OMNI

OCTOBER 1983 $2.50

SPECIAL ANNIVERSARY COLLECTOR'S EDITION

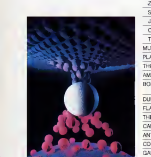
THE CONQUEST OF SPACE

FEATURING:
JOHN GLENN
GERARD O'NEILL
ISAAC ASIMOV
JOHN UPDIKE
ART BUCHWALD
FRANK DRAKE
ROBERT SILVERBERG
TRACY KIDDER

OMNI

VOL 6 NO 1 OCTOBER 1983

EDITOR & DESIGN DIRECTOR: BOB GUCCIONE
PRESIDENT KATHY KEETON
EXECUTIVE EDITOR DICK TERESI
GRAPHICS DIRECTOR FRANK DEVINO
ART DIRECTOR ELIZABETH WOODSON



Michel Tcherevkoff is in the vanguard of his profession as an advertising photographer. His mania for perfection and his creative use of fantastic images result in arresting exotic photos. "This picture is representative of what the artist calls his 'bowl period.'"

OMNI (ISSN 0149-8711) is published monthly in the United States and Canada by Omni Publications International Ltd., 1965 Broadway, New York, N.Y. 10023-5965. Second-class postage paid at New York, N.Y. and at additional mailing offices. POSTMASTER: Send address changes to Omni Magazine, 80 New Bridge Road, Bergenfield, N.J. 07621. Volume 6, Number 1. Tel. (212) 496-6100. OMNI is a registered trademark of Omni Publications International Ltd. Printed in the U.S.A. by Meredith Printing Corp. and distributed in the U.S.A., Canada, U.S. territorial possessions, and the world (except the U.K.) by Curtis Circulation Company, 21 Henderson Drive, West Caldwell, N.J. 07006. Distributed in the U.K. by COMAG, Tavistock Road, West Drayton, London, UB7 7QE, England. Subscriptions: U.S., APO—$24 one year; Canada and elsewhere—$34 one year. Single copies $2.50 in U.S., APO, and Canada. Telephone 1-800-247-5470, in Iowa 1-800-532-1272.

FIRST WORD

By Bob Guccione

"No major new space venture has been undertaken since the shuttle program was begun. Now is the time for a new commitment to space"

In July of this year, NASA Administrator James Beggs announced that he expected to receive the Reagan Administration's blessing for the development of a permanent manned space station in the very near future. If Beggs is right, it will be joyous news indeed. This next step in American space development is as logical as it is long overdue, particularly since the Soviet space program continues at a pace that NASA could never have afforded even during its spirited heyday.

An official declaration of support—backed by the kind of money and materials such a vigorous program requires—would be a fitting tribute to the space agency in this, its twenty-fifth anniversary year. It would further justify the faith that moved us to create *Omni* five years ago this month.

When *Omni* was born, its editorial purpose was already as clear as its graphic beauty: to give science and technology the popular voice they had never had. To help laymen experience and understand the excitement of discovery and the quality of the scientific and philosophical vision that will transform the world we live in. And to do it all entertainingly, without the prohibitive technical jargon or incomprehensible diagrams so common to other science magazines of the time.

We knew, too, how to accomplish our goal: how to find writers whose own interests and knowledge brought them to the frontiers of science, who could unravel with tireless wonder and enthusiasm the complexity of startling new ideas and who could communicate that sense of excitement to others. Add probing interviews with the premier researchers and visionaries of our day. Include the finest in art and science fiction—works by such masters as Arthur C. Clarke and James Michener, Rene Magritte and Marc Chagall—because in the special philosophical alchemy of art and science one finds human truths that ordinary journalism is powerless to express. And in the end, it is the dynamic interrelationship of science and humanity that really matters.

Not at all to our surprise, however, a chorus of skeptics arose to claim that *Omni* could never survive. Science, went the universal declaration, was not "commercial" enough to support a major consumer magazine.

This, *Omni*'s fifth-anniversary issue, proves otherwise. Having more than 5 million readers per month dramatically endorses our belief that science can be as compelling as sex and as entertaining as *Real People*. This vast readership teaches us that we, editors and readers alike, can actually influence the course of human history. Five million intelligent readers, concerned with the quality of life and the future of our species, can become a formidable constituency. Five million eager minds anxious, if not determined, to advance science, peace, and intellectual prosperity in our world can swing a presidential election. This is a fact the present administration might bear in mind where issues of such fundamental scientific and technological magnitude as an American space imperative are concerned.

Science has never been more productive than in the last decade, yet, five years ago, when we introduced our first issue, there were signs of trouble. NASA was entering a period of frustration as the shuttle's main engines repeatedly failed and its heat-shield tiles fell like autumn leaves. After the well-intentioned Asilomar Conference three years earlier, biotechnology was laboring under strict regulations that—needlessly, it turned out—inhibited much valuable research. The microcomputer revolution, which would help to rekindle interest in technology, was still floundering in its infancy.

The many triumphs in these fields since 1978, however, suggest that American science might be regaining, if not sharpening, its productive edge. Such medically important products as insulin and human growth hormone are being produced in abundance by genetically engineered bacteria, and monoclonal antibodies promise soon to make cancer nearly as treatable as heart disease. And personal computers are appearing on almost every desk, bringing new and expanded efficiency to our daily work routines as well as to our thought processes themselves.

Only space development, perhaps the most universally visible of all technological frontiers, has fallen behind. Whereas we may have seen wondrous pictures of Saturn and Jupiter, and although the space shuttle has now proved itself capable of lifting commercial satellites into orbit, these triumphs are the work product of technology a decade old. No major new space venture has been undertaken since the shuttle program was begun. It is time—long past time—for a new commitment to space.

For a brief moment we hoped that the commitment would be made on July 4, 1982, when President Reagan celebrated the return of the shuttle *Columbia* from its final test flight by speaking of "establishing a more permanent manned presence in space." Sadly, no action has followed the President's words delivered over one year ago.

Now Administrator Beggs believes that the commitment will at last be made. President Reagan, he thinks, will finally restore a full-blown American program of space development—a program that scientifically, militarily, economically, and humanistically must ultimately represent the most profitable investment of American resources ever undertaken.

It is to those principles that we dedicate this anniversary issue. ◻◻

CONTRIBUTORS

OMNIBUS

ASIMOV

SILVERBERG

O'NEILL

KIDDER

KENDIG

UPDIKE

BUCHWALD

In the postwar euphoria of the Fifties, visionaries expounded endlessly about conquering space. But the future they painted was a sketchy one, an outline not yet colored in by reality. Magazines of the time displayed fantastic cone-shaped rockets—with gargantuan tail fins—aimed toward the blue sky. The "canals" of Mars seemed within reach.

Today, as this fifth-anniversary issue of *Omni* proves, we have more than blue-sky dreams and fantasies. We have preliminary blueprints for the ships of exploration. And so this issue's theme—the conquest of space—is no space cadet's fantasy but a hard-nosed vision of what we can do with the technology within our grasp. The writers and experts who have contributed to this special issue have one thing in common: They know we can reach the stars.

In "Conquest of Space" (page 158) Princeton University physicist *Gerard K O'Neill* unveils a cost-effective plan for building factories in space. In "Space Arks for the 21st Century" (page 78), *James E. Oberg*, a NASA specialist in orbital rendezvous, describes the next generation of spaceships. And in "Zero-G Lab" (page 60) former *Omni* editorial director *Ben Bova* details the future of Spacelab 1, the manned scientific laboratory that is scheduled to ride the space shuttle *Columbia* into orbit this fall.

You'll also hear what it would be like to have a space activist in the White House from none other than presidential candidate Senator *John Glenn* (D-Ohio). The former astronaut is the subject of this month's Interview (page 126).

Our fifth-anniversary issue also offers some very special fiction. "During the Jurassic" (page 134) is a charming fantasy from *John Updike*, America's chief chronicler of the cocktail party. At this affair, however, all the guests are dinosaurs. An excerpt from *The Robots of Dawn*, *Isaac Asimov*'s new novel, begins on page 148. In "Multiples" (page 72) *Robert Silverberg* describes the plight of a young woman who lives in a society where people can split their personalities at will. The second part of "Carrion Comfort," a novelette by *Dan Simmons*, begins on page 166. And *Nancy Kress* and *Jeff Duntemann* present a moving high-tech story, "Borovsky's Hollow Woman," beginning on page 116.

Also in this issue, *Frank Kendig*, *Omni*'s first executive editor, reviews the state of science journalism (page 51). Freelance writer *Dava Sobel* updates the research *Omni* has covered since 1978 (page 140). America's foremost humorist, *Art Buchwald*, reports in Last Word on a strange UFO incident. And *Tracy Kidder*, Pulitzer Prize-winning author of *The Soul of a New Machine*, profiles an exciting new science writer (page 38). ΩΩ

LETTERS

COMMUNICATIONS

A Touching Future

I would like to offer a positive note for the future that Barbara Rowes described in her article "Techno-Kids" [May 1983]. Rowes made no mention whatever of something that such trend analysts as John Naisbitt have observed for several years, namely that paralleling the high-tech evolution of our society is a trend that is being referred to as "high touch." Our society is increasingly conscious of diet, physical fitness, human needs, and personal interaction.

Rowes painted a bleak future for the Technology Age. I am inclined to believe that our future promises extraordinary growth in human potentials to balance the rapid changes in technology.

J. L. Morgan
Bloomington, MN

And Now for Something Completely Different

I would like to comment on Ted Mann's Last Word, which appeared in the March 1983 *Omni*. The answer to his search for a replacement for the late "Gerbil Gang" of dope-detecting animals is contained elsewhere in the same issue, as I'm sure other readers noted.

But first a word in defense of the intelligence of the tortoise. The common wood turtle or tortoise, of New England ranks high on the roster of reptilian reason. This was determined by one Dr. Tinkepaugh who studied the maze-learning ability of the wood turtle (*Clemmys insculpta*) and concluded that the creature ranked right up there with the rat, which is usually accorded high marks on the rodent I.Q. scale. Only in the time-factor tests was the scurrying *Rattus rattus* superior. I once owned a wood turtle, named Torby, that was quick to learn to crawl out of the backyard goldfish pool and accept finger-held goodies, including such delicacies as meatloaf and strawberries.

But enough of this, and back to the problem at hand. The solution sought by Mann has already been mentioned in my previous paragraph; it is the rat. In the Continuum section of the March issue the training of the "Rat Patrol" is fully detailed. Merely substitute the aroma of certain controlled drugs for the explosive vapors during the described conditioning process. Use of the rat patrol will be simplicity itself. Just let them run free in a secured customs area where suspects are temporarily confined. One look at a hoard of onrushing rodents squeaking hilariously as their pleasure centers transmit increasing pulses of impending ecstasy will be enough to unhinge even the most seasoned drug runner.

F. W. Chesson
Waterbury, CT

Bull Talk

In response to the article "Seeing Red" by Eric Mishara [Continuum, July 1983], I am surprised that a magazine of the scientific stature of *Omni* continues to perpetuate a myth. Bulls do not charge at a red cape because it is red. Bulls, like all bovines, are color-blind. They see only in shades of black, white, and gray. The reason a bull charges at a red cape is because of the movement of the cape. By the time a matador faces a bull, the animal has been teased into a state of rage by the picadors. They run at it, shout, wave their arms, and prick it with sword points. Any old Kansas farm girl, like me, can attest to the fact that when a bull is enraged it will charge at *anything* that moves, including a cape being flapped in its face.

Donna Mansell
Kansas City, KS

Correction

In the article "UFO Update" [Antimatter, May 1983] I am quoted as saying that the Rev. Harrison E. Bailey's photographs "showed no trace of a hoax." This is incorrect. What I actually said was, "Enlarged examination shows no trace of any extraneous marking effects damage or alteration to the images," which is a very different thing.

Cyril Permutt
Director
Bureau for the Investigation of Paranormal Photographs
London, England ◘◘

DIALOGUE

FORUM

In which the readers, editors, and correspondents discuss theories and speculation arising out of Omni. Readers are encouraged to debate views and pose questions to Omni, the scientific community, and the science-fiction establishment. The opinions published are not necessarily those of the editors.

AIDS and Morality

Baruj Benacerraf [Interview, July 1983] has brought a breath of fresh air to the emotion-muggy AIDS debate. As a family-loving, nonpromiscuous, quasi-religious gay man, I'm particularly irritated by the current spate of articles linking AIDS with God's punishment of homosexual "perversion." I'm also angry as hell that it's taken the spread of the disease into the heterosexual segment of our population to elicit any concern at all from the community at large.

I would like to thank Benacerraf for treating the problem as a medical, and not a moral, one.

Rand Lee
Key West, FL

Sex Wars

So the battle of the sexes rages on, even in the pages of *Omni*. I read the letters in Forum [April 1983] expressing female amusement and anger over slights to the "fairer sex," and the letter filled with male outrage at the presumption that women could ever aspire to be as great as men. I have to admit to being amused, a little saddened, and very much dismayed at the self-righteous arguments from both camps.

Okay, so there have been slights, mistakes, and insults on both sides. But isn't it time to suspend these hostilities? Intelligent people have come to the conclusion that war is an unreasonable alternative. Isn't it possible that figurative war is just as senseless? Are *Omni* readers, who claim higher intelligence, intelligent enough to begin a motion for peace between the sexes? It seems about time to stop this nonsense.

Marquita Cook
Danville, VA

Look Again

The suggestion made by professor Robert Lee to blind all criminals as a form of punishment and/or rehabilitation in "Visionary Punishment" [Antimatter, July 1983] is outrageous and insulting. As a blind person, I thought I had heard all the misconceptions about blindness and blind people, but this one takes the cake. There are so many false implications behind this suggestion, and the results could be so damaging that I felt it could not go unanswered.

First, the suggestion implies that by blinding criminals, either temporarily or permanently, they would no longer be able to commit a crime and, if they did, could be easily apprehended. This would appear logical because the public has the misconception that blind people cannot do much of anything, let alone commit crimes or get away with them. Well, blind people do commit crimes and get away with them as well.

Second, the suggestion leaves the reader with the impression that if such a policy were implemented, fewer crimes would be committed. Why would this be? The public fears blindness, and it has been shown in national surveys that the loss of one's eyesight is thought to be the worst thing that could happen to a person short of dying. This is because blindness has always been pictured as something frightening and terrible. Blindness is not frightening or terrible. It can be reduced to the level of a simple nuisance if the individual has good training and a positive attitude about himself. A blind person can live as full and meaningful a life as his sighted neighbors.

Finally, if such a suggestion were undertaken, the public would begin to view all blind people as criminals. We do not need another negative stereotype hung around our necks.

David Robinson
Omaha

A Modest Proposal

Ben Bova's article [Space, June 1983] quoted me accurately enough but left the wrong impression about some of the problems in the space program. Some of my statements, used as counterpoints to Hans Mark, were either taken out of context or juxtaposed incorrectly.

First, it is no longer true that the Reagan Administration "has been nothing but negative." It was, but as a result of education and, I believe, perception of public interest, it has become more positive, if not enthusiastic, for some exploration initiatives. Administration officials have proposed the important Venus Radar Mapping mission as a new start, have spoken favorably of the Solar System Exploration Committee (SSEC) report—which calls for a core program of approximately eight planetary missions in ten years—and have also issued statements in favor of a steady, active space-science program.

The second point of disagreement is that I do not feel the shuttle is too expensive to use for science. The shuttle is fine; its planning was a disaster. A more orderly development, with expendable launch vehicles, would have been better for science, exploration, and all of NASA.

The suggestion that Mark is for the really big "breakthrough" missions of space exploration, while I am for the modest ones, is ludicrous. Mark's citing of the Mars Sample Return is obfuscation. An excellent sample-return mission could be initiated tomorrow if NASA wanted to propose it. NASA hasn't even supported an advanced missions-study program for a Mars mission in four years. Bova is correct in quoting my statement that we need modest but scientifically necessary missions of the SSEC core program. If Mark sees no "advantage" to these, I can introduce him to 1,000 scientists and 100,000 members of the Planetary Society who do. Bova is wrong in suggesting that I'm against more ambitious projects. I emphatically urge this nation to undertake greater missions of exploration now that will serve as landmarks for our society in the future.

Louis Friedman
Executive Director
The Planetary Society
Pasadena, CA **DO**

EARTH

By Douglas Starr

The assignment was a science reporter's dream Visit the top environmental labs learn as much as possible about the nation's pollution problems and come up with some solutions Months later after traveling thousands of miles and interviewing hundreds of scientists, laypeople and officials Zev Volfson had his story an exposé of government blindness and stupidity Unfortunately that's where his problems began Volfson worked at the government television station in the Soviet Union

"They would only let me use ten to fifteen percent of what I had gathered" recalls Volfson And so, while presenting the "sanitized" optimistic version of his report for Soviet public TV he quietly wrote under the pseudonym of Boris Komarov about what he had *really* seen

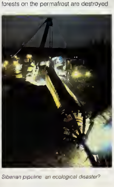
For six months he labored in his Moscow apartment then gave copies to two or three friends Friends gave copies to other friends, and within a year a copy had been smuggled to West Germany where it was published in German and Russian Finally in 1980 three years after Volfson had written it *The Destruction of Nature in the Soviet Union* was published in the United States

The book startled American researchers Never had environmental problems in the Soviet Union been portrayed in such a sweeping way Komarov described the city of Leningrad for example whose residents breathed air tainted by 440 times the USSR's national standard for lead He wrote about the once thriving Sea of Azov now a latrine for the industrial south And he wrote about the chemical slag heaps covering an area the size of 17 Belgiums

The book, frequently compared with *Silent Spring* presented a tantalizing puzzle Who could have written this insider's account and who had access to such widespread confidential information? Surely it must have been a dissident ministry official

That mystery would have remained unsolved if not for some news reports Volfson read last year after quietly emigrating to Israel He was working for the Israeli environmental ministry at the time when reading about Western Europe's support for the Siberian gas pipeline he saw that no mention was made of environmental threats And so now drawing on his past research as well as volumes of scientific papers smuggled from the Soviet Union he has released another body of work

This recent series of articles which identify Volfson as the infamous Komarov describe the pipeline as a catastrophe in the making That catastrophe begins he says with the geologists who drive across the fragile permafrost in military vehicles They leave thousands of miles of tundra split by straight yellow stripes which soon erode into ugly jagged ravines Then come the shoddy construction camps where raw sewage pollutes the ground while flaring gas blackens the sky Whole forests are destroyed as heavy-equipment operators make way for the pipes "It's practically impossible to reforest the land once forests on the permafrost are destroyed"



Siberian pipeline an ecological disaster?

says Volfson Moreover the equipment includes leaky primitive pipes with manual valves rather than the automatic-shutoff models used in Alaska today Volfson writes that one oil leak ran for 12 days into the once-pristine Siberian Ob river before technicians contained it with floating barriers And he cites a Soviet study showing that 2 million to 4 million tons of oil per year were lost to Siberian marshes rivers and lakes "The project is exacting a heavy toll on the Siberian environment" he concludes "The government is willing to exploit Siberia's oil and gas at any cost"

Yet that damage pales beside a problem Volfson says could reach far beyond Soviet borders, creating significant damage throughout Europe and Asia The problem involves a climatic phenomenon called the albedo effect which occurs when the earth's surface reflects excess sunlight making the ground increasingly cold The more dark surfaces—like brush cropland or trees—that are destroyed, the theory goes the more land area there is that reflects light and heat The result is a decrease in the area's temperature If enough vegetation is destroyed some scientists claim temperatures might plummet around the world

According to Volfson that's just what will happen if the Russians continue to build the pipeline Each year Soviet engineers cut about 150 square miles of Siberian forest to lay pipes and roads over vast stretches of swamp The practice removes large areas of heat-absorbing vegetation opens the region to winds and increases the reflectivity of the now-barren ground The process says Volfson may trigger a feedback loop similar to those that triggered the ice ages tens of thousands of years ago It could even spawn a new Siberian ice sheet and throw a crop-killing chill over Europe as well As proof he cites a Soviet study indicating a half-degree chilling over at least 200 000 square miles in Siberia—the first sign, he says of global disaster

This generation of Europeans and succeeding generations" he warns "will

CONTINUED ON PAGE 107

MIND

By Tim Whitaker

Maybe the possibility of encountering extraterrestrials no longer strikes you as a bizarre fantasy Maybe you are comfortable with the idea that other beings inhabit other worlds—if not in our solar system then somewhere in the galaxy But have you really considered what *contact* with these creatures might be like?

I'm not talking about contact as radio astronomers have defined it long-distance communications with orders of intelligence that live impossibly far away That brand of encounter entails no awkward confrontations just radio transmissions traversing the light years

Nor do I mean contact as exobiologists see it first collecting organisms from another world and subsequently enacting carefully enforced quarantine measures lest one life form inadvertently infect, infest or destroy the other

I have in mind true social contact Earthling meets extraterrestrial not in a *War of the Worlds* scenario but as envoys of peaceable states Who would we choose to be our ambassador in this most crucial social exchange? What would alien society be like? How would we react to the extraordinary challenge they would present us by their very existence confirmed at last?

