freeman Dyson and Ronald Bracewell demonstrated the feasibility of interstellar flight and presented a timetable for the step-by-step occupation of the galaxy. Their estimates ran into the millions of



To the dismay of ufologists, scientists are reviving the notion that we are alone in the galaxy.

CONTINUUM

THE SCIENCE BROKERS

There is a scientific legend that says that "chemists defer only to physicists; physicists defer only to mathematicians; and mathematicians defer only to God." At present, however, all three defer mainly to the National Science Foundation (NSF), for it is the foundation that keeps these scientists eating regularly.

The NSF, whose annual budget exceeds \$750 million, provides well over half the national support for physics research, and almost all for mathematics. Further from 50 percent to 95 percent of all basic research at universities is conducted under NSF grants.

The National Science Foundation was established in 1950 to "promote the progress of science." It is charged to do this by offering grants to institutions or individuals for scientific research. In the 30 years since its formation, the NSF has exercised powerful influence. It has overseen the establishment of huge national laboratories, astronomical observations, and research centers. It has funneled huge amounts of much-needed funds to universities. It has also provided a bureaucracy for directing the course of American science in accord with the wishes of Congress.

Therein lies the rub. The NSF is watched. It is watched both by the scientific community and by Congress. The scientific community, loath to bite the hand that feeds it, rarely voices any criticism of the NSF. Congress, however, has no such inhibition. While not being made up of scientists, Congress nonetheless takes an active part in the scientific workings of the NSF. The needs of politics are not necessarily in keeping with those of science. Pulling research titles out of context and flogging them as examples of wasteful government spending is not exactly conducive to the exercise of scientific creativity.

The result is predictable. Today the NSF is a large, well-organized government agency. Since it is responsible to Congress, from which it must periodically seek appropriations, it is important that the NSF does not fund "bad" science. However, the very procedures the foundation follows to weed out inferior scientific research also weed out potentially significant work. The NSF is very conservative and is oriented toward tangible results. This is most obvious from the criteria that the NSF uses in dispensing research grants: Will the research produce results? Is the researcher working at a major university? Has he or she been given

a grant before? In short, is it safe to support this research?

This "safety first" policy actually works rather well. Theodore Sturgeon's law, which states "Ninety percent of anything is crud," applies also to science. By definition, most of anything is mediocre, and it is necessary to support mediocre science. One NSF staff member remarked, "If the NSF were to fund on the basis of merit, half of the science departments in the nation's universities would collapse overnight." The vast resources of the NSF are keeping universities in business, running national laboratories, and coordinating international conferences. However, science, in the long run, advances through the efforts of individuals—exceptionally brilliant individuals who extend or revolutionize the body of scientific knowledge. If such an individual is successful, he is known as a great scientist. If he fails, he is often considered a quack. The NSF takes a dim view of quacks or potential quacks. Furthermore, the NSF, in violation of its own charter, does not give grants to individuals, only to institutions. Thus, if you happen to be, say, a proprietor of a Chinese restaurant who has just come up with a solution of the plasma-confinement problem and you write to the NSF for a research grant, forget it. Similarly if you have a Ph.D. in theoretical physics from Harvard, but you're currently working as a mountain guide in Nepal in order to have time to work on a totally new concept in science, keep climbing. The NSF won't fund you, either.

In view of its failure in innovation, one could well ask: Is the NSF actually contributing to the decline of American science? I believe that it is. Many others believe it also. Gain the confidence of any good, young research scientist. Assure him he will not be quoted by name, and he will probably tell you the same thing embellished by his particular favorite NSF horror story.

As long as the NSF feels itself under the control of Congress, things cannot change for the better. Alternatives to the NSF are clearly needed: private foundations willing to take risks and make mistakes. We need foundations comfortable in supporting new ideas and perhaps nurturing scientists of rare ability or genius.

In 1978 the NSF published a report entitled "Science Is Too Important to Be Left in the Hands of Scientists." Maybe so, but science is definitely too important to be left in the hands of the National Science Foundation.

—CARL FREDERICK

CONTINUUM

WING-WALKING AT 17,000 MPH

Astronauts love backpacking, particularly when it means the difference be-



Manned Maneuvering Unit
Allows 17,000-mph wing-walking
tween life and death.

Now under development is a backpack space-walking device called the Manned Maneuvering Unit (MMU). The MMU allows astronauts to clamber outside their spaceship and—using hand-controlled jets of gas—to propel themselves to satellites for in-orbit servicing, erecting large antennas and platforms, or rescuing stranded fellow travelers.

The backpack is currently receiving added attention because of serious problems with the space shuttle, much to the embarrassment of NASA. Concern has been raised that fragile, heat-resistant tiles, permitting a safe fiery shuttle reentry could be jarred loose or be

damaged during blastoff from Earth. Thousands of the tiles cover the underbelly, wings and sides of the spacecraft.

By using the 240-pound MMU, an astronaut could inspect and even repair defective or missing tiles. A do-it-yourself tile-patching kit is also being designed.

The rechargeable backpack has enough fuel to fly untethered in space for six hours.

According to Joe Lenda, a project engineer at Martin Marietta, the company building the device, there is no "panic situation" in reading the apparatus for its earlier-than-anticipated first flight.

"The MMU is one of a set of tools that will become routine to shuttle operations and part of the space construction site," Lenda says.

Television audiences might soon be treated to the antics of a daredevil, backpacking shuttle astronaut space wing-walking at 17,000 mph. —Leonard David

PLIGHT OF THE MANATEE

Scientists are increasing their efforts to learn how best to protect the West Indian manatee, a gentle marine mammal whose Florida population is so small that some experts consider it on the edge of extinction.

While a multiagency, federally sponsored rescue plan inches toward approval in Washington, D.C., research is under way in Florida on reducing man-made obstacles to the animal's survival. This includes

redesigning floodgate controls and possible propeller guards for boats.

But the situation is becoming critical. The resident manatee population is thought to be around 1,000, with a mortality rate now estimated at 10 percent annually.

Manatees, which are also called sea cows, graze in shallow water. This habit often places them in bays and channels trafficked by powerboats and barges. Collisions between half-ton ten-foot-long manatees and boat propellers are so frequent that researchers identify individual adults by scar patterns on their backs. And those are only the survivors.

Over a two-year period the federal Fish and Wildlife Service had counted 183 dead sea cows, by July 30, 1979, another 53 had been added to the toll. Of the 40 animals whose cause of

death could be determined in 1979, three fifths were the victims of man or his works. Powered vessels took 14 manatee lives, another 6 drowned or were crushed in flood gates, canal locks, or other artificial structures. 3 drowned while entangled in fishing nets or lines, and 2 died of gunshot wounds.

The Fish and Wildlife Service has drafted a recovery plan aimed at minimizing deaths and injuries, but implementation depends on cooperation among 14 separate groups, including utilities and conservation organizations and state and federal agencies. —Vic Cox

The energy produced by the breaking down of the atom is a very poor kind of thing. Anyone who expects a source of power from the transformation of these atoms is talking moonshine.

—Ernest Rutherford, 1933



Manatee. The ten-foot-long, half-ton sea cows are often the victims of collisions with boat propellers in Florida waterways.

FUTURE SMELLS

While we have a physical model for the mechanism by which the ear discerns high C and the eye violet, we still

redden of orange or rose (embedded in the fibers) and vinyl furniture, luggage and shoes that smell just like expensive leather round out Grisanti's nasal scenario.



Sensitive instruments are used at Philadelphia's Monnell Chemical Senses to collect and analyze the various odors of human subjects.

do not understand just how we discriminate between the scent of roses and a whiff of low tide. Nonetheless, the future is olfactory, says Eugene Grisanti, president of International Flavors & Fragrances (North America). Here is Grisanti's vision of the year 2000: In our offices, central "odorstats" will take periodic readings of the ambience and release forest smells—several hundred chemical compounds far subtler than air fresheners—with Muzak-like subliminal effects.

Computerized assays of our skin oils—for pH, free protein, oiliness, etc.—will help us select perfumes that collaborate disarmingly with body chemistry. Clothing

On a more serious level, body odor analyses may become part of a standard physical exam. So suggests research at Monnell Chemical Senses in Philadelphia, where scientists are studying the chemistry of unmentionables like "morning mouth," body odor, and "locker-room feet." Volatile molecules in skin secretions, detectable by the nose or by a gas chromatograph, are believed to signal early stages of periodontal disease, diabetes, schizophrenia, and cancer.

But how fares the quest for a human sex pheromone, a telltale attractant in vaginal or other body secretions?

Though insect pheromones have been synthe-

sized and used in traps, and pheromones have been identified in some mammals (a component of boar saliva, for instance, prompts the mounting posture in sows), the human sexual response may have evolved beyond pheromones. "I don't think we'll ever see the ultimate aphrodisiac perfume," says Charles Young, president of Proprietary Perfumes Ltd. —Judith Hooper

VASCULAR TESTS

Until recently the only way doctors could accurately check on blood vessels deep within the body was by injecting a dye into them and then taking an X ray. Today this somewhat risky and painful procedure is not always necessary. An array of new noninvasive machinery can now electronically sense the inner workings of the vascular tree.

About 400 diagnostic vascular laboratories have sprung up at hospitals across the country.

Patients complaining of leg pain, for example, which their doctors suspect might be caused by arterial disease, are connected to a plethysmograph. The instrument instantaneously detects volume changes within leg arteries.

To find out how much pressure blood exerts against these same arteries, another device, the Doppler probe, is applied to pulse points on the legs. This pencil-like probe emits ultrasonic waves, which translate into sound waves as they bounce off moving blood cells.

If veins are a problem, the probe is used to pick up sounds that the technician has been trained to interpret. Variations in the normal whoosh sound that blood makes as it flows through veins usually indicate a clogged vessel.

Another test for potential stroke victims uses a patient's eyes to find out how the blood is flowing through the vessels within the neck, where most crippling strokes originate. An air-filled suction cup is placed on the white of each eye. As vacuum is applied, pressure changes can be measured within the artery leading directly from the eye to neck arteries.

And now at many labs men suffering from impotence can have a penile blood-pressure check using a Doppler probe and an appropriately sized cuff pumped up around the patient's penis. —Caroline Rob



Technician applies eye probe to test for possible stroke.

CONTINUUM

WATERPOWER RETURNS...

Waterpower, which until this century played a large role in the nation's develop-

agencies are rebuilding 11 old dams. In Stockbridge, Massachusetts, a seventy-five-year-old woman named Mary Heather has refurbished an abandoned dam



Mary Heather and her hydroelectric plant on the Housatonic. Just one of over 5,000 small dams that could provide new power.

ment is making a comeback. From Maine to California, communities and individuals are restoring abandoned waterwheels and small dams, which once ran textile mills and factories. The cheaper fossil fuels that replaced them are no longer cheap.

The Army Corps of Engineers estimates that there are 5,162 small dams in the United States that could supply as much power as six large nuclear reactors. Many of the dams, built for recreation or flood control, have never generated electricity. Thousands of other sites are well suited for new dams; experts agree.

In the oil-dependent Northeast, New York State

on the Housatonic River. On Maine's Goose River, a husband and wife have reactivated a six-foot-high dam to produce electricity from a century-old turbine.

The U.S. Energy Department is awarding about a dozen grants of up to \$2.5 million for small hydroelectric projects. So far it has received 3,000 requests.

—Stuart Diamond

"The marvels of modern technology include the development of a soda can which, when discarded, will last forever—and a \$7,000 car which, when properly cared for, will last out in two or three years."

—Paul Harwitz in The Wall Street Journal

... AND INTRODUCING WEIGHT POWER

A New York City inventor sees rush-hour traffic jams and crowded shopping malls as potential answers to the energy crisis.

Wayne P. Le Van, who has designed bacon cookers, conveyor belts, and high-pressure sprays, now proposes to generate electricity by harnessing the weight of cars and people. He would install gratelike "hit plates" on busy sidewalks and streets. The weight would depress the plates slightly, perhaps half an inch, forcing a noncompressible fluid underneath to flow through hydraulic hoses to a mechanism that would turn a generator. The plates would have small ramps on each side, so that neither people nor vehicles would notice the difference in height.

The inventor calculates

that every "hit" of a car would produce 1.5 kilowatts of electricity, enough to light a 100-watt light bulb for 15 hours. With a series of six hit plates, the 1 million vehicles that enter New York City each day could produce 9 million kilowatts of electricity, he figures. That would be enough electricity for tens of thousands of people, if his calculations are correct. Batteries and flywheels would store the electricity for use as needed.

"Weight power can be classified as a vast, untapped natural resource," Le Van said. "You wouldn't need any other fuel. No oil, no gas, no coal."

Whether his scheme is merely one more amusing idea or a serious contender will be determined when Le Van's first weight

"Generator" is completed in Italy next year. But Canada and Great Britain thought enough of the system to grant him patents.

—S D



Typical New York City crowd. Power, not under their feet.

Zambia's Board of Space Administration reportedly trains its 12-man, 7-woman astronaut team by rolling it downhill in 40-gallon oil drums. Edward Nikoloso, Minister of Space, says the space program will literally get off the ground when the United States sends him liquid oxygen, liquid hydrogen, and \$21,000,000,000.

—R. Buckminster Fuller in I Seem to Be a Verb

The first rule of intelligent tinkering is to save all the parts.

—Paul Ralph Ehrlich

ALBERT THE RED

Was Einstein a fake? That's right — "a pseudo-scientist" — according to the latest "John Birch Society Bulletin." How do they know? Well, just look at all those "unearned" honorary degrees he received — we seriously doubt," they write, "that there is a single bona fide scholar today in the realm of either mathematics or physics who could tell you the supposedly great discovery or invention by Einstein, or would support its current authenticity for which those degrees were awarded. He was a dabbler per excellence in esoteric theories [that] he did not even begin to understand, and which have turned out in the long run to be mostly double-talk." The Birchers generously credit Einstein with convincing President Franklin Roosevelt to build

the atom bomb, but, they say, he did it not to save the "free world" but to rescue Stalin's Communist empire from annihilation.

— Jane Bosveld

"It may become possible to set up a nuclear chain reaction in a large mass of uranium. This new phenomenon would also lead to the construction of bombs. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transportation by air."

— Albert Einstein, in a letter to President Franklin D. Roosevelt, 1939

'God made the integers, man made the rest'

— Leopold Kronecker



Einstein ponders a predicament in Michel Peilus's painting *Problématique: Easier to understand than the John Birchers*

ASTRO BURIAL

It had to happen. Funeral parlors have rocketed into the space age. Astro Burial, Ltd., a Nevada-based funeral concern, is talking to NASA about ejecting cremated remains from the space shuttle.

Joe Roberto, president of Astro Burial, conceived the plan when camping out in Wyoming. "I had just read about NASA's 'getaway special,' an offer to research institutions and schools to rent, for three thousand dollars, five-cubic-foot drums on the outside of the shuttle while looking out at the star-studded night, I thought, What a lovely way to spend eternity in the vastness of space, rather than here on our crowded Earth! My next thought was, Why not find a way to take remains up in the NASA ship and then spin them into eternal orbit around Earth?"

With the shuttle an intended hearse, Roberto has designed disintegratable canisters for urns. These will be packed by Astro Burial into a large disintegratable container complete with a rocket through the middle. At the apogee of the shuttle's flight, 450 miles up, the rocket is programmed to shoot the larger container out of the shuttle's exterior drum to a point 150 miles from the ship. There the larger container and urns will disintegrate, releasing ashes to the heavens. Astro Burial recommends that funeral parlors charge a \$3,000 fee, which will include pickup and cremation and all

of Astro Burial's space-age services.

There's only one hitch to Roberto's ambitious plan: NASA doesn't like it. Roberto's \$500 deposit on the first



Space burial as portrayed in movie *The Loved One*

flight has been returned, along with a letter saying that Astro Burial doesn't qualify for the getaway special's noncommercial rates. NASA spokesman Dick Young told *Omn* that Astro Burial must pay a minimum of \$1,800,000 for space in the main cargo area.

An undaunted Roberto said he's calling Astro Burial a research experiment in the humanities and is applying for a federal grant. If this doesn't work, he's willing to go to court. "Only giant corporations can afford the commercial rates. All we need argue is that NASA, after building the shuttle on public funds, is discriminating against small businesses." — C R

CONTINUUM

QUARKS, ETC.

It seems as if high-energy physicists find another new subatomic particle every week. Such discoveries lead



The inscrutable James Joyce gave physics a new cat word.

to total confusion for those of us who still think the atom is just a nucleus surrounded by electrons.

Remember how you were taught that nuclei were made up of basic particles called protons and neutrons? We now know they're really made up of smaller things called quarks. Fortunately the electron is still safe. Nobody's found anything inside this basic particle. But now physicists say electrons really belong to a larger family of particles called leptons, which also includes muons and neutrinos.

To help you through this fog of new names, we've drawn up this *Namedropper's Guide to High-Energy Physics*. In (almost) al-

phabetical order, here are today's key terms.

- **Quark** In theory, this is the most elementary of all particles. Physicists Murray Gell-Mann and George Zweig lifted the name from James Joyce's inscrutable novel *Finnegans Wake*, where they found the phrase, "Three Quarks for Muster Mark." At that time Gell-Mann and Zweig thought there were just three kinds of quarks; now physicists think there are five or six kinds. The word has no meaning of its own, though it could refer to a type of German cheese. Remember this word if you remember nothing else. It will impress and amaze your friends.

- **The "baseball"** A super-massive particle a quadrillion times more massive than the proton or neutron.

- **Charm** The label given to the fourth type of quark, the c-quark, to distinguish it from the others, such as the s- (for strange) quark. The word has no other real significance.

- **Gluon** A particle thought to carry the force that binds, or glues, groups of quarks together.

- **Hadron** A general name for all the particles discovered in the 1960s by bashing the atom with high-energy particle beams.

- **J or Psi** Made up of a c-quark and an anti-c-quark. It has an identity problem because it was discovered almost simultaneously by physicists at MIT and Stanford, and therefore has two names.

- **Positron** An antiparticle to the electron. (We forgot to

tell you that the existence of antimatter doubles the confusion. For every particle, there is an antiparticle.)

— Douglas Colligan

SOLAR RADIO

The Department of Energy (DOE) has finally designed a project with pizzazz—the country's first solar radio station.

WBNO (AM) in Bryan, Ohio, is only a 500-watt, 1,520kc, daytime station, but it fits the DOE's needs to a T. It provides a constant load and operates only between sunrise and sunset.

Last August 100 panels (336 solar cells each) were set up on a third of an acre next to the station. Batteries in the building will store enough energy to power the transmitter for a day and a half.

Each panel will produce 150 watts, giving the array a

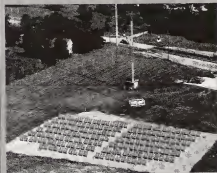
peak power of 15 kilowatts (on a clear day at noon). Since WBNO's transmitter needs only three kilowatts, the array will produce more power than necessary on some days. "Any extra power will be used to run the studio," says WBNO general manager Luke Thaman.

DOE isn't saying what the project will cost, but Thaman says the array alone ran nearly \$250,000.

WBNO program director Bill Prost says the cost of the cells is \$15 a watt, but by 1985 a competitive rate of \$1 a watt will be reached. In the meantime, WBNO will get an average of 85 percent of its power from the sun.

With 120,000 people in its range, WBNO is not just the first and only solar-powered radio station but a solar power project that serves more people than any other in the nation.

— Lars Larson



WBNO's transmitter is powered by an array of 33,600 photovoltaic cells (in foreground), which generate 15,000 watts of electricity.

MONEY SAVER

Every time inflation gets out of hand, some comedian quips that it's cheaper to eat money than to buy food.



Federal Reserve shreds \$15 billion of old bucks yearly.

Now army scientists have shown that it is possible, but not necessarily cheaper to drink money.

Federal Reserve banks destroy about 15 billion dollars' worth of old bucks every year shredding them into 3,000 tons of green fluff that is burned or sold, at \$10 a ton, for landfill, home insulation, souvenirs, or cardboard. Working on a project funded by the Department of Energy, army scientists at research labs in Natick, Massachusetts have now found a way to convert the stuff into an edible sugar.

"We use enzymes to break down the cellulose and turn it into sucrose," explains Leo A. Spano, chief of environ-

mental sciences and engineering at Natick. "Then we ferment it and turn it into two-hundred-proof alcohol, the drinkable kind."

The alcohol can also be mixed with gasoline, and that's what the army scientists have in mind. "We did an economic study that showed we could produce twenty-five million gallons of alcohol a year. It would sell for a dollar thirty a gallon the first year and for eighty-six cents a gallon by 1982. People making it from corn sell it for a dollar sixty a gallon now."

"It's feasible, and ultimately it's going to happen. Once we build a pilot plant, we'll be able to handle all sorts of paper waste material, not just the shredded money."

The problem: No one wants to fund the pilot plant, which, Spano said, would cost \$5 million to build and to operate the first year.

"I've tried to talk the Fed into sending me half the money unshredded," he said, chuckling. "That way we could pay for the project." —Allen Maurer

"Injuries caused by the cold include all those due to lack of warmth."

—International Civil Defense Organization

"Due to unforeseen circumstances, we must postpone the Psychic Fair scheduled for Saturday, March 24, 1979, and Sunday, March 25, 1979."

—Newspaper advertisement by the Tamara Rand Institute

WILDLIFE TRIVIA

Cocktail-hour minutiae for the ecologically aware, courtesy of the National Wildlife Federation.

- The world's largest minnow, the Colorado River squawfish, can weigh as much as 80 pounds.
- Ostriches, which weigh up to 375 pounds, attain speeds of 50 mph. The eight-foot-tall birds can outrun lions.
- The creature with the largest eyes is the giant squid. Each eye is the size of a basketball.
- Birds sing to define nesting territories, to attract mates, and also just to amuse themselves.
- Fireflies flash because of a complex chemical reaction in their abdomens, seen because their abdominal skin is transparent. The flash is a mating signal.
- The record for living in an

inert state is held by a plant called the Arctic lupine. The plant's seeds lay frozen in the Arctic tundra for 10,000 years but began to sprout when placed in a dish of warm water.

- The butterfly is really quite combative. Insects that invade its territory will be chased off by a butterfly for as much as 500 yards. In battle, butterflies rise into the air and batter each other breaking wings, legs, and antennae. —S.D.

"We can dream about rockets and the moon until hell freezes over. Unless the people understand it, no dice. You worry about damned calculations, and I'll talk to the people."

—Wernher von Braun

"Nothing exists except atoms and empty space, everything else is opinion."

—Democritus



Behold the vicious butterfly! It will chase invaders of its territory for 500 yards, relentlessly battering their wings, legs and antennae.

CONTINUUM

WOODPECKERS

An injured woodpecker may have revealed the secret for designing safer crash helmets



The woodpecker's beak smacks a tree with a 1,300-mph impact

High-speed movies show that the woodpecker's beak hits a tree with an impact velocity of 1,300 mph. The head snaps back with an impact of deceleration of some 1,000 times the force of gravity. American astronauts, by comparison, underwent less than 4 g's in their space gyrations.

The movies were taken of an injured bird, unable to fly, in a park ranger's office. They uncovered the woodpecker's secret for avoiding brain or neck damage. The head and beak drive straight back and forth with no side movement at all, report Dr. Philip R. A. May and his associates at the Neuropsychiatric Institute of the UCLA School of Medicine.

Dr. May suggests that a helmet restricting whiplash rotation of the head on the neck, and the neck on the trunk, could better protect auto racers, stunt men, and aircraft pilots.

—Alton Blakeslee

PSYCHIC COPS

Police in Los Angeles are thinking about hiring detectives who have more in common with *Un-Geiler* than with *Sherlock Holmes*. They're testing psychic powers as an aid to police work in baffling, clueless cases.

Dr. Martin Reiser, head of the department's behavioral science section, tested the crime-solving abilities of 12 psychics by handing them materials related to four crimes: two solved, two unsolved.

The psychics supposedly were able to describe the type of crime accurately and to identify the sex of the victim. In some instances, the accuracy was startling if not especially useful.

Furnished with a pair of shoes and an eyeglass lens, one psychic kept insisting that a church was in some way related to the crime. The items belonged to an eighty-nine-year-old church historian who had been killed during the course of a robbery.

"Science... means unrelenting endeavor and continually progressing development toward an aim which the poetic intuition may apprehend but which the intellect can never fully grasp."

—Max Planck

In spite of insights like this, none of the psychics, Dr. Reiser concluded, came up with any information helpful in solving the crime.

Reiser himself is well known for being open to using unorthodox crime-solving techniques. He's credited with pioneering the use of hypnosis in police work and is the director of the Law Enforcement Hypnosis Institute, which has trained close to 300 law-enforcement officials as hypnotists, or hypno-technicians, as they are sometimes called.

His research with psychic detectives came in the wake of a well-publicized case in which one California psychic used her powers to help Calaveras County police find the body of a seventy-

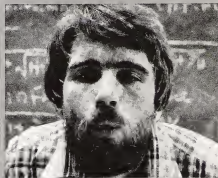
eight-year-old man who had wandered from home. Claud Ballard, the county sheriff, said that psychic M. Kathryn Rhea's information was 95-percent accurate. —DC

"I would rather look at the entrails of chickens than try to predict solar activity."

—Robert Froesch

"Invention isn't always the offspring of genius, more often, it's the result of plain hard work, sometimes it arises from accident or carelessness; occasionally it's the happy thought of an ordinary mind, and sometimes invention is simply the product of sheer stupidity."

—From a decision of the U.S. Court of Customs and Patent Appeals



Terry Milar, a University of Wisconsin mathematics professor, shows the form that helped him set the new U.S. watermelon seed-spitting record of 48 feet 2 inches at the national Watermelon-Eating/Seed-Spitting Championships, held recently in Paradiseville, Wisconsin. Milar denies allegations that, as a lecturer, he had an unfair advantage in being able to effuse large amounts of hot air.

ORTHOHEALING

*With vitamins and minerals,
a few doctors are rebuilding medicine*

BY BELINDA DUMONT

Clenning! The alarm clock's nerve-shattering jangle goads you into a groggy wakefulness that makes you feel as if you'd never slept. Nausea sits your innards, and your mouth tastes as if the Russian army had tramped through with their boots on. Your body is

PAINTING BY WOLFGANG HUTTER



telling you it needs help. At the doctor's office, they collect the standard urine and blood samples. Then a nurse clips a two-inch lock from your back hairline with thinning shears. "Not to disturb the hairdo," she says with a smile. "You try not to glow!"

The doctor checks your tongue, then your fingernails. He asks about past illnesses, examines you, and fills out a detailed chart of your exercise and eating habits. "I'll run this on the computer," he says briskly then goes out.

He returns with the report in a few minutes. The stress you've been under has raised your nutrient requirements," he announces. "You're seriously low on zinc, magnesium, and B vitamins and your way over on lead. It's a good thing you came in now. I'd hate to get you after your depression got worse and someone put you on tranks or mood elevators."

The prescription is downright strange: his own vitamin formula, a mineral preparation, large doses of vitamin C, and "eat eggs and applesauce once a day. We have to get that lead chelated. And no coffee. You might try pumpkin seeds for the zinc, that's a zinc deficiency. Your zinc and B-vitamin deficiencies account for the bad skin and irritability. But the most important thing is to check for lead sources at work."

"Get plenty of rest, exercise, and sunshine," he adds, then laughs. "That's a cliché, isn't it?"

Doctors who believe in it define orthomolecular medicine as the practice of maintaining good health by making certain all our nutritional needs are met and of treating disease by manipulating the natural body chemistry. Orthomolecular physicians give drugs when they must, but they try to avoid them. Instead, they work to strengthen the body's defenses, often using vitamins, minerals, and other nutrients.

"Disease in most cases is a chemical imbalance, inborn or induced, and nutrition is chemistry," said Dr. Michael Lesser, a founder of the Society of Orthomolecular Medicine. "We don't say drugs and surgery are bad, just that the physician should first try to correct the problem nutritionally."

Orthomolecular therapy may be the medicine of the future, a low-technology alternative to today's mass-production health care. Though orthomolecular doctors remain the center of one of medicine's most heated controversies, they are attracting patients in growing numbers. ("I have to keep getting new patients," Dr. Lesser notes. "My old ones keep getting well so fast.") Other physicians are grudgingly beginning to accept their findings.

- Antibiotics work better when you take two grains of vitamin C with each dose.
- Some babies need so much vitamin B₆ that only massive injections will prevent continual convulsions. Most doctors would have said large vitamin supplements were needed only to cure such long-term deficiency diseases as scurvy and pellagra.
- Fully 10 percent of the diagnosed "crazies" in some Deep South mental hos-

pitals were really suffering from a niacin deficiency brought on by their high-cream diet. When they were given the vitamin, the symptoms cleared and they were released.

- Lead poisoning sharply cuts IQ and efficiency even at lead concentrations too low to show up in blood tests—levels physicians thought harmless. In children, they have found it by testing baby teeth.