These questions are not just idle musings but the core of a new discipline called exosociology It is a small field unpopular in the extreme even though it has as its center of interest the social aspects of life in space from human contact with extraterrestrial societies to the experience of living in space

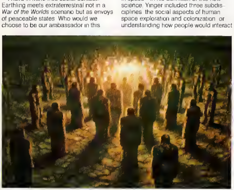
In 1974, some ten years after Carl Sagan and others had established exobiology as a legitimate field of space science sociologist Richard E Yinger of Palm Beach Junior College in Florida introduced the term *exosociology* "If we were going to study life in space Yinger says matter-of-factly then it made sense that we would study society in space In his definition of this new science Yinger included three subdisciplines the social aspects of human space exploration and colonization or understanding how people would interact with one another in the off-Earth environment the constitution of nonhuman intelligent societies or defining what alien cultures might be like and the ramifications of human contact with extraterrestrials or how to handle public reaction to an actual encounter

Professional response to Yinger's call for action was limited and guarded at first Most sociologists have a negative view of space exploration in general explains Alan Hill of Furman University in South Carolina They know we ought to think systematically about space development but they don't want their profession to get its hands dirty

Even so the Seventies saw enough activity in exosociology—research, symposia presentations—to prove that the field's exponents had an important contribution to make Darlene Thomas for example an anthropologist who was then affiliated with Lock Haven State College in Pennsylvania conducted classroom experiments to assess the emotional reaction to extraterrestrial contact She asked her students to create "space creatures"—to describe their biological and psychological makeups Then she arranged a sequence of simulated contact situations with some pupils playing the creatures so the students could test their reactions to the situation Ominously by the third simulated contact the students deemed the space creatures to be hostile In fear they fired at them with zap guns This kind of antagonism is precisely what the science of exosociology seeks to avoid

Hill credits science-fiction writers with having made the best attempts to date to conceive of societies made up of intelligent creatures that have natures different from our own 'But ' says Hill, "science-fiction writers for the most part are not sociologists and usually do not attempt to explore systematically the consequences of human constants becoming variables when other intelligent societies are encountered In other words anthropologists visiting human societies for the first time are at least assured of a few familiar elements

CONTINUED ON PAGE 188



What do you say after you say hello to an extraterrestrial? Exosociologists want to know

SPACE

By Barbara Rowes

Someday it could be the ultimate class trip. With little lunch pails in hand and parental permissions reluctantly signed, five-year-old future astronauts would actually ride the action course of the space shuttle *Challenger* for a first-grade space odyssey.

Since there are only seven seats aboard the shuttle and a couple of astronauts and mission specialists are bound to go along, we couldn't fly a whole first grade class," says William O'Donnell, spokesman for the National Aeronautics and Space Administration. "I guess we'd have to carry one kid at a time."

Since June 21, when a NASA advisory council recommended sending civilians—including educators—into space at least one key issue has remained unresolved. Will the United States be the first to shoot kids into orbit? Well, muses O'Donnell, "we haven't said we're not taking kids. We've not set any age limits."

Far away in Mountain View, California, at NASA's Ames Research Center, at least one key visionary in the space agency has long been dreaming of flying kids in space. It isn't a Steven Spielberg-style fantasy or the framework for a great new video game but a creative approach to exploration by one of NASA's most imaginative administrators. "The idea is to start them off very young in space and maybe twenty years later send them up again," projects Joseph Sharp, deputy director of life sciences at Ames. "If you actually launch a four- or five-year-old aboard the space shuttle and tell him there's a good chance he will be going up when he gets older, you will create the time and inspiration to develop sensitive perceptions and a more meaningful understanding of the world. By nature kids are inquisitive and receptive to new experiences. They may come up with refreshing insights more worldly adults have never even thought of. To discover totally the human dimensions of space, we need to fly not only people at the age of thirty-five but the little people of this planet at the age of five."

While Sharp has long been convinced of the invaluable contribution children could make to space exploration, NASA is not yet ready to lift off the recent graduates of *Sesame Street*. "Eventually kids are bound to go," O'Donnell predicts, "but I don't think you'll see a five-year-old up there flying solo for at least the next one hundred years."

Still, at Ames, space scientists are slowly gearing up for the children's flights of tomorrow. A first major step in this direction has been taken by research scientist Emily Morey-Holton, who has investigated the effects of weightlessness on the bone formation of young rats. "Zero g is potentially dangerous for immature animals because weightlessness might disrupt growth patterns," she says.

"We don't really know the effect on young human beings since we haven't done spaceflight simulations on children yet," observes Dr. Danielle Goldwater, NASA physician. "On missions of long duration there is some evidence raising concern about the sustained health of the young. Long-term exposure to weightlessness might lead to a decrease in cardiac output, decrease in muscle mass and muscle strength, and even possibly cessation of bone formation," observes Dr. Goldwater.

Future mission for children: exploring space

For brief space trips, Goldwater says, "children should adapt quickly to new environments such as weightlessness. And at least from a neurological perspective they should be able to readapt quickly to Earth after a shuttle flight."

But not every child watching the reruns of *Star Trek* will be eligible to follow the footsteps of Captain Kirk into space. "We're going to interview potential candidates to make sure they are mature enough," O'Donnell promises. "You will have to undergo psychological or mental testing whether you are a kid or not. We don't want to take anybody along who will get too excited under stress."

According to Sharp, a psychologist, some children four and five years old appear to be born astronauts. "They are naturally cool in crisis, sensitive to new experiences, and capable of integrating their strange encounters in a dynamic context. And I think we will be able to identify these children out of a classroom. It is like discovering young Arthur Clarkes." In fact, many kids of this breed are already rising to the surface.

Over the years, kids have written thousands of letters to NASA. The majority want only the kid stuff—photographs and printed information. "But a few have really impressed me," admits Sharp, who is notoriously cool himself. "They have written again and again over the years asking probing questions and offering suggestions that reflect an intense involvement in the space program."

Children aren't the only crusaders for putting children in orbit. A young mother from Palo Alto, California, recently wrote NASA: "I have a three-year-old son who is determined to become an astronaut.... What I would like to find out is what information or material you have available for grammar-school children and what activities you have available for kids at your center.

"I realize three sounds awfully young, but I am planning ahead to the day when kids blast off." So is NASA. **OO**

MILKING THE MICROWAVES

BREAKTHROUGHS

By Anthony Liversidge

Pick up a home videophone, call two-way to an Arab businessman trekking across the Sahara and send him a printout of the latest stock prices or sales projections.

It'll be possible soon if the prototypes of a new communications system patented by an ex-IBM engineer work as he predicts. And in the near term, the system developed by sixty-five-year-old Elliot Gruenberg could replace much of the tangle of newly installed two-way TV cables with a single clean, neat new microwave network.

Microwaves—radio waves with comparatively short wavelengths—are currently in wide use, for example, for relaying telephone calls or data communications with satellites. But Gruenberg's system, code-named Synapz, has several advantages over existing microwave links, he claims. It will allow as many as 3,000 users in any small area to operate on virtually the same frequency, instead of having to use different frequencies, as existing systems do. That's up to 120 times more users than a standard microwave network can carry. Yet, Gruenberg claims his microwaves can accommodate as much complex information—computer data, voice and video signals—as cable. And Synapz will use 1,000 times less power than existing microwave systems, he says.

Gruenberg's idea for milking greater use from microwave frequencies depends on setting up electromagnetic resonance between senders and receivers. The principle is at work when a soprano sings a note matching the natural resonating frequency of crystal, which quivers in response. Operating in the microwave range, roughly 1 billion cycles per second, Gruenberg's components resonate to transmitted signals—and send back signals of their own, forming a powerful and narrow connecting beam. The central antenna, or "node," automatically switches from one subscriber to another.

The company Gruenberg heads, Broadcom, is currently installing a prototype of the system for Westinghouse's marine division, which makes ships' propulsion units and other large gear. Synapz will connect some 54 buildings on two sites, eventually replacing an aging underground cable system and opening up two-way mobile communications over the dozens of acres at the Sunnyvale, California, plant. In a joint project with Telescan, a Canadian company, Broadcom is also building a TV installation to serve an area in southern Ontario. Investors have already put some $600,000 into Broadcom, betting that Synapz will connect them to future profits.

Synapz communications system uses resonance for two-way telephone, computer, or TV links.

NEW PRODUCTS

A new watch from Seiko Time Corporation contains a speech-synthesis chip to store and play back a message up to eight seconds long. What's the point? Now you can tell your watch to tell you phone numbers, addresses of appointments, or other useful—albeit terse—information. The watch also includes a regular alarm function. Keeps time, too. ($195, from Seiko Time Corporation, 640 Fifth Avenue, New York, NY 10019.)

Nissan Motors, maker of the popular Datsun car, has just introduced what it claims are the world's first rain-detecting windshield wipers. The trick: A sensor attached to the engine hood reacts to the first drop of rain by sending an electrical jolt to the windshield-wiper motor. ($37, without installation, from Nissan Motor Company Ltd., 17-1 Ginza 6-chome, Chuo-ku, Tokyo, Japan.)

Someday tiny, cheap dish antennas may be sprouting from rooftops around the world, receiving signals directly from a new generation of supersatellites. But in the meantime Regency Electronics has come up with a small—if not miniature—dish that it says performs as well as today's 12-foot models. Invented by Howard Taylor, of Stanford University, the 90-inch dish has a deep design engineered to maximize the reception of signals transmitted on the C-band frequency broadcast by current-day satellites. ($1,495, from Regency Electronics, Inc., 7707 Records Street, Indianapolis, IN 46226.) DO

EXPLORATIONS

By Susan Lichtman

Steam rises from the Rotorua countryside like milky vapors punctuating the region's rolling green hills and valleys. It is a site both breathtakingly beautiful and eerie once one realizes these white clouds emanate not from a local paper mill but from the ground itself, which is still wrenching from a series of volcanic explosions that took place 100,000 years ago.

The Rotorua district on New Zealand's North Island is situated along a volcanic fault line that runs 150 miles from Mount Ruapehu north to White Island in the Bay of Plenty. Billed as New Zealand's "Ring of Fire," most would agree that this is the world's premier hotbed of thermal activity. North Island's vast geothermal fields consist of oozing, bubbling, spouting lakes of steam set against a backdrop of lush, rugged terrain. Yet these unbridled forces of nature are valued not merely for their beauty.

With an eye toward future energy needs, petro-poor Kiwis aren't about to let this vital resource evaporate in a cloud of steam. The Wairakei power station, which was designed to harness raw geothermal energy, supplies both North and South Island with 192 megawatts of electricity.

Although it's been only in this century that geothermal reserves have been transformed into a practical source of power, interest in nature's own steam and hot water has roots deep in the fossil record. Paleontologists hypothesize that arthritic dinosaurs eased themselves into warm water springs to soothe their aches. And long before mankind hit upon the civilized notion of cooking or the mastery of fire, boiling water from the earth was used to soften roots and vegetables for eating. In the written record, use of geothermal water for its reputed therapeutic and medicinal benefits dates back to the ancient Greeks. Later, battle-weary Roman legions built bathhouses around hot springs.

The city of Rotorua, located at the southern tip of Lake Rotorua, is considered the gateway to geyserland, with Whakarewarewa (or Whaka, as the locals call it) your first stop. This thermal reserve, which is owned by New Zealand's native Maoris, boasts more than 500 springs, which vary from cold to violently boiling caldrons. Some are crystal clear; others plop with seething mud. Much of the water, particularly that discharged by geysers, contains a high silica content, which builds up large multicolored cones and terraces.

Geysers, the number one attraction at Whaka, are the result of groundwater that percolates down to meet molten rock lying in pockets beneath the basin. When water hits this magma, it becomes superheated and, together with hot gases, it escapes to the surface. Geyser behavior is affected mainly by the supply of heat and the level of the water table. But it's also determined by barometric pressure, wind, air temperature, deposition of silica, and occasional earth movements. All these components change with time, which explains the ever-mutating behavior patterns of the geyser.

Whaka plays host to Geyser Flat, a green, yellow, and white silica terrace that is pierced by seven geysers. The most famous is Pohutu (the Maori word for *big splash* or *explosion*), which shoots water 15 to 30 meters skyward for periods of 20 minutes to three hours. Nestled in this visual paradise is a traditional Maori village, where natives can be seen bathing, cooking, and cleaning in the limitless supply of hot water. They're not the only ones who take advantage of the thermal reserve, however. Local hotels have tapped nature's furnace to provide hot water and central heating for their guests. And Rotorua attracts visitors from around the globe who take to the waters for therapeutic reasons. Never mind the pungent odor of rotten eggs that pervades the city. You'll get used to it once you've soaked in the local spas' soothing radium and sulfur pools, which are all fed by nearby natural springs.

There is nothing soothing, however, about Tikitere, a thermal reserve 16 kilometers north of Rotorua. This volcanic area, also known as Hell's Gate, takes its name from an old Maori legend. Overcome by domestic strife, Maori princess Huritini reputedly threw herself into one of the boiling pools rather than endure her husband's wrath. She was discovered by her mother, who cried out, "*Aue, e tere nei taku tiki*," or "Alas, here floats forever my precious one." The name Tikitere is derived from this phrase.

Tikitere resembles the Badlands of South Dakota. It is not pretty. Clouds of steam rise from "The Inferno," a black, graphite-laden body of water that bubbles fiercely, 3° C above boiling. There is no greenery to soften the crags of white pumice deposited here 40,000 years ago by a raging avalanche. And despite the presence of the only hot waterfall in the Southern Hemisphere, Tikitere is a desolate wasteland. A stark reminder of how cruel Mother Nature can be.

The Waimangu Thermal Valley, just a 45-minute drive from Tikitere, is heavenly compared with Hell's Gate. It looks like a tropical rain forest, bearing as its welcome mat all the colors of the rainbow. The Waimangu Thermal Valley was created in 1886 when Mount Tarawera

New Zealand: a hotbed of thermal activity

CONTINUED ON PAGE 164

TERRORS OF THE WOMB

LIFE

By Peter Korn

A sudden, awful clarity overtook Jean Harbeson one day in 1976, when she read a poster tacked to a hospital wall. The sign requested that women who had taken any of a number of listed drugs during pregnancy contact Children's Orthopedic Hospital in Seattle, as part of a research project. On that list was Dilantin, a drug commonly used by epileptics to control seizures. Harbeson, an epileptic, had taken Dilantin throughout her pregnancy. Her shattered life, the unrelenting trauma of over two years, now had an identifiable cause.

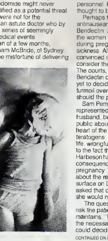
Harbeson had been living in a hellish psychological no-man's-land ever since giving birth to two retarded children. Doctors and social workers from the Madigan Army Medical Center, in Tacoma, had failed to recognize the children's problems, blaming their arrested development first on the Harbesons' confining mobile home and later on a lack of maternal nurturing.

Seven years later, in February 1983, U.S. district court judge Jack Tanner awarded the Harbesons more than $330,000 in the first wrongful-life wrongful-birth lawsuit successfully fought in this country's court system. Dilantin was the cause of the retardation, the court ruled. The doctors who treated Harbeson before and during pregnancy *had* erred in allowing her to take the drug during term. But more important than the findings or the award was the wording of the lawsuit itself: Wrongful-life, wrongful birth. The court's ruling stated, essentially, that a life, or in this case two lives, should never have been conceived.

The temptation is great to label this a horror story, both because of what we've found out and what we're not finding out. Today Dilantin is one of 30 known teratogens, environmental agents that the medical profession recognizes as the cause of birth defects. Other proven teratogens include radiation, androgenic hormones (testosterone, progestogens), rubella and other viruses, DES, pesticides, industrial solvents, alcohol, and perhaps most notorious of all, thalidomide. Yet many experts believe this lengthy compilation is far from complete.

Unlike carcinogens, most teratogens produce little reliable data through testing on laboratory animals. The dissimilarities in the gestations of *Homo sapiens* and other species are too vast. Thalidomide, for example, has little effect on the offspring of mice and rats. Yet the range of deformities found in the children of mothers who took thalidomide to combat nausea during their first trimester reads like a nightmare of disfigurement. The problem was not merely the number of people it affected, but the numbers it did not affect. Only about 5 percent of the women who took the drug produced children with defects. Like so many other teratogens, thalidomide might never have been identified as a potential threat to the fetus if it were not for the observations of an astute doctor who by chance linked a series of seemingly unconnected medical events.

Within the span of a few months, obstetrician William McBride, of Sydney, Australia, had the misfortune of delivering three infants with stunted or missing limbs—normally a rare birth defect. He was also aware that each of the mothers of these children had taken thalidomide. It is such coincidences that provide the foundations for the science of teratology. Small wonder that the field has progressed so haphazardly, with myriad suspected teratogens still languishing in the twilight zone of nonacceptance.



A two-year study by the American Society of Anesthesiologists shows an increased rate of heart defects and other deformities in children born to women who work in operating rooms, as well as to children whose fathers—but not mother—serve as operating-room personnel. Residual anesthetic gases are thought to be the cause.

Perhaps the most widely prescribed antinauseant for pregnant women is Bendectin. An estimated 25 percent of the women in this country take the drug during pregnancy to combat morning sickness. Although some doctors are convinced it too is a teratogen, others consider the reports insubstantial. The courts, which have hundreds of Bendectin cases in adjudication, have yet to decide. With medical experts in turmoil over the evidence, when should the public be warned?

Sam Pemberton, the attorney who represented Jean Harbeson and her husband, believes that informing the public about the latest research is at the heart of the legal issue surrounding teratogens. He maintains his wrongful-life, wrongful-birth lawsuit boiled down to the fact that, before conceiving, Harbeson had asked her doctors about the consequences of taking Dilantin during pregnancy. The doctors failed to tell her about the reports that had begun to surface on Dilantin. If Harbeson had not asked that question, Pemberton insists, she would not have had a case.

"The question is not whether it was a risk the patient could bear," Pemberton maintains, "but whether she was given the necessary information so that she could decide what to do."

CONTINUED ON PAGE 212

THE ARTS

By Vicki Lindner

The name of the destination is ONECITY. A labyrinthian maze of "unfathomable complexity," its spiral of intercellular hives covers a square 675 miles on each side between the Mississippi River and the Rocky Mountains. "Jetubes" encased in translucent walls take inhabitants to Over Buildings, where they live in sky chambers, and Under Buildings, where computers mastermind the city's commerce. Criminals are confined there, too, eliminating one another in "mental structures" not unlike video games, called the Theaters of Death. In a central field lies the Abstract Building—the Opaque Library—housing the city's mythological secrets. Here curious visitors from other centuries spy on mystery but see only beams of light penetrating the slits in the building's shell.

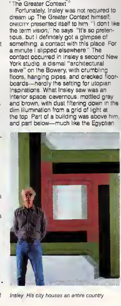
Built by nomads who fled our present-day metropolises, which self-destructed into nonfunctioning husks, ONECITY is "buried" somewhere in the future, and its potential ruins are being slowly explored.

The set for a science-fiction thriller, or a mad architect's utopian dream? ONECITY is neither of these, but is instead a series of paintings called wall fragments—meticulous ink drawings of abstract architectural projects—and three-dimensional models in Masonite and wood. Their creator is Will Insley, who has been "receiving information" about his city for years, writing it down in poetic treatises and depicting it in art for galleries and museums.

As an architecture student at Harvard's School of Design, Insley began to seek a vocation "less located in the practical world." He found himself doodling designs that appeared to be plans for a city—the first evidence, he now says, that ONECITY existed—and studying cities of the past. After a stint in the Army Insley was delighted to drop the practical for good, and began painting, "always aware that what was happening in the painting wasn't right. Finally," Insley says, "it occurred to me that if I kept operating as an artist while thinking as an architect, it would help me, and it did." In 1963 he produced his first successful synthesis of architecture and art—the large grids of connected squares called wall fragments.

"Then I asked myself the obvious question: Where did the wall fragments come from? If they came from buildings, the buildings must be in a city; if you have a city, you must have a civilization, religion, and mythology," or, as he calls it, "The Greater Context."

Fortunately, Insley was not required to dream up The Greater Context himself; ONECITY presented itself to him. "I don't like the term *vision*," he says. "It's so pretentious, but I definitely got a glimpse of something, a contact with this place. For a minute I slipped elsewhere." The contact occurred in Insley's second New York studio, a dismal "architectural sieve" on the Bowery, with crumbling floors, hanging pipes, and cracked floorboards—hardly the setting for utopian inspirations. What Insley saw was an interior space, cavernous, mottled gray and brown, with dust filtering down in the dim illumination from a grid of light at the top. Part of a building was above him, and part below—much like the Egyptian labyrinth, an ancient maze of subterranean palaces that had fascinated the artist for years. "I was contained as a bug is contained if you put it in one hand and cover it with the other." Insley thinks he saw ONECITY's Theater Space, the concourse between Over and Under Buildings, where citizens circulate and public meetings are held, "but I couldn't define it at that time."



Insley: His city houses an entire country.

It took Insley ten years to assimilate sufficiently the information he'd received to draw the city's comprehensive plans. While he waited he received further communications, continued painting wall fragments, which he learned were facsimiles of those in the Opaque Library, and began drawing a series of the Abstract Buildings that lie on the city's outskirts and are used for religious functions. "I didn't just sit down and design an entire city," he declares. "From my point of view ONECITY is real. I guess it had better be real. Would I spend so much time on nothing?"

How did this chimerical reality come to exist? "Anyone who lives in New York is aware how rapidly it's deteriorating," Insley says. "I envision that our urban infrastructures crumble away. They don't disappear, but they cease to function, and only the factories continue to work. That would be the only condition where I can foresee ONECITY, which houses an entire country, could come about."

When the city comes about, however, is an intriguing problem. In his writings Insley states that it is a future civilization, but he often describes it as a ruin, or a major archaeological discovery. Visitors to the Opaque Library, for example, must hike across a wilderness known as the Inner Field and camp in the devastated building's shell. "I first thought that ONECITY existed in science-fiction time," Insley says, "but this began to seem too simplistic. ONECITY exists in the *potential*. If you equate *potential* with *future*—all right—but *potential* to me is a more open word. ONECITY is about myth, and mythology exists outside of normal time, in a kind of all-time. The idea is bigger than just one temporal location. In any case,

CONTINUED ON PAGE 222

THE ARTS

By Mitch Tuchman

Early newspaper accounts of the making of the movie version of Tom Wolfe's *The Right Stuff* emphasized the filmmakers' quest for verisimilitude The press featured stories on the casting of actors who resembled the astronauts the search for vintage aircraft and the manufacture of fine replicas when the real stuff could not be found and the incorporation of period documentary footage—partly an aesthetic partly a budgetary choice Somewhat credulously the reporters tallied the aircraft space suits ground-support equipment and miscellaneous paraphernalia being assembled to get *The Right Stuff* right REALITY IS ALSO A STAR said *The New York Times* headline CAPTURING AN ERA ISN'T SO EASY *Rolling Stone* commiserated Not one of these articles questioned the purpose of amassing these Space Age mementos or pondered the relationship between hardware and history Was it any more significant in *The Right Stuff* to duplicate the rivets in a Mercury capsule than it was in *Return of the Jedi* to duplicate exactly the details of the chubby droid R2-D2 in *Star Wars* and *The Empire Strikes Back*?