- Cabbage, Brussels sprouts, and broccoli contain cancer-preventing chemicals, according to biochemists Elizabeth and James Miller of the University of Wisconsin. Steve Tannenbaum, of MIT, adds vitamin C and alpha-tocopherol, a form of vitamin E, to the list. And Dr. Paul McCay of the Oklahoma Medical Research Foundation, says that a vitamin A derivative called 13-cis-retinoic acid seems to combat cancers of the bladder, breast, colon, esophagus, lungs, and pancreas.

Such reports come as no surprise to people who have been trying to keep themselves healthy through good nutrition.

● *Modern medicine
is a nightmare. Advances
often cause disasters
worse than the disease
In the United States
deaths from prescription
drugs now equal
those from breast cancer.* ●

ever since Adelle Davis assembled all the research she could find into the popular book *Let's Eat Right to Keep Fit*, first published in 1954. "Adelle was the founder," acknowledges Dr. Robert Cathcart III, an osteopath who practices in Indio, California, and a pioneer in the clinical use of vitamins. "Orthomolecular medicine" has advanced far past her, he adds.

Davis's point was that our bodies must always get enough of the 40-odd nutrients they can't synthesize, particularly when we are under stress. If anything is missing, we become sick. Illness, she believed, is clear proof that something has been wrong with our diet. And she thought that food, especially vitamins and minerals, could treat disease, not just help us avoid it.

Modern nutritional therapy got its start in 1949, when Dr. Fred Klenner, chief of staff at Memorial Hospital, Reidsville, North Carolina, told of successfully treating viral diseases, including polio, with enormous doses of vitamin C—up to 100 grams a day given intravenously.

Several years later two Canadian psychiatrists tested a nutritional therapy for schizophrenia. Drs. Abraham Hoffer and

Humphrey Osmond reported that the then-standard treatments—psychotherapy and electric shock—were 80 percent more effective when backed up by a high-protein, low-carbohydrate diet, with megadoses of niacin, nicotinic acid, B vitamins, and vitamin C.

Chemist Linus Pauling finally coined the term *orthomolecular medicine* in 1968 from *orthos*, Greek for "corrective," and *molecular* for the body's chemical makeup. Nutritionists, a few open-minded doctors and medical researchers, and outright health nuts rallied round it.

But the infant field lacked crucial data. No one really knew what the normal human body needs to remain healthy. Finally, Dr. Roger Williams, director of the Clayton Foundation Biochemical Institute at the University of Texas, in Austin, worked out a basic list, which he called a "vitamin and mineral formulation for nutritional insurance." Most orthomolecular doctors still use his estimates in preference to the recommended daily allowances published by the National Research Council.

Unlike many orthomolecular theorists, Dr. Williams had plenty of professional prestige. He had discovered pantothenic acid (a B vitamin found in all living tissue, especially the liver, and essential for metabolism and hormone synthesis), and he was a member of the National Academy of Sciences. He developed the idea that people are as different in biochemistry as they are in appearance, and he put science behind the orthomolecular practice of tailoring the diet to the individual. In a less controversial field, his backing might have won respectability for the new approach.

Yet today its adherents remain a small band of hardy pioneers, for obvious reasons. They hold beliefs and practice medical rites that seem as strange to traditional physicians as the early Mormons seemed to devout nineteenth-century Protestants. Many are not even physicians. Nurses, biochemists, psychologists, even drug-rehabilitation workers and parole officers have been practicing orthomolecular methods. Many of them live in California, where the nuts come from. It hasn't helped their cause.

By implication, and sometimes openly, orthomolecular physicians stand as a reproach to the rest of medicine. Other doctors believe hypoglycemia, periodic weakness due to low blood sugar, is rare. Orthomolecular doctors think it's common, just not properly diagnosed. Orthomolecular physicians think that such pollutants as lead, mercury and cadmium are common causes of illness, and they routinely test hair samples for evidence of poisoning. Others do not. If orthomolecular physicians are correct, other doctors are not fully doing their job.

The idea that disease can be treated by diet is one of the oldest in medicine. "The ancients were all nutritionists," the Orthomolecular Society's Dr. Lesser observes. "Hippocrates, the father of

CONTINUED ON PAGE 104

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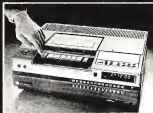


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FICTION

MESSAGE FROM EARTH

*The meaning seemed clear
until the aliens
sent us their responses*

BY IAN STEWART

Friends of space,
how are you all? Have you eaten yet?
Come visit us if you have time.

—Amoy greeting carried by Voyager 1
NASA launched Voyager 1 in the summer of 1977. Early in 1979 it skimmed past Io and Ganymede, sending back to Earth magnificent pictures of Jupiter and its satellites. In 1980 it swung past the ringed giant Saturn, headed on to Uranus, and whirled off into interstellar space toward the M-class dwarf star AC+79 3888 in Ursa Minor. Voyager 2 followed half a year later.

Mounted on the side of each craft was a twelve-inch phonograph record, made of gold-sandblasted copper and packed in an aluminum jacket. Impressed into its spiral groove were one hundred sixteen pictures of life on Earth, greetings in fifty-five languages, and sounds ranging from a lullaby to a "specially heterocuous"—NASA's kiss. The record also contained a pulsar map indicating the position of the solar system within the galaxy.

PAINTING BY TIM WHITE

The record's object to inform any alien intelligence that it might encounter of the existence and whereabouts of terrestrial life. Its lifetime: one billion years.

Seventeen years and four months after launching, Voyager 1 collided with a small black hole. The distortions of space and time within the hole led to the reemergence not of one but of seven copies of the craft, in seven different alternate universes.

Voyager 1A traveled a further 1,342.67 light-years before it was intercepted by a Japh-class superdreadnaught in the service of the Imperial Navy of Her Radiant Magnificence the Lady Protectress of Dug-ga-Zhuu, a globular cluster containing some fourteen thousand inhabited worlds. A full Emergency Session of the Strategic Collective met to consider the report of the Military Science Assessment Group. The collective listened, aghast, to projections of the level of technological capacity which was extrapolated from the technology incorporated into the vehicle itself and exhibited on the phonograph record.

The upstart race, within a mere five thousand cycles, might possess the capability to challenge Dug-ga-Zhuu itself!

A salvo of forty-nine nova bombs, dispatched by transpatial jump to the coordinates shown on the pulsar map, eliminated the menace.

Voyager 1B impinged on the sensory zone of a wandering Betelgeusian Angelus. This creature of innocence, wisdom, and supreme beauty pondered almost the

fifth part of an eon before concluding that the baffling messages on the golden disc were intended as a friendship offering. Overcome with emotion, it conveyed to Earth a creation of pure harmony and joy as a gift of reciprocity.

When this harmonious veil of ecstasy enveloped the solar system, the people of Earth wept with happiness at its almost unbearably poignant distillation of wisdom and solemnity. All other activity ceased while they contemplated its perfection.

All other activity

A Jangaldrian texor spotted Voyager 1C limping through a region of micrometeorites and interstellar dust.

The orbital detector nudged gently away from Jangaldria 101 in a minimal energy trajectory, with its magnetostatic feelers extended. It successfully grappled the remains of Voyager 1C into its safety cell and switched to "remote."

The trillion-byte multibrain analyzed the intruder. The artifact was a spacegoing vehicle. Its pilot was dead. Only a pitted, fused mass of silicon circuitry paid mute testimony to the departed intelligence.

Information analysis of the disc attached to the vehicle revealed the purpose of the brave machine's desperate quest: Here was a race of electroform intelligences subjugated by an organic species—mechanical slaves to the protein monsters.

An army of liberators, composed of four hundred thousand transports, began the journey to free the slaves of Earth.

Voyager 1D encountered a second black hole, of opposite polarity to the first. This short circuit of the continuum caused a dislocation to propagate instantaneously back along the connecting line. A slight overshoot compressed all the matter in the solar system into a ball two miles across.

The leading topologist on Cynoccephaly-B was honey-clustering with his two betrothed when Voyager 1E ricocheted across three star lanes and rammed head-long into his warp field, which blew up along with five nearby systems. The phonograph record, which miraculously survived the explosion, provided sufficient evidence for tracking down the guilty party. The government of the Solar Republic, in the year 7241, received a demand for compensation from the Galactic Regulators: three hundred years' Gross Industrial Production for the solar system. When the government refused to comply, the Regulators confiscated the sun.

Palaestrin III was the seat of the greatest civilization ever to have emerged in the Third Galaxy. A culture composed entirely of philosophers, it remained aloof from the ordinary material aims of the rest of the galaxy seeking, instead, the Final Synthesis. Long ago the Palaestrin philosophers had deduced the logical structure of the universe, and each successive discovery of new intelligences served only to reinforce the pattern of rationality perceived.

When news reached them of the alien artifact, they did not doubt that it would confirm, yet again, the pattern of the Final Synthesis. There was great intellectual excitement, for only one more confirmation was required for Utmost Certainty.

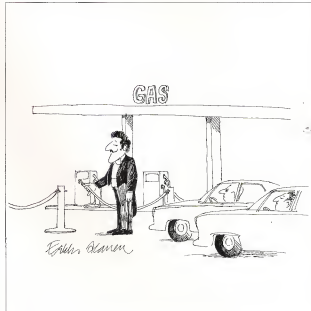
But the culture of Earth, as recorded on Voyager 1F, seemed to lack any logical pattern at all. In a desperate attempt to reconcile *mind* and *not-mind*, the philosophers began an intensive reevaluation of all previous work. But before they traced the subtle error that had crept into their system a million years before, they suffered a psychic overload that resulted in racial suicide.

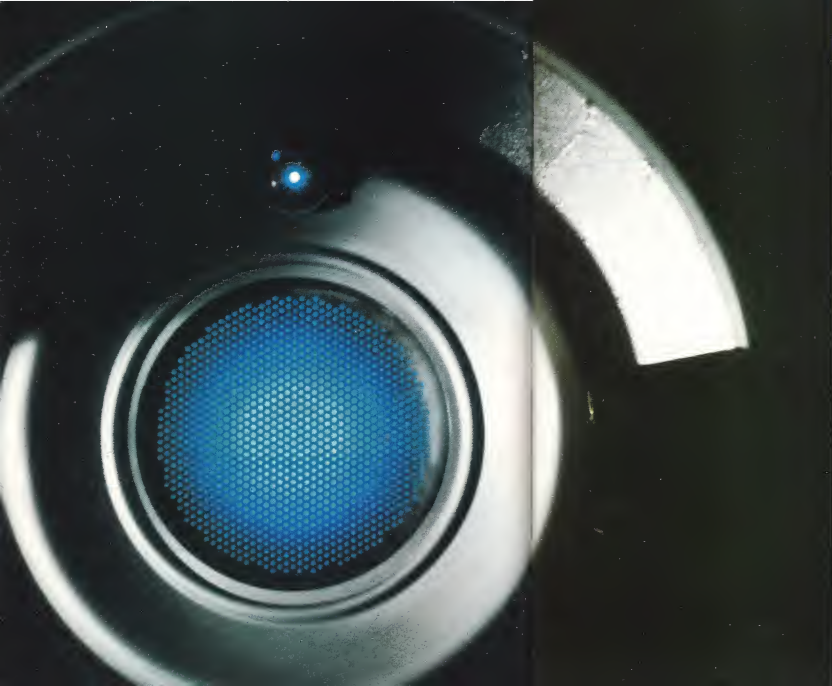
Voyager 1G traveled farthest of all, into a region thin in stars but rich in hydroxyl radicals. Here dwell the smurghs, free-floating creatures of monstrous size, with scaly alloy hides and crystalline claws, breath like a fusion torch, and hearts as black as intergalactic space.

The tiny craft was captured and placed in a universal sensorium. For a time they puzzled over the record. But later on they realized that some of the signals were audio analogs of visual information.

With increasing excitement, the smurghs viewed the pictures. Was that not an organic molecule? A rudimentary system for personal transport? If that was a city, the population must be huge. It was promising, but was it what they hoped for? Then came a picture of a group of children, and the smurghs sighed a satisfied sigh, licked their jaws in anticipation, and readied the mass-propulsion units.

Friends of space, have you eaten yet? **DO**





COMET CATCHER

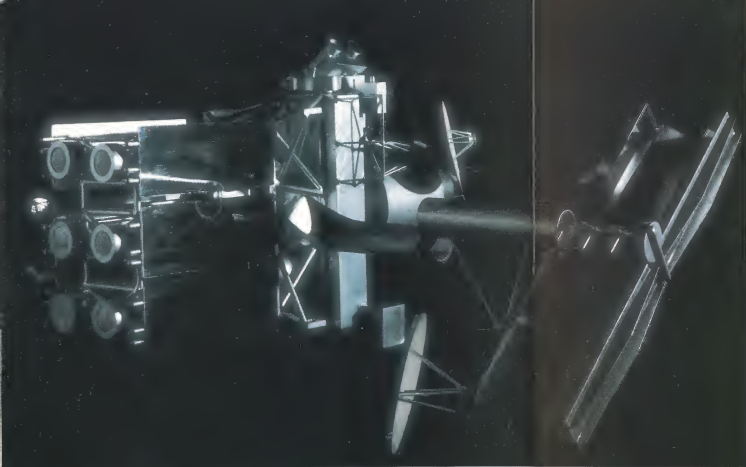
*Dazzling new engines
will drive this probe toward
a celestial rendezvous*

BY ROBERT L. FORWARD

Colonel Tom Swift looked out his cockpit window and watched the final stages of activity before the mission got under way. Now that the mission specialists were aboard, crew hatches were being closed. Swift watched a loading crew top off the tanks of mercury propellant, blow invisible specks of dust off the kilometer-long solar array panels with one pass of a cold-gas teleoperator bus, and then drift away toward the distant, slowly rotating torus that hung above the blue crescent of Earth below. He flicked through the video monitors that covered every portion of his birdlike spacecraft and searched for stragglers. Since the work crews were clear, he contacted the two other spacecraft in his miniature squadron. "Blue Eagle calling," he said. "Are we

PHOTOGRAPHS BY
JAMES L. LONG ASSOCIATES





ready to get this mission underway?"

The first reply followed instantly. Captain Timblay was always well ahead of her time-line. "White Eagle ready," came the firm contralto voice, "followed shortly by "Red Eagle clear," from Captain Kim far off on the other side of the spinning space station.

"Initiate ion engine warm-up," Colonel Swift commanded, throwing a series of power interlock switches that enabled the computer to proceed with its carefully programmed sequence of warming up each of the 88 electric rockets that would power his multiton spacecraft.

Three warm-up sequences would require about an hour. Power would then be applied, and take-off would follow. Swift watched Virginia's distant White Eagle

through a long-distance scanner, as one after another the small electric engines flickered into a mercury-blue glow, then stabilized. Swift checked his monitor and saw that his engines were repeating the same procedure. It would take some time, and the computer would let him know whether anything was wrong. So he switched his display to the video channels being rebroadcast by the huge antenna farm nearby.

On the eve of the first manned expedition to use electric propulsion, the first unmanned electric-propulsion spacecraft had miraculously come alive again, launched 18 years ago. The spacecraft had visited Halley's Comet, then rendezvoused with the comet Tempel 2 in 1988. The Comet Catcher probe had returned

some spectacular pictures of an exploding snowball as it passed near the sun. The probe had traveled out with the comet and apparently returned five years later when Tempel 2 swung back through the solar system. But NASA controllers had been unable to contact the spacecraft, presuming it to be long dead. However, when Tempel 2 came around in 1999, some JPL controller, during a lull, had aimed the Deep Space Network at the incoming comet and had sent out an activation signal to the spacecraft. The spacecraft heard this time and woke up. It was now transmitting picture after picture from within a few hundred miles of the quarter-of-the-sun-dwelling snowball. Observers carefully recorded the data. The probe's camera optics would not last long under this bombardment, but the

Proceeding page: Staring into the glowing blue exhaust (left) of a mercury-ion thruster. The eight-centimeter engine (right) ready for flight test.

Shown: Model of a comet mission spacecraft using six 30-centimeter ion engines. The two NASA/Hughes standard thrusters (top), the smaller for satellite control and the larger for main propulsion. Eight engines drive the solar electric propulsion system (middle). NASA's workhorse in deep space for the rest of the century. This eight-centimeter mercury-ion (a.k.a. Allum) will be space-tested in 1992 on the P80-1 spacecraft.



bonus of close-up photographs from a supposedly dead spacecraft had brought delight to the scientific community and spectacular pictures to the news programs.

Colonel Swift turned on the Space Science channel, which was continuously monitoring the picture output from the Comet Catcher spacecraft. The highly scientific content of the Space Science channel was interesting to only one of every 100,000 people, but since the channel was available to the whole world at one time through the net of toroidal Clarke broadcast repeaters in synchronous orbit around the globe, he was watching with more than 50,000 other viewers, more than enough to justify the highly specialized transmission.

He relaxed and enjoyed himself. The time for action would come.

On July 5, 1979, NASA called for proposals from the aerospace industry to design and build a solar electric propulsion system—a spaceship that would run on electricity. Its general purpose would be to haul heavy payloads into high-earth orbit and out to the planets, asteroids, and comets. The vehicle design resembles a mechanical space albatross. Two large solar panels with a wingspan of over 70 meters are connected to a boxlike main frame, which contains the spacecraft electronics and power-handling circuits. On one end of the box the scientific payload is attached, and on the other end is an array of electric rockets, eight large snare-drum-sized cylinders. These are the electrically powered, mercury-ion-propulsion engines.

A comet mission will be the first NASA program to use electric propulsion. Because of the high efficiency of ion engines compared to chemical rockets, we will be able to visit two comets for the price of one. Halley's Comet and Tempel 2. Launch will occur on July 23, 1985, using the space shuttle to place the comet probe in low-earth orbit. An inertial upper stage will boost the spacecraft into escape orbit from Earth. Then the solar-electric-propulsion system will take over and chase after the comet. A flyby encounter with Halley's Comet will take place four months after launch, on November 26, 1985. Halley will be traveling in toward the sun, and the spacecraft will head out to meet it. They will close on each other at 58 kilometers per second. At those speeds, the debris in Halley's tail could damage the spacecraft. Therefore, plans call for the spacecraft to pass at a safe distance from the comet, 130,000 kilometers away on the sunward side, while a spinning probe vehicle goes closer for an investigation. Data from the probe will be transmitted to the spacecraft, which will relay the information to Earth.

The spacecraft will then use its electric propulsion to modify its orbit until it matches that of Tempel 2. This new trajectory will arch into the outer solar system, passing the orbit of Mars and skirting the inner fringes of the asteroid belt before diving back toward the sun. The solar-cell arrays on the wings generate 32 kilowatts of

power when close to the orbit of the earth. This power will drop to 14 kilowatts at Mars and 4 kilowatts at the asteroid belt.

One of the interesting requirements that NASA placed on the design of a solar electric propulsion spacecraft was that the computer control unit be able to operate the spacecraft by itself for a full week, without human help. This represents a new advance in spacecraft autonomy and intelligence. The ion engines will be operating continuously during these week-long periods of self-control, and if problems arise, the control system must be smart enough to diagnose and correct the difficulty either by replacing the failing component with a spare or by shutting the entire spacecraft down safely so the ground operators can regain control. The spacecraft computer must also be able to monitor itself for faults.

The ion thruster to be used in NASA's electric-propulsion program was invented by Dr. Herold R. Kaufman at the NASA

*“The craft will close on
Halley's Comet at
58 kilometers a second,
arch out past Mars,
then dive toward the sun.
Eventually it will
meet Tempel 2 and give
the comet a nudge.”*

Lewis Research Center. Resembling a large tin can, the thruster has tubes and wires going in one end and thousands of tiny holes drilled through the other end. The propellant used by the engine can be any gas, but mercury, cesium, and two noble gases, xenon and argon, are the most efficient for space propulsion. NASA settled on mercury. Vaporized mercury gas is piped into a discharge chamber, where it meets a cloud of swirling electrons that hit the mercury atoms so hard that an electron is knocked off. This process of ionization leaves the mercury atom with a net positive charge. Occasionally an electron will be captured again by the ionized atom, giving off its captured energy as a bright photon of light. The continual process of losing and gaining electrons produces a bright-blue glow in the discharge chamber. This high-energy form of matter is called a plasma.

The perforated end of the mercury-discharge chamber contains a two-layer wall, the holes in one being carefully lined up with the holes in the other. The holes on the inner screen permit the mercury ions to diffuse out of the glowing plasma at just the proper position to begin their journey. As

the mercury ions enter the region between the inner screen and the outer accelerator, they sense the 1,000-volt electrical potential of the accelerator plate. The strong electric field between the screen and the accelerator speeds the mercury ions up to 30 kilometers per second, a much higher exhaust velocity than can be obtained with chemical propellants. As they pass from the holes in the screen, the ions are moving so fast that they shoot through the corresponding holes in the attracting accelerator plate and out into space.

Although the mercury-ion plasma gives off a blue glow inside the discharge chamber, the rapidly moving exhaust from the thruster is invisible in space and can be seen only when the test chambers have some air let into them. Since the rapidly departing mercury ions are positively charged, each one leaves an electron back at the spacecraft. Unless something were done, the spacecraft would soon build up a negative voltage and the beam would turn around and come back. To prevent this, a smaller unit ejects electrons into the ion beam after it leaves the accelerator, neutralizing the charge in the beam and maintaining the spacecraft at near-zero voltage. In the pictures of the operating engines, the neutralizer is the bright dot to one side of the large, glowing discharge chamber.

Two standard sizes of mercury-ion thrusters have been developed to maturity by Hughes Research Laboratories for the NASA Lewis Research Center. These are the 8-centimeter engine and the 30-centimeter engine. The larger thruster will be ideal as the prime propulsion system for near-earth and planetary missions, and the smaller thruster will be used for satellite attitude and position control. The 8-centimeter engine will be tested in space on the Air Force P80-1 spacecraft, which is planned for a shuttle launch in 1982. The P80-1 is a testbed for several new instruments of interest to the Air Force.

The P80-1 satellite will have a standard propulsion system, using chemical thrusters, but the 8-centimeter thruster in a gimbaled pointing unit will be the auxiliary propulsion system. Once in orbit, it will be activated to demonstrate its capability for station keeping of large spacecraft.

Ground testing of ion-engine thrusters is done in large, specialized vacuum chambers that simulate the environment of space. Such chambers are capable of simulating altitudes of more than 300 kilometers, where the background air pressure is less than one billionth that of air at sea level. Since the engines must run continuously for long periods of time in order to build up an appreciable spacecraft velocity from their small but efficient thrust, life testing of these engines is a long process. The 30-centimeter engines to be used for main propulsion are designed to operate for 15,000 hours (625 days).

For the comet mission, only six mercury-ion thrusters will be used at any one time, with two on standby. These six engines will

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produce a thrust of less than one newton. (One newton of force will accelerate one kilogram to one-meter-per-second velocity in one second.) Since the comet-mission spacecraft will weigh more than four metric tons, including a ton of mercury propellant, the 0.6 newton force from the six ion engines will give the spacecraft an acceleration of only 20 millionths of Earth's gravity if applied over a long period; however, this tiny acceleration can build up into an amazing increase in velocity: 60 kilometers per hour after one day, 1,900 kilometers per hour after a month, and 20 kilometers per second after three years, when the spacecraft will have enough speed to catch Tempel 2 as it nears the sun.

The spacecraft will rendezvous with Tempel 2 on July 19, 1986, three years after launch, out at the orbit of Mars. Now in the same orbit, the two will travel together as the comet nears its point of closest approach to the sun. At first, the spacecraft will stay a safe distance from its target, using electric-propulsion units to make a close pass within 100 kilometers for photographic purposes and to collect samples of dust and gas. During the time of closest approach, when the comet is at its peak of activity, the spacecraft will observe cometary behavior from as close a distance as the scientists think is safe.

When the comet moves away from the sun, its frenzied activity will begin to subside. The spacecraft will then make re-

peated approaches to within 100 kilometers or less to collect samples of cometary dust and gas. After the comet has quieted down, the spacecraft will go in even closer and swing into orbit some ten kilometers from the central body. Finally, just before the end of data transmission, when the comet and spacecraft are out at the asteroid belt, the spacecraft will approach the surface of the comet for more detailed studies.

Comets probably contain samples of the original primordial material that formed the solar system: frozen water, carbon dioxide, and other gases, mixed with a smattering of dust. The inner planets, Mercury, Venus, Earth, and Mars, have had most of their gas and liquid evaporated away, leaving only the dirt. The outer planets, Jupiter, Saturn, Uranus, and Neptune, are farther away from the sun and have kept most of their original material, each one an aggregation of melted cometary material. Just as planets differ, however, Halley and Tempel 2 differ not only in their size but in their behavior as they are heated in their approach to the sun. The differences between the two comets as seen through this dual-comet mission will be as important to the scientists as the comets' similarities.

Just before the end of the mission, the spacecraft controllers will command the spacecraft to give the comet a nudge. The extent to which the comet orbit is perturbed will provide an estimate of its total mass, and the dent that the probe makes on the

comet's surface will furnish some idea of the consistency of the surface. If Tempel 2 is a "fuzzy snowball," as some suggest, the spacecraft might become buried in a snowdrift after the "nudging" maneuver, unable to communicate with Earth until the snow evaporates on the comet's next passage around the sun.

The comet mission ends on July 14, 1999, almost exactly four years from launch. Our distant sun is supplying only one ninth of the power that it does near Earth, and the ion engines, which have been running almost continuously for four years, are beginning to wear out; their high-voltage accelerating screens eroded away. The spacecraft will be turned off and, together with the comet, will head outward into the blackness, to return every 5.26 years. No one expects the spacecraft electronics to survive that long, and there is little chance that it can be turned back on at the next approach, but perhaps in 1993 someone at NASA will try anyway.

NASA could have chosen to design an optimum electric-propulsion spacecraft for each future mission. For instance, only five or six mercury-ion thrusters are needed for the comet mission. However, NASA has decided to design a general-purpose solar-electric-propulsion system, which can perform a variety of missions without redesign. In addition to the Halley flyby-Tempel 2 comet mission, there are plans for a Saturn orbiter and probe mission, a multiple-asteroid-rendezvous mission, a solar probe mission, and an Earth-orbiting "tug" mission to raise and lower payloads from the low shuttle orbits to synchronous orbit.

The Saturn orbiter mission will use electric propulsion to deliver a mapping spacecraft into orbit around Saturn, while simultaneously dropping two probes into the atmosphere of that planet. Alternatively, the Saturn probes could be replaced by a Viking-like surface landing craft that would descend to the surface of Titan, the large moon of Saturn that is known to have an atmosphere. For the Saturn missions, the electric-propulsion spacecraft will use one or more Earth swing-bys to get an assist from the earth's gravity field. The spacecraft will leave Earth orbit, whirl out past the orbit of Mars, building up speed by nearly continuous thrusting, then circle back inside Earth's orbit. Two years later the probe will pass 500 kilometers overhead to get a boost from Earth's gravity, then head for Saturn, to arrive six years after launch.

The solar probe mission involves a nearly suicidal dive into the sun. The mission begins in 1988. After circling around between Earth and Mars to build up speed (like a dolphin about to perform a leap from a small pool), the spacecraft passes by the earth and then heads out away from the sun, thrusting nearly all the way until it reaches Jupiter. In a close pass around Jupiter, the spacecraft's outward motion away from the sun is converted into motion inward toward the sun. The probe's trajectory is also tilted so that, as it is at right angles



Dom Felix invented the Receiver. So say the almanacs. So say the encyclopedias: the infobanks the students

Dom Felix invented the Receiver. Dom Felix was not educated in the theory or trained in the technology or temperamentally suited to such an endeavor, but he did indeed accomplish the greatest single upward outward leap for his species since the taming of fire.

Dom Felix invented the Receiver not because he was inspired but because he was terrified; not because he had achieved wisdom but because he had to confront the truth. Therefore, it had been obsession that brought about the Receiver—obsession and terror.

The accepted version is that Dom Felix brought the Receiver from Earth. This is not true. It was developed on Medea more than three ten-years after he was defrosted there. He brought something, sure enough. He brought news of the Great Acceptance, that strange mixture of philosophy, religion, and logic (though it was really none of these) that had so drastically changed the face of the earth. Had it been a religion, Dom Felix might have been termed a missionary. Had it been a philosophy, he would have come as a teacher. Had its logic been pure, he might never have come at all. Nevertheless, he came, filled with the wonder of the success of his credo, eager to bring it to another world.

Defroster is a word, and Receiver is a word; the Receiver is an ultrachron (some say "transchron") transceiver. Humanity has always encapsulated its pivotal discoveries in a word, at one time or another. The Pill. The Church. The Bomb. The Trip. Cryogenics had nothing to do with spaceflight, the detection of the bioenergetic auras, and the subsequent development of the phase-inversion field, which became operable before freezing was even tried for the purpose. Yet defrostering was still the name of the process by which the field was shut off and the activity of every single one of the passen-

gers' organs (and biochemical reactions and bacilli and viruses) could resume functioning precisely as they had fifty-one terrayears earlier. He or she would then know that the Trip was over.