The reporters were not in a questioning mood If screenwriter-director Philip Kaufman stated that he was interested in Tom Wolfe's story but not his style that was good enough for the press No one suggested that the story and style were inseparable If Kaufman assured them that the right stuff was an ineffable quality of test pilots then it was just that ineffable, hardly worth defining

If to the reporters the astronauts appeared to be characters in pursuit of manly virtue somewhat like the Scarecrow the Cowardly Lion and the Tin Man at the outset of *The Wizard of Oz* the reporters themselves were somewhat like the Wizard simplifying the complicated and mythologizing the mortal In short the press had not changed much from the way Wolfe portrayed it in the days of Project Mercury and Project Apollo

Indeed the astronauts did seem in the book rather like Dorothy's companions in the land of Oz—but near the end, not the beginning of their journey Remember the scene in which the three look down on the Witch's castle and demonstrate for us the viewers if not yet for themselves that they already possess the right stuff for rescuing Dorothy "I've got a plan how to get in there," says the Scarecrow smartly "I'll go in there for Dorothy Wicked Witch or no Wicked Witch" the Cowardly Lion roars Demonstrating virtue not virtue itself was the theme of Wolfe's book as it has been for most of his writing

From his Cold War-era doctoral dissertation *The League of American Writers Communist Organizational Activity Among American Writers 1929–1942* to the present Wolfe has been secularizing a sacred theme popularly known as the Protestant Ethic In its original religious version the Protestant Ethic holds that God alone chooses who among us will join Him in Heaven we can neither foresee nor influence His choice Still who does not flatter God with ostentatious piety and examine his life for clues? Surely those who demonstrate the greatest accumulation of blessings in this life are most likely to be blessed in the next

Wolfe's secular version, never more explicitly stated than in *The Right Stuff* is a paean to rampant self-promotion as the motor of postwar American society Time and again Wolfe compares the astronauts with "believing Presbyterians of a century before who used to probe their own experience to see if they were truly among the elect" Even defining the right stuff Wolfe makes clear that "there [was not] a *test* to show whether or not a pilot had this righteous quality There was, instead, a seemingly infinite series of tests" meant to manifest the hallowed attribute over and over again "in a cause that means something to thousands to a people, a nation, to humanity to God"

This is why the pious John Glenn more than any other of the first seven astronauts stands at the center of Wolfe's book "There was no contradiction whatsoever" Wolfe writes "between the Presbyterian faith and ambition even ambition grand enough to suit the invisible

CONTINUED ON PAGE 148

No one in the screenplay except a NASA recruiter says right stuff *claims director Kaufman*

THE ARTS

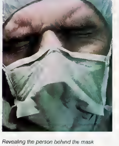
By Tracy Kidder

For the past few years I've felt uneasily aware that while other writer friends of mine sat in the library or conducted interviews over lunch, Mark Kramer was holed up in operating rooms. He was watching surgery and contemplating surgeons. And now he has come out of those places with an arresting book, *Invasive Procedures: A Year in the World of Two Surgeons*. It may be unique in medical literature.

Patients have written notable books, but such works have often lapsed into sycophancy toward doctors. Doctors themselves often write books, but they're usually composed in the manner of military memoirs. And the extensive literature of medical sociology won't keep many people up all night reading. Kramer, however, has written a reporter's book. Surgeons often sound like generals; Kramer sounds like a war correspondent—and a brilliant one. Although he begins with the story of an operation he underwent as a young man, he quickly turns away from his own scene, painful memories, and comes back to watch surgery with all his wits about him. He watches surgeons perform a wide variety of repairs, from installations of pacemakers to amputations. He doesn't condescend to his readers as doctors often do to their patients, and he doesn't assume that surgeons are heroes. I came away from this book firmly convinced that Kramer knows a great deal about what surgeons do—and sometimes a lot more than they about why they do it.

Kramer lives on a quiet street in Northampton, Massachusetts, not far from the campus of Smith College, where he teaches writing. He is thirty-nine but looks younger. He's lean and firm of jaw, and the black hair that he still possesses is shiny. No one would mistake him for an athlete—indeed, he likes to describe himself as "duckfooted"—but he radiates good health and good cheer. Also, on occasion, something else. When you call Kramer on the phone and he's not in, you must listen to a few minutes of music of his own choosing before you can leave your message. When your turn finally comes, you feel like saying to his tape recorder, "Mark, I hate to interrupt this tune I was whistling when I called. I know you'd want to hear it right to the end, too." He has a way of watching you from the corners of his eyes; sometimes he even manages to convince you that he's forgotten you're there. I have known him for eight years, yet in his company I still occasionally feel that a jujitsu move has been pulled on me—a subtle touch to my elbow that is about to land me on my nose. But a little discomfort now and then seems a small price to pay for Kramer's company. He tells marvelous stories, about himself as a rule. He is generous toward would-be writers, and among friends he is a quiet gift giver. He's a gregarious soul above all. He seems to know everyone within a 50-mile radius of his house, and he finds reasons to value all his acquaintances. He talks kindly of people behind their backs, more kindly than to their faces.

Kramer has a well-developed sense of human vulnerability, both his own and



Revealing the person behind the mask

others'. He has more than the usual endowment of nerve endings. The son of a prominent New York publisher, he came of age in the Sixties and was working as a left-wing journalist when he got a sudden fright. "When I was twenty-three, a bump crawled onto my hip," he writes at the beginning of *Invasive Procedures*. He believed that the lesion, "the surfaced knuckle of some buried fist," was mortal, even after his surgeon told him that it was benign. He doesn't burden the reader with the information, but he went through a little scrape with death and rebirth. After that first encounter with surgery he moved to the country—to the Berkshires and a farm on the cold north side of a hill—and he proceeded to become a different sort of writer than he had been. He wrote a series of essays, which Knopf eventually collected in a charming volume called *Mother Walter and the Pig Tragedy*. He published those pieces first in an underground newspaper in Boston, but they were very different in style and flavor from the standard fare in such journals, being neither strident political articles nor breathless rock reviews. His stuff was gentle, witty, affectionate, and, if a little romantic, not sloppily so.

About the time he began to visit operating rooms, Kramer left his farm and moved to town. During the book's long construction, he separated from his wife. I think that he has softened in his personal manner and his writing—but softened only in the sense of smoothing rough edges. In approaching his subjects, he seems to have abandoned old preconceived notions and judgmental tendencies. In his previous writings he has portrayed technology as a large and usually villainous force. In *Invasive Procedures* he approaches technology on its strongest ground. Sooner or later boosters of modern technology always invoke the great and recent advances in the medical arts. Kramer found that he could not wholly disagree. "I guess I've changed my view of what's possible in politics," he says. "Even before I was a wistful free market capitalist

CONTINUED ON PAGE 208

THE BODY

By Albert Rosenfeld

An "International Symposium on Poliomyelitis Control" in the year 1983? Have we not for nearly three decades been celebrating the conquest of polio? Or was it really conquered after all?

Yes and no In most of the Western world the once-fearsome epidemic has been virtually eliminated thanks to two effective vaccines the Salk and the Sabin But unlike smallpox, polio has never been eradicated worldwide Throughout the Third World where large populations have never been vaccinated paralytic polio runs unchecked

There are other reasons too why polio is back in the news—reasons that drew me to Washington DC to an international polio symposium organized by the Fogarty International Center of the National Institutes of Health Jonas Salk and Albert Sabin the eponymous heroes of the vaccines were there So was an eminent assemblage of virologists and vaccinologists, many of whose names loom large in the history of polio

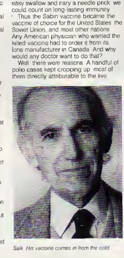
In a curious way this conference devoted to discussing ways to immunize the world's children became a quiet rerun of an old debate That controversy has often been glibly billed as Salk versus Sabin or as injected versus oral vaccine, but it goes deeper than that It really revolves around a near-dogma that until recently dominated mainstream virology that only a live vaccine can provide reliable and lasting immunity against *any* viral disease Convictions so strongly held do not die easily

A little history is in order What Salk set out to do while still working on influenza in the early Forties—and herein may lie his major scientific contribution—was to prove that totally inactivated viruses could provide effective immunity His enterprise made even better sense when immunologists discovered that it is not the virus's infectious nucleic acid core but its harmless protein overcoat that stimulates the body to make antibodies That means that a killed-virus vaccine with its DNA inactivated should work just fine It also presages an era of totally synthetic virus vaccines that are made from just the protein

American children got their first Salk shots in 1955 and that was the beginning of the end of the epidemic Yet to vaccinologists of the Fifties the killed vaccine was only a stopgap while Sabin (supported, like Salk by the March of Dimes) prepared his live-virus vaccine When that came out in 1961–62 the polio rate had already dropped by more than 90 percent Nevertheless the whole nation was drummed out to be revaccinated on those Sabin Oral Sundays reassured that now with an easy swallow and nary a needle prick we could count on long-lasting immunity

Thus the Sabin vaccine became the vaccine of choice for the United States the Soviet Union and most other nations Any American physician who wanted the killed vaccine had to order it from its lone manufacturer in Canada And why would any doctor want to do that?

Well there *were* reasons A handful of polio cases kept cropping up most of them directly attributable to the live vaccine itself (Even such longtime live-vaccine advocates as Nobelist Frederick C Robbins accepted this judgment at the symposium though Sabin himself did not) Some of these victims filed sizable lawsuits, and the vaccine manufacturers, as well as the medical profession repeatedly urged a reluctant government to indemnify them Meanwhile year after year Jonas Salk pointed to one stark fact In the few countries such as Finland, Sweden and Holland that used only killed vaccine there were *no* cases of polio (except for a few obvious imports) Why settle he argued for any? But the die had long since been cast for the live vaccine



Salk His vaccine comes in from the cold

At the Washington conference however it became clear that the live vaccine simply isn't working in many regions—notably in tropical and subtropical Asia and Africa—because of some mysterious interfering factor in the human gut In India thousands have been paralyzed despite multiple doses of the live vaccine In occupied Gaza Israeli doctors now use both vaccines just to be sure

The second reason for the Salk vaccine's recent coming-in-from-the-cold is a new improved version of the killed vaccine Developed by Dutch engineer-microbiologist A L van Wezel and manufactured by the Institut Merieux in France it has been pilot-tested in such places as Senegal and Upper Volta Contrary to earlier claims it seems to require fewer doses than the live In fact a single dose may provide lifelong immunity True it still must be injected but the Dutch and Merieux are now able to incorporate it into the same shot that vaccinates against diphtheria tetanus and whooping cough

Though scientists from many lands testified on behalf of both vaccines the conference had a single rallying call Stop the needless tragedy of mass paralysis We now have *two* good polio vaccines noted longtime polio-vaccine specialist Alexander D Langmuir, now retired from the U S Center for Disease Control The problem is how to get them into the world's children

ARTIFICIAL INTELLIGENCE

By Peter J. Ognibene

By the turn of the century the patois of the air-traffic controller—the calm, concise flow of words from the tower to a plane in flight—may become a dead language.

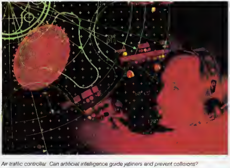
In its place will be an even more concise exchange in the form of digital messages between airborne and ground-based computers. Pilots and controllers will read those messages in the cockpit and tower without a word spoken between them. Proponents of the new technology say it will replace the patchwork quality of the current air-traffic control (ATC) system with seamless efficiency. Critics suggest that a fully computerized system could turn into a real life version of a video-arcade game with no chance for a replay if something goes wrong.

The ATC system in use today is a hodgepodge of electronic, human, and mechanical links. IBM 9020 computers run the programs, or software, that keep aircraft safely separated in flight, air-traffic controllers on the ground use radar and radio to clear pilots for takeoffs and landings, redirect their courses, and talk them through airborne emergencies.

Last June that system saved 23 people after an electrical fire knocked out the flight instruments of an Air Canada DC-9 and filled the cockpit with smoke. His vision obscured, the pilot focused on an old-fashioned instrument called a horizon indicator to keep the wings level while an ATC controller spoke calmly over the radio with the copilot, telling him when to turn and helping him adjust his rate of descent from 33,000 feet to a safe landing in Cincinnati. (Unfortunately 23 other passengers died from smoke inhalation.) So the system can work well.

But the current ATC technology is far from perfect. Instead of taking direct and fuel-efficient routes, for instance, pilots must fly to their destinations in segments laid out according to fixed radio navigation beacons.

Why? The IBM 9020s aren't fast enough to provide direct routes and still keep track of all the aircraft flying under Instrument Flight Rules, or IFR.



Air-traffic controller: Can artificial intelligence guide jetliners and prevent collisions?

The new computer system, called Automated En Route ATC, or AERA, will change all that. Direct routing, takeoff clearances, midcourse corrections, weather updates, airport holding patterns, emergency maneuvers—these and many other functions will be taken over by computer. Aircraft will maintain their half of the electronic data link with something called a Mode-S transponder. An on-board beacon known as TCAS (for Traffic Alert and Collision Avoidance System) will warn pilots of potential (or impending) midair collisions and instantly compute explicit evasion tactics.

Though the technology of Mode-S and TCAS seems well within reach, not everyone in the aviation community is gung ho about them. The military believes the TCAS antenna could degrade the aerodynamic characteristics of its high-performance fighters. Many private pilots oppose Mode-S and TCAS because they believe the cost (several thousand dollars) is an unnecessary investment for their type of flying (low and slow). Thanks to their lobbying, the Federal Aviation Administration (FAA) will not require light planes operating under Visual Flight Rules (VFR) to install either device.

So while every commercial airliner would carry TCAS, most private planes would not. And that situation may create a whole new set of problems. Unlike radar, TCAS works only when *all* aircraft have it. If a light plane without the device wandered into restricted airspace, the airliner would be unable to detect it.

How can the FAA tolerate such a gap in coverage? "The airspace belongs to the users, and the mission of the FAA is to control—but not to interfere with—the free use of the airspace," says Valerio K. Hunt, director of the FAA's Advanced Automation Program Office. Yet he acknowledges, "We're going to come to the situation where all aircraft will have to be controlled. Eventually traffic densities will pass the point at which it's safe to allow uncontrolled VFR aircraft to penetrate controlled airspace."

The FAA's goal is an electronic brain

CONTINUED ON PAGE 147

CONTINUUM

WHAT WE LEFT OUT

A few days after the first issue of *Omni* went on sale in 1978 I received a letter from the editor of another publication The letter said succinctly "Congratulations It s nice to see a magazine about science that does not include Carl Sagan, Barry Commoner or Margaret Mead ' With all due respect to Drs Sagan and Commoner and the late Dr Mead I was proud of that letter Not long after it arrived Dick Teresi, now executive editor of *Omni*, added stories about holography, the life cycle of the monarch butterfly and the voyages of the *Glomar Challenger* to the list of things *not* included in that first issue of *Omni*

What Sagan, Commoner and Mead held in common with holography, the monarch butterfly and the *Glomar Challenger* back in the dim dark past of 1978 was a kind of Good House keeping Science Seal of Approval from the popular press For two decades, starting with the *Sputnik* scare editors seemed to hold the opinion that science was important perhaps vitally important but dull After all, who knew any scientists? They didn't play celebrity tennis or endorse products Excepting Sagan Commoner Mead and perhaps a handful of graying Nobel laureates the man on the street couldn't name a single one Moreover science was difficult complicated and most of it was about things you couldn't see or touch And worst of all somebody was sure to yell at you if you got it wrong

The complexity of things scientific was particularly trouble some to the popular press In those days I borrowed from C P Snow, frequently claiming that the world was made up of two kinds of people—those who understand how a refrigerator works and those who don t Publishers and editors, for the most part, fell into the latter group The prevailing attitude in the publishing community seemed to suggest that committing great swatches of Dante's *Inferno* to memory was considerably more important than understanding the thermodynamics of the place The press took a timid, sometimes even frightened approach to science, characterized by an almost religious reliance on professional journals One of the best-selling magazines in the country, for example refused to report any medical story that had not first appeared in *The New England Journal of Medicine*

Science journalists through the Sixties and into the Seventies were a clubby lot bound together by small numbers and even smaller incomes, the scarcity of places to publish, and the narrow range of stories acceptable to editors Holography was one of those stories, with its promise of 3-D everything Never has so much paper been spent explaining a technology that so far has produced little more than trinkets The monarch butterfly was another proving again that even editors like animals The appeal of the *Glomar Challenger* the research ship that informed us that the continents are in fact adrift beneath our feet (although we needn't worry about it for several million years) is harder to define, but *Challenger* s voyages were reported everywhere So was any experiment, however tentative, suggesting that anything—from peanut butter to asbestos—was bad for your health (I sold many of these stories myself, some of them several times which is something I ll have to answer for when I finally confront the great belt sander in the sky)

Omni changed the picture entirely Almost before the ink on the first issue dried, imitators started springing up like weeds Scientists only found in the gray pages of technical journals were suddenly smiling from the covers of general-circulation magazines Television increased its science coverage—witness Sagan s *Cosmos*—and newspapers started devoting entire sections to it Suddenly there were so many popular science publications that *The New Yorker* ran a cartoon showing a cor ner newsstand that displays nothing but science magazines, it is manned by a pipe-smoking vendor in a white lab coat

The publishing world discovered almost overnight that not only were there a lot of people who understood how a refrigerator worked, but they made up a responsive and lucrative segment of the market Moreover, a good number of people who didn t know how a refrigerator worked seemed to decide that perhaps they should Science journalists who were starving in the pre-*Omni* days began selling everything that spurted from their word processors and sports reporters, fashion writers, and other scientific sorts rushed in to take up the slack It made for interesting reading if nothing else

When I left *Omni* the magazine was a precocious toddler It has grown considerably since then and, I think aged well Here s looking at you kid —*FRANK KENDIG*

Frank Kendig was Omni's founding executive editor

CONTINUUM

CURSES! FOAMED AGAIN

Four A.M. The terrorist has made his way past a formidable alarm system to the storage room where he hopes to retrieve a few pounds of fissionable material for a homemade nuclear bomb. Crossing the threshold, he flicks on the light.

Suddenly, as if some giant washing machine had overflowed, the room fills with a soapy, slippery foam. Disoriented and finding it hard to breathe, the intruder places one hand over his face and gropes through the bubbles; in seconds his feet slip from under him and he falls, his head striking a nearby wall. Hours later, when security guards cautiously enter the room, the would-be thief is found lying unconscious just eight feet from the door. The foam is almost gone.

Farfetched? The U.S. Department of Energy has recently filed for a patent on just such a system: a liquid concentrate that generates foam, which in turn expands to 500 times its original volume. Developed by chemist Peter B. Rand and colleagues at Sandia National Laboratories in Albuquerque, New Mexico, the foam is released from a generator at the rate of 35,000 cubic feet per minute. Intended mainly for the protection of nuclear facilities, it fills an entire building in seconds.

Until now, says Rand, foams of this type retained only 50 percent of their bubbly state after 30 minutes. The Sandia foam, on the other hand, remains stable for up to six hours, allowing security guards to seal off areas and search while thieves are deterred. Moreover, he adds, the foam obscures vision, clouds hearing, and impairs breathing. And because one of the prime ingredients is a detergent like dishwashing liquid, an intruder is likely to slip.

Rand emphasizes that the foam is just a "deterrent." Still, terrorists might be overwhelmed unless they bring gas masks, suction shoes, and a pump.

—Rick Boling

Anti[illegible]rorist s[illegible] latest in nucl[illegible]

"Real generosity toward the future lies in giving all to the present."

—Albert Camus

[illegible]

LIGHTNING DANGER

When aircraft engineers replace weighty metal bodies with carbon fiber and epoxy materials, airplanes will be lighter, faster, and vastly more efficient. But there's a catch. The new materials in the skin of an aircraft will also make it vulnerable to lightning.

When lightning flashes by a plane, explains physicist Richard Richmond, of Wright Patterson Air Force Base in Ohio, it can play havoc with electrical and computer systems. Older planes' metal acts as a shield, blocking out the unwanted electrical surges. Graphite and plastic do not.

To close this technological loophole, Richmond says, researchers are studying the way an aircraft responds when lightning strikes. Scientists from the NASA-Langley Research Center [illegible] tackled the problem by flying a [illegible] thunderstorms. Richmond himself helped focus lightning onto a 40-foot-high, fuselage-shaped cylinder in the New Mexico mountains.

Protecting these newer-model planes," says Richmond, "boils down to one thing—shielding technology." That means developing special housing for the electronics, lining a composite body with metallic strips to divert high-current surges, and spraying aircraft panels with a thin aluminum coating.

Some of the wiring, he adds, might even be replaced with fiberoptics, since light-beam signals would be unaffected.

—Marcia Bartusiak

"All of life is a dispute over taste and tasting."

—Friedrich Nietzsche

San Quentin ex convict/programmer Bruce Cape When it comes to rehabilitating inmates, COBOL sure beats license-plate making

SOFTWARE AND HARD TIME

While inmates at most other penitentiaries work in laundries and license-plate factories convicts at California's tough San Quentin prison are learning the latest in computer-programming skills—and finding greater success when they return to the outside world than corrections officials ever dreamed possible

The project working this wonder is a two year-long prison course in COBOL a versatile programming language used extensively in business applications The course is highly restricted It accepts only 36 students at a time and has a year-long waiting list for admission. It's also plenty tough Inmate students receive as many as eight hours of instruction and hands-on experience each day

"A few other prisons have similar programs, but none are as complete as this one," says Stanley Rahl one of two instructors at the prison "We are really pioneers in the field

Rahl says only one of every 19 software course graduates returns to prison after three years the system-wide average is two out of three Our record is much much better than that of most other prison rehabilitation programs he adds

As part of the course inmate students are put to work solving real program ming problems for various tax-supported agencies One recent software package created by inmates for the U S Navy for instance is such a smash that it has been adopted by the Army and is being considered by the Air Force

More than 100 prisoners have graduated from the course so far, says instructor Lee Cook Most were quickly snapped up by such firms as Fireman's Fund Insurance Company Western Pacific Railroad, and Bank of America Several graduates have even been offered jobs before their release—Bill Wallace

---

"The function of the expert is not to be more right than other people, but to be wrong for more sophisticated reasons"

—David Butler

FROSTY THE BACTERIUM

Old Jack Frost may turn out to be a bacterial "disease" of plants according to agricultural scientists And if their hunches pay off, there's a cure for the frost damage that now costs North American farmers billions of dollars a year

Chilly air it seems isn't the only factor responsible for the formation of frost ice crystals also need a catalyst around which to form Water, for instance may form ice crystals more rapidly in the presence of dust and other impurities. And according to meteorologist Conrad Geitz frost in forests and fields forms around tiny molecules—probably proteins—produced by common plant bacteria called *Pseudomonas syringae* and *Erwinia herbicola*

To rid crops of the deadly frost Geitz who works for the Alberta (Canada) Department of Agriculture suggests treating them with chemicals Another antidote might be the introduction of competing bacteria to stem the growth of the frost-causing organisms

Geitz adds that in some instances we'd want to *increase* the quantity of frosty bacteria To prevent drought and produce rain he explains we've got to have ice crystals form in the buds Without plants and their protein-producing bacteria the result is an endless cycle of drought and deforestation—as in the Sahal region of Africa By reintroducing the ice-nucleating bacteria Geitz concludes we might bring rain and vegetation restoring such regions to fertility. —Peter von Stackelberg

Frost on cabbage leaves Now man can change the rules

CONTINUUM

If you [illegible]
infectio[illegible] n R[illegible]

DOG BREATH

If you suffer from c[illegible] sore throats you might want to visit the veterin[illegible]ian—because your dog may be the problem

So claims Stuart M Copperman a Long Island pediatrician who became aware of the link between animal and human streptococcal infection some 20 years ago while working as an Army physician A strep throat epidemic hit his Army post and patients were treated routinely with antibiotics In one family however the seven children came down with sore throats repeatedly In desperation the doctor finally ran a throat culture on the family dog and the test showed a positive strep infection After the pet was treated with antibiotics the family s sore throats promptly cleared up

[illegible] was p[illegible] [illegible] C[illegible]pperma[illegible] [illegible] er the years, I [illegible] people whose [illegible]tantly had [illegible]roats whether they had a pet ' Out of 100 cases of recurrent sore throats in a household with a pet he found that 40 percent of the family pets (including dogs cats and even birds) had a strep infection His findings were reported in the *New York State Journal of Medicine*

Copperman emphasizes that he is anything but antipet 'I think animals are great We have a dog in my family, and we hug and kiss him I m not saying people should get rid of their pets But if someone has a recurrent sore throat and human contacts have been eliminated as the source, then it s a good idea to bring the family pet in for tests —Sherry Baker

CANCER-CELL OWNERSHIP

Do patients who donate tissue samples from their bodies to medical science own part of the resulting research product? Yes says Dr Hideaki Hagiwara who last year took cells from a University of California laboratory—without permission—to treat his cancer-stricken mother (The cells [illegible]own as hybridomas [illegible]duce specific antibodies [illegible] attack only the cancer [illegible], leaving all other tissue [illegible]med) Hagiwara in[illegible] that part of the new [illegible] belonged to his [illegible]ecause tissue from [illegible]'s cervix had been used to develop it in the first place

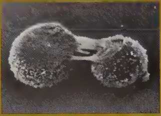
At first the University of California managed to keep the incident out of the news But then the plot—and the publicity—thickened Hagiwara claimed that while doing postdoctoral work at the university, he had been instrumental in developing the cell line in question

Meanwhile Ivor Royston head of the California research team said the allegation was "completely false ' Finally it came to light that Hagiwara s father was president of a Japanese pharmaceutical company interested in patenting the cell line

Deciding against a legal battle the parties involved reached an agreement out of court Patent rights go to the University of California and the Japanese firm is licensed to use the cells in Asia Nonetheless the original question remains ominously unanswered Do patients who contribute flesh and blood to research own part of the product made as a result?

—Sherry Baker

"If I had to choose between pain and nothing I would always choose pain '
—William Faulkner



Cancer cells, magnified 11 000 times Who owns test-tube life—patients doctors or institutions? The controversy lingers

GRIEF THERAPY

Alice grieved to see her formerly robust grandfather waste away to a skeletal 99 pounds on his deathbed After he died Alice began to eat like a bird—until her weight, too dropped to 99 pounds

It took Dr Vamik Volkan a psychiatrist at the Blue Ridge Hospital in Charlottesville Virginia to unravel the problem For Alice he discovered, 99 pounds had become a magic number, a symbolic link to the grandfather she had loved and feared Unable to come to terms with his death, she was stuck in an emotional limbo—and hers was not an isolated case

Bereavement plunges many people into a state of "complicated mourning," Volkan says, especially when they harbor strong but mixed emotions toward the deceased Mourners like Alice may adopt a physical trait of the loved one, while others may hide away a ceremonial "linking object"—the watch worn by the dead person or the teacup he was holding when he died, for example "It casts a magic, eerie spell that keeps the dead person within reach" the psychiatrist explains

To help these troubled mourners Volkan has devised what he calls regrief therapy A course of regrief therapy helped Alice admit her contradictory feelings toward her dead grandfather for instance and she began to eat normally again In other cases, the mourner s linking object is systematically stripped [illegible] its emotional power During therapy one patient [illegible]ually burned her dead [illegible]ther's nightgown—which she had kept hidden in a paper bag—in order to resolve her conflicts

But not all linking objects indicate pathological behavior, the psychiatrist points out "All of us have links like grandmother's wedding dress," he says "Some people even create their linking objects They write poems and books They build the Taj Mahal"

—Susan Tyler Hitchcock

Some bereaved people become obsessed with the deceased

But I doubt that the magazine [Omni] will last It was flawed way back at conception The result is too feeble to live very long"

—Stewart Brand, 1979

What n[illegible]? Sc[illegible]ce sought the an[illegible] hate[illegible] lovers

DUCK OUTRAGE

"Egbert Was a Lucky Duck" is the title of a report by wildlife biologist Fred Van Dyke published in *Wisconsin Natural Resources* magazine not long ago But Egbert s luck has been small comfort to angry readers

Egbert was one of 34 wild ducks that Van Dyke anesthetized crippled and then set loose in a Wisconsin marsh Egbert whose wing was snapped was the lone survivor the others died from starvation or in attacks by predators

It was all part of a privately funded research project that Van Dyke conducted as a graduate student at the University of Wisconsin to find out exactly what happens to ducks that are wounded by hunters who can t shoot straight

Van Dyke even broke the wings of 40 more ducks and confined them to cages "We found that those cripples placed in a pen with unlimited food and water had a healing rate of twenty-two percent" Van Dyke says "so in certain hunting areas it's feasible to collect wounded ducks and care for them"

Outrage followed "Let s hope that the author s sadistic streak fades" wrote one reader "before he can cripple deer to study car kills or before he can move on to people"

But the Research Animal Resources Committee of the University of Wisconsin at Madison refused to condemn the study According to committee chairman Bernard C Wentworth it could help save wounded waterfowl establish new hunting regulations and eliminate 4 million cripplings a year—Eric Mishara

CONTINUUM

[illegible] also [illegible]

SCHIZOPHRENIA VIRUS

Schizophrenia could [illegible] a contagious disease That at least, is the opinion of British psychiatrist T J Crow, who proposes that the psychosis may actually be triggered by a virus The infectious agent he adds could be transmitted from schizophrenics to 'genetically susceptible people with a proclivity for the disorder

The idea that schizophrenia is linked to a virus is certainly a controversial one " notes Crow, a staff member at the Northwick Park Hospital in Harrow But there are several studies that are consistent with that idea

According to a Soviet study, for instance schizophrenia in one Moscow neighborhood increased significantly when schizophrenics moved into the area s brand-new apartment buildings In fact says Crow new cases of the [illegible] s where [illegible] s resided than [illegible] t streets

Cr[illegible] s there must be a genetic basis to schizophrenia But, he insists genes alone can't account for the disease's occurrence Writing in the British medical journal *The Lancet* Crow points out that when one twin suffers from schizophrenia, chances are less than 50 percent that his identical sibling will also develop the disorder But if the twins are living together during the time the disease strikes one of them the other is likely to come down with the illness too

These findings suggest either that both twins are exposed to an [infectious] agent at the same time Crow states, 'or that such an agent is passed from twin to twin —Sherry Baker

I don t mind your thinking slowly I mind you publishing faster than you think
—Wolfgang Pauli

ZERO-G MACHINE

Former Canadian paratrooper Jean St.-Germain wanted to teach his family skydiving without making them take the risk of jumping from a plane So he installed a DC-4 engine and airplane propeller beneath the grated floor of a 52-foot-high padded chamber in his backyard near Montreal The whirling prop blades create powerful vertical winds, allowing St -Germain and his kids to float soar and glide without fear of a single scratch

American entrepreneur Marvin Kratter tried St Germain s invention in 1980 found it a euphoric experience and promptly bought the international franchising rights Dubbed Flyaway the first U S version recently opened to enthusiastic crowds in Las Vegas Other Flyaways are in the works for Tampa and Orlando, Florida Ocean City New Jersey Cleveland Knoxville Tennessee and San Diego In addition investors recently acquired a franchise for Japan

To date thousands of people donning jump suits knee pads earplugs goggles and crash helmets have tried indoor skydiving Fliers called aeronauts rece ve 15 minutes of ' pre-f ght nstruction before stepping from a platform into the 80 to 125-mile per hour column of air Holding a spread eagle position perpendicular to the air stream (see photo) aeronauts r se and with practice, lear o soar and dive To lan the flier simply squirms nto an upright position creating less resistance to the wind

The expenence of indoor flying has been compared to bouncing on a trampoline

The Flyaway experience A former paratrooper s indoor flying method offers the exhilaration of skydiving without the risks

[illegible] basis may simply b[illegible] [illegible] g a post puncture hi[illegible]

and [illegible] space [illegible] remarka[illegible] fail Others [illegible] ence to flying in a dream

While no one has compared the exercise value of indoor flying to jogging or swimming, Flyaway representative Jerry Digney says that the activity burns up calories and is definitely aerobic According to Kratter, indoor flying may even grow into a true sport Already experienced fliers and instructors are learning to walk backward up walls and combine somersaults with dives —Sherry Baker

BLOOD-DONOR ADDICTION

People who donate blood on a regular basis may be seeking a pleasurable possibly addictive high

That at least is the conclusion of University of Wisconsin psychologist Jane Allyn Piliavin who asked 12,000 donors to describe their feelings imme[illegible]ely before and after giving blood The responses were matched to the number of times donors had given blood and how often they planned to give in the future The result? The more a person gave—blood—and the more negative he felt before giving—the more frequently he experienced a positive mood swing immediately afterwards

The warm glow reported by some blood donors may be relief from acute anxieties felt before the donation procedure began Piliavin explains In fact, as donors continue to give blood, negative reactions prior to puncture become less intense while positive feelings experienced after ward grow stronger Piliavin compares the act to parachuting from an airplane Initially the thought of jumping is associated with fear But once the jump is completed the experience can produce such feelings of relief and exhilaration that it often inspires repeated jumps

To what extent do people actually get hooked on giving blood? "Our information is strictly anecdotal Piliavin notes It s clear that some people do feel a need to give blood regularly possibly to experience the positive mood swing following donation

I'm one of those people, she adds I give blood every eight or ten weeks And if I can't do it—if I get to the blood-donation site and it s closed, for example—I feel really really mad —Sherry Baker

TROUT BRAINS

A French scientist has come up with a scheme for turning a trout s brain into a handy pollution alarm

Fish have a keen smell for whatever is dissolved in their [illegible] And these sensations are ultimately registered as electrical signals in the brain So thought brain researcher Jean-Louis Huvé why not decode the brain waves corresponding to a fish's perceptions and get a reading of its habitat?

To do that Huve's team at Pierre and Marie Curie University in Paris planted electrodes in a trout s brain—coupled to a tiny transmitter that sent the signals to a computer for analysis The result? A cheap exquisitely sensitive pollution monitor Huve s trout can inform him which of several pesticides and herbicides is polluting its tank down to ten billionths of a gram per liter

—Debora MacKenzie

In baiting a mousetrap with cheese, always leave room for the mouse

[illegible] —Saki

[illegible] wired for action With a few electrodes and a [illegible] the fish brain is an [illegible] pollution alarm

CONTINUUM

What spaghetti breath is to humans, the new garlic-scented fir trees of the Pacific Northwest are to potential animal pests

TREES WITH GARLIC BREATH

Scientists at the University of Washington have cooked up a spicy surprise for animals that damage forest and fruit trees: a time-release capsule that gives the trees garlic breath.

The pellets, containing a compound of the chemical selenium, are planted with the trees, protecting them for three to five years until they're too tall for deer to munch.

Capsules a half-inch in diameter are first filled with the compound dimelamine selenite, explains chemical engineer and project scientist Donald Gustafson. The pellets are gradually dissolved by rainwater, absorbed by the roots, and taken up into the tree. The tree then eliminates the compound as dimethyl selenide, "the very same gas your friends complain about after you've eaten spaghetti with garlic bread."

According to Gustafson, Douglas firs tested at seven different locations in western Washington showed no slowing of growth when planted with the garlicky pellets, but even the hungriest rabbits and deer were repelled. The International Paper Company planted 10,000 garlicky Douglas fir seedlings in Oregon, and a number of private timber companies are now studying the pellets as a potential repellent for other commercial tree species. The Environmental Protection Agency is also investigating the use of the pellets for fruit trees and grapevines.

Humans can detect the garlic odor on a warm day, Gustafson adds, but people generally don't find the smell overpowering.

—Joel Schwarz

"If I do not believe as you believe, it proves that you do not believe as I believe and this is all that it proves."
—Thomas Paine

EMERGENCY LUNG SPRAY

It's a typical night in the big city. The emergency room at Big City General Hospital is crammed with patients, mostly victims of accidents and random violence.

Suddenly a patient goes into shock, and his heart stops beating. Frantically a doctor searches for a vein, any vein, in which to inject epinephrine, a drug that literally restarts the heart's contractions. But the patient's veins are collapsed, so as a last resort the doctor injects the lifesaving drug directly into the heart by sticking a large needle through the chest wall—an extremely risky procedure. The patient is saved, but the same result could have been achieved much more safely with a fast lung-spray technique.

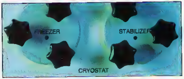
With that technique, the lifesaving drug is sprayed directly into the lungs through a plastic tube inserted down the patient's throat, explains Philadelphia physician Michael Greenberg, who invented the procedure. "Drugs are absorbed very, very quickly in the lungs," Dr. Greenberg says, "because they have a large surface area and a rich supply of blood."

The American Heart Association recommends the lung-spray technique for use with a variety of emergency cardiac-care drugs, and it would probably save thousands of lives each year. But even though the technique has been around for a few years, most emergency-room doctors aren't aware it exists.

"We have published about twenty papers on it," Greenberg says, "but unfortunately lots of doctors don't bother to read scientific literature."—Eric Mishara

"The more I think about it, there is something futile, mediocre, even (I am tempted to say) foppish about speech. By contrast, how the gravity of nature and her silence startle you."
—Johann Wolfgang von Goethe

Cardiac arrest can now be treated with a lung spray



ZERO-G LAB

BY BEN BOVA

"The bone-rattling roar and vibration of liftoff suddenly died away. He was no longer plastered up against his seat, but touching it only lightly, almost floating in it, restrained only by his harness. It was the fourth time he had felt weightlessness. . . . When he reached the

PHOTOGRAPHS BY DON SPARKS

laboratory hatch he slowly rotated, like a swimmer doing a lazy rollover and pushed himself inside His arms tended to float out, but they touched the equipment racks on either side of the narrow central passageway

"The laboratory was about the size and shape of the interior of a small transport plane Nearly its entire length was taken up by instrument racks, control equipment, and the computer humming almost inaudibly behind light plastic panels

I wrote those lines almost 15 years ago for a science fiction story Today they are a fairly good description of Spacelab 1 the first manned scientific laboratory to go into space The lab itself is a 24-foot-long aluminum cylinder about a yard shorter than Charles A Lindbergh's *Spirit of St Louis* It's about 15 feet in diameter comparable to the size of a small transport plane And as presaged in fiction most of its interior is filled with instrumentation and electronics It carries roughly five tons of scientific gear Unlike the airplane though, it doesn't fly on its own Orbiting 250 kilometers (about 150 miles) high Spacelab 1 rides in the payload bay of the shuttle *Columbia*, drawing some 7 5 kilowatts of electricity from the shuttle's fuel cells and relying on the shuttle's life-support system

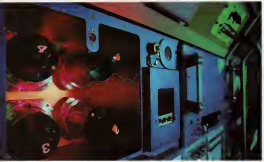
But this blunt wingless and engineless cylinder—scheduled to debut at about the time you read this—offers researchers the best chance in the history of space exploration for doing science in space just the way it is done on the ground And the launch of the mother ship bearing Spacelab will mark several other beginnings

• For the first time NASA is bringing foreign nationals into space Although the Soviet Union has orbited guest cosmonauts from almost every nation in the Soviet bloc and even a French "spacionaute" Ulf Merbold of West Germany will be the first non-American to fly a NASA mission Merbold is no mere guest astronaut, however Like Byron Lichtenberg of MIT he is a working scientist The two men are called payload specialists, and they are responsible for running some 69 experiments aboard Spacelab 1 They are assisted by mission specialists Owen Garriott and Robert Parker, who hold doctorates in electrical engineering and astronomy, respectively Garriott is a veteran of the *Skylab 3* mission; this is Parker's first orbital flight Piloting *Columbia* is the veteran John Young, commander of *Columbia*'s 54-hour maiden voyage in April 1981, and Brewster Shaw one of the new generation of shuttle astronauts It will be the first time the shuttle has carried a six-man crew

• Another of Spacelab's firsts is that the laboratory module itself and roughly half of the experimental equipment flying with it were built by the European Space Agency (ESA) A consortium of 11 West European nations (see "Uncorking Ariane Space September 1983), ESA has spent roughly $1 billion on the Spacelab program Actually they have built two modules, one of which has been purchased by NASA Each module is designed to be flown at least 50 times so 100 missions can be carried out over the lifetime of the modules

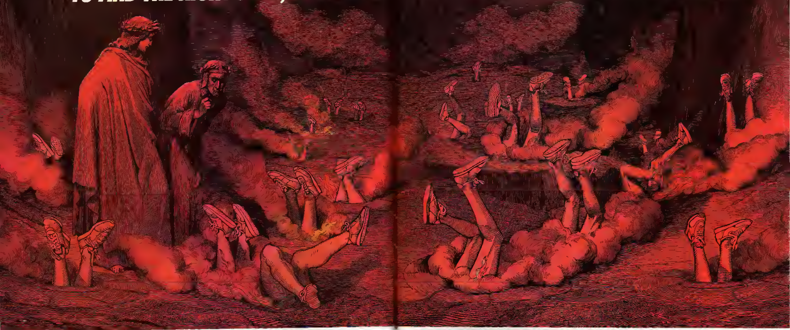
• For the first time in the quarter-century history of NASA astronauts will provide blood samples while working in orbit The procedure breaks a venerable taboo against puncturing an astronaut's body while in space The samples may help pin down the currently uncertain causes of the spacesickness that debilitates many crew members during their first days in orbit

The most significant thing about Spacelab though, is that it is a working scientific laboratory in orbit, manned by scientists who are in communication with each of the scientists who designed the 69 different experiments aboard the lab Human beings at the controls will be ready to alter an experiment here, fine-tune a measurement there, and take immediate advantage of a change in conditions or environment Until now virtually all space science has been done by automated equipment or—at best—equipment tended by astronauts who were not actual research scientists (That was the case on *Skylab*, sometimes confused with Spacelab *Skylab* was a 117-foot-long orbiting laboratory supporting



Previous pages Ulf Merbold (right) and Byron Lichtenberg work in a Spacelab mock-up at Marshall Space Flight Center Close up shows controls used in materials science studies These pages Plant containers (above) permit studies of zero g growth Data-display unit (near right) helps control equipment Windows on shuttle's flight deck (far right) provide a view of Spacelab nestled in the payload bay

TO FIND THE RIGHT SHOE, YOU DON'T HAVE TO GO TO THE ENDS OF THE EARTH.



Finding the right running shoe has become so confusing, so filled with scientific and pseudo-scientific claims, it's enough to make anyone hot under the collar.

We'd like you to remember just three things about Nike.

We have shoes for runners who need extra stability. Shoes for runners who want a combination of light weight and cushioning. And shoes that are versatile,

Odyssey

for those who are after a bit of both worlds.

While you may need a doctorate to understand why these shoes do what they do—and do it so well—finding a pair that's biomechanically correct is pretty simple.

For some runners, the overriding concern is stability. They need to limit the amount of pronation, or rolling around, that occurs on footstrike.

Terra Trainer

*Available at selected dealers November, 1983

There's no better way to do that than in the Nike Odyssey. Expensive, but a true technological breakthrough, in that it gives maximum control to the hard-core pronator yet never over-corrects anyone else.

On the other hand, if your first priority is lightweight cushioning, you want a shoe like our new Terra Trainer*. It weighs next to nothing. But it was built for strenuous road work and can take a low-blow as

Pegasus

well as, or better than, any shoe we've ever made.

Anatomically, most runners fall somewhere in between. Rather than choose between the two extremes, they can benefit from a little of both. In the Nike Pegasus.

That's it. We make several other models as well, but they are all variations on the same three themes: stability, lightweight cushioning, and versatility.