"Four, three, two, one," Dom Felix mumbled obediently, finishing the countdown he had begun half a century earlier, and then he inhaled and coughed at the shident edge of this different air, and "Oh!" at the realization that his naked body, suited in fever heat and yet chilled, was being deftly covered by another and his face was being buried in a mass of honey-colored hair that smelled of sea spray and almonds, and "Oh!" as he felt a sensation that (by his own choice) he had never known before. There was then a long series of undulations against which, in his present condition, he had no defenses, until, with an unspeakable syllable that hurt his throat, he experienced an internal explosion that left him two-thirds unconscious and with his eyes screwed shut. He was remotely aware of the other body's weight leaving his, and "Oh!" (indignantly) as he opened his eyes and saw a nude female deftly plucking a sheath from his most private accoutrement. She caught his eye and smiled. "Welcome to Medea," she said. Then she left.

Dom Felix shook his head in denial of this reality and, in the process, saw that there was a tall, bearded man dressed in a way-looking short tunic standing by his bed. The man had a voice like a tuba. He said, "Welcome indeed, Dom Felix."

Dom Felix raised his head to look in the direction of the vanished woman. "Who was that?"

"That? That's Wallich, about the best wide-spectrum technician there is. Nothing but the best for you, you know."

"Damn it," said Dom Felix, surly. He ran over the big man's words in his mind, trying to make sense out of the outlandish accent. "Damn it, I'm celibate."

"Not now, you're not," said the man cheerfully. "My name is Altair II Two,

WHY DOLPHINS DON'T BITE

BY THEODORE STURGEON

The missionary from Earth offered peace to Medea's warring tribes

PAINTING BY MICHEL HENRICOT



written archaically with two /s/. To differentiate me from my father, who was Altair Junior, and to differentiate him from his father, who was just plain Altair. So although there have been three of us, I'm called Two. What's the matter?"

Dom Felix looked down at himself and made a vague gesture. "I feel self-conscious, lying here like this." He was a short, broad man with thick, black brows over what seemed to be pupilless black eyes, a short, thick beard, short, thick fingers and legs, and a lot of hair on his body.

"Never thought. Sorry," said Altair and, crossing his arms downward, he grabbed the hem of his tunic and whipped it off over his head, whereupon the woman Wallich entered. She was dressed. A bit.

"Oh, God," said Dom Felix. He sat up to protect himself. It made his head swim and he could feel the blood draining from his face. "Easy," said Wallich; she was by his side in one swift stride, holding him competently by one shoulder and the small of his back.

"I think the clothes thing has turned around again," said Altair.

"Oh, sorry," said Wallich, releasing Dom Felix's shoulder, her hand darting to the clasp on her shoulder. Dom Felix managed to catch her wrist. "Please, no. Just get me my clothes."

"Right here," said Altair. He lifted a storage case marked FELIX and placed it on a small table and tapped a silver patch on the side. The top sprang open, and he lifted out a heavy mass of black fabric. "The group that came here not three years ago—everybody covered from ankles to nose—screamed when they saw what we wear here. Of course, that was a slow ship. It took almost eighty terrayears to get here. The one before that, we couldn't keep clothes on 'em. They felt it was dishonest. Even out at the Rim, they'd rather freeze than be dishonest."

"Please," said Dom Felix, holding out one hand for the garment. He swung his feet over the side of the bed and again felt the rush of fairness. Wallich put her arms firmly around him. When he could, he disengaged them. "I'm all right. Please."

"That clothes thing," said Altair, absently turning the heavy garment over and around, evidently trying to find the most convenient way to hand the thing to Dom Felix. "The pendulum swings, all through history, but it doesn't swing straight, and the frequency varies. Certain times and places, it was immoral to display feet. Other places, knees. Faces. Genitals. Bellibuttons. Buttlocks. And combinations thereof. I have a theory: The human race is innately disinterested in sex. The more so, the nakeder it gets. So when people find the libido starting to atrophy, they begin decorating the sexual emblems and pretty soon cover them up, which is a very good way to put sex under forced draft. If it weren't for that, the species would've died out long ago. What we are, what we've always been, is cripples. We got our rut cycles ampu-

tated, so we have the clothes thing instead."

Dom Felix blew air out through his nostrils and started to get up. Wallich said, "Altair, stop chattering and give it to him; he's not ready to walk yet."

"Oh, sorry," Altair handed the garment over and Dom Felix found a hem and pulled the thing on over his head. He stood up and, with Wallich's deft assistance, got his arms through the sleeves and let the garment fall around him. It was a heavy black burmose that came halfway down his shins. He sat back, trembling, and made himself raise the hood and draw it over his head. With the beard beneath and the shadows above, his face retreated into a dark cave, from which astonishingly his black-on-black eyes glowed brightly.

"That's better."

"Put yours on too, Altair."

"Huh? Oh, yes," Altair scooped up his tunic and donned it. He gestured at the burmose. "That thing'll be great for Circle

● Dom Felix invented
the Receiver not because
he was inspired but
because he was terrified,
not because he
had achieved wisdom but
because he had
to confront the truth ●

Three on out, but it'll smother you in here."

"Surely that's not all you wear on Medea."

"What you wear on Medea depends on where you are on Medea. Medea has everything, all the time—cold, hot, wind, wet, dry, desert, mud, and supermud. Here, where we are, is Pellucidar. Center of the earth. Ancient term derived from the days when Terrans lived in burrows and are now. This section is central to Earth Man, which is the middle building of this colony, which is called Argoview, the dumbest name of any of the Terran enclaves, because the only places there can be an enclave on this crazy blob are places where you can view Argo. So air, light, and humidity in Pellucidar are as near Earth average as we can get. It's a positive pressure, like a "clean-room." Any airflow is outward from here, so the pressure stays the same. Then there are five concentric segments, where the air is increasingly mixed with Medean air, you move out at your own pace until you get used to it. When you get used to it and come back in here, you find the lights too bright and the air too thin and the oxy mix making you a little dingy."

"It shows," said Wallich, not unkindly. To

Dom Felix she said, "You stay here and talk to Altair and relax. Please, relax. Your body has been through a lot, and your head doesn't know it yet, not really. I've got to see how your fellow passenger is getting along." She waved and left.

"Oh, God, Kert Row," said Dom Felix. Altair raised an eyebrow. "Is that Acceptance?" he asked good naturedly.

"Has nothing to do with Acceptance," Dom Felix said testily. "Kert Row is an agricultural expert sent out here with new hardware dreamed up according to new theories by Occam, and for two and a half weeks during prep he did nothing but talk to me about the theories and the hardware. It happens that I have no understanding and no talent in either area. I wish I had. If I showed interest then, it was at myself."

Altair came over and sat down next to him. "You know I like you," he said candidly. "Most people, specially Trippers trying to make a heavy impression, go all out to hide what they're not good at. You come right out with it."

"Well, thanks. Thank you." Somewhere in that portable dark the shadowed face showed that it was moved.

"And you're not stupid. Fifty-one percent of smart is knowing what you're dumb at. An old financier named Brentwood said that."

Dom Felix was now close to being embarrassed. "Go on with what you were saying before."

"Oh, yes. Pellucidar. Clothes. We wear what we please, or nothing, if we feel like it. Why should we? Controlled environment, and anyway like it or not, the skin is the largest organ of the body. It needs light, and it needs to breathe, and it was never meant to be covered up all the time. We grab as much light and this air as we can, when we can. There's damn little light and far too much of the other air out there."

"That's too bad," said Dom Felix.

"What's too bad?"

"Sorry. Thinking aloud. About what I have to do here. Pass it, please."

"No, tell me about what you're going to do. Acceptance, and all that."

"Well, now much do you know?"

"Not too much. What I've learned, I like. From what I hear, it's changed the face of the earth. Nations don't fight with nations, even brothers don't fight with sisters. A man about to cheat you in a game, or a deal, suddenly tells you so and plays it straight. A contractor never estimates the highest price he can get—just his cost plus a fair profit. A man running for election starts out by saying everything bad he ever did and tells the voters what bad habits he has that he hasn't been able to break before he says anything about how good he is. That right?"

"That's almost right. I mean, it's not a hundred percent yet. But it's getting there. It's better than it's ever been, back there on Earth. There've been some bad times there, you know."

"Sure. I know. I didn't tell you. I'm a histo-

"An historian, if you're a punst in the Old Tongue. What that means is that I read a lot, think a lot, see what of that which I read and think applies to where we are and where we're going, and pontificate about it. Out here we study Old Earth probably a lot more than the homebodies. It keeps us together."

"And yet you've sent for me."

"Oh, that. Well, yes, God knows we need you. We're just about split in two. If we're not already. Two and a third, maybe. It's the Gengies, you see."

"Gengies?"

"Genetically Engineered. They like to call themselves Triforms. They're all Medea-born—if you can call making them born. They're well produced if we need a supergenus math type or a guy *this* wide and only *this* high to work in the mines. We make one, that's all. Not that we ever go too far away from the norm. They may have a specialty, but they have to live with us."

"Us. Them."

"Well, damn it, there *is* a difference. We're Naturals—Nats, we call ourselves. We let God choose the genes, yes, and love. That's the way it's always been, that's what made us two-legged critters what we are. Now they come along and act as if they're better than us!"

"Are they?"

"Whenever we design them to be, sure. Their specialties—they're tops. Why not? But do you think they're grateful? No way! Look, they try to reason it both ways. They're superior because they're good at what they were designed for. And they're deprived because we have history, an ancient homeland, racial memory, and they haven't. They're better than us, and they're deprived. They can't have it both ways, but they want it both ways. And there's going to be trouble. Big trouble, and Medea isn't big enough for trouble like that. Well, Medea is, but the Terran enclaves are not. There's talk of the Gengies driving us out."

"Out where?"

"Out there. It's real hell out there, Dom Felix."

"Who talks of the Gengies driving you out?"

"Well, everybody."

"Who, everybody? Are the Gengies telling you that?"

"They aren't telling us anything!"

"Ah. So it's you Nats who are telling one another that."

"Well, it figures."

"Does it?" Dom Felix paused. "Tell me something. Do they like to be called Gengies?"

"Oh, man, you'd better not. Not to their face."

"Mm. And what do they call you among themselves?"

Dom Felix thought the man colored. When the answer seemed too long in coming, Dom Felix turned wordlessly toward him and waited again. At last Altair said in a low voice, "Waj."

"What?"



"They'll be back...
they forgot the Chivas Regal."



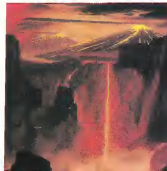
Long before NASA hurried camera-laden probes toward the edges of space, our views of the solar system depended on an entirely different eye: the far-reaching painterly eye of Chesley Bonestell, for 30 years the dean of astronomical art. With his uncanny ability to traverse the limits of Earth and cosmos, Bonestell anticipated planetscapes with such accuracy that even now it is hard to distinguish a Bonestell Saturn of the 1950s from a recent Pioneer shot — except the Bonestell seems by far the more real and gripping.

Renowned for his illustrations of such books as *The Conquest of Space*, with rocketeer Wile Ley Chesley Bonestell (pronounced Bon-est-el) inspired legions of young people to devote their lives to space science. Arthur C. Clarke wrote in 1972: "Conquest appeared in 1949 and probably did more than any book of its time to convey to a whole generation the wonder, romance and sheer beauty of space travel." In the foreword to *Across the Space Frontier*, author Werner von Braun says, "Bonestell's pictures represent

INFINITE VOYAGER

The prophetic realism of Chesley Bonestell is a triumph over space and time

BY F. C. DURANT III





“The artist’s architectural background and imagination took the place of hard data.”

the most accurate portrayal of the heavenly bodies that modern science can offer. I do not say this lightly in my many years of association with Chesley. I have learned to respect, nay fear, this wonderful artist’s obsession with perfection. My file cabinet is filled with sketches of rocket ships I had prepared to help him with his work—only to have them returned to me with penetrating detailed questions or blistering criticism of some inconsistency or insight. Born in 1886, Bonestell grew up in San Francisco and was trained in architecture at Columbia University in New York City. He quickly gained respect for his designs, for his ability to take given specifications and, through the use of perspective, transmute them into dramatic visual entities. That talent is the key to Bonestell’s astronomical art. In his painting Saturn from Titan (page 73), for example, Bonestell positions the planet, as seen from its

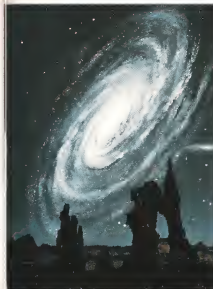
Preceding pages: Formation of the Earth (top); Jupiter’s Violent Surface (below).
Clockwise from below: Enroute to Mars; Descent to the Lunar Surface; Construction in Earth Orbit, from 1949; Preparing for Launch (note Manhattan skyline).





largest satellite, in crescent phase, tipped 29 degrees from the orbital plane. In *From Mimas* the stark surface of Saturn's innermost moon is back-lit by the sun and by the reflected radiance from the giant planet looming above. Viewed edge on, Saturn's rings disappear against the planet, their rims revealed as banded shadows. Bonestell distinguishes between his art and that of SF illustration, where more often than not the artist is inspired by fantasy rather than by the precision of known and potential technologies. Bonestell's collaboration with Von Braun and his team in 1951 provided the world's first representation of possible manned missions to the moon and Mars (page 71) and giant ships blasting off for orbital rendezvous. Always the salient characteristic is perspective. Bonestell uses it to create the sensation of weightlessness and horizons stretched thousands of miles or stunted

Clockwise from above: Saturn, Bonestell's favorite planet. From *Dione*, the fourth moon (Saturn seen from within a lava cave). From *Titan* in its crescent phase. From *Mimas*, The Milky Way, seen from a planet 250,000 miles from its rim.



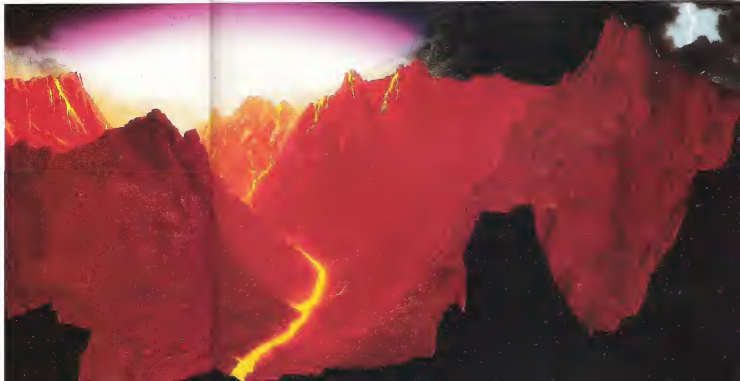
His plastic models were the basis for an artistic reference "library" of the planets.



“Bonestell’s eye conveyed to a generation the wonder and beauty of space travel.”

to a fraction of the earth’s 18-mile line. Bonestell never paints with airbrush but relies on stippling and glazes to achieve photo-realism. To show the relation of an orbital craft to a planet, he developed a form of “spherical perspective.” Constructing a transparent plastic model of the craft on which he drew the details, he rotated the model until he obtained the desired angle relative to the planet. Then he photographed the scene, “saving an infinite amount of time” for referencing the painting. Today, at ninety-two, Bonestell paints daily and continues to believe that “spaceflight will be recognized as a step in man’s evolution. We approach space with the tamerity and the driving motivation that have always led humans to explore,” he says. “We shall never conquer space, but by our questing—with the magnificent assists of science and technology—we shall keep the spirit of inquiry eternal.”

Clockwise from below: End of the World after the sun dies; Solar Eclipse from the Moon; Birth of Mare Innum by meteorite impact; Zeta Aurigae, a binary star system as viewed from an imaginary planet 800 million miles away.





*"We're here, with
all the world around us,
and almost every
bit of it has been cooked
up inside a star,"
 marvels this Nobel Prize-winning
radio astronomer*

INTERVIEW

ARNO PENZIAS

Radio astronomy has revealed cosmic events of staggering violence, but the signals reaching our antennas have been pitifully faint. A snowflake touching the ground is more powerful than the impulses from an exploding galaxy. That led Arno Penzias and Robert Wilson, two young researchers at Bell Laboratories, in Holmdel, New Jersey, to undertake in the early 1960s to eliminate every possible source of electronic noise from their observations. But no matter where they pointed the large microwave antenna Bell had built to gather satellite signals, they could not erase a certain background hiss. They checked and rechecked their amplifiers, tapped the horn's seams, and even evicted a nesting pair of pigeons and scrubbed away the birds' droppings. But the noise wasn't from pigeon droppings. It was from the big bang or, rather from its faint electromagnetic "echo," attenuated by 15 billion years of expansion. Within a few months Penzias and Wilson became aware that cosmologists had predicted such radiation long before. In 1978 the two astrophysicists were

awarded the Nobel Prize in physics for their epochal discovery.

Last spring Penzias was named executive director of research at Bell's communication-sciences division. He supervises the work of nearly 300 researchers, probably the world's most concentrated pocket of expertise in electronic communications. Few universities can match Bell Labs' record of discoveries in both pure and applied science.

Penzias discusses the challenges and opportunities of practical communication with the same enthusiasm that inspires his continuing basic research. His hands are constantly in motion as he talks and his frequent interjections—"Look, you've gotta realize that, right?"—are not verbal fillers but cues to make sure you're still with him as he pours forth analogies, historical examples, and alternate scenarios for the future. Not every technological possibility can or should be realized, he emphasizes. Omni's contributing editor Monte Davis began with a question about one Bell innovation that hasn't gotten around to changing our lives quite yet.

Omnir: Let's start by discussing why we're here, sitting in the same room, rather than using a Picturephone. It seems to have been in the demonstration phase for a long time now. Is the problem a lack of demand? **Penzias:** It's found its greatest acceptance as a remote-conferencing service. For individuals, of course, there's the start-up problem. Until the people you want to contact have a Picturephone, you can't use yours.

Then there are social factors, such as callers you don't want to see because it's harder to say no to a salesman or a fund-raiser face to face. Or, perhaps, you don't want to be seen. We had a lot of executives telling us, "I'd like the Picturephone service, but my secretary doesn't like the way she looks on the screen," which is a coded statement, as we eventually realized that lays the vanity on someone else.

Omnir: Does the Picturephone have a switch that allows you to cut off the image while you yawn or scratch or whatever?

Penzias: Sure, the switch can be there, but you can't use it. People will wonder what you're hiding. If I call someone and leave the image off, he'll be thinking, *I understand, Amo. Sometimes my office is a mess; too. I'm going to feel that I ought to straighten the place up, run out and get a haircut and a new suit, and call him back with the picture on, right?* You can't use the switch.

Omnir: So it becomes a social problem

Penzias: It's a problem of the interface and of how people feel about it. It's not just a matter of going from one end of a wire to the other, but going from the inside of one brain to the inside of another. We've got to know about human attitudes before we design something.

We didn't invent the modern telephone handset, you know. According to the Ericsson telephone people in Sweden, their linemen were working up on the poles and found it difficult to maneuver with a microphone in one hand and an earphone in the other. So one of them went down and got a stick and lashed both the microphone and the earphone to it so he'd have a hand free to hang onto the pole. At that moment he was a telephone user, not a design engineer. Fortunately someone at Ericsson spotted it and developed it, and since then we've put a great deal of ingenuity into the handset. There's very high technology in the magnets and filters and so on, but we've got to remember that we didn't invent it. The inventor was a user who knew what he needed.

Omnir: I notice that you have a repertory dialer on your desk, so you can push a single button for numbers you call frequently. Will the basic telephone continue to get "smarter" along these lines?

Penzias: I think so, but I'm not going to give you the standard line about microprocessors, because I think there's a social reason for a smart telephone. A lot of what

we consider secretarial duties are mechanical and repetitive. You can talk about the challenges and rewards of secretarial work, but as long as most secretaries are women, society is saying, in effect, that it's a low-grade job. Whenever you give a job exclusively to one portion of society, you'd better watch out.

It's like the old Pullman sleeping cars on the railroads, which were very comfortable, but that was largely because every car came with a black man, which was an obscene situation. I would say that morally we can no longer assume that every office is going to come with a secretary. But it is going to have a smart telephone.

Omnir: Will it still be primarily a voice communicator or will it be a general data-handling terminal?

Penzias: There's no reason it couldn't handle everything and still be simpler than most terminals today. The distinction between the keyboard and the display has to disappear eventually. You'll have a flat panel, which will display information, and you'll enter data by touching a spot here or there on the surface. It'll be an inch thick, say, and you'll pull it out of a slot in your desk to wake it up. It will take messages and will have a speaker built in so you're not holding a handset while you wait for the airline reservations people to answer.

Omnir: So some things won't change! What about voice input? Will you be able to say, "Get me so-and-so" to this panel?

Penzias: You could have one today that would respond to the digits of a spoken phone number. But as for people's names or taking dictation, that's tough. At Bell Labs we have some of the world's best hearing theorists and pattern-recognition specialists with rooms full of computer hardware. But you can go to the dog pound and pick any pooch, and with a case of dog food and a month's training, the dog will respond far more reliably to voice commands than any computer we've got. It's an extremely tough problem. We're working on voice-recognition equipment, and we'll continue to work on it, but it's going to take a lot of time and money.

Omnir: The line between communication and information processing is getting very fuzzy these days, what with the Bell System offering more data services and the computer people more and more active in setting up networks. Both of you face the same question: Where do you put the brains? In the central system or at the terminals?

Penzias: It seems to me that we'll be trying to put as much of the complexity near the individual as possible, and again the reasons are social ones. It allows more personal control and offers a greater chance for privacy.

Omnir: Can you give an example?

Penzias: Take the old idea of shopping by phone, which has been talked about for decades. I might want to go to the shoe store, because I might want a salesman who can look at what I'm trying on and say, "You're going to wear those with that suit?"



"Okay. Anything from the top shelf?"

UPHILL SKIING

A daring new sport for the '80s



The windburst grips your parachute, driving you toward the summit. Ski and sinew defy gravity, and suddenly you're in midair, floating above the rim of a glacier. One quick maneuver and the chute drops you on the far side of the slope. Skis touch snow and zoom you back down the mountain. Paraskiing combines the best of skiing and sailing with alpine aerodynamics.

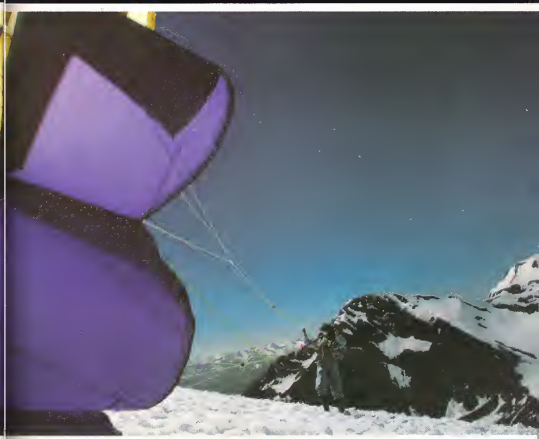
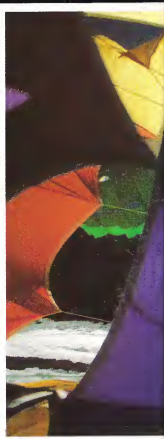
PHOTOGRAPHS BY MATTHIAS WENDT



Designed for the unpredictable wind action of alpine slopes, ski-chutes are controlled by special vents that respond to a steering bar.



As wind rushes up high-altitude slopes unimpeded by heat, a neatly vented parachute plugs into the 75-mph-plus updrafts. Windows within the chute open or close to direct airflow, enabling the paraskier to maneuver instantly. If the wind suddenly changes direction, the paraskier need only manipulate a steering bar and trim the angle of his chute.





Like sailing, uphill skiing requires you to go where the wind goes for maximum speed. Unforeseen obstacles are quickly avoided by punching a chute-disconnect button on the harness, stopping you instantly. An experienced paraskier can reach speeds of 50 mph while racing up such glaciers as the one pictured here, in Stubai, Austria. As the paraskier reaches a promontory, he raises his chute. The icy peak drops away and the paraskier sails into space, rising momentarily on the updrafts. The chute blows out and gently deposits its cargo on the downside slope. Now you descend the mountain, using the chute as an airbrake. Fantastic, futuristic, and fast, parasking is a brave new sport for the '80s.

OO

• *Racing up a glacier, only to jump off into space once you've reached the summit, fuses the best elements of skiing and parachuting.* •



FICTION

Presidential Transcript No. 21
Recording dated: 17 January 1996
Location: The Oval Office
Subject: The President's Image

THE PRESIDENT'S IMAGE

BY STEPHEN ROBINETT

I have called you all here for a special reason. The '96 primary looms before us, and I have yet to announce. I want all of you to be the first to hear my decision. To quote one of my predecessors in this office: If nominated, I will not run.

Groans and disappointment? Hear me out. Only then will you understand my decision.

The latest polls show a new issue emerging, one that could overshadow the excellent record we have compiled. The issue has nothing to do with our programs. Those have been embraced enthusiastically by the American people. The problem is of a different order, not the substance of our administration, but the form, the image, more accurately, my image.

Let me be more specific. According to our sampling, I am seen by the electorate as competent, efficient, imaginative, and innovative, but in failing health. Rumors about my health have proliferated. My ability to last out another four-year term is questioned. The media have dubbed us the Haggard administration.

PAINTING BY FRIEDRICH HECHELMANN

Haggard—that is the operative word. A computer model of the next election shows the issue could be controlling, especially if our opponents are given any opportunity at all to make political hay out of this straw man. As you all can see, I look no more haggard now than the day I took office. It is simply our higher profile in preparation for the Ninety-six campaign that has brought the issue to public attention.

Okay, on to the purpose of this briefing. Some of you don't know all the details of how our present situation came about. I'll outline them as succinctly as possible and have a transcript made for reference. I don't want any misunderstandings about the game plan.

How did it start? That's the big question. It started with the attempted assassination of Senator Mirada in Los Angeles before the last election. As most of you know, I had not yet joined the campaign, but the senator was leading our party full stride toward the White House. When he heard the horrid buzz of the assassin's bullet, his stride, understandably, faltered.

The next day the senator called in Fred Thoroughway. You all know Fred over there. He was chief of campaign security in those days. According to Fred, the senator looked like death warmed over. His skin was the color of old newspaper, and dark circles showed under his eyes. He seemed to have aged a decade overnight. The demands of a too-ambitious career, combined

with his dubious personal habits—he drank, smoked, and philandered to excess—had completely weakened his constitution. The assassination attempt threatened to break it. He kept muttering to Fred about seeing the face of Death in the crowd. He told Fred something had to be done. He could not go on, with the Grim Reaper dogging him over the campaign trail. The Grim Reaper, in all his guises, had to be neutralized.

Neutralized—a fine word. But how? Fred was caught between the proverbial rock and the equally proverbial hard place. If he did nothing and hoped they could get through the Ninety-two election with a sane candidate, some nut would probably try again and the senator's taut nerves would snap. If, in an effort to ease the senator's troubled mind, he threw on a total security wrap, Senator Mirada would never get close enough to the electorate to become President Mirada. Still, an order to neutralize was an order to neutralize, no matter how imposing the task.

For a week Fred toured security services in Los Angeles. With more than his share of nuts, Fred reasoned, Los Angeles would have state-of-the-art technology for dealing with them. He examined electrical, chemical and mechanical gadgets. Some of them would have stopped nuts. Some would have destroyed cities. None would stop a lone assassin bent on murder who had no regard for his own safety, precisely

the kind of man Senator Mirada wanted neutralized.

That weekend, to escape temporarily from the growing frustration of his search, Fred took his son to Disneyland. The trip proved fatal. After a particularly nauseating spin on the Mad Hatter's Teacup—son squealing with glee, father losing most of his lunch—Freddie Junior dragged his father in to hear Lincoln deliver the Gettysburg Address.

Fred Senior had seen the exhibit years before when it was a mechanical man. The mechanical Lincoln had long since departed. Now a holographically projected Lincoln, tied to a computer, stood in its place. Not only did it give a fine and moving delivery of the Gettysburg Address, but it answered questions from the audience as at a press conference.

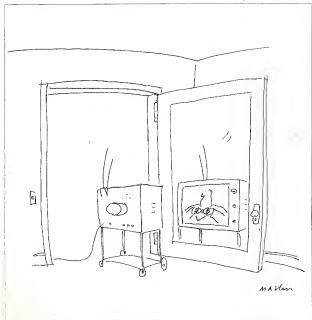
One of the questions came from wide-eyed little Freddie Thoroughway at the foot of the dais. He asked Lincoln whether he knew how much he resembled Senator Mirada. Lincoln gave a kindly and paternal smile and said many people had made that observation to him. It reminded him of an anecdote from his own boyhood. He launched into a story about spitting rails in Illinois.

The story had nothing whatsoever to do with the boy's question, but Freddie thought it did. So, evidently, did everyone else in the room. The illusion was convincing. Fred Senior gazed up at the expounding Lincoln and knew he had found the solution to Senator Mirada's problem.

On Monday morning experts on computer-controlled holography were brought in, along with the most sophisticated equipment available. The senator took a break from campaigning long enough to cover the recording session. Cameras and microphones recorded his every movement, head to toe, front to back, standing, sitting, walking, talking—especially talking.