Whichever you choose, you are in for a pleasant surprise. Because each has attributes we simply don't have room to explain.

The point is this. Instead of getting bogged down with all the technical claims and counterclaims being made today, why not trust your own two feet?

It can seem like divine guidance.

NIKE

Beaverton, Oregon

three-man crews of astronauts until it was snagged by the atmosphere and broke up over Australia on July 11, 1979.) This has restricted the scientific studies that can be accomplished in space because automated equipment can do only what it has been programmed to do. It is impossible for researchers to change the programming in mid-mission to take advantage of new unforeseen opportunities.

Even automated probes as sophisticated as the *Viking* landers on the surface of Mars or the *Voyager* spacecraft that journeyed out to Jupiter and Saturn are limited in this way. The *Viking I* lander, for example, has fallen silent on the plain of Chryse after six years of faithfully sending pictures and other data back to Earth. NASA engineers fear that the reason for *Viking*'s silence is that the lander inadvertently turned its communications antenna away from Earth and is now beaming data into deep, empty space and cannot receive fresh instructions from Earth. If a human were present, such a minor problem would be resolved quickly. Without human intervention *Viking I* is now useless, even though its equipment should continue to function for years to come.

The advent of human scientists in space may well mark the end of a debate that has racked the space program for more than 20 years. Many scientists have argued bitterly that the billions of dollars NASA has spent on such manned missions as Apollo and the space shuttle would have produced more results if the money had been spent on unmanned scientific probes.

Now, with real-time scientific research being done in orbit, this old schism may begin to heal. The next generation of scientists may look forward to working in space aboard Spacelab or one of its descendants. NASA will also be placing the Space Telescope in orbit within a few years, opening a new dimension in space-borne research for astronomers.

"The exciting thing about Spacelab," says payload specialist Lichtenberg enthusiastically, "is that we are the beginnings of a new breed, the first generation of scientists who are going into orbit."

Lichtenberg has devoted his entire life to being a scientist in space. Turned on by reading science fiction as a youngster, he decided that to become an astronaut he had to be a jet pilot first. After serving in the Air Force as a fighter pilot and flying F-4s in Vietnam, he went to MIT, where he received degrees in mechanical engineering and biomedical engineering. He is a member of MIT's research staff, not a NASA employee, and makes his home in Massachusetts, where he still flies with the Air National Guard.

If Spacelab truly marks the end of the tensions between research scientists and NASA's manned space programs, it also marks the beginning of a new era of international cooperation. Scientists from a dozen nations have produced the experiments that went into Spacelab 1. West Germany has 21 experiments aboard: France, 13; the United States, 12; Great Britain, 6; Italy, 4; Austria, Belgium, and the Netherlands, 3 each; and Japan, Switzerland, Sweden, and Spain, 1 apiece.

Merbold, a quietly intense solid-state physicist from the Max Planck Institute for Metals Research in Stuttgart, thinks that the international aspect of the Spacelab program is its most important feature.

"Working with scientists from so many different countries widens your personal horizons," he says. "You find that, despite national differences, people in research are pretty much the same everywhere. And they become friends."

But there have been differences and problems during Spacelab's ten-year-long gestation. Most of the difficulties stemmed from the delays in the space shuttle itself. NASA originally expected to fly the first Spacelab mission in 1980, and they invited scientists to design experiments to be flown then. The scientific communities of Western Europe and the United States were also invited to select researchers who would go aloft with the Spacelab.

> *"This blunt, wingless, and engineless cylinder offers researchers the best chance for doing science in space just the way it is done on the ground."*

The scientists reacted with enthusiasm, and soon NASA was sifting through hundreds of proposals for experiments. From these NASA selected the 69 to be flown aboard Spacelab 1, plus others to be flown on follow-up missions.

Of the dozens of hopeful scientists who wanted to go into orbit, the American community finally settled on Lichtenberg and Michael Lampton, a physicist from the University of California at Berkeley, whose main interests are X-ray and ultraviolet astronomy. The Europeans picked Merbold as well as Wubbo Ockels, a nuclear physicist at the University of Groningen, the Netherlands. Lampton and Ockels trained as backup payload specialists with Lichtenberg and Merbold.

The four scientists left their homes to begin training in 1978, expecting to fly in two years. They spent most of their training time either at NASA's Marshall Space Flight Center, in Huntsville, Alabama, the prime site for the Spacelab mission, or at the Johnson Space Center, near Houston, where manned operations are directed. The Marshall Center is often called "the house that von Braun built," because it was there, on the grounds of the U.S. Army's Redstone Arsenal, that Wernher von Braun and his team of rocket engineers developed the first American satellite, *Explorer I*. Later, after NASA had been created and the Apollo program raced to send Americans to the moon, von Braun built the huge Saturn boosters that rattled the city of Huntsville like a minor earthquake when their mighty engines were tested.

Because of the delays in the shuttle's first flight, there was a year's training hiatus when the scientists were able to return to their normal lives at home campuses.

Meanwhile, the scientists designing the experiments for Spacelab were using the extra time to refine—and often redesign—their equipment. While waiting for the shuttle to get off the ground, NASA had to juggle dozens of different human and technological equations.

The man who had to keep all the experiments and experimenters in line with the engineering requirements of spaceflight was Charles "Rick" Chappell, a plasma physicist who wears two hats at Marshall SFC. Chappell, chief of Marshall's solar-terrestrial physics division, is also the mission scientist for Spacelab 1.

Most of the managers for such programs as Spacelab have come up through NASA's engineering ranks. "dealing with scientists from a dozen nations and many different disciplines isn't easy for them."

"Typically a group of engineers will view a group of scientists as a roomful of chaos—*unmanaged* chaos," Chappell says in his soft, calm Southern drawl.

"The engineers tend to view the scientists as people who are way out—who make impossible demands and are never satisfied. So there's a little bit of fright on the engineering-management side about what the scientists are likely to do—how do we bring them into order?"

Chappell's job has been to bring the scientists and engineers together so that Spacelab can accomplish the major goal of its first mission: to demonstrate that the laboratory will be useful for doing many different kinds of flexible scientific research in orbit.

As Chappell kept Spacelab plans and personnel in order, a new problem suddenly cropped up in space, threatening that fundamental goal.

Doing science in "real time" means that the payload specialists in the orbiting laboratory are to be in constant communication with the principal investigators who designed each of the lab's many experiments. The aim is to have data rain down continuously from the lab's experimental equipment and the payload specialists to the scientists on the ground. In return, the principal investigators would be able to talk directly to the payload specialists and make changes in the experiments, taking advantage of the data they are receiving and any changes in the conditions aboard the lab or in space. In the past communications from orbiting vehicles have come in bursts lasting only as long as spacecraft are in touch with a ground-tracking station.

The real-time communications link was to have been provided by two tracking and data relay satellites (TDRS). But the first TDRS almost failed to achieve its proper orbit and the second was never launched.

The TDRSs are carried into low-Earth orbit aboard the space shuttle, then injected into geostationary orbit 22,300 miles above the equator by a booster rocket called the interim upper stage (IUS). On the sixth shuttle mission, this past April, the first TDRS was deployed from the *Challenger*'s payload bay with no trouble. But the IUS malfunctioned shortly after leaving the shuttle and failed to boost the satellite into the geostationary orbit. Ingenious NASA engineers gradually nudged the TDRS up to its proper orbit using built-in 45 caliber maneuvering thrusters that deliver one pound of thrust each. By July the space agency announced that the first TDRS was functioning properly.

But the malfunction of the IUS caused NASA to postpone the launch of the second TDRS indefinitely. And that sent a tremor through the Spacelab program.

Only half of the communications relay system was working. In fact, for many weeks during April and May the Spacelab team was not even sure that the first TDRS would be usable. How could they do real-time science without the all-important communications link from orbit to the principal investigators?

The alternatives facing NASA's management were few and grim. One was to scrub the Spacelab 1 launch until both TDRSs were in their proper orbits and functioning well. But after three years of delays that might have killed the Spacelab program altogether. The scientists who had waited for NASA to get its act together might simply have given up hope and dropped out of the program.

The second alternative was to try to do as much of the research as possible aboard the orbiting lab, recording results, as in previous missions, and skipping real-time communication to scientists on the ground. No one wanted that.

The third alternative was to try to get along with one TDRS and to make up the difference by packing additional recording equipment aboard Spacelab. NASA chose that option. The laboratory now carries a sophisticated tape recorder that can store 32 million bits of data. Each time the spacecraft comes within range of the one orbiting TDRS, the stored data will be squirted to the satellite and relayed in a dense batch to the ground.

John Thomas, the Spacelab program office manager at NASA/Marshall, claims that this compromise will allow the mission to accomplish its scientific goals. "We will not lose any bits [of data]," he says.

Thomas is a serious, careful engineer who has worked his way up through the ranks to head the Spacelab program. A veteran of the Saturn and Skylab programs, he wants to be able to prove that Spacelab will be a reusable, flexible, and *economical* facility for valuable scientific research in orbit.

ESA has spent roughly $1 billion on Spacelab, and NASA has put in nearly a comparable amount toward ground facilities, launching costs, and personnel. Facing numbers like these, Thomas is the kind of practical engineer who knows how to shave a corner when it can be shaved.

Standing in the National Air and Space Museum in Washington, DC, is a fully equipped *Skylab*, the real article, which served as backup to the one launched in 1973 and would itself have gone into orbit if the first *Skylab* had failed.

One of the most popular exhibits at the museum, the *Skylab* vehicle has also become popular with Thomas and his engineers. They have raided it several times for equipment that is now installed in Spacelab, including spark-free air-circulation fans, special cleated shoes that allow the astronauts to clamp their feet to the lab's floor despite the zero-gravity condition in orbit, and a large high-optical-quality window that has been placed in Spacelab's forward hatch.

The scientists will be able to photograph the earth and the stars through that window without leaving the shirt-sleeve safety of the laboratory module.

All of this problem solving and preparation will reap extraordinary rewards, NASA hopes, after the first scientists clamber through a 3.5-foot-wide aluminum tunnel from *Columbia*'s living quarters to Spacelab and begin their weightless research. Among their first subjects for investigation: the astronauts themselves.

The debate about whether crew members in space ought to be subjects of medical research has smoldered since the start of the Mercury program and the selection of the original seven astronauts. Drawn from the ranks of hotshot jet jockeys, these fighter pilots and test pilots always viewed medical doctors with trepidation. M.D.'s were always the guys who redlined a pilot, declared him unfit for flying duty because of slightly high blood pressure or some other reason the pilots found unworthy. With that kind of background, the astronauts cooperated only grudgingly with NASA's medical specialists and steadfastly refused to allow themselves to become guinea pigs—especially while on a complex mission in space.

The medics, on the other hand, have had to face all the challenges of understanding how the human mind and body react to prolonged periods of zero gravity. (Actually, NASA specialists refer to "microgravity," pointing out that *zero* gravity is not really attained in orbit because the spacecraft itself exerts a microscopic

"They're calling ahead for reservations! What do I say?"

gravitational influence over the crew inside it For anyone but a specialist however *zero gravity* is close enough to the truth)

Astronauts have become ill when undergoing weightlessness Despite the exhilaration and sense of freedom that zero g brings there have been plenty of cases of what the media now call spacesickness

Dr William B Lenoir mission specialist aboard the fifth shuttle flight in November 1982 was one of the first medical doctors to experience that malady

"It's not like seasickness at all " he said "It's really nothing more than a wet burp "

"You just feel sort of lousy " another astronaut reported "It's like you're coming down with the flu you don't quite feel up to doing the work "

While this upset feeling usually disappears after a day or so in orbit NASA's medics are still working hard to pin down the causes of spacesickness Once they understand the malady's cause they feel they may be able to produce a cure—or at least a palliative

So one of the major areas of investigation on the Spacelab 1 mission is the life sciences and the payload and mission specialists will be both investigators and experimental subjects

For months the crew members and their backups have subjected themselves to all sorts of tests They have been spun on rotating chairs while wearing contact lenses with cross hairs (to enable researchers to track eyeball rotation) They have swallowed heavy water deuterium oxide which disrupts the sense of balance And they have given blood samples

All these tests are designed to explore the workings of the vestibular system inside the ear the human body's natural balancing system Spacesickness is apparently the result of conflicting signals from the vestibular system and the eyes In zero gravity your eyes may be telling your brain that you are standing right side up but your vestibular system is telling your brain that you're falling like a lead weight dropped from the top of a very high building These conflicting signals are suspected to be the cause of the slightly groggy grumpy drained and unsettled state characteristic of spacesickness

The tests on the ground provided a baseline measurement of the astronauts physiology The tests will be repeated aboard Spacelab under zero-g conditions to compare results

Experiments developed by American German Italian British and Swiss scientists include the use of television cameras and sensors attached to the astronauts' bodies to monitor body motions and orientations Each member of the lab crew wears a small tape recorder on his belt to collect data on heartbeat rate electrical activity in the brain and motions of the eyeballs Blood samples are taken before during and after the flight to see whether there are any changes in the count of red and white cells In addition white blood cells will be grown in a culture medium to see if weightlessness affects their ability to fight bacterial infections

But the life-sciences experiments aboard Spacelab 1 are not restricted to studying the problems of human physiology Other experiments will study the effects of weightlessness and radiation on cell growth Bacteria sunflower seeds and fungi will all be examined in an effort to learn whether plants can determine which way is up in a zero-gravity situation and how the 24-hour circadian rhythm of terrestrial organisms may change in space

Four other major areas of research will make up the rest of Spacelab's work

Astronomy and solar physics Telescopes cameras and other detectors can examine the sun and stars without hindrance from the earth's blanket of cloudy turbulent air Several investigations will look at very faint sources of ultraviolet light and X rays wavelengths that do not reach ground-based instruments at all Another group of experiments will make precise measurements of the sun's output of energy which astronomers call the solar constant Recent research has indicated that the constant may be subject to minute fluctuations Since the earth's weather depends on the energy beamed from the sun these new measurements will have an important impact on efforts to understand and predict global weather

Space-plasma physics The "vacuum" of interplanetary space is actually filled with a very thin electrified gas Physicists call it a plasma A ghostly solar wind blows from the sun sending atomic particles hurtling past the earth at speeds of 1 000 miles per hour or more Magnetic storms on the sun travel through this plasma and affect the earth's magnetic field causing auroras and sometimes disrupting radio and telephone communications and even knocking out electrical power cables

A half-dozen experiments on Spacelab 1 will probe this space plasma Japanese and French experiments for example will fire electrified particles—electrons and ions—into the earth's magnetosphere (a region extending thousands of miles into space dominated by the earth's magnetic field so that charged particles are trapped in it) to create temporary artificial auroras

Atmospheric physics and Earth observations From its perch 155 miles above the surface Spacelab can examine the composition temperatures and motions of the gases that make up the earth's atmosphere Instruments will study our planet's landmasses and water surfaces on a global scale A large-film camera will take high-resolution photographs that can be used for unprecedentedly precise mapmaking and microwave radar will allow detailed observation of the earth's surface even through cloud cover

"Yes, I'd say that yours is the definitive performance of Swan Lake "

CONTINUED ON PAGE 106

FICTION

MULTIPLES

BY ROBERT SILVERBERG

There were mirrors everywhere, making the place a crazy house of dizzying refraction: mirrors on the ceiling, mirrors on the walls, mirrors in the angles where the walls met the ceiling and the floor, even little eddies of mirror dust

PAINTING BY BEATE BRÖMSE

periodically blown on gusts of air through the room so that all the bizarre distortions, fracturings and dislocations of image that were bouncing around the place would from time to time coalesce in a shimmering haze of chaos right before your eyes. Colored globes spun round and round overhead, creating patterns of ricocheting light. It was exactly the way Cleo had expected a multiples club to look.

She had walked up and down the whole Fillmore Street strip, from Union to Chestnut and back again, for half an hour, peering at this club and that before finding the courage to go inside one that called itself Skits. Though she had been planning this night for months, she found herself paralyzed by fear at the last minute, afraid they would spot her as a fraud the moment she walked in, afraid they would drive her out with jeers and curses and cold mocking laughter. But now that she was within, she felt fine—calm, confident, ready for the time of her life.

There were more women than men in the club, something like a seven-to-three ratio. Hardly anyone seemed to be talking to anyone else. Most stood alone in the middle of the floor, staring into the mirrors as though in trance.

Their eyes were slits, their jaws were slack, their shoulders slumped forward, their arms dangled. Now and then, as some combination of reflections sluiced across their consciousnesses with particular impact, they would go taut and jerk and wince as if they had been struck. Their faces would flush, their lips would pull back, their eyes would roll, they would mutter and whisper to themselves, then after a moment they would slip back into stillness.

Cleo knew what they were doing. They were switching and doubling. Maybe some of the adepts were tripling.

Her heart rate picked up. Her throat was very dry. What was the routine here? she wondered. Did you just walk right out onto the floor and plug into the light patterns, or were you supposed to go to the bar first for a shot or a snort?

She looked toward the bar. A dozen or so customers were sitting there, mostly men, a couple of them openly studying her, giving her that new-girl-in-town stare. Cleo returned their gaze evenly, coolly, blankly. Standard-looking men, reasonably attractive, thirtyish or early fortyish, business suits, conventional hairstyles, young lawyers, executives, maybe stockbrokers—successful sorts out for a night's fun, the kind of men you might run into anywhere. Look at that one—tall, athletic, curly hair, glasses. Faint, ironic smile, easy, inquiring eyes. Almost professorial. And yet, and yet—behind that smooth, intelligent forehead, what strangenesses must teem and boil! How many hidden souls must lurk and jostle! Scary. Tempting.

Irresistible.

Cleo resisted. Take it slow, take it slow. Instead of going to the bar, she moved out serenely among the switchers on the floor, found an open space, centered herself, looked toward the mirrors on the far side of the room. Legs apart, feet planted flat, shoulders forward. A turning globe splashed waves of red and violet light, splintered a thousand times over, into her upturned face.

Go. Go. Go. Go. You are Cleo. You are Judy. You are Vixen. You are Lisa. Go. Go. Go. Go. Cascades of iridescence sweeping over the rim of her soul, battering at the walls of her identity. Come, enter, drown me, split me, switch me. You are Cleo and Judy. You are Vixen and Lisa. You are Cleo, Judy, and Vixen and Lisa. Go. Go. Go.

Her head was spinning. Her eyes were blurring. The room gyrated around her.

Was this it? Was she splitting? Was she switching? Maybe so. Maybe the capacity was there in everyone, even her, and all that it would take was the lights, the mirrors, the right ambience, the will.

> She was alone in the bed. She felt a surge of confusion and dislocation, remembered after a moment where she was and how she happened to be there, sat up, blinked.

I am many. I am multiple. I am Cleo switching to Vixen. I am Judy and I am— No. I am Cleo. I am Cleo.

I am very dizzy, and I am getting sick, and I am Cleo and only Cleo, as I have always been. I am Cleo and only Cleo and I am going to fall down.

"Easy," he said. "You okay?"

"Steadying up. I think. Whew!"

"Out-of-towner, eh?"

"Sacramento. How'd you know?"

"Too quick on the floor. Locals all know better. This place has the fastest mirrors in the west. They'll blow you away if you're not careful. You can't just go out there and grab for the big one—you've got to phase yourself in slowly. You sure you're going to be okay?"

"I think so."

He was the tall man from the bar, the athletic, professorial one. She supposed he had caught her before she had actually fallen, since she felt no bruises.

His hand rested easily now against her right elbow as he lightly steered her toward a table along the wall.

"What's your now-name?" he asked.

"Judy."

"I'm Van."

"Hello, Van."

"How about a brandy? Steady you up a little more."

"I don't drink."

"Never?"

"Vixen does the drinking," she said.

"Ah. The old story. She gets the bubbles, you get her hangovers. I have one like that too, only with him it's Hunan food. He absolutely doesn't give a damn what lobster in hot and sour sauce does to my digestive system. I hope you pay her back the way she deserves."

Cleo smiled and said nothing.

He was watching her closely. Was he interested, or just being polite to someone who was obviously out of her depth in a strange milieu? Interested, she decided. He seemed to have accepted that Vixen stuff at face value.

Be careful now, Cleo warned herself. Trying to pile on convincing-sounding details when you don't really know what you're talking about is a sure way to give yourself away sooner or later.

The thing to do, she knew, was to establish her credentials without working too hard at it, sit back, listen, learn how things really operate among these people.

"What do you do up there in Sacramento?"

"Nothing fascinating."

"Poor Judy. Real-estate broker?"

"How'd you guess?"

"Every other woman I meet is a real-estate broker these days. What's Vixen?"

"A lush."

"Not much of a livelihood in that."

Cleo shrugged. "She doesn't need one. The rest of us support her."

"Real estate and what else?"

She hadn't been sure that multiples etiquette included talking about one's alternate selves. But she had come prepared. "Lisa's a landscape architect. Cleo's into software. We all keep busy."

"Lisa ought to meet Chuck. He's a demon horticulturelist. Partner in a plant-rental outfit—you know, huge dracaenas and philodendrons for offices, so much per month, take them away when they start looking sickly. Lisa and Chuck could talk palms and bromeliads and cacti all night."

"We should introduce them."

"We should, yes."

"But first we have to introduce Van and Judy."

"And then maybe Van and Cleo," he said.

She felt a tremor of fear. Had he found her out so soon? "Why Van and Cleo? Cleo's not here right now. This is Judy you're talking to."

"Easy. Easy!"

But she was unable to halt. "I can't deliver Cleo to you just like that, you know. She does as she pleases."

"Easy," he said. "All I meant was, Van and Cleo have something in common. Van's into software too."

Cleo relaxed With a little laugh she said, "Oh, not you too! Isn't everybody nowadays? But I thought you were something in the academic world A university professor or something like that "

"I am At Cal "

"Software?"