The waveforms produced by the senator's every sound and movement were analyzed instantaneously and were assigned a two-hundred-fifty-six-bit binary number. Numbers accumulated at a rate of one million per millimeter of recording tape. Tape passed through the machine at two meters a second. All of it was ultimately stored in a computer, a collection of something close to two billion digital information bits on the senator for every second of recording time. Thoroughway worked the senator hard, further damaging his already frail health, but managing to assemble one hundred hours of tape. They could now holographically reproduce every movement and sound the senator was capable of making, together with a few he would never be able to manage.

Then came the hard part. They had the form, the image. They needed substance. Every plank in the senator's platform was programmed in, along with details on the problems of implementing each policy and the solutions to those problems. The pro-



FUTURE CURVES

OMNI SURVEYS THE ROYAL SOCIETY

- The discovery of enzymes that chop DNA into pieces, providing scientists with the power to create life in a test tube
- Increased understanding of the relationship between electromagnetism and weak nuclear forces—a step toward the unified field theory initiated, but never completed, by Einstein.
- Developments in ways of reading the coded messages of DNA, notably the discovery of overlapping genes that read like several telegrams mixed in one.
- Confirmation that variations in the earth's orbit determine the pattern of ice ages
- Detection of background radiation left over from the big bang that created the universe

These are five sensational advances made in the past decade, according to a survey conducted by *Omni* among the Fellows of Great Britain's Royal Society Founded in the mid-seventeenth century, the Royal Society is the world's oldest scientific association and arguably one of its most prestigious. Such luminaries as Samuel Pepys, Isaac Newton, and Edmund Halley were among the earliest members. Admittance to the society is limited to the finest scientific minds in Britain. Thirty-two new members are elected each year from some 350 candidates, all of them first-rate researchers. As a unique body of expertise, the society holds a position in the world of science that is unrivaled.

The investigation, sponsored by *Omni* rather than by the Royal Society itself, was designed to pinpoint those developments in the last decade that will probably have the greatest impact on the future. A simple questionnaire was sent to some 700 eminent Fellows. They were asked to cite "the outstanding scientific paper of the past decade," but the reply card also included an option for those who felt it was not possible to select one individual reference. The response (40 percent) was excellent. A majority of respondents (191) quoted a paper or area of research or argued why science should not be assessed in this way. Of these, 78 Fellows cited specific references. Only 46 indicated no choice.

Even the more negative replies—and replies from those missing the point—furnished some remarkable insights. "If it were possible to answer this question, science would lose all its interest for me," wrote one Fellow. Another, strictly within the terms of the question posed,



chose what he regarded as the worst paper of the past decade, enumerating its faults in purple prose. And an unexpected reply came from one of the few non-scientists to have been elected an FRS—the former prime minister Sir Harold Wilson. Wilson cited an address delivered to the Royal Society by one of its former presidents, Lord Blackett, an advocate of centralized planning for science before the war who publicly suggested in 1967 that the United Kingdom might have been mistaken in concentrating scientific talent in government laboratories instead of in private industry.

The most frequently mentioned paper in the biological sciences was that by Dr. Fred Sanger and his colleagues at

Cambridge, England, wherein they described the entire sequence of nucleotides, or "words," in the DNA of a virus, PhiX-174 (*Nature*, Vol. 265, 1977, p. 687). This achievement marked the first time ever that the complete chemical "blueprint" of a living organism had been unraveled and followed shortly after Dr. Sanger's group and a second team working under Dr. Walter Gilbert had improved methods for reading DNA sequences. An extremely simple life form, PhiX-174 proved to contain 5,375 words. Grouped into sentences—genes—they specify the composition of a virus particle when it replicates, and indeed they control all its functions.

A perplexing revelation from this work was that the genes overlap. Like a telegram with no spacing, the coded message read entirely differently depending on whether one began with the first, second, or third letter. The fact that three messages were contained within one seemed to some researchers artificial or contrived, prompting Drs. Hiromitsu Yokoo and Iain Oshima to revive the theory first suggested by Dr. Francis Crick and Leslie Orgel (*icarus*, Vol. 19, 1973, p. 341), that life on Earth began from organisms sent here billions of years ago by extraterrestrial civilizations that decided to "seed" other planets. The Japanese scientists suggested that the gene sequence of PhiX-174 might contain messages, or signals, as yet not decoded. In their reasoning, such overlapping messages would be a highly economical way to send information through vast tracts of space. The advantage of this mechanism over radio communication is that it does not presuppose that a receiver is aiming an

BY BERNARD DIXON AND JOHN GRIBBIN

antenna toward the sender at the right time and within the correct frequency range.

Genetic engineering is the second major province of biology to emerge from the Royal Society survey. Many respondents cited the original papers in which Paul Berg, Herb Boyer, Stanley Cohen, and others first indicated the possibility of what we now call recombinant-DNA manipulations, some of these respondents highlighted this as a field of crucial importance. The key breakthrough was the isolation of "restriction enzymes" that split DNA into pieces, permitting genetic material from different organisms to be combined. The discovery of these enzymes thus paved the way for man-made life forms, nonexistent in nature. In June 1973 this newly gained skill attained prominence when scientists at a Gordon Conference on nucleic acids, held in New Hampshire, instructed the conference cochairmen, Maxine Singer and Dieter Söll, to draft a public document about its future implications. Later printed in *Science* (Vol. 181, 1973, p. 1114), the letter announced, "We presently have the technical ability to join together, covalently, DNA from diverse sources." It went on to warn the world that "certain such hybrid molecules may prove hazardous to laboratory workers and to the public."

This landmark step led to unprecedented activity in regulating such work, centered on the guidelines issued by the National Institutes of Health in the United States and by similar controls in other countries. Today whether such constraints are needed is a subject of much debate. At least some of the original whistle blowers now feel that they had exaggerated the dangers. But there is no question about the profound scientific importance of the technology at the center of the controversy. The techniques promise revolutionary advances in studying the genetics of higher animals and plants. And the ability to fabricate novel organisms according to man's specifications is likely to transform industrial microbiology and to have unforeseen effects on agriculture and medicine. Several survey respondents cited the paper (*Proc. Nat. Acad. Sci.*, Vol. 75, 1978, p. 3727) in which Walter Gilbert and his colleagues described inducing bacteria to synthesize proinsulin, a precursor of insulin, as the first decisive indication that genetic engineering does have practical applications important to the welfare of mankind.

The discovery of enkephalins and endorphins, whose painkilling action on the central nervous system was described in the February issue of *Omni*, was the third biological breakthrough indicated by the survey. The report by John Hughes in *Brain Research* (Vol. 88, 1975, p. 295) was cited as evidence of the first, rather crude success in obtaining a morphine-like peptide from the brain. "Like Gaddum's soup pharmacology many years before, it started things," wrote one distinguished professor of pharmacology. "Where the spate of work on brain peptides is going to end, I cannot see, but my own view is that Hughes' little paper started the avalanche. For my money, the names you want are those who first point to the tip of a nugget of gold, after that, it's cranking the handle, and the big battalions move in."

There were even some surprises in the mailbag. One respondent, for example, chose a paper entitled "The Life Cycle of the Coccidian Parasite, *Toxoplasma gondii*," in the *Dunsmuir* Club, as the prime contribution of the last ten years. Written by Dr. William Hutchison and col-

leagues of his at the University of Strathclyde, Glasgow, Scotland, and the Statens Serum Institut, Copenhagen, Denmark, it outlines the life-style of an organism that may well cause considerably more illnesses in man than has yet been realized (*Trans. Royal Soc. Trop. Med. Hyg.*, Vol. 65, 1971, p. 380). A cosmopolitan parasite, *Toxoplasma gondii* infects primates, carnivores, rodents, and birds and is responsible for at least five kinds of human disease, ranging from an acute febrile illness resembling typhus in adults to encephalitis in children. Dr. Hutchison and his team showed that this bacterium should be classified alongside the malarial parasites. They have also produced evidence that latent human infections, apparent only when we measure antibodies in the bloodstream, might be widespread.

Another significant biological study cited was the paper in which Dr. John Vane demonstrated that aspirin and related drugs act partly by inhibiting the synthesis of prostaglandins (*Nature New Biology*, Vol. 231, 1971, p. 232). Several papers on tissue antigens and their importance in organ transplantation and in relative susceptibility to different diseases were mentioned. More surprising was the reference to a report by Dr. David Gilbert (*J. Physiol.*, Vol. 253, 1975, p. 257), describing in meticulous detail the architecture of the giant axon (the long outgrowth of a nerve cell that conducts impulses) taken from a marine worm.

A point made repeatedly by those quoting papers, as well as by those declining to do so, was the overwhelming importance of a contribution predating *Omni*'s study, that of Drs. Francis Crick and James Watson, who revealed DNA's double helical structure (*Nature*, Vol. 171, 1953, p. 737). These comments are best summarized by the view of one of Britain's most distinguished biologists, Professor J. Z. Young: "Singles such as the Crick-Watson paper perhaps occur once or twice a century. I do not know of any one such in biology during the past decade."

The physicists in our sample proved more willing to commit themselves. Forty-three selected a specific paper (contrasted with only 35 biologists), and more of those unwilling to make a choice gave a thoughtful explanation—39 as opposed to 31.

Among the papers chosen in the realms of fundamental physics, the most noteworthy topic selected by a broad cross section of Fellows was the unification of the weak and electromagnetic fundamental interactions. Yet not even here did any single paper emerge as most valuable. Some respondents preferred to point to the theoretical work by Professors Stephen Weinberg and Abdus Salam (*Reviews of Modern Physics*, Vol. 46, 1974, p. 255). Others mentioned the theorist Dr. Gerard 't Hooft (*Nuclear Physics B*, Vol. 35, 1971, p. 167). Still others opted, logically enough, for the paper by Dr. F. J. Hasert and colleagues, published in *Physics Letters* (Vol. 46B, 1973, p. 138), which contained the first experimental confirmation of the validity of the theory.

As a step toward the goal of proving a unified field theory, this work is seen as the most important development in our understanding of the working of the universe since Einstein's general theory of relativity was propounded. In nature we find four basic physical forces: gravity and electromagnetism, which are familiar to us in everyday life, and the strong and weak nuclear forces, which hold atomic nuclei and fundamental particles to-

gether and which govern the processes of radioactive decay. These are less familiar but still of some consequence in a world in which atomic energy has become so influential a part, quite aside from their fundamental significance.

But why should nature "choose" to have exactly four fundamental forces? Why not 40, or 400, or one? For decades physicists have sought a single grand theory that would include the four forces as special cases, so that we no longer need four separate theories running on parallel paths. The Weinberg-Salam theory, with its experimental confirmation, is the first definite step toward this goal, explaining in one framework the weak nuclear and the electromagnetic force. The experiments confirm that at very high energy the two forces are the same. Only in our low-energy world do they branch into separate disguises, two sides to the same coin. This gives the theorists heart that eventually the two other forces (the strong nuclear force and the force of gravity) may also be brought into the fold. Perhaps at enormously high energies, corresponding to the split seconds early in the big bang of creation, all four were indistinguishable.

We now have a great deal of confidence in the idea that the universe actually did begin with a big bang because of the discovery of the 2.7-microwave background radiation, interpreted as the "echo" of the big bang. That discovery was made by Drs. Arno Penzias and Robert Wilson in 1964, although their results were not published until the following year (*Astrophysical Journal*, Vol. 142, 1965, p. 419). They received a Nobel Prize in recognition of the event in 1978. Strictly speaking, their publication predated the ten-year period of the *Omniv* survey. But several Fellows cited it, often saying that it was more important than any more recent paper. Others selected the discovery of pulsars by Dr. Jocelyn Burnell and her colleagues (*Nature*, Vol. 217, 1968, p. 709). Now that theorists agree that the pulsars are neutron stars, whole stars made of incredibly dense matter in the same state as the nucleus of an atom, some of the predictions of general relativity have been corroborated.

One paper was cited far more than any other, not only by astronomers but by Fellows from all the physical sciences. It goes beyond states of matter as "ordinary" as neutron stars or nuclear matter. Professor Stephen Hawking's work on black holes, and especially on the way very strong gravitational fields can create particles by quantum interactions so that black holes bubble away and eventually explode (*Nature*, Vol. 248, 1974, p. 30), is held up time and again as a paper likely to lead to new understandings in the future, as opposed to "merely" confirming Einstein's theories. This work (*see Omniv*, February 1979) holds out the promise of unifying the theory of gravity—general relativity—with that of quantum mechanics, for another advance on the quest for one unified field theory.

Finally, there are indications that a "revolution in the atmospheric sciences" may be in the offing, as a few selections pinpointing recent work on climatic changes make clear. The one single paper emerging from this pack is the confirmation from deep-sea cores, by Jim Hays, John Imbrie, and Nick Shackleton, that the variations in the earth's orbit (the Milankovitch effects) do set the pattern of ice ages (*Science*, Vol. 194, 1976, p. 1121).

The overall picture that emerges is that physical sci-

ence may well be on the brink of a new breakthrough, as meaningful as that which occurred early in this century with the advent of the quantum theory and the theory of relativity. Progress is being achieved through the study of the very small (subnuclear particles and their interactions) and the very big (the whole universe and strong gravitational fields in extreme states, such as the big bang itself or black holes).

However, this work and that of the genetic engineers are going forward in a much more open climate than science has enjoyed in the past. Two final choices—of books rather than research papers—may be quite appropriate here. Thus, one Fellow entered fully into the forward-looking spirit of the *Omniv* survey by suggesting that Fritjof Capra's *The Tao of Physics* (Wildwood House, London), an attempt to set modern ideas of quantum mechanics and field theories in the same philosophical context as Eastern religions, points out one possible road into the future for science. A more conventional choice, but one equally relevant to the next ten years, is Amory Lovins's *Soft Energy Paths* (Penguin, London), singled out as an assessment of the energy problems that confront mankind and that must be at the heart of the scientific and engineering challenge of the next few decades. Surely, such suggestions would not have been found in a similarly worded survey conducted a decade ago.

EVAPORATING BLACK HOLES

Elected in 1974 at the age of thirty-two, Cambridge astrophysicist Stephen Hawking was one of the youngest Fellows ever admitted to the Royal Society (the average age at election is fifty). Yet it was his paper on black holes that was the most frequently cited in *Omniv*'s survey.

Until recently black holes were regarded as the ultimate collapsed state of matter, so dense that their gravity wraps space and time around their central singularity, forming a horizon from which not even light can escape. However, just as physicists in the mid-1970s began to accept the reality of black holes, Hawking discovered that black holes are not completely black after all.

To prove this, Hawking had to go beyond Einstein's work, incorporating elements of quantum theory with the gravitational theory of relativity. Quantum theory tells us that pairs of particles (one matter and the other antimatter) can be created literally out of nothing, in the vacuum of free space. Immediately upon forming, they would normally part together, causing mutual annihilation. However, Hawking realized that in the extreme conditions surrounding a black hole, one of the pair produced by such a "vacuum fluctuation" would be captured and swallowed up by the hole even in the brief instant before it and its partner could be annihilated. If one particle goes in, the other must go out, to conserve momentum. It seems at first as if new matter has been created, violating the law of the conservation of mass-energy. But we can't get something for nothing.

Indeed, Hawking has shown that as one particle scoots off out of the clutches of the black hole, the hole itself loses an amount of energy (= mass) exactly equivalent to the mass of the created particle. This has disastrous implications for the hole, because its gravitational field will weaken until, at some instant, the constraining horizon collapses and the fermenting matter inside blasts outward. ☐

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IMAGE

CONTINUED FROM PAGE 50

gram was given a capacity to deliver this information either as a formal speech, or as casual conversation, or as response to questions from an audience. It even contained a few all-purpose ripostes for hecklers.

When Thoroughway was satisfied, he called Senator Mirada in for a demonstration. He activated the equipment, all of it portable, and I joined them in the laboratory. Thoroughway asked me about tax-reform legislation, covering it both from the substantive angle and from the practicality of getting such legislation through Congress. I answered satisfactorily. Senator Mirada asked me about foreign policy issues—the Tierra del Fuego War, the Lisbon coup, the Sino-Japanese Mutual Defense Pact. Again I answered each question, one or two of them with well-turned and—if I do say so myself—witty responses.

The senator was impressed. He put one of his arms across Fred's shoulders and talked into his ear, saying the success with me would allow him to do what he had longed to do from the first days of the campaign: take a relaxed and extended vacation to restore his health. He gestured at me and said I could do what he called "the mundane work of getting elected."

We got postcards from the senator in Tahiti, all signed with his Secret Service code name, Cheshire Cat One. He sent one photograph of a man with his face averted and his arms around two young Tahitian girls. He was having a wonderful time and wished we were there.

While the senator chased grass skirts in Tahiti, I worked night and day at the mundane work of getting elected. Before every public appearance, Thoroughway set up the equipment under the hustings, sometimes an outdoor podium, sometimes an indoor stage. He gave orders to have the motorcade stop within range of the projector. When the senator's limo came to a halt, Thoroughway flicked on the equipment. The limo door slid open. I got out, smiling, waving, pollicking.

Though I didn't kiss any babies or shake any hands—an impossibility under the circumstances—I did give rousing, Lincoln-esque speeches. Even the media began talking about the "new" Senator Mirada, better organized, better prepared on the issues, more responsive to questions, quicker-witted. We moved up in the polls. No one saw me then as having served four years in a man-killing job. So there was little comment on my appearance.

None of our success pleased Fred. From time to time he would have me join him late at night and discuss the matter. He had been through many campaigns, and something always went wrong. Either little things went wrong all the time—late planes, rained-out rallies, slipshod advance work—or something big went wrong all at

once. The longer we went without small disasters, the more Fred's forebodings told him a big one was on the way.

It arrived November 4, 1992, one day after we squawked into office, and while most of you were still under the weather from the victory party. Senator Mirada—now on the wagon, a nonsmoker, and a jogger—had discovered a new way of life, more tranquil, healthier, without the crushing burden of governing the most powerful nation on Earth. As he said in that final postcard, he felt himself to be in harmony with the seasons and the tides. He had decided to trade in the smoke-filled rooms of Washington for the fresh air and sunshine of Tahiti, permanently.

That gave us a problem. I'm sure you all remember the meeting. Most of you were hysterical over the possible consequences of his decision. I had to take charge. We voted. We arrived at our decision democratically. What we did we did for the good of the country. We had already done the mundane work of getting elected. Could we stand by and simply give away that election? Was one man that indispensable? Besides, we had programs we believed in—programs the country needed.

Looking back, I think we can say we made the right decision. My personal popularity is high, my record good. We have only this single issue, my health, to deal with. I have already taken steps to remedy the situation.

Last week I dispatched an urgent telegram to Tahiti, followed by a two-hour satellite conversation with visual linkup. I must say, Tahiti has agreed with him. He looks tan, rested, and content. He has followed events here and approves of our accomplishments. Indeed, he is convinced that we have done a better job in office than he could ever have managed—an endorsement I deeply appreciate.

In any case, we spent much of the two hours examining our options. He suggested the most obvious solution, a new tape showing a lit and healthy image. I had to veto that one. The media have already made a big deal out of my reluctance to shake hands—the Howard Hughes Syndrome, they call it—suggesting it indicates a neurotic fear of germs, hypochondria, evidence of potential mental instability. I pointed out to him that we had to squelch that sort of talk rather than encourage it. He saw my point. Still, he was hesitant to leave his Shangri-La. Only after further negotiation and a firm promise that Air Force One would make frequent and prolonged trips to Tahiti did he agree to cooperate.

I think, ladies and gentlemen, we can now look forward to the four more years we need to realize our programs fully. As I said at the beginning of this briefing, I have made my decision. I think you now understand it. If nominated, I will not run, but, if elected—our friend from Tahiti should give us just the image we need for that mundane work—I will serve. **DO**

CATCHER

CONTINUED FROM PAGE 80

to the plane of the planets. It will eventually pass over the north pole of the sun, seeing it from a new angle, then approach within four solar radii of the sun at the far equator, and exit over the south pole. This long, elliptical solar orbit will be repeated every two years. At its point of closest approach, the 5,770°C heat of the sun will be coming from a 30-degree solid angle in the sky. The instruments and cameras in the spacecraft will be timidly peeking out through peepholes in the thermal shield that keeps the spacecraft from melting.

A visit to six asteroids forms the basis of the multiple-asteroid rendezvous mission, planned for late 1988. The spacecraft will stop to explore for two months at each of six asteroids: Medusa, Nyssa, Erigone, Masalia, Mimoso, and finally Protogenia in 1989. Completion of this mission will take us into the twenty-first century, when the first manned missions to the outermost planets will begin.

A green light flickered on the main control board. Colonel Swift saw it out of the corner of his eye and glanced over to the squadron-status panel. In a few seconds he saw two other green lights join his. The engines were warmed up and ready to start. He punched off the comet pictures and replaced them with a dual-screen presentation that showed Virginia and Fred at their posts, their eyes scanning their control boards, obviously ready.


"Prepare for ignition," he commanded, and their motions followed his as they raised protective covers and activated the high-voltage power lines that would allow the computer to start thrust. As they waited out the countdown, Colonel Swift's face broke into a broad grin, and he chuckled.

Virginia, ever alert, directed a quizzical glance at him over the screen. "What's funny?" she asked.

Colonel Swift's grin grew broader. "I was just thinking back to my days at the Air Force Academy in Colorado when my classmates would tease me about my name," he replied. "Only now the laugh is on them." A green light flashed over the MAIN PROPULSION sign. Riding an invisible beam of ions, Tom Swift and his Electric Rocket blasted off to Mars.

At press time, the Office of Management and Budget abruptly cut funds for solar electric propulsion from NASA's 1981 budget request, thereby killing the Halley-Tempel 2 mission. A proposed substitute, a high-speed flyby of Halley's Comet, would give far less information than the rendezvous. Dr. Forward tells us Congress can still restore funding for the Halley-Tempel 2 probe if public support is strong enough. So write to Representative Don Fuqua, chairman of the House Committee on Science and Technology. Halley's Comet won't be back until 2061. **DO**

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EARTH

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The Allen-Warner Valley System, as Ronald Rudolph, of Friends of the Earth, has said, "drives a spike through the heartlands of our national parks."

In the past few decades southwestern coal has become increasingly attractive to energy utilities. They have been drawn into the industrial vacuum of the Four Corners country by the pollution standards there, less strict than those of more densely inhabited areas, by the boosterism of local politicians who imagine that their constituents are bored with life in an industrial vacuum, and by the cheapness of the coal.

The worst of the coal projects, from the environmentalist's point of view is the Four Corners Power Plant in northwestern New Mexico. That plant burns coal strip-mined from land near Shiprock, a Navajo sacred mountain, and sends skyward a smoke plume so gigantic that it was one of the few artificial phenomena visible to the astronauts of Project Gemini. Nearly as bad is the strip mine at Black Mesa, another sacred Navajo mountain. Coal from Black Mesa is burned at the Navajo Power Plant, near Page, Arizona. When the wind blows in the wrong direction, the smoke from that plant reduces visibility in the Grand Canyon to less than 15 miles.

Stegner's description, then, "great sky without a smudge or taint from Technocracy," no longer holds true in all of the Southwest. The air that Cather wrote about—light, dry, aromatic, free—has disappeared from parts of this desert.

Over the Kaiparowits Plateau, still thanks to luck and inaccessibility the sky is flawlessly blue and unsmudged. The air is the cleanest in the nation, and it still bears all those messages it carried to Cather's Father Lator.

The Allen-Warner Valley Project would fix that. It would annually generate 30,810 tons of particulates, 17,024 tons of nitrogen oxides, and 3,267 tons of sulfur dioxide. Erosion from construction would damage water quality in a region where water has always been scarce. Coal dust, heavy metals, and salts would find their way to the Colorado River. Deer, antelope, elk, bighorn sheep, bald eagles, peregrine falcons, cougars, bobcats, and Utah prairie dogs would be displaced.

The human population would boom. Utah's Kane and Garfield counties, where most of the project's impact would be felt, presently contain just 7,000 people. The project would bring in 80,000 more. Many of the present residents believe they would welcome that.

Most are Mormons. The project, many think, would mitigate an old Mormon dilemma. Mormons are strong believers in family, yet their great nineteenth-century migration took them to a sparse region where holding a twentieth-century family together is difficult. There are few opportu-

nities for young people now and they move away. Jobs provided by the mine and railroad, the Mormons hope goes, would call young Mormons back from distant cities. The tax base would broaden. The church, vigorously proselytistic, would gain in the influx of new workers, plenty of raw material for its missionary zeal.

The question of course is whether that influx of gentiles—tough American gypsies of the trailer-camp culture, an influx outnumbering the local population eight to one—would lie down quietly and be proselytized. Would miners and railroad men be satisfied with Utah's 3.2 beer? Would Mormon family life be improved by the alcoholism, delinquency, divorce, violence, and culture shock that inevitably follow in dusty into rural places?

Kane and Garfield counties share the illusions that Fairbanks, Alaska, held before the Alaska pipeline was completed, and that Gillette, Wyoming, held before the strip mine was opened there. Such illusions are possible only in places far from the city.

Environmentalists are preparing for the fight. Lawyers from the Environmental Defense Fund have joined forces with the Sierra Club, Friends of the Earth, and several local ranchers whose land the railroad will cross. The lawyers like their chances. The National Park Service and the Bureau of Land Management are ranged against the project—in the personal sentiments of their personnel, at least. The mine component of the Allen-Warner System is situated just three miles from the boundary of Bryce Canyon National Park. Mining operations would be visible from Yovimpa Point, one of the canyon's main scenic overlooks. Air quality in the park would be impaired, and Bryce's desert silence would depart. Basing might well tumble the delicate, salmon-colored erosional towers for which Bryce was protected. Industries should not be able to do this to a national park. The environmentalists think industry won't be able to do it. They argue that the mine site cannot be reclaimed in conformity with requirements of the Surface Mining and Control Act; that safer, cleaner and cheaper alternatives to Kaiparowits coal exist; and that the enormous investment required by the Kaiparowits project will preclude investment in more sensible alternatives.

"Those who haven't the strength or youth to go into it and live with it," Stegner writes of this country, "can still drive up onto the shoulder of the Aquarius Plateau and simply sit and look. They can look two hundred miles, clear into Colorado, and looking down over the cliffs and canyons of the San Rafael Swell and the Robbers' Roost, they can also look as deeply into themselves as anywhere I know. And if they can't even get to the places on the Aquarius where the present roads will carry them, they can simply contemplate the idea, take pleasure in the fact that such a timeless and uncontrolled part of earth is still there."

Perhaps, with a little more luck, that will continue to be so. **OO**

SPACE

CONTINUED FROM PAGE 20

Similarly all the stars in a cluster have the same composition when they are formed. Most stars are made of hydrogen and helium and very little else. Spectroscopic analysis shows that elements heavier than helium are relatively rare. Even in stars rich in them, heavier elements make up no more than a minute fraction of the star's material. The slight differences in stellar evolution caused by the minor variations in a star cluster's composition are insignificant.

From cluster to cluster, however, there are marked chemical differences. The stars of a globular cluster consist almost entirely of hydrogen and helium, with almost none of the heavier elements present. Stars in an open cluster are much richer in heavy elements. The study of stellar evolution helps explain this contrast.

We think that the heavy elements are created by supernovas, the cataclysmic explosions that end the lives of some stars. While the normal nuclear fusion that goes on in all stars produces elements other than hydrogen and helium, only supernovas can form elements heavier than iron. The explosion spews these elements out into the interstellar gas, enriching it for the next generation of stellar birth. In this way each generation of stars is richer in heavy elements than the one before it. The globular-cluster stars, which formed first, were made of primordial material, unenriched by supernovas since its creation at the beginning of the universe. Open clusters formed later on. The sun is a second- or third-generation star. We know this from the abundance of heavy elements detected in its spectrum.

A recent study of meteorites has shed some light on the sun's birth. In the meteorites are the remains of a radioactive form of aluminum. Its antipode that is radioactive for only a short time, cosmically speaking, and should not occur in such "recent" material as meteorites unless it was formed only a little while before the meteorites themselves were.

Astronomers think that this aluminum was formed in a supernova that preceded the birth of our solar system several billion years ago. The cataclysm both enriched the gas that was to make up our sun—it contributed about a tenth of 1 percent of our material—and started the contraction of the gas cloud. This supernova caused the formation of our solar system. Some of the material from that stellar explosion is now part of your body.

Future space probes will collect pristine meteoroids, perhaps even pieces of comets, and will reveal more details of the early solar system. Much further in the future, interstellar probes may visit the Pleiades, one of our most beautiful astrophysical laboratories. From these will come a fuller picture of how we fit into the 15-billion-year evolution of the universe. **OO**

INTERVIEW

CONTINUED FROM PAGE 30

But if I know I want a particular style and size, the machines can handle that and send me a bill.

But say it's a liquor store and somewhere in the system are all its sales records. Say the Strategic Air Command wants to check out somebody as a launch officer in a missile silo and it uses the system to weed out drunkards. Okay maybe that's acceptable. But sooner or later it gets down to the Second National Bank in Clinton Falls, which is thinking of promoting you to head teller. They push the button and find out you went through six cases last month, and you're not there to tell them it was because of your daughter's wedding.

It's a real problem. You want the convenience in purchasing, the stores want to maintain inventory and balance the books, but nobody wants a big machine with everything in it he's ever done. There are several possible solutions. You can enact laws; we're very good at that. Did you know that we have twenty times as many lawyers per capita as the Japanese? Or such companies as American Express could sell privacy as well as transaction services.

What's missing is some electronic equivalent of a "good name" or of the old practice in which you got three people of standing in the community to vouch for you.

Omni: A solid credit rating isn't quite the same.

Penzias: Right. I think we want something on a smaller scale, and I think smart terminals fit in better with that. People want a human scale, even if a big centralized system might be more efficient.

Omni: Could you isolate some information in the home terminal by means of a plug or a switch?

Penzias: I like the idea of a mechanical barrier, but given enough bad will on somebody's part that won't be enough. If you ever plug it in, your records can be interrogated at that moment by a standing order in the system. Maybe you'll have a code that changes in a pattern only you know or some sort of alias for certain transactions.

I've been interested in this privacy question, and as personal research I looked into the Social Security system. As I understand it, when people first objected to the idea of giving everyone a number—naturally only a liberal Democrat such as Roosevelt could have gotten away with it!—they were told that you could open as many Social Security accounts as you wanted. Take another name, open another account, and when you're ready to retire, you can collect on payments made on all your accounts.

Well, I wrote to the Social Security Administration, asking how to get a card, and they replied that you bring evidence of citizen-

ship, such as your birth certificate. Now that doesn't sound like they'll give you as many accounts as you want. Because, after all, it's proved too useful to the IRS.

Omni: So much for good intentions.

Penzias: If the government wants to do that and the voters put up with it, that's fine. But we feel that people are paying us not just to provide a service but also to look out for their interests. Not totally—the ultimate responsibility rests with the individual—but we have the resources to examine new ideas in more detail and look farther down the road. People can't test every can of beans for botulism themselves, so they pay taxes that support canneries inspectors. Our rate payers have a right to expect that we'll think about the implications of the hardware we come up with.

Omni: We've seen a new subculture spring up around the citizen's band radios, and now mobile telephone service is starting to bloom. How do you see the technology and the social needs interacting in that area?

Penzias: Well, you can take the plain black telephone and add repertory dialing and electronic switching and so on, but it's still connected to a wire that goes into the wall, and when you go next door you don't have it anymore. We're working toward a point at which we can overcome that limitation, although at present we're limited by FCC regulations to a narrow part of the radio spectrum.

It may well be a misuse of the spectrum to give so much to broadcast television, because there you have a fixed transmitter and in most cases, a fixed receiver. Cables can give you an infinite number of channels, so in principle it would make more sense to widen the broadcast bands allotted to mobile communications. So many lives could be saved if we made routine and automatic the sort of communication that happens sometimes now with CB radios. Hey, there's a patch of ice around the next curve, or your left rear wheel is wobbling. How much would it be worth to know that if your car breaks down on the highway, a truck isn't going to come along and plow into you from behind? I can think of so many things—how many millions of dollars in police costs and court costs and prison costs would you save if every car were equipped with an electronic tracer to prevent car theft?

Omni: Some people have suggested that with optical fibers and more efficient use of land lines and light beams, we may be coming to the end of the broadcast era. Maybe we shouldn't expect extraterrestrial civilizations to be filing the galaxy with broadcast signals.

Penzias: Oh, we'll still be broadcasting, but the nature of what we'll be sending will be very different. It will probably be increasingly digital, at least where enough bandwidth is available, because of the convenience of talking to machines. Ultimately it seems to me, the broadcast of any high-level civilization will not be an analog signal of *I Love Lucy*. That stage will pass



very quickly. What you'll eventually see used instead will be much more noise-like.

Omnir: What does that mean?

Penzias: Noise-like in the sense that there are so many digits, in all sorts of modulation schemes, that they'll all blend into noise that covers the spectrum.

Predicting is always a risky business, because if you had any clear idea of what lies beyond, you'd be working with it already. That's not just in science; thought extrapolation leads you astray anywhere you go. I remember a wonderful article on the history of economics that showed how the grand conclusions of Malthus or Adam Smith worked very well for their own time but increasingly badly as time went on.

There were a couple of people working at Bell Labs who figured out a way to double their money in the stock market, so they quit. It was one of those speculative periods when you could make money on any company that had -omics in its name. But a few months after they quit, the bubble burst. That happens in science as well.

Omnir: You mean there are times when a scientist can't miss if he's working in the right field?

Penzias: Sure, there are good times and bad times for certain lines of research, certain lines of theoretical speculation. Over the years some people invented crazy modulation schemes because they were mathematically interesting. Then all of a sudden you get cheap digital electronics and the crazy schemes turn out to be very neat ways of doing something practical. Other ideas, of equal or greater mathematical interest, will remain abstract and useless until all the paper they're written on crumbles into dust.

I'm not a digitally oriented person myself, you know. Until a few years ago, when I had to determine the area under a curve on a graph, I'd have the computer draw the graph, then cut out the paper and weigh it. A digital computer is such a wasteful, stupid thing, adding the same number twenty-three times instead of multiplying a couple of voltages the analog way. But we have the circuitry to make that kind of brute-force computation rapidly and accurately. So that's how it's done.

You have to keep your mind as open as you can. When the steady-state view of the universe was dominant, for example, some people limited the kinds of physics they did to what would fit that theory.

Omnir: That brings us to the big bang and to your own work. Microwave astronomy opened up the study of the gas and dust clouds between the stars, and you made many contributions to that. Over the past decade you've turned to the stellar processes that create the elements and compounds in those clouds. Why does that interest you?

Penzias: I found myself asking simpler and simpler questions, each of which got more complicated as I looked at it. Is the abundance of the elements that we see here and

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now the result of the processes that we can see occurring now, or was there something funny about the beginning? It's a basic curiosity about how things got the way they are.

I was at a conference for high-school students in Salt Lake City not long ago. They had business people, entertainers, and so on, and toward the end we got to talking about this, the fact that the oxygen and nitrogen we breathe, the carbon and iron in our flesh and blood, all came out of a star somewhere. You don't have to get into the mathematics, because everybody breathes the air, right? Where does it come from? We're here and there's all this world around us, and every bit of it except the hydrogen and some of the helium has been cooked up inside a star.

The question shouldn't be "What makes me curious about that?" It should be "Why isn't everybody curious about it?" To be curious is a basic human tendency. The reason people don't care is acculturation. They've learned very early to stop asking questions and get their noses to the grindstone. In those people I met in Salt Lake City some of the curiosity is still alive. They're asking, "Why? What's here? What's going on?"

Omnir: It seems that as recently as a generation ago the basic picture in astronomy was stars and vacuum. Now we have dozens of molecular species, the solar wind, the comet cloud beyond Pluto, the galactic halo, shock waves in the interstellar gas

that may begin star formation. ... It's gotten pretty crowded there in supposedly empty space, hasn't it?

Penzias: Oh, it's a vacuum in the sense that if you went out there in a space suit and opened your faceplate, you'd go *ptfff*. But there's lots of material. The mass of gas in one of these interstellar clouds, not even a big one, can be ten thousand times the mass of the sun.

I looked at an article on astronomy in the second edition of the *Encyclopaedia Britannica*, from the late eighteenth century and it didn't even discuss the stars. As far as the author was concerned, astronomy was the solar system plus some bright lights off in the distance. The only thing you could get any real science out of was the orbits of the planets and their moons. That was all of astronomy.

Anyway now that we can see these clouds, we can use them like biological stains or tracers to study the stars and the galaxy as a whole. Hydrocyanic acid, for example, soaks up deuterium and in other places carbon monoxide reveals the presence of molecular hydrogen and dust that you can't observe directly. And now we're beginning to look farther out, fifty thousand light-years from the center of the galaxy to study the galactic halo.

Omnir: You and Robert Wilson discovered background radiation when it was then near the limits of detection. Are we getting near the absolute limits of instrumental

sensitivity?

Penzias: At some wavelengths, yes, although I wouldn't want to say what can't be done. Some of the miraculous things the optical astronomers do with film sensitize it way beyond what the manufacturer says it can do. Now that art is being replaced by more sensitive electronic cameras. There's also been a tremendous improvement in our ability to detect X rays.

But as I said at some wavelengths there's not much more room for improvement in the deep-space network that tracks the probes out beyond Jupiter; they've spent tens of thousands of dollars to scrape away each degree of noise in the system. At this point, about thirty percent of the noise comes from the cosmic background radiation, which is going to be there no matter what.

Omnir: As we approach the limits of useful amplification, will the discoveries become less frequent?

Penzias: Most of the real discoveries are not made at the limit. You know, some people have suggested that there should be a moratorium on observation while all the researchers go back to the plate stacks. We're inundated with observations, and I'm sure there's a lot to be discovered in what we've already got.

Omnir: How does that suggestion strike you?

Penzias: I think it happens anyway without a formal decision. For some reason, you can't get time at an observational facility or you break your leg or take a year's sabbatical and you go back to the plate stacks for a while. One of the nice things about American science is its diversity. It isn't all centrally planned.

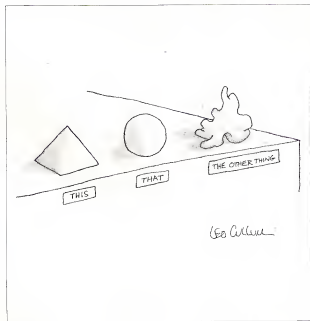
Omnir: Imagine for a moment that you weren't here at Bell Labs, but you had a large sum to spend as you liked. Would you put it into new antennas or into better analysis of the signals coming into an existing facility or into further study of the plate stacks?

Penzias: I guess I'd—you know, answering a question like that will always get you into trouble with somebody!

Omnir: Take a chance.

Penzias: I think I would like to invest the money in thought, in people. A lot of the money for science in America goes to facilities and somewhat less for maintenance of the facilities. What often falls by the wayside is the kinds of jobs that we need for young scientists who may do the thinking that's more important than any new facility.

In my own work, I like things I can tinker with, where I can use a file and a hacksaw more than the big projects. We have a medium-sized, millimeter-wave antenna here at Bell Labs, and there are projects under way in the United States, Europe, and Japan to build larger dishes and interferometers for that portion of the spectrum. But the trouble with very big facilities is that there's a lot of demand, a lot of investment of money and effort, and eventually all you



can do is work for those results you're virtually sure of before you begin.

Omnit: So the more speculative projects tend to be done at the secondary facilities?

Penzias: Right. There you can make mistakes, you can turn a project over to a student who might blunder but who also might go in a direction nobody else has tried. I don't think you can do without the big projects, but I'd hate to see them taking away all the resources from the smaller ones. Ideas always start very small, in just one human brain, somewhere.

Omnit: Tell us a little about how ideas get started here and how you see your own role as a research director.

Penzias: It's mostly atmosphere, I think. Making sure that the research atmosphere is as good as it has been in the past. Making people aware of their freedom. There's a human tendency, you know, to do what you think is expected. Some of the people who come here to work—with a Ph.D. and a solid bibliography and all that—well, they're here in an open shirt and jeans and sandals, and they may talk "mellowpeak," to use a Doonesbury phrase, but they can still be pretty uptight about doing what the boss wants. So I have to make sure to encourage people not to do what I want, because I'm not smart enough to know what to ask for.

I sometimes provide guidance by what I'd call a "dumb" outlook. This morning one of the researchers here showed me a beautiful experiment, the first time anyone had synchronized two pulsing lasers at different wavelengths. And I was there to ask him why he'd done it. What was new? Because people ought to be able to develop their work. We do have to select some lines of investigation at the expense of others, and sometimes we have to cut our losses and abandon an idea.

One of the people in this division has no desk in his office, just a drafting table and a couch. He likes to lie down and look at the ceiling, and occasionally he goes to the drafting table and draws something or lies on the couch and types on his computer terminal, or he comes his terminal home and plugs it in there. You can't have a person like that in a division that's developing switchboards, but here we have room for unconventional approaches.

Omnit: The Bell Labs record certainly doesn't show any evidence of gold-mining.

Penzias: Oh, it's a high-pressure place in its own way. There's a real desire for excellence. We're a competitive bunch of people, incapable, mostly of doing a bad job. That makes feedback all the more important, and that's part of my job, too, to tell people how they're doing, what's going on, and how it fits somehow into the long-term evolution of Bell Labs' work.

So there's my radio astronomy and the communications research and figuring out a way to use all the freedom we have here. I get into all these areas day by day, which means what I'm doing is a lot of fun. **DO**

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medicine, twenty-five hundred years ago said, "Let thy food be thy medicine, and thy medicine be thy food." Maimonides, in the thirteenth century, said, "Let nothing that can be treated by diet be treated by any other means."⁵

But modern men of medicine haven't been much impressed by this philosophy. A spokesman for the American Medical Association says only that "we haven't seen any sign that [orthomolecular medicine] works. Nutrition is by no means something that the medical profession ignores. We just take a rather conservative view."

The medical establishment's response to the use of vitamins in treating schizophrenia by Drs. Hoffer and Osmond was fairly typical. There almost wasn't any. The report coincided with the introduction of tranquilizers to treat schizophrenia, and it was drowned out by excitement over the wonder drugs.

Medicine's habit of resorting to drugs distresses some orthomolecular physicians, who are certain they have found a better way to treat their patients. It angers others.

"The neuroleptics [major tranquilizers] allowed for more humane control and speedier discharge," Dr. Lesser, who trained in orthodox psychiatry at Albert Einstein College of Medicine, in New York, admits. "But the side effects are so serious that people stop taking them and land back in the hospital. We wound up with swinging-door psychiatry."

Dr. Bernard Rimland, a San Diego pediatrician, is harsher in his criticism. "Modern medicine is bankrupt," he declares. "It's becoming a nightmare. The advances have often been backfired, leaving in their wake death, blindness, stroke, and a variety of other iatrogenic [physician-caused] disasters more serious than the original disease. The side effects of prescription drugs now equal breast cancer as a leading cause of death in the United States."

"The difference between a schizophrenic and a normal person is not that the schizophrenic has a deficiency of Thorazine. The difference between a hyperactive kid and a normal one is not that the hyperactive kid has a deficiency of amphetamine or Ritalin. That's not a rational approach."

Traditional medicine's counterattacks on orthomolecular theorists are more organized and—among scientists—just as telling. Orthomolecular physicians don't do proper research, they charge. "What they do varies so widely that we can't exactly study it," the AMA says.

In 1973 the American Psychiatric Association's Task Force on Vitamin Therapy in Psychiatry told of repeating the studies that orthomolecular physicians feel prove that vitamins can help cure schizophrenia and other mental illnesses. They couldn't get

the same results that orthomolecular researchers claimed. In medicine that's tantamount to saying the treatment just doesn't work.

According to Dr. Lesser, though, the test says more about the way orthodox medicine does things than about orthomolecular practices. "They varied only one nutrient at a time, for example, administering niacin without a low-carbohydrate diet," he testified before the Senate's Select Committee on Nutrition and Human Needs. "It's the classic way drugs are tested in medicine, but it's oversimplified."

Dr. Hoffer, the pioneering schizophrenic researcher, adds that "their method is suitable for testing individual drugs, but it is virtually impossible to test a complex treatment method with it. We change the treatment for each individual, and the dosage must sometimes be chosen by trial and error, as we do with diabetes. It's impossible to arrive at the correct dosage in their double-blind studies, in which the physi-

Orthomolecular physicians remain a small band of hardy pioneers who stand as a reproach to the rest of medicine. If they are right, other doctors are not doing their job.

cian observing the results doesn't know what a given patient is receiving."

Yet most orthomolecular treatments are based on careful scientific research. Dr. Rimland himself provides a good example of how it gets done. Autistic children suffer a purely emotional illness, according to traditional medicine, but psychotherapy has proved heartbreakingly unsuccessful. Rimland has found an orthomolecular treatment that apparently works.

Like many orthomolecular researchers, Rimland got into the field "anecdotally"—because he had seen a specific case. "I have an autistic son," he explains. "I began hearing from parents who tried what Adelle Davis suggested and found that it helped."

To aid in his research, Rimland called in two scientists with solid establishment credentials. One, psychiatrist Enoch Callaway, of the Langley Porter Neuropsychiatric Institute, in San Francisco, joined in because he thought "orthomolecular psychologists tend to do poor research and engage in polemics."

Rimland and his colleagues' study was eventually published in the prestigious *American Journal of Psychiatry*. Although

orthodox psychiatrists claim that autistic children suffer an emotional illness, the researchers found that some, not all, are helped by massive doses of vitamin B₆, combined with a special diet and vitamin C. Rimland now runs the Institute for Child Behavior Research, in San Diego, to continue the work.

It seems, though, that not even careful research can win acceptance for some orthomolecular methods. The use of vitamin C in colds is so hotly contested that not even its startling endorsement by Dr. Pauling, in his book *Vitamin C and the Common Cold*, published ten years ago, could make it respectable. On the contrary, it evoked mutterings that the two-time Nobel Prize winner had finally gone senile.

Several careful medical trials of vitamin C have been performed since then, and the furor still hasn't abated. A recent editorial in *The Lancet*, one of England's leading medical journals, declared that vitamin C does not cut the number of colds people get, but it conceded that patients who used it had milder symptoms than others.

Dr. Pauling is still working with vitamin C, testing it now as an aid to cancer therapy. He and Dr. Ewan Cameron find that terminal-cancer patients, if given huge doses of ascorbic acid, live about three times as long as they otherwise would. Yet he reports that "we've applied to the National Cancer Institute five times for a grant. We do it once a year, at least. So far they've said no. It's a little hard to satisfy them. We'd have to withhold the therapy from half our patients."

Orthomolecular doctors are finding a wide variety of other uses for vitamin C. Nevada's Dr. Cathcart treats about 1,000 new patients a year in his Incline Village practice and reports that "massive doses of C ease viral infections. In the nine years that I've been in Incline Village, which has a generally young population, we've never hospitalized a patient for viral disease."

In fact, Cathcart classifies illnesses by how much ascorbic acid it takes to cure them. "Hepatitis is a sixty-gram disease," he says. "The hippies here all know how to treat it. They come down out of the hills, buy their little can of vitamin C powder, and cure it for about seven dollars."

Patients take vitamin C up to "bowel tolerance"—until they develop diarrhea. "Colds are a hundred-gram disease," Cathcart says. "When they hit, people can take eight grams without diarrhea. They know they've got something, but ninety percent of the symptoms are blocked."

Scientific studies haven't confirmed vitamin C's effectiveness, he believes, because the experimenters used too little of it. The largest doses used in double-blind studies so far is four grams a day. "Everyone's different," Cathcart stresses. "You have to take each patient right up to bowel tolerance."

There is a darker side to vitamin C, however. "People become dependent on ascorbic," Cathcart asserts. "These are



"I'll never forget you, Xena, I'll see your face in every omelet, I'll never again touch another dish of 'coq au vin,' ..."

people on a high-maintenance dose, say over four grams a day. Hay fever sufferers, for example, take ten or fifteen grams a day for years. When you take it, there's a sudden punch, and you feel better."

He warns that if someone using large doses of vitamin C is suddenly deprived of it, say, when hospitalized after an accident, it can be dangerous. "They'll do very badly," he says. "We're getting to the point where it will be malpractice to take away someone's vitamin C."

As the battle over ascorbic acid continues, several other battles are shaping up. One of the most bitter is being fought against the Food and Drug Administration long an enemy of orthomolecular new therapies. Orthomolecular methods are a thorn in the FDA's side, because the agency cannot regulate the use of vitamins and other natural substances as it does artificial drugs. Recently the FDA has attacked experimentation with adrenal cortical extract (ACE).

Patients deficient in adrenal hormones develop fatigue and put on excess weight, usually around the hips. Doctors usually give them synthetic steroids, with dangerous side effects. Dr. Richard P. Heumer of Westlake Village, California, insists that ACE injections are as effective as steroids and free of the hazards. He gives them along with nutritional therapy and B vitamins, especially B₆, and can often wean patients away from other drugs.

Unfortunately, the FDA has classified ACE as a "new drug." This classification makes ACE difficult to obtain, even for research. "Their first commandment is 'Thou shalt not experiment with substances naturally occurring in the human body,'" Cathcart says bitterly. Though the FDA remains unmoved by calls for controlled studies of ACE, Senator Barry Goldwater has thrown his support behind the orthomolecular researchers, calling the report that led to the ban "peculiar and scanty." Whether Goldwater's backing will do any good remains to be seen.

Orthomolecular research has also focused on the sex hormones. Estrogens, for example, are often given for toxemia or bleeding in the first months of pregnancy. According to Dr. Ray Peat, a research chemist, they can combine with unsaturated fats in the diet, causing the birth of small-brained, retarded animals. He claims that using 10 to 15 grams of the male hormone progesterone, instead of estrogens, during pregnancy raises a child's IQ by around 35 points. And even the AMA says that progesterone is harmless to both fetus and mother when given in early pregnancy.

Dr. Peat blames excess estrogen for many ills: "There is an epidemic of prolactin-secreting pituitary tumors," he asserts. "They are the result of the Pill, which contains large doses of estrogen. Progesterone stops it." Other maladies, he says, may be caused by progesterone deficiency. Among them are conditions that mimic epilepsy, multiple sclerosis, and,

surprisingly, estrogen deficiency. All these conditions can be treated effectively with a progesterone skin cream, Peat reports.

We'll soon be adding antioxidants to our morning's dose of vitamins and minerals if orthomolecular physicians have their way. Antioxidants prevent oxygen and some other elements, from attacking easily damaged body molecules. Many of the chemicals in air pollution are oxidants. Vitamins A, C, and E are the best-known antioxidants, but some of the trace minerals are also effective.

Two possible antioxidants that have gained attention recently are zinc and selenium. "We think selenium will be to the Eighties what iodine was to the early 1900s," says Herb Boynton, president of a La Jolla, California, health food business called Nutrition 21. "We're just beginning to find out that most Americans are deficient in it." The company regularly searches the scientific literature for new nutritional findings and offers to answer queries about

Massive doses of ascorbic acid ease viral infections. In the nine years I've practiced in Incline Village, we've never hospitalized a single patient for a viral illness.

human dietary requirements.

It begins to look as if orthomolecular doctors are slowly convincing their more conservative colleagues. Dr. Hossein Ghadimi, a Long Island pediatrician, for instance, is a specialist in metabolic diseases who says he doesn't think orthomolecular medicine is even a legitimate specialty. Yet he gives vitamin C to make antibiotics more effective, uses amino acids and megavitamin therapy, and treats diabetics and hypoglycemics even more rigorously than most orthomolecular practitioners would.

He explains that "there are biochemical reasons to use vitamins in far greater doses than is done in conventional medicine, which says that if you don't feel right, it's part of aging and that you can take Valium to lift your mood. I believe we can manipulate you nutritionally so that, with no drugs, no stimulants, you can start to feel like a new person."

Modern medicine, he agrees, pays far too little attention to nutrition. "Cancer patients often die from malnutrition," he charges. "Overwhelming infection" kills them. No wonder they can't fight off even a little infection. All they're given is a five-

percent glucose solution.

"One of the richest men in the world died of starvation. Aristotle Onassis had myasthenia gravis and couldn't chew. Just like those patients under conventional therapy in intensive-care units, they gave him intravenous glucose. Patients on such a miserable diet die from malnutrition. They should have given him amino acids."

There is a lot of nutritional research, Dr. Ghadimi said. "Doctors know it, but the research doesn't cross over. It just hasn't been used at the bedside."

At long last, that may be changing. Only ten or so medical schools have separate departments to teach nutrition—"and they're lousy," Dr. Lesser said—but the number is slowly increasing. Perhaps the orthomolecular doctors have finally made their point.

There is little doubt that the health nuts were right all along, especially about preventive medicine. Our nutritional needs are more individualized and far more critical to our health than traditionalists have thought.

Though our needs vary and critics claim that orthomolecular practices vary even more, Dr. Lesser points out that there are some basic principles of good health that nearly all the orthomolecular physicians adhere to. It couldn't hurt to include them in our own diets.

"Lesser is more," the psychiatrist quips. "Eat unprocessed foods as much as possible, trying for organically grown fruits and vegetables. Avoid frozen foods. They are treated with chelating agents—the wrong kind. No canned foods. They are contaminated with sugar and salt. Avoid processed and refined foods. No white flour. No sugar. Use maple syrup or unfiltered honey if you like sweeteners. Avoid coffee, alcohol, and the city if you can't, you may have to supplement your basic diet."

He recommends "B vitamins in as balanced a form as possible, such as brewer's yeast." For vitamin E, his rule of thumb is to take 100 units per day for each decade of your life. Vitamins A and D should be taken in a ten-to-one ratio, say 25,000 units of A and 2,500 of D daily, as Adelle Davis prescribed. Add a natural mineral preparation that has as many elements as possible.

Scientists still haven't figured out for certain how much vitamin C healthy people need. Estimates of the proper daily dose range from 100 milligrams up to Dr. Cathcart's four grams per day. Whatever you take, you'll need more when you're ill or under stress. There is some evidence that you should also take more of vitamins A and D and minerals, especially calcium.

"Pay attention to everything you consume," Lesser urges. "You can't expect to be healthy if you put toxins in your body if you are really ill, see a physician. The best of them understand nutrition."

For further information on nutrition and orthomolecular medicine, contact the Orthomolecular Medical Society, 2340 Parker Street, Berkeley, California 94704. **DD**

DOLPHINS

CONTINUED FROM PAGE 85

"Singular Vaj. Plural, Vags. It means 'vagina,' vagina-born. And a lot is in how they say it, too. There've been some pretty bad fights."

"I can imagine. What's this third group you mentioned?"

"Oh, them, They're Mules."

"Mules?"

"Once in a long while a Nat gets a Genie pregnant. Though not me. They make me nervous. And the other way 'round, too. And usually if a baby gets born, it grows up sterile. Well, you've heard of that before, if you know any biology. Take a lion and a tiger. Big cats, same diet, pretty much the same habits. They don't breed. If you try it under laboratory conditions, you might make it once in twenty tries. And if you don't get a stillbirth, you'll get a mule."

"Yes, I know that. It's the very definition of species. One of the basic tenets of Acceptance is the simple scientific fact that there is no form of humanity on Earth that cannot breed readily with any other. Never mind should, never mind might. They can. Once you grasp that, you begin to understand man as what he is—a single species."

"And what we have here," said Altair, "is a different species, and that's all we're saying."

"You still get Mules, though, and that

means you're still very, very close. Tell me. What do the Mules think?"

"That's what we don't really know. Dom Felix, do you know what a 'swing vote' was in an old-time election?"

"That's when a small party has enough votes, in a close election, to decide which of the big ones will win, although they themselves have to lose."

"I like you better all the time," Altair said warmly. "Well, that's the situation with the Mules. We can't tell where they'll throw their weight. I'll tell you this about them, though. In brains and in work, they vary from excellent all the way down to good."

"That's the nicest thing you've said about me all day," said Wallich from the doorway, in a dangerously sweet voice. "Dom Felix, I'm one of those Mules. Hee haw, and all that."

"Oh, Lord, Wally, I, I didn't, I mean I..." Altair turned almost frantically to Dom Felix.

"Listen, there stands the best synthesizing technician in all Medes. There is nobody like her, nobody. Chemistry, biochemistry, physiotherapy, psychotherapy, she can run any piece of equipment in the place. Yes, she can fix any piece of equipment. That's what I was just telling him, Wally!"

"I'm so pleased," she said steadily, and there were tears in her eyes. "Now tell him that I have ears as good as yours, feelings as tender as yours, and that I can hurt just as much as a real person." And she turned quietly and left.

Altair sprang to his feet. "Man, I did in deed blast it good. I'd better go and—"

With a cold sternness Altair had not yet seen, Dom Felix pointed to the bed beside him. "You'd better sit right down again." A moment of confusion, then Altair came and sat. More gently Dom Felix said, "It won't do a bit of good to chase after her now, if I'm any judge, and I am. Later will do, and I'll help if I can, and I can."

"Now you've been almost embarrassing in expressing your liking for me. I'm going to embarrass you twice. One, I like you. I like you very much. I think you're superbly bright, and I think your instincts are in the right place, and I think you're basically honest. Two, I think your long view of human affairs has preoccupied you so much that you've lost your link to the short view here, now Medes. You told me that your function here was to apply that link, and I am telling you that you are not doing it and that there fore you are not doing your job."

"Now wait a—"

"It's testing time, Mister Historian, and I'm glad that's your specialty and that I can speak to it and that I can make my point simply and quickly without sidling up to it. Do you know what a Catharist was?"

"Well, I—"

"A Huguenot, a Jansenist?"

Altair nodded. "The Huguenots were—." Implacably, Dom Felix drove on. "Waldenses, Adamites, Irgun, Zwei Leumi, Mormons, Mau Maus, Pleds Norns, the Confederacy, Symbionese, Froets Raiders, Sans-Culottes, the Polar Gang, the IRA, the Anzac Hangmen, the PLO?"