"In a manner of speaking Linguistics Metalinguistics actually My field is the language of language—the basic subsets the neural coordinates of communication the underlying programs our brains use the operating systems Mind as computer, computer as mind. I can get very boring about it '

"I don t find the mind a boring subject "

"I don't find real estate a boring subject Talk to me about second mortgages and triple-net leases '

"Talk to me about Chomsky and Benjamin Whorf, ' she said

His eyes widened "You've heard of Benjamin Whorf?"

"I majored in comparative linguistics That was before real estate "

"Just my lousy luck " he said "I get a chance to find out what s hot in the shopping-center market and she wants to talk about Whorf and Chomsky "

"I thought every other woman you met these days was a real-estate broker Talk to them about shopping centers '

"They all want to talk about Whorf and Chomsky More intellectual

Poor Van "

"Yes Poor Van ' Then he leaned forward and said, his tone softening, "You know, I shouldn't have made that crack about Van meeting Cleo That was very tacky of me '

"It's okay Van I didn't take it seriously "

"You seemed to You were very upset '

"Well maybe at first But then I saw you were just horsing around "

"I still shouldn't have said it You were absolutely right This is Judy's time now Cleo s not here and that's just fine It's Judy I want to get to know '

"You will," she said "But you can meet Cleo, too and Lisa and Vixen I ll introduce you to the whole crew I don't mind "

"You re sure of that?"

"Sure "

"Some of us are very secretive about our alters '

"Are you?" Cleo asked

"Sometimes Sometimes not "

"I don't mind Maybe you'll meet some of mine tonight " She glanced toward the center of the floor ' I think I've steadied up now I'd like to try the mirrors again

"Switching?"

"Doubling," she said "I'd like to bring Vixen up She can do the drinking and I can do the talking Will it bother you if she s here too?"

"Won't bother me unless she s a sloppy drunk Or a mean one

"I can keep control of her when we're doubling Come on take me through the mirrors

"You be careful now San Francisco mirrors aren't like Sacramento ones You've already discovered that

"I'll watch my step this time Shall we go out there? '

"Sure " he said "

As they began to move out onto the floor a slender, T-shirted man of about thirty came toward them Shaven scalp, bushy mustache medallions boots Very San Francisco, very gay He frowned at Cleo and stared straightforwardly at Van

"Ned? he said

Van scowled and shook his head "No Not now "

"Sorry Very sorry I should have realized ' The shaven-headed man flushed and hurried away

"Let's go Van said to Cleo

This time she found it easier to keep her balance Knowing that he was nearby helped But still the waves of refracted light came pounding in pounding in pounding in The assault was total remorseless implacable, overwhelming She had to struggle against the throbbing in her chest the hammering in her temples, the wobbliness of her knees And this was pleasure for them? This was a supreme delight?

But they were multiples, and she was only Cleo and that she knew made all the difference She seemed to be able to fake it well enough She could make up a Judy a Lisa a Vixen assign little corners of her personality to each, give them voices of their own facial expressions, individual identities Standing before her mirror at home she had managed to convince herself She might even be able to convince him But as the swirling lights careened off the infinities of interlocking mirrors and came slaloming into the gateways of her reeling soul the dismal fear began to rise in her that she could never truly be one of these people after all however skillfully she imitated them in their intricacies

Was it so? Was she doomed always to stand outside their irresistible world hopelessly peering in? Too soon to tell—much too soon she thought to admit defeat

At least she didn t fall down She took the punishment of the mirrors as long as she could stand it and then not waiting for him to leave the floor, she made her way—carefully, carefully walking a tightrope over an abyss—to the bar When her head had begun to stop spinning she ordered a drink and she sipped it cautiously She could feel the alcohol extending itself inch by inch into her bloodstream It calmed her On the floor Van stood in trance, occasionally quivering in a sudden, convulsive way for a fraction of a second He was doubling she knew bringing up one of his other identities That was the main thing that multiples came to these clubs to do No longer were all their various identities forced to dwell in rigorously separated compartments of their minds With the aid of the mirrors and lights the skilled ones were able briefly to fuse two or even three of their selves into something more complex When he comes back here she thought he will be Van plus X And I must pretend to be Judy plus Vixen

She readied herself for that Judy was easy Judy was mostly the real Cleo, the real estate woman from Sacramento with Cleo's notion of what it was like to be a multiple added in And Vixen? Cleo imagined her to be about twenty-three a Los Angeles girl a one-time child tennis star who had broken her ankle in a dumb prank and had never recovered her game afterward and who had taken up drinking to ease the pain and loss Uninhibited unpredictable untidy fiery fierce all the things that Cleo was not Could she be Vixen? She took a deep gulp of her drink and put on the Vixen face eyes hard and glittering, cheek muscles clenched

Van was leaving the floor now His way of moving seemed to have changed He was stiff almost awkward his shoulders held high his elbows jutting oddly He looked so different that she wondered whether he was still Van at all

"You didn't switch did you? '

"Doubled Paul's with me now "

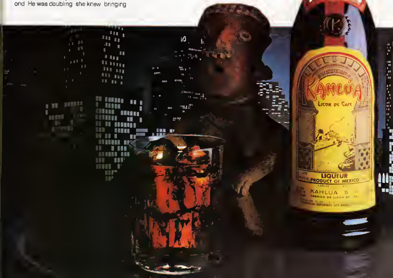
"Paul?"

"Paul's from Texas Geologist, terrific poker game, plays the guitar " Van smiled, and it was like a shifting of gears In a deeper, broader voice he said, 'And I sing real good too, ma'am Van's jealous of that because he can't sing worth beans Are you ready for a refill?' '

"You bet,' Cleo said sounding sloppy, sounding Vixenish

His apartment was nearby, a cheerful, airy sprawling place in the Marina district The segmented nature of his life was immediately obvious The prints and paintings on the walls looked as though they had been chosen by four or five different people, one of whom ran heavily toward vivid scenes of sunrise over the Grand Canyon, another to Picasso and Miro someone else to delicate, impressionist views of Parisian street scenes and flower mar-

CONTINUED ON PAGE 94



Accelerating gently
to awesome speeds, huge craft will whisk
man to the planets

SPACE ARKS FOR THE 21ST CENTURY

BY JAMES E. OBERG

A ten-month trip to Mars is "nuts," argues physicist Robert Bussard. Instead, he proposes a space voyage lasting a mere three weeks at the turn of the century. "This is the way to do it," he continues, "with point-to-point travel times equivalent to those of the Old West."

Despite today's retreat in farsighted national space commitments, there is no lack of ideas for future interplanetary-spaceship propulsion. They range from Franklin Chang's "ion drive with an afterburner" to Rod Hyde's laser-pulsed fusion drive, to Robert Forward's multidimensional fascination with antimatter-annihilation drive. (A preliminary version of Hyde's design is the centerpiece of an artist's conception of future ships, at left.) All of these, as well as others, might work when the time comes for really serious interplanetary trucking. It's safe to suppose that at least some of the unstreamlined but sophisticated engines will work, and then the solar system—and Earth—won't look quite the same.

The duration of the trip—not the distance—has long been the true measure of geographical separation on Earth. Years-long Renaissance voyages around the world can now be made at leisure in a few months, and hurriedly in 40 hours. Transatlantic excursions today are a matter of weekends, not months. And as flight times shrink, our perception of the world changes. We grow less insular. As we control the travel time, we become masters of the space.

So it will be with space itself. The new generation of long-haul ships will change our perceptions of other planets. Within a generation or two humans will grow up with a sense of dominion over once forbidden territories. The solar system itself will take on the manageable dimensions of a Renaissance world.

Last spring *Pioneer 10* departed the solar system after

PAINTING BY PAUL LEHR

coasting up and out for 11 years. Had the spacecraft been able to maintain the high acceleration that characterized its first ten minutes of flight, the trip would have taken about a week.

The time will come when voyages to Mars no longer consume the better part of a year. With the right kinds of engines, people could get from here to there and back again within the span of a summer vacation.

Some simple calculations can demonstrate the true point-to-point temporal dimensions of the solar system if engine power were no longer a limiting factor. Since human beings will be aboard future spaceships, a ship's acceleration should probably be limited to the force of gravity on Earth's surface, or one g. The flight plan would probably call for continuous thrusting, building up speed to the halfway point, then flipping the craft around and braking to the destination.

With such an engine, a manned spaceship could reach the moon in three hours and 40 minutes, instead of the three days needed by Apollo astronauts. With such an engine, a manned spaceship could reach Mars in 55 hours, instead of the ten months it took the Viking robots. And with such an engine a manned spaceship could reach the edge of the solar system in 16 days, instead of the decade needed by *Pioneer*. With such an engine, even the nearby stars come within planning range.

That may be asking for the impossible, at least for the next century. But even an engine capable of a mere 1 percent of Earth's gravitational force would be extraordinarily fast. It could get a spaceship to the moon in 35 hours and to Mars in three weeks—remarkably rapid trips in terms of today's space technology. And such engines are almost certain to become feasible within a few decades.

Blueprints for these engines are now being drawn up. The designers share one purpose: Get from here to there and back as quickly and cheaply as possible—and before the next century is half over.

Spaceship engine power, like any other element in the statistical universe, can be measured and quantified. Numbers can be applied to it, and equations can simulate the way one rocket functions compared with another. Central to all such engineering calculations is the concept of the specific impulse of a spaceship engine. Oddly enough, the unit of measurement of this quantity—abbreviated Isp (impulse specific) and pronounced "eye-ess-pee"—is seconds of time.

The specific impulse is the duration, in seconds, of how long one pound of fuel can provide one pound of thrust.

In more precise engineering terms, Isp is equal to exhaust velocity of burned fuel from the rocket nozzle, divided by the acceleration of gravity (small g) and by the molecular weight of the expelled material. Furthermore, exhaust velocity is in turn proportional to the chamber temperature. The strategy for rocket designers to increase engine efficiency: increase the exhaust velocity, increase chamber temperature, and use as light an exhaust material as possible—preferably hydrogen gas.

Standard liquid-fueled military rockets have an Isp of about 250 seconds, which they can maintain for several minutes. The space shuttle's main engines, burning liquid hydrogen, have an Isp of more than 450 seconds and fire for more than eight minutes. Nuclear rockets using fission to heat hydrogen were able to deliver 800 to 1,000 seconds of Isp in ground tests in the late Sixties in burns lasting tens of minutes. Ion drive, or electric propulsion, offers an Isp of 10,000 seconds or more for weeks or months on end, but with all the push of a butterfly's kiss.

The engine of the semimythical solar-system spaceship would need an Isp of 1 million seconds. The question is: How do we make it to a million? There are a great many possible answers, only a few of which will turn out to be right.

"Voyages to Mars will no longer take the better part of a year. With the right kinds of engines, people could get there and back within a summer vacation."

To demonstrate confidence in a proposed new rocket propulsion system, perhaps a specialist should be willing to ride on it. And there is indeed a propulsion researcher who also happens to be an astronaut: Franklin Ramon Chang, a Costa Rican-born physicist who is a member of the NASA astronaut corps.

Scientist astronauts (now called mission specialists) have always been encouraged by NASA to pursue their outside scientific work along with their flight training. For Chang, who was picked as an astronaut in 1980 and is working on the research program for a 1985 Spacelab mission, that outside work primarily has been a propulsion idea he first developed while working with MIT researchers.

Basically it's an ion drive with an afterburner," explains Chang. Called a hybrid plume plasma engine, the rocket takes an ordinary high-temperature plasma generator and couples it to a nozzle system designed to inject inert gas in a sleeve around the plasma jet. Plasma, the natural atmosphere of stars, is a superheated gas (with temperatures in the tens of thousands of degrees Kelvin) composed of charged particles. The exhaust column, or plume—a core of plasma and its outer sleeve of inert gas—has more bulk than plasma alone. So it provides more thrust than a simple plasma rocket. The amount of inert gas can be controlled to change the bulk of the fuel and the specific impulse. The plume would have highest bulk—and slowest flow—when first ignited.

"I consider the number-one feature of this concept the variable specific impulse," Chang says. And the second major feature is that the exhaust plume is cooler in its outer borders—in the sleeve of inert gas—than in the plasma center. The key advantage of such a system: The cooler layer of inert gas insulates the plasma from the rocket nozzle, which otherwise would melt. Neither of the features is original, but their combination is.

In addition, Chang has pioneered work in the computer modeling of the interaction of the plasma jet with the inert material surrounding it. "Film cooling"—cooling the nozzle containing the plume with an outer gaseous sleeve—has been seen before in rocket designs but not over such extreme temperature ranges.

The result is an engine that may be able to propel both interorbital space tugs as well as fast interplanetary probes with significantly larger payloads than is possible with current systems.

"In a lot of this stuff I'm still a Lone Ranger," Chang admits. "We don't have all the numbers worked out yet." But with the help of a graduate student at MIT, and with serious interest from NASA's Jet Propulsion Laboratory and the Air Force Rocket Laboratory at Edwards Air Force Base, Chang has seen the concept evolve from an idea to a plan for laboratory testing of plume stability.

Testing could come within a year or two. Following that, Chang envisions an orbital engine, based on his design, attached to a platform in the space shuttle's payload bay—perhaps with astronaut Chang along to assist in the test.

Someday, upon arriving at a gas-giant planet, a vehicle with such an engine could scoop up atmospheric gas—hydrogen would be ideal—and use it as the inert gas for the return trip. (At launch, from orbit around the earth, the ship would carry material to make all the plasma needed for the whole journey.) "The engine will work with just about any gas, if tuned properly," Chang asserts.

The current limiting factors are associated with the engine's electrical-power source, which creates and expels the plasma jet. Chang foresees first the use of nuclear reactors. Under current technology the reactors could allow the engine to operate with an Isp ranging from 500 seconds (not much better than chemical systems—but the engine could use almost anything for propellant, even gas snatched from the upper atmospheres of giant planets or Titan) to 5,000 seconds for really serious interplanetary trucking.

"This is not fusion power," Chang is quick to point out. "But if we knew how to do fusion power it would work even better." And when fusion drives are built they may be advanced versions of his hybrid-plume design. Chang, who is now thirty-one, may help build them—and ride them.

While science-fiction spaceships tend to zoom through Hollywood skies in what might be called the belch-fire mode, there are likely to be other technologies for interplanetary travel or for important segments of such travel.

So as not to miss a trick with potential nonobvious space-propulsion breakthroughs of the next century, the Air Force's rocket lab recently funded a series of study contracts. One of the grant recipients was Robert Forward of the Hughes Research Labs, in Malibu, California. Forward promptly took a year's leave of absence to examine new ideas for extracting, storing, or using energy in space.

"I collected about sixty ideas," Forward tells *Omni*, "of which I looked carefully at twenty-six." And from them he chose several that he thought deserved serious additional investigation.

One idea involves using solar energy collected in space to run a mobile electric-power generator based on MHD principles. MHD—for *magnetohydrodynamic*—is a system to collect the electric power that develops in a flow of gas as it is pumped at high speed through a magnetic field (see "Firepower Plant," February 1983). In Forward's system, the solar energy would do the pumping. And the resulting electric current would be used to provide power for other methods of propulsion—for example, expelling plasma in Chang's drive. By itself, the solar-pumping system is not a propulsion device. But it promises to make other schemes requiring large power sources much more efficient.

A second idea is a light sail full of holes. "I invented it," Forward says, "although Freeman Dyson thought of it too." Light sails—pushed through space by the light energy from stars—have already been shown to have highly attractive super-long-haul cargo-carrying ability even without improvement. Perforating a large "solar sail" (Forward prefers the term *light sail* since "I intend to push it with other energy sources, such as laser beams") could cut its mass by 90 percent while not reducing the sunlight pressure—as long as the holes are smaller than the wavelength of light.

The holes might provide another advantage, Forward says. In Earth orbits below 1,000 kilometers, light sails cannot be deployed because of the retarding effect of collisions with air molecules. But a perforated sail might not be nearly as susceptible to interference. Air molecules would pass through the holes while sunlight would bounce off. Forward suggests a space-shuttle experiment as soon as possible to hold up a sample of such a carefully riddled sail during a mission and measure its actual sunlight push and air drag.

There are, of course, other propulsion possibilities. Fusion energy is the most obvious. Fusion rockets would depend on the energy released when the nuclei of hydrogen atoms are forced—by lasers, for example—to unite into heavier nuclei. "It's worth looking at," Forward suggests, "once it gets going—but it hasn't yet. It is definitely a viable technique."

Rod Hyde certainly thinks so too. Hyde is a physicist at the Lawrence Livermore Laboratory in California working on laser-induced fusion for commercial power generation. But Hyde is also interested in future spaceship propulsion designs. He has helped conduct several advanced studies along those lines, and this month will be presenting a report to the International Astronautical Federation annual convention in Budapest. "Once laser fusion works on Earth," Hyde says, "it becomes trivial to build a spaceship."

The interplanetary spaceship Hyde envisions is a 1,000-ton space freighter to haul cargo throughout the solar system at 0.1-g acceleration. "That's two weeks to Mars, five weeks to Jupiter, and twenty-five weeks to Pluto," Hyde notes. "The trajectories aren't very sexy—almost just straight lines." But the payload fraction—the percentage of the total weight taken up by the payload—very definitely is sexy, at least to spaceship designers. It's about 50 percent, by Hyde's calculations.

Laser-induced pulse fusion is the key. That concept itself got its impetus from the seminal Orion scheme for a spaceship propelled by exploding hydrogen (fusion) bombs. Orion was the vision of physicists Freeman Dyson, Ted Taylor, and others working in the Fifties at the California laboratories of the General Atomic Company. Their hope was to put men on Mars by 1965. In the version that may well fly, the explosions are much smaller and much more frequent ("tens per second" is all Hyde can say), and they are to be caused not by detonating bombs but by the ignition of tiny pellets by aimed lasers. The desired results: Mass is expelled from the engine at very high velocities, and appropriate mixtures of pellet material can produce appreciable thrust levels.

Work is progressing on high-energy lasers for possible military applications on Earth, and Hyde believes the high-energy beams will become attractive for use in operational fusion-power plants.

The next step is to adapt the plants for space. "There is no market for such a rocket now," says Hyde. But the practicality of this rocket, if widely known, could contribute to a demand for one in coming decades.

According to Arthur C. Clarke, prophets of technological progress tend to be over-optimistic in the short run and underoptimistic in the long run. One of the reasons science seers are too conservative about the distant future is that they fail to allow

"Let's see. At 20 cents per ounce, your weekly salary will be . . ."

for occasional quantum leaps in knowledge by people like Chang, Forward, and Robert Bussard.

Currently Bussard, a physicist in La Jolla, California, is working on what he calls a Riggatron Fusion Tokamak, a trademark name for a revolutionary new fusion-power generator. It's a small device to contain fusion reactions within a field emanating from superconducting electromagnets—magnets operating at such low temperatures that they offer almost no electrical resistance. Bussard says the Riggatron makes cheap steam and cheap neutrons and produces energy at a cost equivalent to a two- or three-dollar barrel of oil.

By the end of the Eighties, Bussard expects to be working with experimental units, and within five years after that, the first commercial power plants should be available. "If that works," he says, "we can push it to work on deuterium deuterium reactions alone, with higher efficiencies." (Deuterium is an isotope of hydrogen with twice the mass of ordinary hydrogen.)

Bussard goes on: "If we let plasma leak out past magnetic diverters and mix it with hydrogen, we have a spaceship drive." Various combinations of Isp and thrust-to-weight ratios are possible with this continuous-drive system, he asserts. The peak efficiency would be about 6,000 to 7,000 seconds, and thrust about 20 percent of the engine's weight.

"For a spaceship that's ten times the force of the sun's gravity out here by Earth, so it's a high thrust system even though the acceleration is only several milligees—about 0.1 foot per second per second. "Because of the [large] size of the fusion device, we would have to build a five thousand-ton spaceship, a comparatively huge craft," Bussard says. "But it could get to Mars in twenty days with a payload fraction of twenty-five percent." Bussard's group figures that the transportation cost of moving cargo and people from low-Earth orbit to low-Mars orbit would be only a few dollars per pound.

At Mars the spaceship could use its fusion-power plant to generate electricity and separate water (found inside the moonlet Phobos) into hydrogen and oxygen. This electrolysis would create all the hydrogen propellant needed for the homeward leg.

How soon could this be done? Bussard is optimistic. "We'll have deuterium-deuterium reactions running in the mid-Nineties on the ground. Within ten years we could have an engine. It anybody wanted to build a spaceship twenty-five years from now we could have such a machine."

The advantage of fusion, Bussard points out, is in the energy bonus. Any electrical propulsion system uses electricity to expel propellant, with varying levels of efficiency. The Riggatron drive would use electricity to drive a fusion reaction. That reaction in turn makes 20 times the energy needed to support the fusion—a bonus of power used to expel the propellant. So the ship pulls itself along by its own nuclear bootstrap. Concludes Bussard: "We see it as rationally possible with the physics we know and with the engineering we know. It's just time and money."

Or maybe not. Hyde argues that Bussard's continuous magnetic fusion would not be nearly as efficient as Hyde's plan for a pulsed-fusion engine.

The weight of the shielding for the superconducting magnets is one objection Hyde complains. "That weight would lower the power-to-weight ratio of the system, cut acceleration, and lengthen trip times. Currently there is no way to resolve the issue among fusion researchers."

But whichever camp is right, fusion alone may not be the most powerful way to propel future spaceships. The most potent fuel now imaginable is antimatter. Reactions as particles of antimatter meet particles of normal matter release up to 1,000 times as much energy per unit of fuel mass as in a typical nuclear-fusion reaction. As a spaceship fuel, antimatter does have

> *Upon arriving at a gas-giant planet, a vehicle with such an engine could scoop up atmospheric gas and use it for the return trip*

drawbacks. No one is certain how to transform it into propulsive force. No one knows how to store it safely. Nor—strike three?—are scientists sure of practical ways to manufacture antimatter.

But the techniques are no longer unimaginable. Speaking to spaceflight enthusiasts of the British Interplanetary Society (BIS) in November 1982, former NASA Deputy Administrator George Mueller asserted that recent developments in nuclear physics had made the technology marginally conceivable at last. "I am not predicting that an antimatter space drive will propel us to Alpha Centauri in the next twenty years," he admitted. "But I am saying that the science of antimatter has advanced to the stage that it merits serious consideration indeed."