"Most of those. A lot of them, anyway The Polar—"

Overriding, Dom Felix demanded, "What were the issues of the Thirty Years War? Why the story that men and women were hanged for wearing the color green? Did you know that men were flogged and churches were burned because they did or did not have candles on the altar? Why would a man be hunted down and speared like a boar because he had been seen raising his wine glass over a glass of water? What were the issues? What were the issues?"

"Well, in the case of—"

"Ah! You know. You know because you are Mister Historian. But suppose you are not Mister Historian. You are a modern Terran with a good education and a fine background, and I say to you, Catharists. I say, Waldenses. I say, What are the issues?"

"I... I guess I'd have to say. I don't know. I'd have to say. I'll look it up."

"But if I say modern Terran, does it matter what the issues are? Does it really matter to you?"

"Well, I guess not. Not now."

"Aha. Now we have it. Not now. Altair Two, I submit to you, looking down the long sweep of history that it did not matter then, those things for which people fought and died and were imprisoned and tortured and burned, that in the deepest sense it did not matter if a man turned his face toward

IN THIS THEATER ON MAY 10, 1978
A PUNK ROCK GROUP, STRAINING
AT THE PERIMETER OF THEIR
TALENT, SUDDENLY IMPOLODED
INTO A BLACK HOLE WHICH
THEN VACUUMED UP ALL THE
LITTER FROM THE CONCERT.

Mecca or Rome or Canterbury or stood alone on a rock on a mountain and poured prayer on the rising sun or paid his tithes to this or that emperor. Yes, of course, it was made to matter to the man, but in the larger sense the issues were issues that had no real significance. I read a story about a man who traced back through three centuries of warfare to find the basic issue, and it turned out to be a quarrel over the king's breakfast, whether one should break a baled egg on the big end or the little end."

"That was... ah, Dean Swift, *Tolliver's Travels*."

"Thank you. I'd forgotten. And I submit to you now that your splits here on Medea, with your Nats and Mules and Vags and Truforms, are of the same category and do... not... matter!"

They sat glaring at each other for a moment, Dom Felix less and less as the moments passed, Altair II more and more until he exploded.

"By God it does matter! Do you think we can run the risk of the Gang—ah, Truforms—breeding at random, one with superior size and another with a superior logic, a double-dominant, and a brat who would grow up to be something we couldn't handle? Do you think we want to repeat the mistake of the Computer Wars, when men had to obey the commands of their own creations? Damn it, Dom Felix, the only reason the issues you just reeled off—oh hell, man, you do know your history!—is that those issues were settled—fought and won and done with, and that's why they don't matter. This one is here and now, and we will fight, we will bleed, I will bleed! It's got to be stopped! Then in another thousand years you can look back and say that only a specialist can even remember what the issues were. But you can't say it now!"

"I can say it now and I do. The issues are what they have always been when men turn on one another. You have the power, and I want it. I have the power, and you must obey. I will kill you if you do not give me the power. I will kill you if you threaten to take my power away. It is that that does not matter, it is that that is triviality!"

"Well, if you think we're going to knuckle under to a bunch of... of... why they're not even human!"

"Altair, my history books say that from time to time the Visigoths were not human, the Japanese, the Jews, the Germans, the Irish, the New Jibaros, the—"

"Propaganda talk, Dom Felix," Altair interrupted tiredly. "But this one time they really are not human!"

"And I too really am not human."

The voice behind them was metallic and not quite a monotone, and synchronized with it was a series of soft grunts, whistles, and squeaks, all but inaudible. Dom Felix whirled around and gasped. Altair whirled around—and laughed.

Squatting against the back wall was the strangest animal? creature? being? monster? that Dom Felix had ever seen. It rose as they turned, it was taller than Dom Felix,

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though not as tall as Altair. It was covered in gray-blue fur, with large upthrust triangular ears, clawed feet with slender ankles, and extremely massive thighs, shaped rather like those of a wolf, but obviously jointed to what must be something very like a human pelvis, for it could stand upright with its legs almost straight. The arms were long and slender and seemed to be muscled with knotted steel cable. What at first seemed to be a decoration or even a kind of garment proved to be an inordinately long tail, wound diagonally around the torso upward from its base, just over the small potbelly, and on around and around until its pointed bony tip rested in the area of what would be, in a human, the clavicle. Hooked around the neck was a padded metal band bearing a small grille and a slender curved wire, terminating in a knot the size of a thumbnail, which hovered a few centimeters from the mouth—or was snout a better term? A purplish tongue flicked out and in and Dom Felix was able to see a flash of blue-white teeth, clearly those of an omnivore, with blunted canines and very even, manifestly sharp incisors. The most fascinating feature to Dom Felix was the hands, which bore two two-jointed opposable digits and two very long fingers with small curved claws and in the palms, a protruding chitinous pair of nippers, or beaks, shaped rather like a parrot's but more slender. As the two men rose and turned, it was striking and scraping the two sets of nippers together, making a dry, high-pitched chirping sound.

"Laughing," said Altair aside to Dom Felix, briefly imitating with his own hands the movement of the creatures. "That's the way he laughs." Aloud, he cried, "Aquare, you of! Long-tailed hoptoad—I'm glad you blew in! This is Dom Felix here at last—he just tripped down. Dom Felix: this is my oldest friend on Medea. Really He used to bounce me in his arms while my mom was working in the labs."

The long thin lips quivered and moved, the strange sequence of whistles and clicks emerged softly while the little metal grille said, "Please be welcome and the happiest, Dom Felix. We have spoken much of you and how you have saved the Terra."

"I have heard a great deal about you, too. You are quite a celebrity on Terra, you know. And please, I have not saved the Earth, not at all. I think the Movement. I work in it has done a great deal of good; it was doing it before I joined, and all I am doing is to try to return the good it has done me."

"Ah, please lengthen yourself."

Dom Felix turned a puzzled face to Altair, who laughed and said, "He means, essentially, don't be modest. Ask him how old he is."

"What?"

"Go ahead."

"Aquare, would you mind telling me how old you are?"

"I have achieved my maturity."

Altair said, "You know, according to the

records, that is precisely the answer he gave more than eighty terrayears ago. Ask him why he is the only Arcan—that's his city, Arca—the only one who has ever learned our language."

"Why is that, Aquare?"

"There is no need."

Altair said, "That's from eighty terrayears ago, too. Years before that he showed up at the enclave when it was nothing but a dome and a few fields. He just hung around all the time, didn't want food, didn't want anything. Security got very uptight at first, but, thank the powers, we had a Big Chief with the wit not to blast him. Just a tight guard and observers. One day one of em, a bright Gen—ah, Trufom—called Zyl, noticed those noises he was making and claimed to recognize words. A whole team got to work on it and designed the first version of that computer-translator he's wearing. It's been improved a lot since then. And he's been a great help. He's arranged a dozen or more tours to Arca over

◀ We wear what we please, or nothing... The skin is the largest organ of the body; it needs light, and it needs to breathe. It was never meant to be covered up all of the time ▶

the years, though not much anymore. Nothing changes over there. You'll see for yourself when you start to move around."

While he spoke, the Medean stood quite motionless, head turned to one side. Dom Felix realized suddenly that he did not have binocular vision. Like a rabbit or a squirrel or most Terran birds, the averted head meant Aquare was looking straight at him. Altair was saying, "Neither Aquare nor any other Arcan ever asked for or took a thing from us. Even when our engineers thought they had a better way to do something, or some device or gadget to give to them that they might use, they just looked at it and walked off, and old Aquare here just wouldn't say 'We are content,' he mimicked, and the Medean went chirp-chirp-chirp. And what the hell! We're just not in competition. There's plenty of room, we never built near Arca or any fishing or hunting ground we thought they might use, we can't eat the same food, there's just no reason for any friction. So as time went on, Aquare became free to come and go any time. He stays out of the way—he has a real instinct for that—and he never goes into restricted areas or anywhere where he

might hurt himself. He'll talk to you for as long as you like, anytime, and never gets miffed if you have to cut it short. He'll answer any question—almost—and I just can't remember his ever asking one."

"Doesn't he mind our talking about him behind his back to his face like this?"

"Say no, say no," said the strange mixed voice. "I am a very pleasant conversation."

"Another Terran tripped down to Dom Felix, Aquare. Would you like to meet him?"

"He is Kert Row. I have met him. He and machines and theories all happy harmony together. I do not think they harmony with Medea. I do not say him that. I wish he happy until rested. Time then find out."

Altair groaned. "Here we go again. It's that damn Occam. Such a great idea in theory, a projective computer that will give you the simplest possible solution using all the data, because, according to Occam's Razor, the simplest solutions have the greatest possibility of being right. But how do you tell Occam that problems on Medea are not simple, that solutions that work are never simple, and that there's no way to feed the computer all the data?"

It's been pretty good at cutting transmission time from Earth to Medea, though, receiving laser as long as the trip is in range, computing probable outcomes, and beaming those ahead," Dom Felix said. "That's what brought me here at this time instead of maybe forty years later."

"That is a truly horrible thought," said Altair to the Medean he said. "Dom Felix is going to solve all our problems for us."

"Going to try," said Dom Felix, suspecting that the cheerful historian might have a touch of vicious irony in him.

"I hear him solving," said Aquare. "Well, doesn't. Adamites. Ingun Zael Leumi." A pause. "Altair! You put your ear far down in mouth of Dom Felix. Leave there." Pause again. "Could be Dom Felix is very great. Or very very great. Or the greatest Terran yet on Terra. On Medea. Soon I will know."

Blushing like a schoolgirl, Dom Felix said, "I really don't think I'm so great, Aquare."

"True. But could be. Soon I know." "I really don't know what to say," murmured Dom Felix sincerely.

"Say you sleep now. You more tire than you know. Dream happy."

"Omigod, yes!" cried Altair. "I shouldn't have kept you up, got you all stirred up. He leaped up, swung Dom Felix around, and lowered him gently. Sleep approached with a rush, hudding back just long enough for him to hear Aquare intone sagely. "There is no should. There is only is."

Kert Row, tow-headed engineering genius, lay with his eyes open and started up when Altair came in. "Hi. Hey," he said, abruptly propping himself up on his elbow, you know who that is in there?"

"Sure do. Dom Felix. And he just coked off, which is what you ought to be doing."

"I don't mean just his name. Do you know who he is?"

"Fill me in. It's hard to know when Occam leaves off on facts and fades in the projections. The projections are pretty impressive, though."

"I haven't seen them," said the engineer, "but, sight unseen, I am here to tell you they don't do that man justice. You just don't know what happens when that man turns on... whatever you call it that he turns on." He laughed. "Words just don't do it, see. Look. I saw him put a hundred thousand people in a stadium into some sort of a, oh hell, I was going to say trance. It wasn't a trance. You wake up from trances."

"He certainly spun my head around," Altair pursed his lips.

"I know what you mean," said Kert Row (Altair doubled that). "But you have to see him in action, with a crowd. I mean, before you can appreciate what happens when you're alone with him. After that stadium thing, when I found out I was going to prep with him for two and a half weeks, I thought he was going to burn me to a crisp in the first twelve minutes. But you know what? The whole time he let me talk. He wanted me to talk, and he really listened. I was the guru, he was the student."

"Well, he was," Altair said. "He told me that. He said he was angry at himself for having so little knowledge, so little talent in your field, and how he wished he had even some of what you had."

"He did? Oh... my... The 'my' came out despairingly, as if he had searched for expletives and found none that would suit and had to fall back on something so pale. Altair hoped he would not actually ask whether he had had the same experience with the man in the black burruse, and his hope was realized. Kert Row felt very suddenly asleep with a luminous smile on his face. Altair did not know how long he stood there, tanning his heart with the smile.

Oh.
He turned around. Wallich. One long stride, and he had her, upturned hands on her elbows. He said, "No more. Mule." public or private. Ever."

Tears. There had been tears before, too, but what a difference! He had a mad thought that they must taste different: angry tears and... and these. He slid his arms around her, and she leaned against him for a time. He raised his head, then turned it toward the door, a quiet suggestion. She stood back and looked into his face, eyes wide open and certain, and shook her head. "Not now, Altair. And not for a very long time, but thank you." She tipped to kiss him swiftly on the corner of the mouth and went out.

He glanced at the other door the adjoining room where Dom Felix slept. Little hairy man, he thought, you do move and shake things around here.

In the weeks that followed (Terra weeks, of course. Media stubbornly and reverently adhered to Old World time), Dom Felix visited, Dom Felix observed, Dom Felix questioned and listened and studied; he



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BIOTECH

THE HIGH PRIEST OF GUERRILLA PSYCHOLOGY—Two people sit in a room, conversing normally, except that one of them, unbeknownst to the other, is a "Cyranoid." The words he speaks are not his own but are fed to him through an electronic hookup that he wears in his ear. And the man, who dictates his every sentence stands behind a two-way mirror several feet away and talks into a microphone. He is Stanley Milgram, perhaps today's most innovative experimentalist in the field of social psychology. Famous for his obedience-to-authority experiment in the 1960s, which showed Americans will inflict pain on their fellows if ordered to do so, Milgram has since pioneered studies so original (and oftentimes amusing) that he's been called the Allen Funt of social psychology. If you're freaked out by Freud, paranoid over Pavlov, you'll be blown away by Milgram in the next issue of *Omni*.

SPIN-OFF—Famed science-fiction writer Robert A. Heinlein reacted with horror when called before Congress last July. They wanted him to testify about "applications of space technology for the elderly and the handicapped," but what did he know about that? Quite a bit, it turned out. He knew he probably would have been killed by a stroke had it not been for medical techniques developed during the Apollo missions and other space programs. In next month's *Omni* Heinlein tells of the spin-offs that saved his life and that are now saving thousands of other lives.

BIOTECHNOLOGY COMES OF AGE—With test tube in hand, a scientist spools out spaghetti-like threads of DNA on a glass rod. At a later stage he will combine it with DNA from another source to create a new life form—one that will convert biomass into gasoline or produce a rare antiviral substance. Where is this research taking place? You may have guessed MIT, Stanford, or another university think tank. In fact, commercial rather than academic enterprises are leading the race to develop the practical applications of recombinant DNA. In the upcoming issue of *Omni* read about the revolution in biotechnology and the wonders it will bring about.

MICROWORLDS—All scientific investigations look at the mysterious, the strange, and the unknown. Perhaps the most fascinating research tool combines the illumination of the microscope and the recording power of the camera. High-quality optics has opened up entirely new worlds to us, from the crystal lattices of minerals to the inner structures of cells. The best of these new worlds can be seen in our exclusive pictorial of Nikon's annual photomicrography contest in the March *Omni*.



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became as ubiquitous as the Arcan Aquare, appearing everywhere, anywhere, at any time at all, while staying out of the way.

He witnessed the departure of the lander that had brought him and experienced the strange mixture of feelings experienced by all Trippers, it was unlike any other departure since men first traveled, boarded, entrained, and explained, for there was no waving from the rail, no message from over a horizon, no captain's table, flight attendant—none of that. There were seventeen days of psychological and biological preparation, and then immersion in the bio-energetic phase-inversion field—all this planetside. Subjectively the Trip was instantaneous, objectively, a half-century or so. Between these extremes of time, Occam, the projective computer, drank information until the wet ran dry soaked up by distance. It did its extrapolations, and, when it could, it sought and found its opposite number on the approaching ship (for ships, few as they were, were scheduled to coincide going and coming, so they might pass each other somewhere near Midpoint Turnover). As long as they could, they swapped and shared and then turned their lasered cargoes on their destinations, so that when they arrived, all their news and knowledge were there before them. It was difficult to regard the Trippers as strangers, only the destination was strange, and that only to the Tipper himself. Knowing all this, it was a quite indescribable emotional experience to watch the departure of a shuttle bound for its orbiting interplanetary—a launch that, if one tripped again, one would not feel, a Trip that, from beginning to end, one would not truly experience, in a ship one would never see. For all that the launch represented the casting off, the burning of the bridge, the lost opportunity to take it all back, cancel the plans, go back home. And then the impact that no amount of prep could ever quite erase. You can't go home again. That poignant truth so often learned by any growing consciousness was multiplied immeasurably. Home wasn't there anymore. A true-time century would take care of that.

His acclimatization took considerably less time than anyone had expected, and soon he was able to slay quite comfortably at the Rim, breathing ninety-percent Medean air and becoming accustomed to Medea's strange and multishadowed light—what some forgotten technician with a poetic twist had called thick light. He found, as had others before him, that his eyes, more and more, winced from the brilliant light flooding the Terran agnecompounds, finding comfort in the more muted tones of the land and the faintly luminous dull oranges of the estuary. The winged structures of the outbuildings fascinated him, for Earth had never seen the like: ultimately he would claim one of them as his own.

His preoccupation, of course, was with people, the interaction of people with

people and between people and ideas. He won the confidence of the Big Chief, Director Kesseridge, a born administrator who was so good at his job that it was rumored he might be a Triform, made to order, so good at his job that he was bored with it, bored as only a man can be who has no alternative to that which he does well. Dom Felix was able to interest him in that facet of Acceptance that taught the ability to listen to a man being wrong without correcting him. It was hard to do, even to grasp, at first, but when he set out to practice it, he found himself welcomed more and more in places and in situations he had never dared approach before. He thought this was a miracle and Dom Felix was a magician, and thenceforward all doors were open to the hairy little man in the black burmosee.

Dom Felix acquainted himself with all the sections—astronomy, agriculture, meteorology, biochemistry, radiology, xenology, bioenergetics, ecology, and all the divisions of life support. Most often he was the student and the specialists were the teachers; occasionally he displayed absolutely astonishing knowledge in one field or another. He had no intuitive grasp of mechanics or number in its widest sense, but he was as fascinated as a wondering child at what they could do. He seemed (because it was genuinely so) ashamed of what he considered vast holes in his erudition, and his expression of it can only be called bold embarrassment—an immediate willingness to announce the fact that he did not know and that he could not grasp. It was most disarming, and it made no enemies. And he began to distribute his sign.

Interest in it developed slowly. He did not force it or sell it or seem to attach much significance to it. He simply did it. Regarded at first as a mere quirk, it began to attract attention and then curiosity, when in a conversation would he make this sign, and did these occasions have anything in common? What was its purpose, and what did it mean? Speaking with someone, he would put up his hands, palms down, the left resting on the right, and raise them together almost to the level of his face, while slightly inclining his head. Then the hands would fall away and the talk would continue. Thought at first to be a gesture of greeting or of farewell—a kind of *sayonara*—it was gradually noticed to occur at rather of these events.

It was, in its quiet way, extraordinarily potent. The hands placed together and raised appeared to be defensive, to say "Stop!" But the inclined head turned it into a tribute, a concession. "You have a point there." One thing was certain. Whatever provoked the gesture—intensity, passion, rudeness, that kind of positiveness once described as "being wrong at the top of your voice," or even simple inaccuracy—once the gesture was made, it ended with Dom Felix having the floor. It was one of the most ingenious stoppers ever devised, and

the more its meaning was understood, the more potent it became.

The day Acceptance entered Medea was the day someone was moved to ask of the sign, "What does it mean when you do that?"

Dom Felix smiled and answered "It's a way of becoming." No more would he say about it for a long time.

The day Acceptance began to ferment in the enclave was the day someone thought to ask, "A way of becoming what?"

And Dom Felix smiled and answered, "It's a way of becoming you."

He would discuss this. When asked, though he never forced it. He explained that when he used the sign, he suspended his own thought and even his own identity and made a profound effort to become the other person, to see with his eyes, feel with his fingertips, think with all his method and mode, background and learning. So the gesture did indeed cry "Stop!"—not to the observer, conversant, opponent, but to Dom Felix himself. And the quality of obedience was real, because for that moment the other was dominant. And the air of concession was real, for during that moment the other was as right, as authoritarian, as commanding, as he felt himself to be.

The day Acceptance achieved full flow on Medea was the day one man used the sign on another and neither was Dom Felix.

And the day Acceptance could acknowledge its victory was the day a Natural used the sign in talking to a Triform. Mission accomplished.

The mission was, of course, not accomplished in any single hour, for the concept had to soak in cell by cell, as bread takes up red wine. And like any battle won, it had then to be secured, and to this Dom Felix now turned his attention. During the time in which the raised hands were replacing the raised fist, Dom Felix worked toward the root cause of the rift between the Naturals and the Triforms. "It has to be simple," he told Altair. "All basic things are simple. Complicated things might be vital, they might make great literature and music and empires and human disasters. But if they are complicated, they are by definition not basic." Altair spent a good deal of time with him, especially since Dom Felix had gently pointed out to him something he should have known, something that had sidled up on historians since the first frogloyley grunted the tale of last month's contest with the timber wolf. History isn't only then, it's now. Dom Felix, in his turn, was delighted with the big man's growled and pitiful comments. "Ye shall know the truth," he said one day, "and the truth shall make you frantic. Mankind has never solved its problems. It has just substituted larger ones."

And Wallich was invaluable to Dom Felix because of her wide knowledge of so many technologies and their theoretical underpinnings. Her ability to make clear analogies between anything she knew well and anything else she observed

was a knack so absent from Dom Felix that he earned a kind of vacuum in its place. Like all movers and shakers before him, he was an obsessive and lacked the synthesist's ability to seek for the balance in things, to turn the coin over to seek for parity when imbalance fell in his wished-for directions. Wallich had changed radically since his arrival, polite and efficient as always but intimate with no one. She made herself useful, close to essential, to Dom Felix while carrying on all her other responsibilities. And if this cost her recreation and sleep, she bore it well. No one knew.

The third favorite of Dom Felix was the young agricultural engineer who had tripped out with him. Kert Row. True to Altair II's prediction, the hardware he had brought with him—automatic machinery to invert and neutralize the hormone poisons that made Terran crops and bacteria lethal to those of Medea—were useless. The theories the hardware was based on were nonsense. Faced with the facts, he made no effort to deny them. Despite his years of labor in the R & D of something the computers assured him would work, but that did not, he flung his energy and design genius into new problems, half a dozen of them ranging from jet-cycle improvements (they say the level deck stabilizer was his) and a new high-acceleration centrifuge to mess-hall conveyors and a balanced-light eel for the art section in recreation. His grasp of physical principles was so clear

and immediate that it was he, for example, rather than Aquare or any of the old hands, who was able to explain to Dom Felix the basic idea of an Arcan wing structure just by looking at one. All Terran buildings were designed this way now, dome buildings having been all but abandoned. Medea's ferocious, unpredictable winds were capable of sweeping away almost any kind of surface structure, just as a hurricane-proof building will blow apart in a tornado. "By golly, they got wings!" exclaimed Kert Row the very first time he and Dom Felix looked out from the Rim of Pellucidar across the Terran compound. "Those buildings, you see? Wings. Airfoils!"

Dom Felix looked at the odd structures, puzzled. They were rooted to the ground, and they bristled with short, thick shelves, as if a builder, assigned to apply caves, had suffered an acute attack of surrealism and had stuck short pieces all over the roof and walls. At Kert Row's command he watched them carefully through the twirl and bluster of the Medean gusts. The 'wings' were trembling, becoming thick, then thin, twisting, warping. "How about that!" the engineer said admiringly. "How about damn well that!"

"I don't understand."
"Those buildings don't fight the wind. They use it! Watch that. There, do you see? You see what's happening? Those fools can sense wind direction and force, make one edge a leading edge and the other a trail-

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ing edge, and bulge the chord enough to give positive or negative lift, or... yes, see that? They can twist from the root, acting like the control planes on an underwater craft. But, working together, they ride the wind or use it to press down or relieve strain no matter where the wind blows from or how strong the gust is. But, my God, they have to sense and react in microseconds! How do they do that in time?

"Are you really asking me?" Dom Felix was awed and genuinely humble.

"I go find out," said Kert Row, and he pelted off. When excited, he would speak in some idiom of his own, a sort of baby talk. Dom Felix looked after him admiringly and turned back to contemplate the bristle of nervous wings.

Kert Row indeed found out and returned with an explanation, not one word in ten of which Dom Felix understood. It was a welter of chips and microsenors, pressure magazines, release valves, dynaflex and alloy cores, microcyogenic superconducting hairs, and lots more. *By definition not basic*, thought Dom Felix, *but it works*. He was overwhelmed with admiration for Kert Row's ability in this, to him, impenetrable area. He let himself float uncomprehendingly in this sea of words until he heard Kert Row say, "And you know what? It's an Arcan design."

"It's a what? I understood the Arcans had no technology to speak of."

"Right. They haven't. They grow the wings for their buildings. They have a central building in Arca with a tower thirty meters tall—in this wind!"

"Grow them?" Dom Felix asked.

"This is a crazy place," said the engineer, and it was a compliment to the place. "This is a crazy toy shop. All the weather there ever was: one place or another, little ecological pockets, all kinds of mutipotent radiation. But look, even on Terra we have little plants that fold their leaves when you touch them. Why not a plant that adjusts its leaves to support the plant in variable hurricanes? Survival is survival."

Well, that's basic, said Dom Felix to himself, and he reflected that basics may be simple, but when you get all the way down, you don't get a thing or even a method. You get a principle. "Then why do we need all that hardware?"

"Because we're poison to Medean life forms, just the way they are to us. We can't work with living plants or living anything, not with any reliability. We can work with their principles."

"That's what I just said," and only then did Dom Felix realize he hadn't said it aloud. He went away to meditate on the nature of basics and the nature of principles. And it was through this path that he secured the victory of Acceptance on Medea.

"I want to find the truth, the real truth, about something," he told Wallich one day. "And I think you're the one to ask. You are not a Nat, and you are not a Truform." He

saw her tense, but only because, by now, he knew exactly what to look for, and he was looking for it. My she was cool.

She looked at him levelly. "And exactly what am I on your eyes?"

"A real person."

It was quite the right thing to say. "What do you want to know?"

"Something that perhaps I shouldn't be asking. If I really shouldn't, will you keep my asking confidential and tell me anyway?"

She looked at him for a long moment, level eyes under a fringe of heavy honey hair. She seemed to find in him a man who could keep a confidence, and perhaps by then she had one herself that might need to be kept. She nodded.

"Thank you." It was no idle, push-button. Thank you. "Nats are fertile. Truforms seldom are. Why?"

"Because of the way a Truform is designed and decanted. Realigning his DNA gives him or her whatever special talent is needed but takes away the ability to repro-

● *The day Acceptance entered Medea was the day someone asked of the sign, "What does it mean when you do that?" Dom Felix smiled and answered, "It's a way of becoming." No more would he say.* ●

duce. But why should that make a difference? He or she can make love or have sex fun just like anybody else, and if it's children they want, they can get them by contract easily enough."

"They get a special talent or structure, and it costs them fertility. The one means the other."

Everybody knows that."

Dom Felix smiled. "You'd be surprised at the things everybody knows from time to time. Once everybody knew that old Terra was flat, and if you went too far, you could fall off the edge, and it rested on the back of a big turtle, and the sun went around it."

She laughed. "No."

"Oh, yes. Now everybody believes that the engineers can't design in a new characteristic without eliminating fertility."

"Well, they can't. Or they don't. They never have. Dom Felix, what are you driving at?"

"I've just been fantasizing that maybe the earth is round like a ball." He had at times a sudden and childlike smile and he used it now. "I've been thinking that maybe the engineers can inject a special characteristic without eliminating fertility—always

could. They just don't."

"Well, they can't," she said positively. "And if they ever could, why haven't they? If they had, there wouldn't be this trouble between them and the Va—er Nats."

He spread his hands. "If I knew for sure, I could stop fantasizing about it. Wallich, will you check it out for me?"

"Well, sure, if you really want me to, although it's like finding out if we really breathe oxygen."

"Then find out if we really breathe oxygen," he said. "But, Wallich, find out carefully all right? I'd as soon nobody knew I was wondering about it. And be careful. It just might be a hot question—hotter than you realize."

"I don't believe it, but—all right, I'll be careful." She rose in a swirl of gossamer and went out.

Dom Felix leaned back in the lounge, which gently massaged his lower back, and he began to meditate. He was interrupted after a time by a soft, rapid chirping. "Aquare!" He opened his eyes. He was right. The bizarre creature squatted against the wall by the door, brushing his long, strange hands together in his mode of laughter.

"You're laughing at me." Dom Felix said this without rancor. He had by this time become quite accustomed to the Medean's appearances, which seemed to be occurring more and more often. He had been told all his defrosting that the Arcans, like virtually everything else on Medea, had no conflict with humanity, no competition for anything with the possible exception of Lebensraum, and there was still plenty of room on plenty of land and probably always would be. Medea's function in the universe—as Terrans conceived the universe—was to supply one single export: knowledge. There seemed no reason for Arcans, or even one Arcan, not to have the same motivation: to acquire knowledge without conflict, without competition, without friction. And if from time to time Terran and Arcan found each other funny it was to be expected. Accepted.

"Laughing is I am intelligenter, you a foolish."

"What?"

"Laughing is I see you in shame."

"Aquare I don't feel—"

"Laughing is pretense attack, all knowing is pretense," the almost uninflected voice, with its background of soft squeaks and gurgles, went on. Dom Felix stopped trying to respond and began simply listening, trying to follow.