The technology of producing antimatter with particle beams is under development at numerous high-energy-particle laboratories around the world. Mueller pointed out, referring in particular to the European Center for Nuclear Research (CERN) near Geneva and to the United States Fermilab. Antiparticles can be created and then stored in magnetic confinement. So far only the tiniest amount of such material has been handled.

The best spaceship-propulsion technique would be to mix small amounts of antimatter with much larger amounts of an inert propellant, such as liquid hydrogen. "This arrangement should produce specific impulses in the range of several hundred thousand to several million seconds," Mueller noted. Therefore, "short-duration solar system voyages can be accomplished readily if antimatter can eventually be manufactured and handled in quantities of a few hundred kilograms." Learning to make even these small quantities, though, is an immense challenge.

Research into fusion power and into beam weapons has importance for antimatter research too. Ultimately the artificial production of antimatter will require specialized particle accelerators of very high currents and voltages. The electrical power requirements alone are huge.

Members of the BIS who produced the Daedalus starship design in the mid-Seventies are not staggered by these problems—they are intrigued by them. The original plans for Daedalus, named after the mythical inventor, called for pulsed-fusion propulsion. A recent issue of the BIS journal was entirely devoted to antimatter propulsion (September 1982), and it contained such papers as "Concepts for the Design of an Antimatter Annihilation Rocket," "The Cryogenic Confinement of Antiprotons for Space Propulsion Systems," and "Design Considerations for Relativistic Antimatter Rockets." The papers were highly technical and excruciating in mathematical detail, but they were solid speculation, not science fiction.

One design for an antimatter factory in deep space uses solar collectors 300 kilometers on a side to produce a power flux 100 times the current power output of the entire world. At an efficiency of 0.1 percent, a high-energy proton beam would be used to manufacture one kilogram of antimatter every month.

"The sun pours 1.3 grams of raw energy per day through every square kilometer of space," noted Robert Forward recently. "If we can convert even a small part of that energy into antimatter, then we become lords of the solar system.

"If we can do better, then we become tourists to the star worlds."

Mueller concurs. "Because of its unmatched capacity to carry available energy in concentrated form, antimatter should be expected to figure prominently in space propulsion for the twenty-first century. Even modest progress with antimatter propulsion would revolutionize travel across the solar system."

Such revolutions are doubtlessly coming. With such engines, even the mind-numbing millions of miles between planets can be overcome and the solar system—spanned by travel times of weeks or months—can assume the dimensions of a rich, enticing frontier. ∞

A rugged individualist of astronomy, Charles Kowal is the

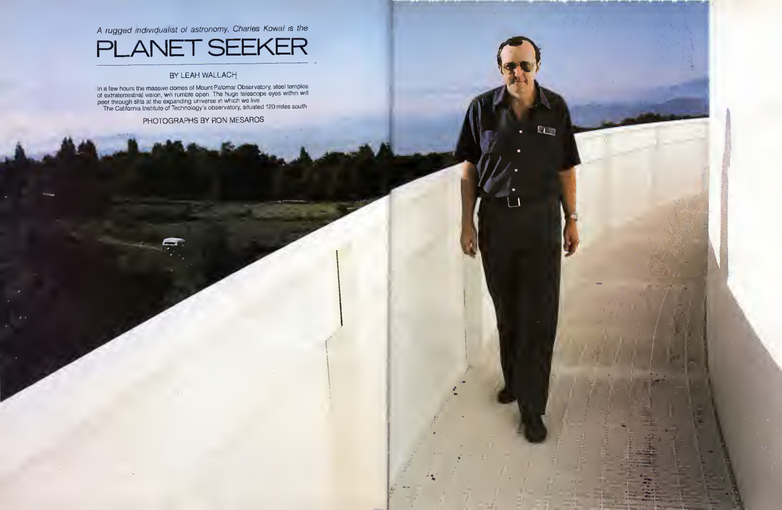
PLANET SEEKER

BY LEAH WALLACH

In a few hours the massive domes of Mount Palomar Observatory, steel temples of extraterrestrial vision, will rumble open. The huge telescope eyes within will peer through slits at the expanding universe in which we live.

The California Institute of Technology's observatory, situated 120 miles south-

PHOTOGRAPHS BY RON MESAROS

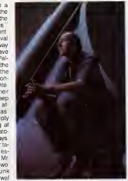


"I'm not really that interested in black holes and quasars. They're so speculative"

east of Los Angeles, is perched atop a chain of lovely lilac-tinged hills where the dry and windless weather minimizes the scattering of photons, or light "particles." The photon-friendly weather is the point. Snapshots made by recording the arrival of light images from long ago and far away give us all the information we will ever have about much of the cosmos. Housed in Palomar's four giant domes are four of the most powerful photon gatherers on the planet. Surrounding them is a self-contained colony composed of the maintenance staff, technical personnel, and their families. Visiting scientists eat and sleep in a gabled farmhouse-style building, affectionately called the monastery. Top astronomers from all over the world apply every year for the privilege of staying at Mount Palomar and using the observatory's magnificent telescopes for a few days.

Seated around the monastery dinner table this afternoon are seven highly esteemed doctors of astronomy—and Mr. Charles Kowal. A tall thin man of forty-two with a ruddy complexion, chipmunk cheeks, and remarkably alert eyes, Kowal slouches at the dinner table, head jutting forward attentively. Thinning hair and a thickening paunch confirm his age, but there is still something boyish about him, an appealing youthfulness in the way he cocks his head like a curious squirrel to listen and in his smile, which is a little detached and, like his wit, a hint sly.

Kowal is the only astronomer there without a graduate degree and the only person not on a university faculty. He is interested in what he calls "doing astronomy," by which he means observing the heavens. And he does that extraordinarily well. In his 20 years as an astronomer he has found 81 supernovas, one of them the second brightest discovered in this century. He has discovered a thirteenth and possibly fourteenth moon of Jupiter; he has spotted numerous asteroids and comets; and he has found a mysterious and intriguing object named Chiron. Recently he has single-handedly taken on a problem that has engaged some of the best minds and equipment of modern astronomy: the search for a tenth planet. In 1979 the National Academy of Sciences awarded him the prestigious James Craig Watson Medal for contributions to the science of astronomy.



At the Palomar dinner table, while the other astronomers talk, Kowal listens. "I can learn more listening to the dinner conversations at Palomar than I ever did at school," he explains. "Here people talk about what they're actually doing."

Doing and getting results is what has always counted to Kowal. He has something of the entrepreneur's approach to life. "He went his own way and did things his own way," Gibson Reaves, one of his professors at the University of Southern California (USC), recalls. "He once did a project in a research course to see whether he could find a plate-filter combination that would decrease the effect of smog. Most students wrote up everything they did—all the procedures. Charlie turned in a half-page report giving only the results, so it didn't look like he had done much. We had to give him an oral exam and pry out of him what he did. He had done a tremendous amount of very nice work."

It was the work of a young man who had little use for school. "Basically I hated it," Kowal says simply. He tolerated it for four years, only because he had to become an astronomer. He knew from boyhood that was what he was going to do when he grew up. The only child of a Buffalo steelworker, Kowal was enchanted by pictures of nebulae, galaxies, and stars. While in elementary school, he attended astronomy classes at the Buffalo Museum of Science and built three telescopes there. "By the time I got to high school," he explains, "it was an absolute certainty that I would be an astronomer." During his junior year at USC he made a bicycle pilgrimage to Palomar, pushing the bike the last 20 miles uphill just to see one of those special places where people "do astronomy."

As a senior instead of applying to graduate school, he wrote to four observatories asking if they wanted a non-Ph.D. assistant. Of the four, three offered him jobs. He accepted a position with a childhood hero, cosmologist D. Allan Sandage, at the Carnegie Institution Mount Wilson Observatory near Los Angeles. There Kowal learned to use a photoelectric photometer to measure the brightness and color of distant stars. From Mount Wilson he went to Caltech (California Institute of Technology) where he spent a year assisting Swiss astrophysicist and supernova expert Fritz Zwicky in a supernova search Zwicky had been conducting at Palomar since 1936.

Kowal then moved on to the Mees Observatory, in Hawaii, where he took time-lapse photographs of the sun. But he found solar work unsatisfying. It involved too much physics and too much teamwork. "There wasn't anything I could do as an individual," he explains. "I wanted to make a mark on the world, still do. Also I don't like to be supervised, and I don't like to supervise." So by 1966 he was back at Caltech searching for supernovas, first with Zwicky and then with Wallace L. W. Sargent, who headed the supernova search program after Zwicky's retirement.

It was the supernova search that introduced Kowal to the two instruments he would later use to make his many discoveries: the 48-inch Schmidt reflecting telescope and the blink microscope.

"It's my telescope," Kowal says of the Schmidt. Palomar's two largest telescopes, the 200-inch and the 60-inch, are ideal for studying single objects—planets, stars, galaxies—in detail. The 48-inch Schmidt and the smaller 18-inch scope are used for surveying large regions of the sky

Each uses a round mirror to bring light into a line focus and a lens to correct for distortion. The 48-inch, a remarkable mapping instrument, was used in the Fifties to do a sky survey, a photographic chart of all the stars visible from Palomar. The chart is still a standard reference tool.

Because human eyes cannot perceive light below a certain threshold, astronomers also use electronic or chemical eyes with the giant telescopes. The 200-inch scope, for example, uses charge-coupled devices (CCDs): arrays of silicon chips containing thousands of light-sensitive elements that release an electron when struck by a photon. The resulting electric impulses are then used by a computer as data bits. Since CCDs cannot be made large enough for wide-angle work, the 48-inch telescope is equipped with photographic plates especially developed by Kodak for astronomers. Before using them, astronomers bake the plates in a special oven that contains a mixture of nitrogen and hydrogen gas. This baking process increases the plates' sensitivity to light—"a black art," Kowal says.

Photographing the universe with these plates and the Schmidt is drudge work that requires an almost athletic ability to sustain a high level of physical energy and mental concentration over long periods of time. Kowal possesses such stamina to a remarkable degree.

When the weather is good, Kowal begins photographing as soon as it gets dark. He prepares the plates in a darkroom and inserts them in the Schmidt. The night assistant uses special controls to point the telescope in the general direction desired and set it to move with the earth's rotation. Because the Schmidt has no viewing lens, Kowal sights in on his target through one of the two 19-inch refracting telescopes attached to the 48-inch, and then he makes fine adjustments.

Once the 48-inch scope is positioned correctly, Kowal opens the shutter and waits—fifteen minutes, two hours, or whatever exposure time he needs to find what he is looking for. He will repeat this procedure over and over and over again all night, running downstairs between shifts in the telescope room to bathe the plates in developing chemicals.

It is far from comfortable work. On a winter night, with the dome open, it can get very cold by the telescopes, and when the Schmidt is angled in certain directions, the only way an astronomer can look through the optical scope is either to lie flat on his back, scrunch up on his knees, or stand perched on a ladder for hours. Kowal has made the job a little easier than it used to be. The main tracking control for the 48-inch scope is not that accurate, and astronomers used to stay cramped under the guide scope during the long exposure time to make periodic corrections. Kowal, with the help of a graduate student, rigged the little optical telescopes with a small electronic device that is able to correct the tracking automatically.

After a long night of observing, Kowal returns to the monastery at dawn for a few hours sleep. After the noon meal, he will be back in the dome, developing and examining plates. After-dinner more observations begin. Five days of this (the maximum time Caltech will ordinarily allow an astronomer to observe) is exhausting—and Kowal loves it.

But the most important part of his work isn't taking photographs; it's analyzing them. Frequently astronomers have taken pictures of important objects they never discovered, simply because they didn't notice anything different on the plates.

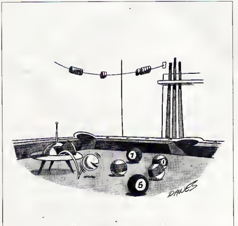
Examining the pictures is hard labor of another kind: it requires meticulous thoroughness, endless patience, a touch of intuition, and a touch of art. While still at the observatory Kowal scans each photograph with a magnifying glass to spot any unusual objects that should be rephotographed immediately. Later, back at Caltech, he reexamines them using a device called the blink microscope. The blink microscope allows the astronomer to alternate rapidly between two magnified pictures of the same piece of sky and compare each point by point. Some of the images in the photos turn out to be so faint that someone looking for the first time won't even see them.

All the images must be matched, paired. One unpaired image could represent a transient object (a planet) or a new event (a supernova). Spending eight hours a day in a darkroom comparing hundreds of photographs is very demanding, very unstimulating, and very productive.

By studying thousands of photographs this way, Kowal has found 80 supernovas. Many bordered on invisibility, but one was the brightest seen in more than 40 years. It was so bright that when he first saw it, on May 14, 1972, Kowal couldn't believe his luck. It must be a passing asteroid, he told himself. To make sure, he went over to the 200-inch telescope and asked the astronomer there to focus on the object. It was no asteroid. It was a supernova, ten times brighter than the entire galaxy in which it was found. And it was a Type I.

There are two kinds of supernovas. Type I is rarer, brighter, much longer lasting, and less understood than Type II. A Type II supernova has a half-life, losing half its brightness every 55 days. The supernova found by Kowal was visible for almost two years, long enough for scientists to study its spectra and begin to determine its chemical composition, temperature, and evolution. "The 1972 supernova has produced more information than any other supernova discovery," says Sargent, of the supernova hunt. (It was also the last major discovery made during the program, which ended in 1983.)

During his supernova years, Kowal was also applying himself to more personal



"Intelligent creatures of Earth ..."

projects. One was girl chasing, which he did as enthusiastically and systematically as he pursued sky objects. Kowal wanted to meet women who shared his belief in traditional family relations, and he wanted to travel, so he prepared for trips to Japan and Italy by beginning pen-pal correspondences with women there. In 1969, a month after he arrived in Naples, he married one of his correspondents. Today Kowal lives with his wife and daughter and pet white rat in the San Gabriel mountains near Pasadena. He likes the area's privacy, and he devotes his spare time there to quiet pleasures: hiking and reading, mostly about computers these days.

About the time he met his wife, Kowal found the next area where he could do his business: the region of space near Earth. In 1968 Brian G. Marsden, of the Smithsonian Astrophysical Observatory and Central Bureau for Astronomical Telegrams, had written Kowal, giving the predicted positions of several lost asteroids and comets and asking him to keep a lookout for them. (Marsden's office monitors short-lived astronomical phenomena and alerts astronomers to their appearances.) Comets and some asteroids are tricky objects. They have quirky orbits and are visible only when they are near Earth. They often disappear before enough positions have been collected to figure out where to find them again.

Marsden knew I was at the forty-eight-inch a lot and that it is perhaps the best telescope in the world for searching for something whose position you don't know," Kowal recalls. "At first I did it as a sort of favor for him. Then I got emotionally hooked. I'm not really that interested in black holes and quasars and such. They're so speculative; the theories change every six months. But an asteroid or comet is there or it's not. It's something I can look for by myself here at this telescope. So I thought, Here is a place where I can make my own contribution."

Asteroids and comets are also interesting because analyses of them can tell us much about the history, chemistry, and mechanics of the solar system. Kowal was especially intrigued by a group called Apollo asteroids, which are interesting for another reason—they are the celestial objects most likely to collide with Earth. It was an Apollo asteroid, some believe, that was responsible for the extinction of plant and animal life 65 million years ago.

Most asteroids stay in the asteroid belt between Jupiter and Mars, but Apollos move nearer to the sun in sharply tilted orbits that cross our own. They are thought to have been knocked free by collisions with other asteroids or by being bounced off the gravitational fields of Jupiter or Mars.

Caltech geologist and planetologist Gene Shoemaker believes that there are over 2,000 Earth crossers that are larger than a kilometer, but to date only 53 of them have been found. Five of the 53 were found by Kowal, making him one of the leading discoverers in this elite field.

In the early Seventies Kowal received his first taste of celebrity when he discovered another moon of Jupiter. Some astronomers have theorized that the two outer groups of Jovian satellites are leftovers of a collision between two asteroids captured by the giant planet. When two objects crash they usually break into a few big chunks and lots of little pieces. For that reason Kowal suspected that Jupiter might have many very small moons.

In 1974 Kodak developed a more sensitive photographic plate, and it finally became possible to look for such small moons. In September of the same year, Kowal discovered Jupiter's thirteenth moon, the first reported since 1951. He named it Leda. The following September he found what appeared to be another moon, 2.5 times fainter, but it slipped behind Jupiter before an orbit could be established. It has been lost ever since.

In the wake of the moon discoveries, a

> *"I can learn more listening to the dinner conversations at Palomar than I ever did at school. Here people talk about what they're actually doing."*

staff reporter from *Time* magazine appeared at Kowal's door. He zoomed in on the fact that Kowal's Caltech office was in the basement, down with all the instruments, and that he was not a professor. He pressured Kowal to express some resentment over his situation. "I was totally put off," Kowal recalls, "and gave facetious answers to everything." One went: "This building is like an ocean liner. All the professors are up there on the promenade deck promenading. The engine room is where all the work gets done." The "real" professors still quote the remark rather fondly. Nevertheless they have a healthy regard for the engine room: most of them work down there themselves. It's observation that makes astronomy a science, not merely an exercise in mathematical mythologizing, and all astronomers, even the armchair theorists, know it.

As a result of his impressive record, Kowal began getting more time to work on his own projects, so he decided to begin a systematic survey of the whole solar system. "I wanted to start from scratch and find everything unusual that's to be found," he says. "I have grandiose ideas." In October 1977 he found something unusual. A tiny trail on two of his photographs indicated a slow-moving body well beyond the asteroid belt. When the discovery was announced, the press almost immediately issued stories about a possible tenth planet. It soon became evident, however, that the object was relatively small and moved in a more elliptical path than planets do. Whatever it was, it wasn't a planet.

Object Kowal, as it was first called, measures some 320 kilometers in diameter, about the size of the larger asteroids or of Phoebe, one of Saturn's moons, which it resembles in surface composition. Kowal decided to rename the object Chiron after the wise centaur, so that if similar bodies were found they could be given other centaur names.

The only thing certain about Chiron is that it couldn't have originated where it is now; its orbit is too unstable. It may have been ejected from the asteroid zone by encounters with Jupiter, then with Saturn. It could also be the first discovered member of a second asteroid belt or a belt of Saturnian comets. Marsden believes that it, Pluto, an asteroid called Hidalgo, and possibly Phoebe are all the same kind of object but with different kinds of orbits. So far Chiron remains a solitary object, in a class all its own. When Chiron comes nearer to the earth in 1995 it will be possible to learn more about it. It should tell us something about comets and asteroids and about how objects move from one part of the solar system to another (see "The Chiron Mystery," Stars, June 1983).

Kowal's next discovery was of an entirely different kind. He came across an article in the magazine *Sky and Telescope* that listed all the dates when one planet had passed in front of another. He noticed there were only two instances when Jupiter had moved in front of Neptune: once in 1613 and again in 1702. This particularly interested him because he had long been intrigued by irregularities in Neptune's orbit. He thought it was possible to dig out some information about the planet's motion from historical records.

"I figured that anybody who had been observing Jupiter would have seen Neptune as well," Kowal says. "There might be a huge quantity of material from 1702 because back then every principality in Europe had a telescope. But in 1613 maybe half a dozen people in the world had telescopes. Galileo was one of those people."

So Kowal enlisted the aid of Stillman Drake, a historian of science at the University of Toronto. A Galileo specialist, Drake could translate the Latin in Galileo's notebooks and interpret the seventeenth-century astronomer's measurement system. Kowal went over the data and found that 233 years before its official discovery date, 1846, the Renaissance stargazer had seen Neptune—twice.

The discovery was an important one for the history of science. "I was more proud of my Galileo work than anything else," he says, "because it was completely out of my field. I found something that even the Galileo experts had overlooked."

Last January Kowal started a new project: mapping the entire northern sky for the Space Telescope, which will need accurate star positions to orient itself. He has also taken on another complex project: computing Neptune's orbit.

The only way to make absolutely sure any orbit is correct is to observe a complete revolution. The problem with Neptune is that it has a period of revolution of 165 years and was discovered only in 1846, so a complete journey around the sun has not yet been observed. It seems impossible to compute an orbit that fits all the data or to predict the position of Neptune accurately. About every ten years astronomers must recalculate the orbit to accommodate new observations. Another problem is that two seemingly accurate observations from the eighteenth century don't jibe with post-1846 observations. "It seems that we are not modeling the system properly," explains Kenneth Seidelmann, director of the *Nautical Almanac* at the Naval Observatory, which has been monitoring the planets for years. The observatory puts out a yearly *Astronomical Almanac*, which astronomers use to find heavenly bodies. Its *Nautical Almanac* office is presently reviewing the orbits of both Uranus and Neptune.

Some astronomers attribute irregularities in Neptune's orbit to observational errors, but the Naval Observatory doesn't accept that explanation. Thomas van Flandern and Robert Harrington have investigated theories postulating that the perturbations are caused by a cloud of comets, a passing dark star, or a black hole; these theories, however, don't fit the data. Some suspect that a tenth planet is the most likely explanation. Van Flandern and Harrington have been analyzing data to get an estimate of the size, distance, and orbit of the body that could cause the irregularities.

A little over a year ago Kowal ambitiously set out alone to work on the same problem the Naval Observatory is tackling with its highly trained staff and state-of-the-art computers.

Kowal now has what he believes is a good orbit for Neptune. "It has taken me fourteen months to get this far," he explains, "because much of the time I was just learning how to do orbits." Kowal likes picking a project in a field he knows nothing about and then competing with the experts, because "it's more satisfying when it works out." *Starting from scratch* is his favorite phrase. "I still identity myself with amateurs," he says.