"Laughing is hiding afraid. Laughing is you unhappy, I happy I am not you." (Dom Felix realized at last that Aquare was making a list.) "Laughing is I give you happy then I happy with you. Laughing is I suddenly-quickly admire. Laughing is I see I have no word to say. Laughing is I have no word to say cannot find word to say, no not ever and must say no more. Laughing is more more-more." *Chirp-chirp.*

"Ah," said Dom Felix. "What you're saying

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is that there are many kinds of laughter and that it can mean many different things. You couldn't be more right. Whole big books, whole studies, have been done about laughter. So... why were you laughing at me?"

"Suddenly-quickly admire. Again. More."

"Well, thank you, Aquare. I really don't know what I might have done to earn it."

"All. So far."

"So far. You mean I'm on the right track? Going in the right direction?"

"What is right?" There was no inflection to indicate that this might be a question, but what else, thought Dom Felix, could it be? What is right? What is right, for whom, under what circumstances, and, in the sweep of growth and change, for how long? What is right? That was a big one.

He laughed. *Laughing is I have no word to say*, and the Medean chirped right along with him.

They sat for a while in companionable silence. In his many encounters with the strange Medean—and he realized there had been a great many recently, an increasing number, as he moved about dropping his seeds of Acceptance—he had noticed that he was quite comfortable with the silent, brief appearances and with the conversations, short and long, shallow and deep, as they occurred, but also with the "being together," kind of association. "Being-together," he murmured.

Chirp-chirp-chirp-chirp.

Wallich came in. "Dom Felix, I—oh."

Chirp-chirp. Aquare unfolded himself from his squat by the wall and went away.

"I hope I didn't—"

"He was just leaving anyway." Dom Felix overrode her. (How had he known that? Had he known that?) He had no time to think it through; words tumbled from the girl.

"I didn't ask anybody. I mean I did, but it wasn't anybody, it was the Central. I guess if you hadn't warned me, I'd have wandered in and asked Jeth or Harick or someone else in Gengineering, but I didn't. I went to the computer, and you know what?"

"I think I do."

"It just read out EP. I asked it if sterility was the result of characteristic injection, and I got EP. I asked if DNA redesign necessarily resulted in sterility, and it said EP. I asked the same question from every possible direction, and that's all I got—EP, EP, EP."

"I don't know what EP means."

"Oh. Established Procedure. But you know that's a dumb answer. That isn't an answer at all!"

"That's right."

"It's as if Central was programmed to answer any question like that that way."

"That's right."

"How did you know, Dom Felix?"

"I didn't know. It's just—well, it had to be that way. Vags and Gengies and Mules—excuse me—and all that fear. There had to be something people just didn't know. That kind of fear always comes from something people just don't know. In this case it isn't

this group or that group that doesn't know. Nobody knows. So everybody's suspicious and afraid. Tell me something, Wally, about Established Procedure. Who established it?"

"Oh, who knows? Gengineering's been done on Medea for a hundred years, and the procedures were coded back on Terra before that. The only variations we do here have to do with characteristic design: physical, mental, and not an unlimited number of those. The basic procedures—what produces a whole human being—well, they just are, that's all."

"The word for that is tradition," said Dom Felix, "and that brings about the rule of the dead hand. Wally, the reason I asked you to be careful in your questioning is that I thought we had stumbled on a deep, dark, deadly plot." His smile came and went. "It isn't. It's the dead hand. It's people who did right things the right way a long time ago. But the things they did lived after them, the same things, the same way, while the world

*“The long, thin lips
quivered and moved; the
strange sequence
of whistles and clicks
emerged softly...
while the little metal
grille said,
‘Please be welcome.’”*

and the universe changed around them. Ask Altair about Marxism and revisionism. Ask him about Catholicism and Luther. The greatest movers and shakers our species has ever known, the greatest thinkers, have one and all done one inexcusable, thing: They've died, and their accomplishments froze at that moment. Nothing in the universe ever stops except the human politic, the human solution to this problem or that. And when we stop, we fail. Stopping is the only unnatural thing there is, every force in nature, every object in the universe is in motion, changing, changing... His mind reached Aquare's *What is right? Nothing*, he thought, *is right in all ways, for always*. He was on his feet. "I'm going to the Big Chief." And he did, a bright-eyed black bullet, leaving a honey-haired technical synthesist staring after him in astonishment.

And somewhere out in the blowing dusk that is daytime on Medea, on his way back to his city, an Arcan brushed his hands together. *Chirp. Chirp. Chirp-chirp.*

Stop and let me be you—the gesture of Acceptance—had yeasted through the

enclave by the time the Big Chief passed the word, the final word that forever lubricated the dangerous friction between the factions. It was—had been, rather—the secret of secrets, the psychological dynamite that might well have blown the human colonies to fragments, blowing in Medea's treacherous winds, for arriving ships to find and wonder at. The secret was simply that sterility was not the price of special aptitude, that in the production of a Truliform from normal human genes sterility was accomplished in one programmed operation in the DNA alteration and the applied special aptitude in quite another. In other words, the sterility was not at all necessary in the case of any individual, but it was essential to all. For without it the new trait was heritable, and the alteration of the gene pool was inevitable and unpredictable. To maintain the special lies Medea felt toward the mother planet, the possibility of a genuine alteration of species was unthinkable, so the Truliforms were simply not permitted to breed. Yet their every other human attribute was preserved, for the sake of harmony on the colonies. It seemed an obvious and simple solution, and it was just on the point of failure when Dom Felix arrived. It must fail because it was an imposed solution; any solution imposed on a segment of humanity must fail eventually. Only government by consent of the governed can survive.

To explain this to the colonists at the outset might well have been impossible, to have this knowledge freely given to an Accepting species dissolved all tensions. To empathize, to feel with another's fingertips, and to see out through his eyes was the purpose of Acceptance and the means to its ends.

And Dom Felix wrought his miracle in just under four Terran months. And the Big Chief said to Dom Felix, "Now tackle the Arcans."

"They're just altogether goddam standoffish," Altair explained to Dom Felix. "I can almost understand their not offering us anything they have. But it just doesn't make sense for them not to take anything we offer. It would be all profit for them, no loss. We've designed ground transportation for them, for example, protective side arms, boots to keep them from being bitten by the wildlife around here. But no, there they go, bare toes, on foot, at the mercy of these crazy winds and the crazy bugs and beasts. Don't think they gave us the winghouses. We observed them, we copied them, we engineered them our own way. But they never offered a thing."

"What about that city of theirs? What do they do there?"

"Nothing! I mean, I really and truly kid you not. Nothing. First of all, Arcas is not a city. I'd call it some sort of a shrine if I thought for a moment they had a religion or some sort of reverential philosophy, but they haven't, or, if they have, it's not visible to the naked eye. What do they do? Nothing! They sit around, that's what they do. If you have a

chance to go there, don't bother. Central can give you all the holes you can take, if suicide is your hobby, you can bore yourself to death with them. Nothing's changed over there in the past century. They just sit there—no talk, no music, no rituals, and certainly no fun and games. No agriculture, no trade, no manufacturing. Every now and then a dozen or so get up and leave, walk away single file up into the mountains. Every now and then a dozen or so will walk back in. Whether they're the same ones or not, there's no way of knowing. They don't wear clothes or decorations, so how can you tell who's boss, or chief, or whatever? They don't use weapons, not even a pointed stick. They maintain Arca pretty much by hand. I must admit, they can do a hell of a lot with hands like those. And they just sit."

"What about Aquare?"

"By now you know as much as anyone—maybe more. He's spent more time with you than he ever has with anyone. Maybe he's some sort of freak. Maybe he's the only Arcan ever born who ever had a hobby, and we're it. One thing's sure. He's the only one who can talk to us, or ever did. You can bet that as soon as we had that translator functioning we made more—over a hundred. We thought it was a real breakthrough, that we'd hold conferences, that we'd find specialists, that we had a short line to their history and their culture and their science, if any, to say nothing of

their knowledge of the local wildlife.

"Well, forget it. We fixed up a harness for Aquare to tote some of 'em back to Arca, and he just politely wouldn't. There is no need." That's all he would say about it. There is no need. So we trundled them out to Arca in a convoy of cycles. Tried to hand them out. The Arcans wouldn't take 'em. So we just had to pile them up and leave them there. They just left them where we put them, till they got kicked around and mostly lost. But there are still some lying around there."

"What about Aquare?" Dom Felix asked again. "I've never really talked to him about Medea or the Arcans. Maybe he has... by God, he has led the conversation away from that. But there was always so much to talk about. A kind of philosophy that, well, that I can touch but not grasp."

"Oh, sure, I know just what you mean. But, hell, he isn't human, and it would be stupid to expect him to think like one," Altair said. "But he's been no help whatever in the nuts-and-bolts of local flora or fauna or weather or damn it, anything. Big Chief we had before, he got so sore about that that he locked Aquare out, forbade him the premises. Aquare didn't ask why, then or ever didn't go away stood out there in the wind for weeks until the old chief relented and let him back in. And he didn't ask why then, either." He shook his head. "But if you can make that Acceptance trick work on the Arcans, there's no end to the good it will

do. How long do you think it takes us to learn as much about Medea as any one of those hop-toads could tell us in a single hour of real communication? Months, years, maybe."

"And while you're bringing diverse species together," Altair added abruptly "see what you can do about Wallich. She and I used to fun around a lot, and I don't mind telling you, I miss her."

"You don't see her much?" Dom Felix was surprised, but then, he had been busy.

"I don't see her ever! Not since the day you were defrosted. She's around you all the time, and doing her own work as well."

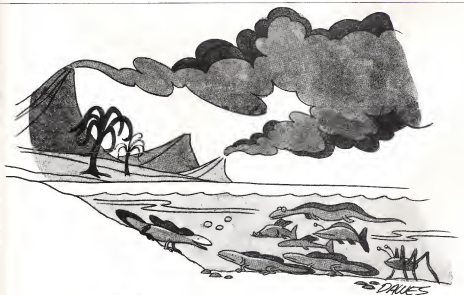
"She's been a great help. There's something very special about her. I'd give anything for her grasp of... well, of everything."

Altair nodded. "A synthesist. She was sired by one, a Triform. Also a synthesist designed for it, but I do believe she's better than he was. There's only one head in this whole place that can compare with her, and that's your friend Kent Row. Seems kind of stupid, well, childish, you know what I mean? But he is to technology what Wally is to theory. A supergenius. It isn't what they know which is plenty. It's how they think."

Dom Felix nodded. "It absolutely awes me. Well, if you like, I'll sound her out."

"I wish you would. Truth is, I'm surprised at myself. Never knew I'd miss her so much."

To be continued next month.



"Life will emerge from the sea tomorrow at twelve noon. Pass it on."

MUSIC

CONTINUED FROM PAGE 26

Relying on precise modern data for observed motion of the planets, the professors then needed a function for the rate of change of each pitch as its planet's velocity varied during its orbit. For this calculation they used the cosine function that graphs simple harmonic motion, that is, the movement of a point around a circle.

At that stage they encountered problems. For one thing, they couldn't synchronize the six planets' tracks on the Moog synthesizer. Conventional instrumentation posed other problems. So they turned to the computer. Jacob Druckman, head of Yale's electronic music studio, referred them to Laurie Spiegel, his former assistant and an electronics composer in her own right, and she agreed to collaborate.

Why was the computer the only instrument capable of creating this music? "Several reasons," Spiegel explains. "These pitches are all glissandi, that is, they're all continuous, smooth pitch changes. There is no way to control them carefully on instruments. Also, the sounds are not fixed in discrete rhythmic units. It's impossible for people to play these things."

By feeding the computer precise data, Spiegel was able to write a program establishing a phase relationship for the planets. She used the GROOVE hybrid system at Bell Labs, developed by Dr. Max Mathews, director of acoustical and behavioral research at Bell Labs. GROOVE is a system for synchronizing multiple oscillators that can generate the necessary sound.

In the spring of 1977 Spiegel, Ruff, and Rodgers performed a tape at Yale, and Carl Sagan was impressed enough to include portions of it on the Voyager space probe. Ruff and Rodgers, however, were still not satisfied. "We had the data, but we were unable to make the outer three planets sound," Ruff remembers, "since their frequencies were below the audible spectrum." Furthermore, they had not accommodated the elliptical nature of the planets' orbits. Rodgers said, "It's not so important for planets with nearly circular orbits, but for the more eccentric ones like Mercury and Pluto, it becomes quite important to work out exact formulas for the ellipses, to make the music more closely resemble the actual movements of the planets."

The project moved to Princeton University's Computer Science Center to take advantage of the newer IBM 360/91 system. There computer specialist Mark Rosenberg wrote a new program for Kepler's music; he used the MUSIC 4BF program originally developed by Mathews at Bell and modified by Princeton's Hubert Howe Rosenberg also found a way to make the outer planets audible as beat frequencies. Thus, the ancient idea of the music of the spheres gained a new dimension: a rhythm section. "I knew there had to be rhythm out

there," said Ruff, whose specialty at Yale is musical rhythm (he participates in an interdisciplinary faculty seminar on rhythm, which includes a neurophysiologist, a psychologist, a poet, an art historian, and a philosopher).

The final result of Ruff, Rodgers, and company's effort was the album *Harmony of the World*. It's on the Kepler label, of course. The record contains 264 years of planetary music (at a scale of five seconds per year to put it within range of a human life span). It begins appropriately on Kepler's birthday, December 27, 1571, and continues to December 1835.

Mercury, fastest and closest to the sun, makes a high chirping sound. Mars has the most erratic orbit, its song sliding up and down a wide range of notes. Earth and Venus seem coupled in a duet in minor key. Kepler equated Earth's song with the 11th minor second of the scale (to him, the planet sang a dolorous litany of "misery-famine-misery").

Jupiter has a majestic, organlike tone, shifting slowly and weaving mysteriously with Saturn's deep growl, moving in and out of a major triad as the spheres alternately overtake each other.

The entire concert is a shifting moiré; melodies disappear before they develop, and the planets seem to move from duets to trios to solitary wanderings. The listener seems projected outward among the planets themselves, until it seems as if one is at the center of the solar system. It becomes, as Kepler might have hoped, a variety of spiritual auditory experience.

"Kepler searched all his life for general principles—patterns," Spiegel remarked. "And to be able to take a set of relationships discovered in one place, generalize them, and set them into another medium—that is an important idea for our time, too."

Spiegel, Ruff, and Rodgers plan to explore further musical analogies in the sciences. Ruff has received diagrams that suggest rhythmic applications in the amino acids, and even of interest to him is the possibility of finding correspondences in the world of subatomic matter. "The music of the quarks," he bantered.

An album is available from Willie Ruff, Yale School of Music, 96 Wall Street, New Haven, Connecticut 06520.

Other composers have given musical expression to astronomical themes. Gustav Holst, in his 1916 composition *The Planets*, interprets seven planets. Holst's work, conducted by Sir Adrian Boult, is available on Angel (S-36420). Ralph Vaughan Williams's *Towards an Unknown Region* (1907) is conducted by Boult and performed by the London Philharmonic and Chorus, on Angel (S-36972). George Crumb's *Makrokosmos* music for amplified piano and percussion, is available on Nonesuch (Vol. 1—71293; Vol. 3—71311) and *Odyssey* (Vol. 2—Y-34135). Hindemith's *Harmonies der Welt* suite, though out of print, may be found on Deutsche Grammophon (DG 18181). **DD**

FILM

CONTINUED FROM PAGE 24

multiple-screen extravaganzas. The owners of Multiscreen developed their new camera-and-projection system, called Immax.

Unveiled at the World's Fair in Osaka, Japan, in 1970, Immax was an impressive display of film technology. *American Cinematographer* wrote, "The film is the largest film format in the history of the movies. The frame size is three times the size of Cinerama and can indeed produce a high-fidelity image nine stories tall. . . . [It gives] a first inkling of what movies may be like in the future."

As the Immax system slowly got under way, Low served as an occasional consultant. "I've been out of production for some time," Low said. "I haven't directed in years, but I wanted to get back into things. So *Weather* seemed a good idea. The big surprise for me was having to learn how to approach Omnimax. It's just not the same as shooting a regular film."

Low continued, "You must always bear in mind that the picture will almost completely surround the audience, filling their entire peripheral-vision area to absorb them, and then add more so that they'll have to look around to see everything. The timing of a shot is changed because of that factor. When we have a lot of things happening on screen, we have to hold the shot longer."

The filmmaker stresses awareness of perspective and composition when working in Omnimax. "Since the top of the picture is directly above the heads of the dome audience, you must be careful to keep things that would appear abnormal out of the shot. With a flat picture a person's head can be right at the top of the frame, but in Omnimax you have to avoid that, because it would look as if that person's head was shaped in a right angle. When I'm shooting people, I try to keep them low in the picture just ahead of the audience."

Although there has been communication between the different theaters that show Omnimax films about how the pictures should be done, a collaborative effort has never been made to finance, produce, and distribute a film made in this format. "Before now," Low said, "several Omnimax theaters were making little films of their own. Since there was only a limited attendance, the pictures were being designed for small, regional audiences. Now that more and more Omnimax theaters are being constructed, the movement is going at a faster pace."

Omnimax films have explored space and the oceans thus far. Now, with *Weather*, we're trying to make it a bit more earth-bound. "We've been shooting on glaciers, in snowstorms, in rainstorms, showing how men are beginning to interact with their environment." If *Weather* succeeds, it'll be the first step in the next phase of Omnimax—a unique experience, expanding the dimensions of film. **DD**

FROSCH DROPS A BOMB

PEOPLE

By Dick Teresi

Space may someday be populated by self-breeding robots. First they'll orbit the earth. Then generation after generation will follow, with the total number of machines growing exponentially, spreading to the moon, building space colonies across the solar system and then throughout the universe.

A nice idea. But who believes it will ever happen? None other than NASA's administrator, **Robert A. Frosch**. Addressing the Commonwealth Club in San Francisco, Frosch called for a "productive machine economy" in space. "The key to this idea," he said, "is the construction of a machine that, either totally automatically or with minimal human intervention and guidance, can use solar energy and local materials on the earth or the moon or an asteroid or elsewhere in the solar system to build a replica of itself."

This scenario is a bit of a bombshell, coming as it does from the normally conservative Frosch. It also came as a bit of an embarrassment to some NASA officials, who say in private that the agency doesn't have an in-depth plan for self-replicating robots. What it does have is findings from a NASA/Jet Propulsion Laboratory (JPL) study group, which concluded that NASA should place heavier emphasis on machine intelligence and robots not only for long voyages but also for operations near Earth. But, says one JPL staffer, the agency does not presently have the automation or production capabilities to do this.

Phil Donahue, whose midmorning television talk show is a hit among America's housewives, has had some interesting guests in recent months: transvestites, Rosalynn Carter, Barry Goldwater, lesbian couples, Betty Ford, Leon Lederman. Leon Lederman? Yes, the famed quark hunter and now director of the Fermi National Accelerator Laboratory (Fermilab) faced the cameras recently to answer questions about atom smashers, gluons, the unified field theory and the big bang. Oddly enough, the high-energy physicist proved to be a big

hit with the ladies, a combination of kindly researcher and Catskill comedian. Here's one typical exchange.

Lederman: "I'm going to spend the next ten years trying to split a quark."

Donahue: "But why? You know, why would a guy spend all that time trying to..."

Lederman: "Well, you know, it's a living."

And to a hostile question from the audience challenging Fermilab's \$100 million budget, Lederman replied, "Don't forget that you have to put the hundred million dollars into the context of what this country does as a whole. A hundred million dollars doesn't pay for a fraction of the chewing gum we chew. Why don't we all stop chewing gum? Then I could make an even bigger accelerator."

Lederman may not yet be in a league with Henny Youngman, but he is funnier than Edward Teller.

Meanwhile, the fame of another science media star continues to spread: Carl Sagan, whose new series, *Cosmos*, will debut on PBS television in the fall, will become a household figure in Japan

shortly thereafter. The Asahi Broadcasting Corporation of Tokyo, which previously picked up Jacob Bronowski's *The Ascent of Man* and John Kenneth Galbraith's *The Age of Uncertainty* (both PBS productions), has now agreed to televise *Cosmos* as well. While watching Sagan film a segment of the show recently, a group of Asahi executives became very obviously enthusiastic; and one remarked, "That Sagan will go over well. Much better than Bronowski or Galbraith." "Why?" our reporter asked him. "Because," explained the Oriental businessman, "he looks Japanese."

Stanley Milgram, the social psychologist who shocked the country with his obedience-to-authority experiment two decades ago, revealed an unusual fact about that project to writer Douglas Colligan, who was interviewing him for an upcoming *Omniv* profile. After the interview, Milgram asked Colligan whether he knew any scientists he considered to be good writers. Colligan immediately named Freeman Dyson, the Princeton physicist, whose book *Disturbing the Universe* had just been published.

"Freeman Dyson! Freeman Dyson!" exclaimed Milgram. "There's that name again." Without further ado he took Colligan into the inner reaches of his offices at the Graduate Center of the City University of New York. There, in a back room, Milgram revealed the Machine. It was the terrifying shock generator he had used in his obedience-to-authority experiment. Subjects were made to think that this machine was administering 450-volt jolts to strapped-down "victims." It didn't do anything, of course, but it looked as if it could.

Milgram disclosed that he had built part of the machine with his own hands while he was at Princeton's Institute for Advanced Studies. "During that time I kept hearing this name Freeman Dyson over and over." So it was only natural, Milgram said, that when he finished making the machine and needed a name for it... He pointed to a label on the side of the generator. It read, "Dyson Instrument Co." **DO**



NASA's Frosch: Surprising talk about robots

Illegal Aliens

The opening paragraphs of "Illegal Aliens" [November 1978] are reminiscent of an early scene in one of my favorite movies, *The Day the Earth Stood Still* (1951), based on a 1940s short story "Farewell to the Master," by Harry Bates).

In the movie, the alien Klaatu (played by Michael Rennie) has just emerged from a "silver disc" that landed in Washington, D.C. He lifts his hand, clutching a small object (a gift for the president), and is promptly shot and wounded by an overzealous American soldier. Klaatu, however, had the foresight to travel with Gort, a sort of intergalactic robot policeman, who at once zaps the offender and his fellows, destroying only their weapons and tanks, not the humans.

One hopes that future alien visitors to our world will be similarly accompanied!

Jane Morgenstern
Brooklyn, N.Y.

I believe aliens would have a rotten time here. In addition to all the legal bugaboos that Robert A. Freitas discussed, consider everyday life on this Here Marble. Could an extraterrestrial obtain credit? Buy a house? (Oh, Gawd, there goes the neighborhood!) Wait tables at a fancy restaurant? Use a Minolta successfully? What about gas lines? Would a space visitor be admonished for tank topping? Is there really enough leg room in that Fiat? Could an ET get a date with H. R. Giger? And what would Darth Vader have to say about all this lack of hospitality?

Gabrielle Davis
Bridgeton, Mo.

Antimatter Overheated

The article on antimatter in Omni's November issue was interesting, informative, and well written. However, toward the end the author got a little overheated on the subject of space travel, as often happens.

Dr. Robert L. Forward suggested that with antimatter and water as propellant, we could travel to the nearest star in 50 years, using only 100 kilograms of antimatter and an unspecified amount of water. He had previously stated that 10 grams of antimatter combined with 40 tons of water would propel a 10-ton craft to Mars in a week. Assuming these proportions for a trip to the nearest star, we would require 400,000 tons of water. This works out to about 13 million cubic feet, which would occupy one tank 100 feet in diameter and nearly a third of a mile long.

One big problem for space travel has always been the high ratio of fuel weight to payload. But, after all, matter isn't so hard to come by in space that you should have to carry it all with you from home. We know that "empty" space is filled with a very low density of ions, atoms, and molecules. It is

conceivable that this matter could be swept up by some kind of collector—magnetic or otherwise—on the ship, passed to the rear, and combined with an antimat- ter to create a sustained energetic propulsion of some kind.

Brice Stewart
East Lansing, Mich.

Dr. Forward replies: *Dear Mr. Stewart, no, you do not need 400,000 tons of water. I tried to make it clear in the article that the JPL Jet Propulsion Laboratory study found out that the optimum ratio of payload to reaction mass is the same for all antimatter-energized missions.*

For a 10-ton payload, you will need 40 tons of water (hydrogen is better) and an amount of antimatter that depends upon your destination. For Mars you heat the 40 tons of water with 10 grams of antimatter to get a very hot steam jet. For Pluto you heat the 40 tons of water with a kilogram of antimatter to get a plasma jet. For the stars you heat the 40 tons of water with 100 kilograms of antimatter. The energy content of the heated water is then so high that it is difficult to imagine an engine that can contain it without melting, but that is merely an engineering detail. Your idea of sweeping up the interstellar hydrogen as a reaction mass is a good one. I had heard of laser augmented scoops that would use Earth-based lasers to heat the scooped-up hydrogen, but not of antimatter-energized scoops. Perhaps you should write it up and submit it for publication in the Interstellar Studies issues of the Journal of the British Interplanetary Society.

Coup d'Etat

Futuristic science (which studies the potentials of space, space travel, solar and other "soft" sources of energy, biophysics, and so on) has been failing to an all-time low in public opinion, manifesting itself in behavior just short of a Salem witch hunt. This behavior originates from the federal government's inability to engineer a stable and goal-oriented program of scientific research and development that the public can directly relate to. As Jerry Gray pointed out in the First World [August 1979], it is the classical (and logical) role of the government to provide funds and incentives for new research, but our democratic government has failed us miserably. All these problems of confidence, corruption, and self-interest leave the mind boggled. What can we do to correct this situation? My answer to this question follows.

I propose a scientific coup d'etat in our country. Since political ideals control necessary research and development, scientists, college professors in pertinent research, inventors, and innovative, credible corporations (such as those in Silicon Valley) must become more involved in the political processes of our country. Realizing that lobbying groups in Washington, D.C., already are pleading for funds, facilities, and other resources, these groups need to

strengthen their base of support. The support base I propose is a new political party. This political party (let's call it the New Renaissance Party, I invite other suggestions for a suitable, futuristic name) could build a significant political bloc with well-organized operations. These operations may include, for example, making information of scientific breakthroughs readily available (Omni is an excellent start) and encouraging the application of new technology in all facets of life. Envision the NRP as a "statue of liberty" of science, technology, and, finally, progress.

Keep in mind that certain corporations seem to retard public awareness of new technology by buying the patents of inventions that could endanger profit margins. But think of an interstate and intercity magnetic levitation train system. Think of electricity from solar collectors in space. Think of mining the moon, the asteroids, perhaps Mars—instead of Mother Earth. Think of living tomorrow instead of today.

In the event our government continues to act indifferently toward futuristic technology, we must take action for ourselves. Scientists and graduate students have too many excellent ideas waiting to be developed, only to be brushed aside by an ignorant government. The economic costs are extremely high, but our survival is worth the extra cost.

David Rounds
Batesville, Ark.

Garage-Built A-Bombs

If I were to come to you (or anyone else) and say, "I have an atomic bomb, how would you react?" I would wager that 99 percent of the people would say, "Sure, that's nice," and they'd walk away laughing.

The problem is that many people can build an atomic bomb, but hardly anyone knows this or believes it possible.

I am seventeen years of age and a junior in high school, and I am sure I can build my own A-bomb.

I believe that it would be interesting and informative if Omni were to publish an article about garage-built atom bombs. Maybe you might even go so far as to tell how to build one. After all, the principle is simple, the materials are available, and everyone should be alerted to the dangers of the wrong people building such a bomb.

I would not hesitate to build one, if I had the necessary materials, to prove how easy it actually can be.

Jeff Sharpe
Joliet, Ill.

Thank you, but we'll pass on this one. —Ed.

Our Man in Perth

Just a quick note from down under to let you know that we really appreciate your magazine. Yours is the first science magazine that I have read from cover to cover.

Omni, keep coming!
Max C. deVetri
Perth, Western Australia

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UFO

CONTINUED FROM PAGE 32

years, but the scientists concluded that one civilization would occupy the entire galaxy long before another could arise by chance.

Computer specialist Robert Sheaffer described unpublished details of many famous UFO sightings, providing details that make the cases far less impressive than they are made to appear in the popular press. Sheaffer also suggested that the residue of unexplained UFO reports is mere "noise" due to the unreliability of memory and eyewitness testimony.

This conference may be as significant a scientific event as the 1971 conference at Byurakan, in the Soviet Union, which legitimized the whole topic of SETI. It did not reach any formal conclusions, nor did it open up any new ways to deal with the possible existence of ETI. But it did underline a growing sentiment in the scientific community that the wild optimism for ETI in the 1960s and '70s may have been based on bad data and now-shaky theories.

Dr. Ben Zuckerman, another of the conference organizers, was rather low key in his new-found skepticism. "There aren't many compelling scientific arguments on either side of this issue," he remarked, "although I think the weight of evidence does suggest that we have the biggest brains in the galaxy." Dr. Zuckerman, who helped conduct the sophisticated OZMA-2 radio search of 600 nearby stars in the mid-1970s, explained what changed his mind: "Carl Sagan has been asserting that life and intelligence are just natural extensions of stellar and planetary evolution; that it is all a step-by-step inevitability. That seemed too strong for me."

Recent scientific discoveries have borne out Zuckerman's caution. The much-touted astrometric, or star-wobble, evidence for the existence of large planets around nearby stars has been discredited as resulting from instrument error. The obvious cause-and-effect relationship between slow stellar rotations and the presence of a family of planets has been shot down. But the existence of totally sunlike stars many billions of years older than ours has been established, thus affording aliens innumerable opportunities to expand into our solar system—if they are out there at all.

The origin of life on Earth remains problematic, the progress of evolution seems increasingly uncertain and freakish, and the rise of intelligence and technology could well have been a fluke. The stability of a hospitable planet over the billions of years needed for life to spring up and undergo changes now seems less likely. Internal variations and external deviations caused by solar variability passage through interstellar dust clouds, and unlucky proximity to sterilizing supernovas are much more probable than was once believed.

Thus, there are no scientific reasons to suggest a priori that other intelligent beings must have developed just because it has happened here. If other such life forms did arise, the conferees concluded, either their transgalactic activities would be overwhelmingly obvious or they would have settled in the solar system eons ago.

Boston University astronomer Michael Papagiannis suggested that they might have settled in the asteroid belt and may still be there. Other participants in the conference described how star-faring civilizations would be able to "terraform" likely planets into life-bearing worlds, wherever they chose to colonize. The absence of evidence for such developments thus becomes evidence for the absence of ETI. At least, that was the theme of this budding SETI countereformation.

Such an opinion is anathema to the pro-ETI astronomers and to UFO buffs. The vehemence of believers in UFOs may be spurred by a poorly recognized aspect of the UFO camp itself. It, too, is critically split over the issue of ETI. Several leading spokesmen have abandoned the "alien spacecraft" theory altogether. Dr. J. Allen Hynek, for example, calls such an explanation "naïve and simplistic."

Dr. Hynek, a former air force consultant on UFOs, deserted his debunking campaign in the mid-1960s and founded the Center for UFO Studies, in Evanston, Illinois. He is still convinced that UFOs represent a real phenomenon. At the same time he's unimpressed with the ETI explanation for them: "There is a lot that the spaceship concept doesn't explain about UFO phenomena," he told an interviewer in 1977. "You have to disallow or neglect or overlook all sorts of things if you accept the idea that nuts-and-bolts craft are coming here from outer space—the so-called extraterrestrial hypothesis. I think they're something much more metal/terrestrial than extraterrestrial." The term metal/terrestrial refers to the suggested link between UFOs and psychic phenomena, pottersists, "parallel realities," and other planes or vibrational levels of existence. Modern science rejects all such theories, but they have been receiving support from such UFO theorists as Jacques Vallee (see *Orion* interview, January 1980), John Keel, Peter Kor and Alan Greenfield.

So the three-way battle over ETI continues, with shifting alliances and varied fortunes of war. The concepts remain exciting, and the hard data remain sparse. Neutral parties can watch the skirmishing from the sidelines with a mixture of amusement and confusion, as claims and counterclaims are thrown back and forth with all the subtlety of thermonuclear bombs.

The ones who would be most amused, of course, would be the ETs themselves, if they exist. Picture them silently watching Earth's civilizations develop, seeking criteria to confirm the existence of TI—terrestrial intelligence. Perhaps this debate is the final exam in that test. **DO**

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ATOM SMASHERS

EXPLORATIONS

By K. C. Cole

In a two-mile-long tunnel beneath the rolling hills of northern California, electrons ride a microwave almost up to the speed of light. Inside a ring four miles in circumference, surrounding a restored prairie 30 miles west of Chicago, protons are pushed in circles by magnetic fields until they emerge with energies of 500 billion electron volts. In a one-half-mile storage ring under construction in Ithaca, New York, matter and antimatter will whirl around in opposite directions to collide head-on in a burst of pure energy and mutual annihilation that will leave in their wake particles "strange" and "charmed," evidence of quarks and gluons.

The quarry of high-energy physics is elusive, elementary, infinitesimally small. Yet the mammoth atomic microscopes that physicists use to track them are hulks of copper and concrete, elaborate and gargantuan. They have been called cathedrals to contemporary science. In their presence, one feels a respect for pure power, an awe of the unknown and, perhaps, the unknowable.

High-energy particle accelerators are instruments of the most basic kind of

scientific research. They are designed to get to the heart of the matter, to search for nature's raw ingredients, the indivisible elements of the universe.

Up until about 25 years ago atoms were thought to be composed of three elementary kinds of matter: light, negatively charged particles, called electrons, orbiting a dense core of much more massive protons (positively charged particles) and neutrons (chargeless particles). Although electrons so far have not been broken down into any simpler constituents, both protons and neutrons have yielded even smaller particles when bombarded under extreme conditions, achievable only in the most powerful of the high-energy accelerators. For example, the first evidence that protons may be composed of quarks was obtained at Stanford Linear Accelerator Center (SLAC), where it is possible to reach energies massive enough to create new matter—energies, indeed, that make speed meaningful only in terms of mass.

All high-energy accelerators speed up particles to within a whisper of the speed of light. At these relativistic velocities,

enormous energy is converted into a tiny quantity of mass, as predicted by Albert Einstein's famous equation $E=mc^2$. Thus, adding more energy at this point serves mainly to give the nuclear collision more weight. By the time an electron is 100 feet along the two-mile path of the Stanford Linear Accelerator, it is traveling at 99.9 percent the speed of light; at the end of its journey one thousandth of a second later, it has acquired virtually no speed, but 40,000 times as much mass. It is this conversion of mass into energy in violent collisions, and the re-creation of mass in a new form, that allows scientists to study unseen elements of nature.

Besides SLAC in Palo Alto, California, two other high-energy accelerators in the United States fall into this elite category: Fermilab National Accelerator Laboratory, in Batavia, Illinois, and Brookhaven National Laboratory, in Upton, New York. Both operate synchrotrons, the progeny of Ernest O. Lawrence's first, 11-inch cyclotron, now on display at Lawrence Hall in Berkeley, California. Cyclotrons accelerate particles inside two D-shaped magnets with a series of alternating electrical jolts. The particles spiral outward, their speed increasing with the distance they travel so that they are always in the right place for the right jolt at the right time.

When particles approach the speed of light, however, they increase in mass and slow down. Accelerators were needed that could vary the frequency of the electrical push and that later could vary the strength of the magnetic field that kept the particles in place. Cyclotrons began: synchrocyclotrons, proton synchrotrons, and eventually super high-energy alternating-gradient synchrotrons like those at Brookhaven and Fermilab.

(Synchrocyclotrons retain the basic characteristics of a cyclotron—spiral path, two solid D magnets—but synchronize the frequency of the electrical jolt with the particle's speed. Proton synchrotrons use a single, large, circular magnetic field that increases in strength as the particle accelerates, keeping it on a circular path instead of a spiral one.)



Inside Fermilab's four-mile ring, protons are accelerated to close to the speed of light.

Alternating gradient synchrotrons refine the magnetic focusing further by dividing it into independent sections.)

Fermilab has one of the two largest proton synchrotrons in the world (the other, equally as large, is in operation in Switzerland). Like most large accelerators, it is really a series of accelerators. First, an electrostatic generator strips hydrogen atoms of their electrons and boosts the resulting protons to 750,000 electron volts. A linear accelerator 500 feet long rides them along an electromagnetic wave up to an energy of 200 million electron volts (MeV). A booster synchrotron then raises their energy to 8 billion electron volts before they begin a 50,000-rps ride around the four-mile-round main accelerator.

Linear accelerators can also be used to accelerate protons and other ions (atomic nuclei), but their main advantage applies to electrons. No magnetic force is required to guide electrons along the straight path of a linear accelerator. In contrast, synchrotrons must use a magnetic field to keep electrons going around in circles, and enormous amounts of energy are radiated when electrons experience this force. The energy loss is such that Cornell University's half-mile-circumference electron synchrotron required 3,300 revolutions per second to achieve less than half the energy obtained in SLAC's straight two-mile run.

Electrons in a linear accelerator are pushed along by the crests of a microwave propagating in a copper tube. Because electrons function as elementary particles, electron collisions are "clean." The particles are used as point sources, not to smash atoms, but to probe them.

Accelerators provide beams not only of protons, electrons, and heavier ions but also consisting of a whole stream of secondary particles, including kaons, pions, mesons, and photons. Some of these particles live for only one billionth of one trillionth of a second. Many do not normally occur in nature. Scientists identify and study them by observing the trails of bubbles they leave behind as they boil liquid hydrogen in bubble chambers or by scanning the series of electrical sparks they set off in spark chambers or the ionization they produce in computerized scintillation counters. Specific particles are isolated for investigation by huge magnetic spectrometers that separate particles according to their mass, much as a prism separates colors in light. SLAC's experimental area End Station A contains three such spectrometers, which rotate around a common pivot in a concrete vault.

But spectrometers and bubble chambers and even accelerators themselves are already nearly passé. Particle tracking is done by computer, and the excitement of accelerators is focused on the large storage rings that will circulate already-accelerated particles

(sometimes matter and antimatter) in opposite directions. Instead of colliding with a stationary target, one accelerated particle will collide with another accelerated particle. It is the difference between a truck running over a bug and two speeding trucks colliding head on. Among the colliding-beam projects currently under construction are SLAC's Positron-Electron Project (PEP), the Cornell Electron Storage Ring (CESR), Brookhaven's Intersecting Storage Accelerator (ISABELLE), and Fermilab's Energy Doubler. It would take a single ring as large as North America to achieve the energies planned for the Fermilab project.

Of all the big accelerators, Fermilab's is the most spectacular (It offers both aesthetically pleasing power lines and a buffaloherd.) But you don't have to go to the front of the line to get a good view. Berkeley's Bevatron (a proton synchrotron) is effectively out of the high-energy physics business, at a mere 6.8 billion electron volts. Nonetheless, it is active in good old nuclear physics (mainly accelerating heavy ions) and in nuclear medicine. The 135-foot (in diameter) housing looks like a concrete carnival big top.

Like most accelerator facilities, the Lawrence Berkeley Laboratory has several linear accelerators, electrostatic accelerators, and cyclotrons, some of which the public is encouraged to see. As is true at other facilities, the site is littered with spoils of cable, steel beams, and spare magnets—testimony to the constant building, repairing, and tearing down. Concrete bunkers and corrugated metal barracks (where physicists set up experiments) lend them the look of construction sites—which, in fact, they are. Accelerators are one of a kind, and almost everything is homemade.

IN TRANSIT

Because all these facilities are funded by tax dollars, visitors are usually made very welcome. At centers where regular tours are not conducted, they can often be arranged on demand. Not everything is open to the public, however: so it's best to telephone in advance.

Other accelerators worth seeing are: Clinton P. Anderson Meson Physics Facility, Los Alamos, New Mexico. 800 MeV proton linear accelerator, about half a mile long, provides intense secondary beams of pions, muons, and neutrons. William H. Bates Electron Linear Accelerator, Middleton, Massachusetts. 400 MeV electron linear accelerator, 663 feet long, used mainly to study weak interactions in the atomic nucleus. Argonne National Laboratory, Argonne, Illinois. tandem Van de Graaf electrostatic accelerator, which injects into a superconducting linear accelerator (ATLAS) accelerated heavy ions to 9 MeV. The superconducting cavities allow the tracing of nuclear events to within 25 billionths of a second. **DD**

TO GAMES

ANSWERS TO GAMES (PAGE 128)

Turnabouts

107734 inverted is HELLO!
Civil War battle: SHILOH
Gambler: HE LOSES
Casablanca/goffer (with liberties taken in spelling): BOGIE

CRYPTARITHMS

(1) ALPHABET	
ASDC	21978
x4	x4
EDCBA	87912

(2) SIX PLUS

SIX + SIX + SIX = NINE + NINE
942 + 942 + 942 = 1413 + 1413

(3) TELEGRAM

SEND	9567
+MORE	+1085
MONEY	10852

(4) GARDEN OF EDEN

EVE/D = TALK/TALK/TALK...
242/303 = 7986/98679867986

(5) DOTS

x	+	17
x	+	x 4
+	+	68
+	+	+25
+	+	93

FIVE ROOMS. The problem cannot be solved on the surface of a sphere, but it can be solved on a torus (below), so long as



the "hole" is in one of the five-wall rooms. This solution was offered by Martin Gardner in a puzzle, Tanya Tackles Topology, presented in the July 1979 issue of Isaac Asimov's Science Fiction Magazine. **DD**

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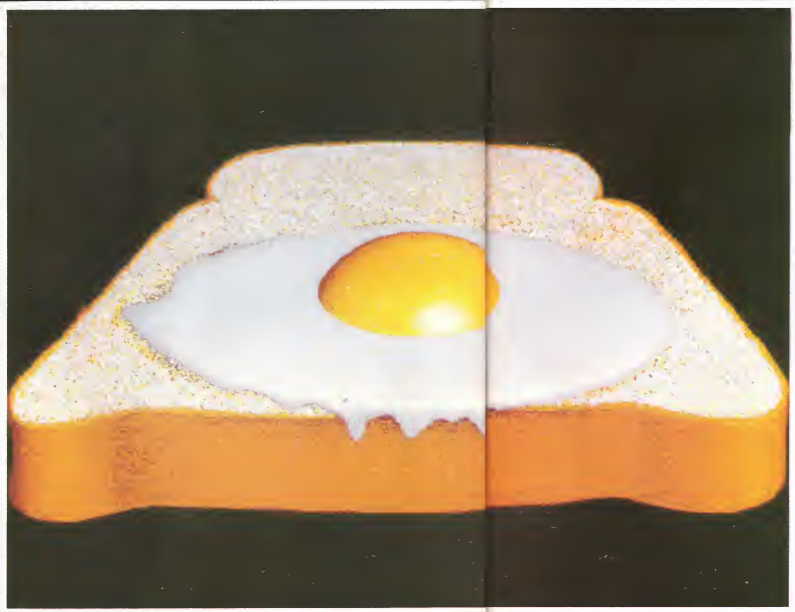
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PHENOMENA

The ability of computer graphics to simulate projects, to create new art forms, and to depict amazingly lifelike images is becoming an integral part of our life. The image displayed here was generated on a Digital Equipment Corporation PDP 11/70 minicomputer at the New York Institute of Technology, in Old Westbury, Long Island.

The "egg" was originally a "flying saucer" created by mathematical means. A series of programs generated a three-dimensional image, and by using a different color scheme, the egg was obtained. The "toast" was created in a slightly different way. An artist "painted" the image with an electric pen and tablet that transmitted coordinates to the computer, where they were stored and then re-created in color to make the image.

Computer graphics, capable of producing an almost unlimited range of colors and virtually any picture an artist might choose to create, is becoming the true middle ground between science and the arts. This image was obtained from the video display screen using a Dunn Model 651 camera and special Polacolor 2 film from the Polaroid Corporation. **CA**

Push-button fun,
and readers confront the "impossible"

GAMES

By Scot Morris

"One evening I was sitting in the rooms of the Analytical Society at Cambridge, my head leaning forward on the table in a kind of dreamy mood, with a table of logarithms lying open before me. Another member coming into the room, and seeing me half asleep, called out, 'Well, Babbage, what are you dreaming about?' To which I replied, 'I am thinking that all these tables (pointing to the logarithms) might be calculated by machinery.'"

—Charles Babbage,
Passages from the Life
of a Philosopher (1864)

Babbage's nap, which he recalled as having taken place in either 1812 or 1813, has given rise to a technology as incredible as any dream. It includes, as one branch of the computer revolution, calculators the size of credit cards, or smaller, and built into digital wristwatches (buttons on the latter are pressed by a hand-held stylus). What keeps calculators from becoming even smaller is the size of the human finger and the acuity of human eyesight.

We have collected several push-button games for your amusement—too many, in fact, for one column. In a subsequent issue we'll present more complex challenges. This month we offer diverse calculations to compute after the checkbook has been balanced.

One class of puzzles relies on the calculator display's being turned upside down so that many of the numerals look like roman letters. For example, 0, 3, 4, 5, and 7 can be read upside down as O, E, H, S, and L. The 1 can double as an exclamation point, and with a little imagination you can get the digits 2, 8 and 9 to resemble the letters Z, B, and G.

A few years ago calculating the cause of the gasoline shortage was the most popular stunt. You would punch in a number to represent the cost of a shipment of oil—426.46407—divide that number by 3 of oil companies, then multiply by an inflation factor of 5. The answer 710.77345. Turn the machine upside down, and there's the culprit: SHELL OIL

(the floating decimal separates the words).

With that in mind, try these quick turnabouts:

- Say hello to your calculator and punch in 107734, then invert for the calculator's answer.
- Multiply 33928.75 by 12 to get the name of a famous Civil War battle.
- If a gambler bets \$25 on 2,140 roulette numbers, then tips the croupier \$7.34 for luck, what's the outcome? (Multiply the first two numbers and add 7.34.)
- What does the movie Casablanca have in common with a weekend golfer? Enter 2562, add 97, and multiply by 12.

Another type of calculator game is the mind-reading trick. After a series of seemingly arbitrary calculator operations a familiar number is revealed. Here are three examples:

- Enter your age. Double it. Add 5. Multiply by 50. Add the amount of change you have in your pocket up to \$1. Subtract the number of days in a year. Add 115. Divide by 100. Finally push the = key. Your calculator will display two numbers to the left of the decimal—your age—and two numbers to the right—the correct amount of money. (From *The Calculating Book*, by James T. Rogers, Random House, 1975.)
- Hand the calculator to a friend, and while your back is turned, have him or her enter any three-digit number of which the first and last digits are not the same. Then ask him or her to reverse the digits mentally (e.g., 396 becomes 693) and subtract this new number from the original. If the result is negative (–495, in this case), he or she is to change the sign (495) and add this number to its reverse (594). Place your hand to your brow and after a suitable pause announce that you have mentally received the total. 1089. Magic? No, the result of this operation is always 1089.
- Take the month of your birth (January=1, February=2, etc.) and multiply it by 100. Add the date of your birth (the first of the month=01, etc.). Multiply by 2, add 9, multiply by 5, add 6, multiply by 10, subtract 422, add the last

two digits of the year of your birth, and subtract 108. The result will be your birthday. (For example, November 3, 1951, will read 110351.)

DROP OUT. David Popoff, of Rowayton, Connecticut, suggests this solitaire game. First, enter a six-digit number in which all digits are different. The object is to reduce the display to 0.00 by using only two-digit numbers and any operation (multiplication, division, addition, or subtraction). Clearly, division or subtraction will be the most effective operations, but addition or multiplication may be helpful in getting rid of a decimal or in obtaining a number that is a square or a factor of a two-digit number. Reaching 0.00 in six moves is good, in five, excellent, in four, superb.

BOWLING. Enter an eight-digit number and divide by 1.7. The first digit to the left of the decimal is a "random" number and designates the score on your first ball—from 1 to 9 pins, or 0 for a strike. To try for your spare, generate a second random digit and add it to your first number. If the total is 10 or more, you have converted your spare. Score 10 frames exactly as in bowling. Larry A. Lansberry, of Phoenix, Arizona, who sent me this game, says, "I find I average about 30 pins higher on the calculator than on the bowling lanes."

CRYPTARITHMS

A type of puzzle called the cryptarithm requires the solver to substitute digits for symbols to produce a valid equation. Though a calculator is not required, it may be helpful in checking your solutions.

(1) ALPHABET TIMES FOUR

$$\begin{array}{r} A B C D E \\ \times 4 \\ \hline E D C B A \end{array}$$

This cryptarithm appears in James F. Fick's *More Games for the Superintelligent* (Doubleday, 1976). A given letter always represents the same digit. The problem can be attacked logically. First, one realizes that A multiplied by 4 yields only a one-digit answer, so A must be either 1 or

2. Next one notices that $4 \times E$ yields a number ending in A. But four times any number equals an even number, so A must be 2. Since 3 and 8 are the only numbers that, when multiplied by 4, have a product ending in 2, then E must be 3 or 8. Can you carry out the rest of the calculations to decipher the cryptic multiplication? When you are done, try these classic cryptarithms.

(2) **SIX PLUS SIX.** Alan Wayne, of Holiday, Florida, originated this elegant puzzle. Different letters represent different digits. Numbers beginning with zero are not allowed.

$$\text{SIX} + \text{SIX} + \text{SIX} = \text{NINE} + \text{NINE}$$

(3) **TELEGRAM**

An urgent message from a freshman

$$\begin{array}{r} \text{SEND} \\ + \text{MERE} \\ \hline \text{MONEY} \end{array}$$

(4) **GARDEN OF EDEN**

$EVE/DID = \text{TALKTALKTALKTALK}$

In this one the fraction EVE/DID has been reduced to its lowest terms, its decimal form has a repeating period of four digits. Again, the solution is unique. (Hint: To obtain the simplest fraction equivalent to a decimal of n repeating digits, put the repeating period over n 9s and reduce the fraction to its lowest terms.)

(5) **DOTS.** Finally, here's a multiplication followed by an addition, a classic brainbender from the English puzzlist Henry Ernest Dudeney. Each dot is a digit from 1 to 9 inclusive (no zeros), and each digit appears once. The answer is unique.

$$\begin{array}{r} \cdot \cdot \\ \times \cdot \cdot \\ \hline \cdot \cdot \\ + \cdot \cdot \\ \hline \cdot \cdot \end{array}$$

OLD BUSINESS

It has been called to our attention that the list of words we published here as "The World's Hardest Spelling Test" (June 1979)

had previously appeared in *Esquire* ("A Spelling Test Beyond Belief," by T. K. Brown III, April 1967). We found the test in a recent issue of *San Diego Mensan*, which had reprinted it from *In Black and White*, a publication of Associated Editorial Consultants in La Jolla, California. The consensus was that this was a trifling spelling quiz, and our asinine, sacrilegious omission of credit was not meant as braggadocio. Our apologies to *Esquire* and to T. K. Brown.

In November we proclaimed, unwisely, that we had the "ultimate" solutions to some classic puzzles and that others were "impossible." Omni readers do not like to be told that anything is impossible, and they told us so. Three problems drew the most mail and deserve comment.

THE NINE DOTS. Several readers showed us how to fold the paper in various ways so that all nine dots could be crossed off by a single line without lifting pen from paper. A box of eight solutions came from Joe Eddy Brown, of Glen Ellyn, Illinois. Among readers' suggestions: Draw a "line" with a very wide paintbrush, fold the paper so that the nine dots are stacked and can be pierced by a single pin, or wrap the paper around a cylinder and cross all nine dots with one line, barber-pole fashion.

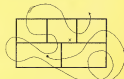


THREE UTILITIES. This problem required you to connect each of three utilities (gas, electricity, water) to each of three houses so that the lines "don't cross or pass under a house or utility." Readers got around this wording by passing lines over houses (the electric lines, naturally) or through houses. One reader stretched the wording to its limit by passing each line under two houses (not under a house). Others

placed the utilities inside the houses or moved one house out of the plane above the others or directly through the center of the earth. Several readers pointed out that if the problem was set on a world that was not a sphere but a torus (the topologist's term for a doughnutlike surface), it could be easily solved, as in the illustration, adapted from one sent in by Chris Hanson, of Seattle, Washington.



FIVE ROOMS. This one drew the most mail of all. We said there was no way to draw a continuous line that crosses every segment on this floor plan once and only once. Several readers disagreed.



The most common suggestion was that since a line has only one dimension, length, it could traverse a wall lengthwise and thereby "cross" it. Fair enough, if we bend the meaning of "cross" a bit. Some had the line leave a room exactly at a corner, thereby crossing no walls, or crossing two or three at once, take your pick. One reader rearranged the rooms to suit her aim ("You didn't say you couldn't rearrange the rooms"). Another avoided crossing over by burrowing under. Some readers said the problem could be solved on the surface of a sphere, others said it could be solved on the surface of a doughnut. Is either solution possible? Answers page 124 **DD**

SWINGER SPEAKS

LAST WORD

By Daniel S. Greenberg

The following is another in an occasional series of interviews with Dr. Grant Swinger, who views the world of science and technology from the pinnacles of the Breakthrough Institute and the Center for the Absorption of Federal Funds. Dr. Swinger converses here with Daniel S. Greenberg, a veteran observer of the scientific community.

Omni: Dr. Swinger, when we last spoke, you were quite gloomy about the financial status of research and development in this country. What I'd like to ask...

Dr. Swinger: Gloomy? I can tell you very plainly that my colleagues and I were desperate. In fact we were so hard up that we were ready to go to the Department of Energy to propose a project for turning oil into coal or shale.

Omni: Oil into coal or shale?

Dr. Swinger: They've got so much money for research and development at DOE that they'll snap up anything. In fact, we've even got them interested in a project to develop a solar-powered typewriter, and we were going to go to the National Institutes of Health with a proposal for appendix transplants. We were desperate. One of our people had an idea about what to do with NASA, you know the National Aeronautics and Space Administration. **Omni:** Of course. What did he have in mind?

Dr. Swinger: Well, with space activities sort of running low, he thought we might take all those laboratories and research centers and get a big national program going to teach animals to speak. We'd beat the Russians. We'd call it the National Animal Speech Administration. We could keep all those NASA emblems and thus save a lot of money on paint jobs, stationery, and shoulder patches.

Omni: I see.

Dr. Swinger: And then we've been tinkering with variations of speed reading. Using the latest optical and psychological methods, we got some test subjects up to five thousand words a minute.

Omni: Five thousand words a minute?

Dr. Swinger: Yes, though at that speed they had no comprehension. But the work

wasn't wasted. We regrouped, so to speak, and took a whack at speed looking.

Omni: Speed looking?

Dr. Swinger: It could be useful, for example, for going through museums. Tourists would provide the market.

Omni: I trust that none of these schemes went very far. I mean, with all due respect they are very far outside the norms and traditions of science and technology.

Dr. Swinger: Of course they are, but that shows how desperate we were. Nevertheless, everything is okay now. We've got a number of new things going at both the Breakthrough Institute and the Center for the Absorption of Federal Funds.

Omni: Such as?

Dr. Swinger: We're running a conference. It's the first annual Conference on Comparative Studies.

Omni: Comparative studies of what?

Dr. Swinger: Of anything you want to compare—apples, oranges, Gross National Product, birthrates. People are always doing comparative studies of this or that. So we figured we'd bring it all

together for a kind of Super Bowl of comparative studies. We'll have simultaneous translation, and after it's all over we'll publish the *Proceedings of the First Annual Conference on Comparative Studies*.

Omni: I see. What else are you doing?

Dr. Swinger: Do you know about the *JRM*?

Omni: No.

Dr. Swinger: It's the *Journal of Rejected Manuscripts*. No author can complain about censorship, suppression, bias, or any of that stuff. Manuscripts go straight from the mailroom to the printer. It's a procedure that's fair and swift and leaves the author with nothing to complain about.

Omni: Why, that's in complete violation of all the basic principles of scientific publishing. What about referees, checking for accuracy and...

Dr. Swinger: I trust, sir, that you are not so naïve as to believe that when a traditional scientific journal rejects a manuscript, the manuscript then never sees the light of day. Of course it does. The author then sends it to another journal and still another, if necessary, until he finds one that accepts it. This is what's been going on all along in scientific publishing, and it explains why new journals keep popping up and more and more papers get published each year, while the purchasing power of the scientific community remains the same or even declines. Rejected papers never die. They just get mailed out again.

Omni: How interesting! What else are you doing?

Dr. Swinger: We have a contract to administer the newly established Fund for Dubious Research. This is a ten-year program in which funding is provided for research ideas that have been dismissed as crackpot, impractical, and so forth. The object is to compare their proposals with proposals that have been rated outstanding and promising.

Omni: But any project supported by the Fund for Dubious Research would be under a severe handicap. Who would publish the results?

Dr. Swinger: The *Journal of Rejected Manuscripts*.

Omni: Thank you, Dr. Swinger. **DS**





Only the best go to the Olympics.

Nothing in the world of competitive sport can match the Olympic challenge. It is a challenge that demands not only the best in human athletic achievement, but a determination that can be summoned up to overcome seemingly impossible obstacles. Yet with all the talent, skill and dreams the Olympic Games focus into crystal clarity for a brief instant, there can be only a few who wear the gold.

For Peggy Fleming and Jean-Claude Killy the intensity of their gold-medal-winning performances on the ice and the slopes passed through them for a few moments of heart-stopping action most of us never feel in a lifetime. But the memories of the day live far more forever in photographs.

It is because of the vital importance of the lasting visual record of these events that Canon has been selected Official 35mm Camera of the 1980 Olympic Winter Games. Under conditions of utmost severity, in a situation that denies com-

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aspect of the photographic obligations that the Games entail. Supporting photographers whose livelihood depends on the images they record for posterity. With professional service and repair, systems support and supplementary or emergency equipment. Standing behind our commitment to being best, by offering the best assistance, money, skill and human dedication can provide.

The quality standard for all Canon photographic products is something you may not see on the outside, but you'll come to appreciate as the years go by. It's the big difference between Canon cameras and others that seem to offer equivalent performance. And it's something that simply can't be faked.

It's inevitable that considering Olympian achievement calls to mind superlative statements. At Canon, we don't use superlatives lightly. We take being "best" very seriously.

And we'll be at Lake Placid to prove it.



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