That remark is not meant to be self-denigrating. There is a proud amateur tradition in astronomy, especially in nineteenth-century England, where many important contributions to the science were made by gentlemen amateurs. Kowal is part of that heritage—American style. "He's an unassuming guy," Shoemaker says of Kowal, adding, "He's extremely confident." It's an odd combination of qualities—Kowal's mix of modesty and pride—but it goes with his values, which are the old-fashioned American business values: self-reliance, independence, achievement through hard work. His confidence is that of a self-made man whose commitment to excellence is highly personal. "Someone once commented, 'Charlie thinks he's the greatest astronomer in the world,'" Sargent says. "But I've never seen it. Charlie knows what he knows—and what he doesn't know."

What he knows and doesn't know is of interest to others. His business has become more competitive lately. The asteroid theories of extinction, Kowal's own discovery of Chiron, and renewed interest in the tenth planet have recently attracted new researchers, some of them self-promoters. "I've never heard him say anything critical of anybody," Sandage notes, "though competitors who are publicity seekers have moved into this field—and that must hurt him. They do their science in the public press. Kowal does his science as a scientist, and he is respected among professionals for it." That respect gives him the kind of security and self-assurance no Ph.D. could bestow. "A lack of a degree isn't a handicap for what he does," Sargent says. "By the time somebody's done something, no one asks about qualifications. The problem is getting started."

Kowal got started in 1961 as a research assistant. He went from there to associated scientist, and he is now Caltech's scientist astronomer—a member of the professional staff, not the faculty. Though Kowal doesn't want to be a teacher any more than he wanted to be a student, he's not altogether content with his position. For example, he has never had more than a one-year contract with Caltech (he has had 20 of those). "They could do more," he says dryly, "but the main thing is being able to do the work I like."

Kowal isn't sure what work he will be doing next. The Space Telescope survey will be completed by the end of this year. Late in 1984 the 48-inch scope will be committed for several years to a second Palomar sky survey, on which Kowal will probably work. That leaves the Schmidt free for other projects in 1984 only. He hopes to have completed further work on Neptune's orbit by October 1983, when proposals for observation time in 1984 will be received. He talks about unraveling the mystery of Neptune's orbit in the same manner he works with the telescope—rapidly but surely, with a controlled excitement. "It's going to be another round of learning from scratch," he says. "A tenth planet would be the simplest explanation. It may not be the only explanation, or necessarily the true one, however. And I have a lot of competition—the Naval Observatory, IRAS [the infrared astronomy satellite]." He smiles, adding with modest confidence, "but if I don't find a tenth planet, I'll find something else along the way." ∞

MULTIPLES

CONTINUED FROM PAGE 77

kets A sun room contained the biggest and healthiest houseplants Cleo had ever seen Another room was stacked with technical books and scholarly journals a third was equipped with three or four gleaming exercise machines Some of the rooms were fastidiously tidy some impossibly chaotic Some of the furniture was stark and austere some was floppy and overstuffed She kept expecting to find roommates wandering around But there was no one here but Van And Paul

Paul fixed the drinks played soft guitar music told her gaudy tales of prospecting on the West Texas mesas Paul sang something bawdy sounding in Spanish and Cleo putting on her Vixen voice chimed in on the choruses deliberately off key But then Paul went away and it was Van who sat close beside her on the couch He wanted to know things about Judy and he told her a little about Van and no other selves came into the conversation She was sure that was intentional They stayed up very late Paul came back toward the end of the evening to tell a few jokes and sing a soft late-night song but when they went into the bedroom she was with Van Of that she was certain

And when she woke in the morning she was alone She felt a surge of confusion and dislocation remembered after a moment where she was and how she happened to be there, sat up blinked Went into the bathroom and scooped a handful of water over her face Without bothering to dress she went padding around the apartment looking for Van

She found him in the exercise room using the rowing machine but he wasn t Van He was dressed in tight jeans and a white T shirt and he looked somehow younger leaner jauntier There were fine beads of sweat along his forehead but he did not seem to be breathing hard He gave her a cool distantly appraising wholly asexual look as though it was not in the least unusual for an unknown naked woman to materialize in the house and he was altogether undisturbed by it Good morning I m Ned Pleased to know you His voice was higher than Van's much higher than Paul s and he had an odd overprecise way of shaping each syllable

Flustered suddenly self-conscious and wishing she had put her clothes on before leaving the bedroom she folded one arm over her breasts though her nakedness did not seem to matter to him at all I m—Judy I came with Van

Yes I know I saw the entry in our book Smoothly he pulled on the oars of the rowing machine leaned back pushed forward Help yourself to anything in the fridge, he said Make yourself at home, Van left a note for you in the kitchen

She stared at him his hands, his mouth his long muscular arms She remembered his touch his kisses the feel of his skin And now this complete indifference No Not *his* kisses not *his* touch Van s And Van was not here now There was a different tenant in Van s body someone she did not know in any way and who had no memories of last night s embraces *I saw the entry in our book* They left memos for one another Cleo shivered She had known what to expect more or less but experiencing it was very different from reading about it She felt almost as if she had fallen in among beings from another planet

But this is what you wanted she thought *Isn t it?* The intricacy the mystery the unpredictability the sheer weirdness? A little cruise through an alien world because her own had become so stale so narrow so cramped And here she was *Good morning I m Ned Pleased to know you*

Van s note was clipped to the refrigerator by a little yellow magnet shaped like a ladybug DINNER TONIGHT AT CHEZ MICHEL? YOU AND ME AND WHO KNOWS WHO ELSE CALL ME

Though Van might have control of the shared body most of the time, he still had no idea what any of his alternate selves were up to He had to depend on fancy footwork

That was the beginning She saw him every night for the next ten days Generally they met at some three star restaurant had a lingering intimate dinner went back to his apartment One mild clear evening they drove out to the beach and watched the waves breaking on Seal Rock until well past midnight Another time they wandered through Fisherman s Wharf and somehow acquired three bags of tacky souvenirs

Van was his primary name—she saw it on his credit card one night—and that seemed to be his main identity too though she knew there were plenty of others At first he was reticent about that but on the fourth or fifth night he told her that he had nine major selves and sixteen minor ones Besides Paul the geologist Chuck who was into horticulture and Ned the gay one Cleo heard about Nat the stock-market plunger—he was fifty and fat made a fortune every week and divided his time between Las Vegas and Miami Beach Henry the poet who was shy and never liked anyone to read his work Dick who was studying to be an actor Hal who once taught law at Harvard Dave the yachtsman and Nicholas the cardsharp

And then there were the fragmentary ones some of whom didn t have names only a funny way of speaking or a little routine they liked to act out

She got to see very little of his other selves though Like all multiples he was troubled occasionally by involuntary switching One night he became Hal while they were making love and another time he turned into Dave for an hour and there were momentary flashes of Henry and Nicholas Cleo perceived it right away whenever one of those switches came His voice his movements his entire manner and personality changed immediately Those were startling exciting moments for her offering a strange exhilaration But generally his control was very good and he stayed Van as if he felt some strong need to experience her as Van and Van alone Once in a while he doubled bringing up Paul to play the guitar and sing or Dick to recite sonnets but when he did that the Van identity always remained present and dominant It appeared that he was able to double at will without the aid of mirrors and lights at least some of the time He had been an active and functioning multiple for as long as he could remember—since childhood perhaps even since birth—and he had devoted himself through the years to the task of gaining mastery over his divided mind

All the aspects of him that she came to meet had basically attractive personalities They were energetic stable purposeful men who enjoyed life and seemed to know how to go about getting what they wanted Though they were very different people she could trace them all back readily enough to the underlying Van from whom so she thought they had all split The one puzzle was Nat the market operator It was hard for Cleo to imagine what he was like when he was Nat—sleazy and coarse yes but how did he manage to make himself look fifteen years older and forty pounds heavier? Maybe it was all done with facial expressions and posture But she never got to see Nat And gradually she realized it was an oversimplification to think of Paul and Dick and Ned and the others as mere extensions of Van into different modes

Van by himself was just as incomplete as the others He was just one of many that had evolved in parallel each one autonomous each one only a fragment of the whole Though Van might have control of the shared body a greater portion of the time he still had no idea what any of his alternate selves were up to while they were in command and like them he had to depend on guesses fancy footwork and such notes and messages as they bothered to leave behind in order to keep track of events that occurred outside his conscious awareness The only one who knows everything is Michael He s seven years old as smart as a whip and keeps in touch with all of us all the time

"Your memory trace," Cleo said

Van nodded All multiples she knew had one alter with full awareness of the doings of all the other personalities—usually a child an observer who sat back deep in the mind and played its own games and emerged only when necessary to fend off some crisis that threatened the stability of the entire group "He s just informed us that he's Ethiopian," Van said So every two or three weeks we go across to Oakland to an Ethiopian restaurant that he likes and he flirts with the waitresses in Amharic

"That can't be too terrible a chore I m told Ethiopians are very beautiful people

"Absolutely But they think it s all a big joke and Michael doesn't know how to pick up women anyway He s only seven, you know So Van doesn t get anything out of it except some exercise in comparative linguistics and a case of indigestion the next day Ethiopian food is the spiciest in the world I can t *stand* spicy food

Neither can I she said But Lisa loves it Especially Mexican But nobody ever said sharing a body is easy did they?

She knew she had to be careful in questioning Van about the way his life as a multiple worked She was supposed to be a multiple herself, after all. But she made use of her Sacramento background as justification for her areas of apparent ignorance of multiple customs and the everyday mechanics of multiple life Though she too had known she was a multiple since childhood she said she had grown up outside the climate of acceptance of the divided personality that prevailed in San Francisco, where an active subculture of multiples had existed openly for years In her isolated existence unaware that there were a great many others of her kind she had at first regarded herself as the victim of a serious mental disorder It was only recently she told him, that she had come to understand the overwhelming advantages of life as a multiple the richness the complexity the fullness of talents and experiences that a divided mind was free to enjoy That was why she had come to San Francisco That was why she listened so eagerly to all that he was telling her about himself

She was cautious too in manifesting her own multiple identities She wished she did not have to pretend to have other selves But they had to be brought forth now and again if only to maintain Van s interest in her Multiples were notoriously indifferent to singletons They found them bland overly simple two-dimensional They wanted the excitement of embracing one person and discovering another or two or three So she gave him Lisa she gave him Vixen she gave him the Judy who was-Cleo and the Cleo who was someone-else and she slipped from one to another in a seemingly involuntary and unexpected way often when they were in bed

Lisa was calm controlled straitlaced She was totally shocked when she found herself between one eye blink and the next in the arms of a strange man "Who are you?—where am I?" she blurted rolling away and pulling herself into a fetal ball

"I'm Judy s friend" Van said

She stared bleakly at him So she s up to her tricks again

He looked pained embarrassed solicitous She let him wonder for a moment whether he would have to take her back to her hotel in the middle of the night Then she allowed a mischievous smile to cross Lisa s face allowed Lisa s outraged modesty to subside allowed Lisa to relent and relax, allowed Lisa to purr—

Well as long as we're here already—what did you say your name was?

He liked that He liked Vixen too—wild sweaty noisy a moaner a gasper a kicker and thrasher who dragged him down onto the floor and went rolling over and over with him She thought he liked Cleo, too though that was harder to tell because Cleo s style was aloof serious baroque inscrutable She would switch quickly from one to another sometimes running through all four in the course of an hour Wine she said induced quick switching in her She let him know that she had a few other identities too fragmentary and submerged She hinted that they were troubled deeply neurotic self-destructive They were under control she said and would not erupt to cause woe for him but she left the possibility hovering over them to add spice to the relationship and plausibility to her role

It seemed to be working His pleasure in her company was evident She was beginning to indulge in little fantasies of moving down permanently from Sacramento renting an apartment perhaps even moving in with him though that would surely be a strange and challenging life She would be living with Paul and Ned and Chuck and the rest of the crew too but how wondrous how electrifying

Then on the tenth day he seemed uncharacteristically tense and somber She asked him what was bothering him, and he evaded her and she pressed and finally he said Do you really want to know?

Of course

It bothers me that you aren't real, Judy"

She caught her breath What the hell do you mean by that?

You know what I mean he said quietly, sadly Don t try to pretend any longer There s no point in it

It was like a jolt in the ribs

She turned away and was silent a long while wondering what to say Just when everything was going so well just when she was beginning to believe she had carried off the masquerade successfully

So you know? she asked timidly

Of course I know I knew right away

She was trembling "How could you tell?"

A thousand ways When we switch we *change* The voice The eyes The muscular tensions The grammatical habits The brain waves even An evoked-potential test shows it Flash a light in my eyes and I'll

give off a certain brain-wave pattern and Ned will give off another, and Chuck still another You and Lisa and Cleo and Vixen would all be the same Multiples aren't actors Judy Multiples are separate minds within the same brain That's a matter of scientific fact You were just acting You were doing it very well but you couldn't possibly have fooled me "

"You let me make an idiot of myself then "

"No "

"Why did you—how could you—"

"I saw you walk in that first night and you caught me right away I watched you go out on the floor and fall apart and I knew you couldn't be multiple and I wondered What the hell's she doing here? Then I went over to you and I was hooked I felt something I haven't ever felt before Does that sound like the standard old malarkey? But it's true Judy You're the first singleton woman who's ever interested me "

"Why?"

He shook his head "Something about you—your intensity your alertness maybe even your eagerness to pretend you were a multiple—I don't know I was caught I was caught hard And it's been a wonderful week and a half I mean that "

"Until you got bored "

"I'm not bored with you Judy "

"Cleo That's my real name my singleton name There is no Judy "

"Cleo " he said as if measuring the word with his lips

"So you aren't bored with me even though there's only one of me That's marvelous—tremendously flattering That's the best thing I've heard all day I guess I should go now Van It is Van isn't it? "

"Don't talk that way "

"How do you want me to talk? I fascinated you you fascinated me we played our little games with each other and now it's over I wasn't real but you did your best We both did our best But I'm only a singleton woman and you can't be satisfied with that Not for long For a night a week two weeks maybe Sooner or later you'll want the real thing and I can't be the real thing for you So long Van "

"No "

"No?"

"Don't go "

"What's the sense of staying?"

"I want you to stay "

"I'm a singleton Van "

"You don't have to be " he said

The therapist's name was Burkhalter and his office was in one of the Embarcadero towers To the San Francisco multiples community he was very close to being a deity His specialty was electrophysiological integration with specific application to multiple-personality disorders Those who carried within themselves dark and diabolical selves that threatened the stability of the group went to him to have those selves purged or at least contained Those who sought to have latent selves that were submerged beneath more outgoing personalities brought forward into a healthy functional state went to him also Those whose life as a multiple was also a torment of schizoid confusions instead of a richly rewarding contrapuntal symphony gave themselves to Dr Burkhalter to be healed and in time they were And in recent years he had begun to develop techniques for what he called personality augmentation Van called it "driving the wedge "

"He can turn a singleton into a multiple?" Cleo asked in amazement

"If the potential is there You know that it's partly genetic The structure of a multiple's brain is fundamentally different from a singleton's The hardware just isn't the same the cerebral wiring And then if the right stimulus comes along usually in childhood usually but not necessarily traumatic the splitting takes place the separate identities begin to establish their territories But much of the time multiplicity is never generated and you walk around with the capacity to be a whole horde of selves yet never know it "

"Is there reason to think I'm like that?"

He shrugged "It's worth finding out If he detects the predisposition he has effective ways of inducing separation Driving the wedge you see? You do *want* to be a multiple don't you, Cleo?"

"Oh yes Van Yes!"

Burkhalter wasn't sure about her He taped electrodes to her head flashed bright lights in her eyes gave her verbal-association tests ran four or five different kinds of electroencephalograph studies and still he was uncertain "It is not a black-and-white matter " he said several times frowning scowling He was a multiple himself but three of his selves were psychiatrists so there was never any real problem about his office hours Cleo wondered if he ever went to himself for a second opinion After a week of testing she was sure that she must be a hopeless case an intractable singleton but Burkhalter surprised her by concluding that it was worth the attempt "At the very worst " he said "we will experience spontaneous fusing in a few days, and you will be no worse off than you are now But if we succeed—"

> *Lisa was calm, controlled, cautious, and straitlaced She was totally shocked when she found herself between one eye blink and the next in the arms of a strange man*

His clinic was across the bay in a town called Moraga She spent two days undergoing further tests, then three days taking medication "Simply an anticonvulsant " the nurse explained cheerily "To build up your tolerance "

"Tolerance for what?" Cleo asked.

"The birth trauma " she said "New selves will be coming forth and it can be uncomfortable for a little while "

The treatment began on Thursday Electroshock drugs electroshock again She was heavily sedated It felt like a long dream but there was no pain Van visited her every day Chuck came too bringing her two potted orchids in bloom and Paul sang to her and even Ned paid her a call But it was hard for her to maintain a conversation with any of them She heard voices much of the time She felt feverish and dislocated and at times she was sure she was floating eight or ten inches above the bed Gradually that sensation subsided but there were others nearly as odd The voices remained She learned how to hold conversations with them

In the second week she was not allowed to have visitors That didn't matter

She had plenty of company even when she was alone

Then Van came for her "They're going to let you go home today " he said "How are you doing Cleo?"

"I'm Noreen " she said

There were five of her apparently That was what Van said She had no way of knowing because when they were dominant she was gone—not merely asleep but gone perceiving nothing But he showed her notes that they wrote in handwritings that she did not recognize and indeed could barely read and he played tapes of her other voices Noreen a deep contralto Nanette high and breathy Katya hard and rough New York and the last one who had not yet announced her name a stagy voluptuous campy siren voice

She did not leave his apartment the first few days and then she began going out for short trips always with Van or one of his alters close beside She felt convalescent A kind of hangover from the drugs had dulled her reflexes and made it hard for her to cope with traffic and also there was the fear that she would undergo a switching while she was out Whenever that happened it came without warning and when she returned to awareness afterward she felt a sharp discontinuity of memory not knowing how she suddenly found herself in Ghirardelli Square or Golden Gate Park or wherever it was that the other self had taken their body

But she was happy And Van was happy with her One night in the second week when they were out he switched to Chuck—Cleo knew it was Chuck coming on for now she always knew right away which identity had taken over—and he said "You've had a marvelous effect on him None of us have ever seen him like this before—so contented so fulfilled—

I hope it lasts Chuck

Of course it'll last! Why on earth shouldn't it last?

It didn't Toward the end of the third week Cleo noticed that there hadn't been any entries in her memo book from Noreen for several days That in itself was nothing alarming An alter might choose to submerge for days weeks even months at a time But was it likely that Noreen so new to the world would remain out of sight so long? Lin lin the little Chinese girl who had evolved in the second week and was Cleo's memory trace reported that Noreen had gone away A few days later an identity named Mattie came and went within three hours like something bubbling up out of a troubled sea Then Nanette and Katya disappeared leaving Cleo with no one but her nameless siren-voiced alter and Lin-lin She was fusing again The wedges that Dr Burkhalter had driven into her soul were not holding her mind insisted on oneness and was integrating itself she was reverting to the singleton state

All of them are gone now she told Van disconsolately

"I know I've been watching it happen

Is there anything we can do? Should I go back to Burkhalter?

She saw the pain in his eyes It won't do any good he said He told me the chances were about three to one this would happen A month he figured that was about the best we could hope for And we've had our month

I'd better go Van

Don't say that

No?

I love you Cleo

You won't Not for much longer

He tried to argue with her to tell her that it didn't matter to him that she was a singleton that one Cleo was worth a whole raft of alters that he would learn to adapt to life with a singleton woman He could not bear the thought of her leaving now So she stayed a week two weeks three They ate at their favorite restaurants They strolled hand in hand through the cool evenings They talked of Chomsky and Whorf and even of shopping centers When he was gone and Paul or Chuck or Hal or Dave was there she went places with them if they wanted her to Once she went to a movie with Ned and when toward the end he felt himself starting to switch she put her arm around him until he regained control so that he could see how the movie finished

But it was no good He wanted something richer than she could offer him the switching the doubling the complex undertones and overtones of other personalities resonating beyond the shores of consciousness She could not give him that He was like one who has voluntarily blindfolded himself in order to keep a blind woman company She knew she could not ask him to live like that forever

And so one afternoon when Van was somewhere else she packed her things and said good-bye to Paul who gave her a hug and wept a little with her and she went back to Sacramento Tell him not to call she said A clean break's the best She had been in San Francisco two months and it was as though those two months were the only months of her life that had had any color in them and all the rest had been lived in tones of gray

There had been a man in the real-estate office who had been telling her for a couple of years that they were meant for each other Cleo had always been friendly enough to him They had done a few skiing weekends in Tahoe the winter before they had gone to Hawaii once they had driven down to San Diego But she had never felt anything particular when she was with him A week after her return she phoned him and suggested that they drive up north to the redwood country for a few days When they came back she moved into the condominium he had just outside town

It was hard to find anything wrong with him He was good-natured and attractive he was successful he read books and liked good movies he enjoyed hiking rafting and backpacking he even talked of driving down into the city during the opera season to take in a performance or two He was getting toward the age where he was thinking about marriage and a family He seemed very fond of her

But he was flat she thought Flat as a cardboard cutout a singleton a one brain a no-switch There was only one of him and there always would be It was hardly his fault she knew But she couldn't settle for someone who had only two dimensions A terrible restlessness went roaring through her every evening and she could not possibly tell him what was troubling her

On a drizzly afternoon in early November she packed a suitcase and drove down to San Francisco She checked into one of the Lombard Street motels showered changed and walked over to Fillmore Street Cautiously she explored the strip from Chestnut down to Union from Union back to Chestnut The thought of running into Van terrified her Not tonight she prayed Not tonight She went past Skits did not go in stopped outside a club called Big Mama shook her head finally entered one called The Side Effect Mostly women inside as usual but a few men at the bar not too bad-looking No sign of Van

She bought herself a drink and casually struck up a conversation with a short curly-haired artistic-looking type

You come here often? he asked

First time I've usually gone to Skits

I think I remember seeing you there Or maybe not

She smiled What's your now name?

Sandy Yours?

Cleo drew her breath down deep into her lungs She felt a kind of light-headedness beginning to swirl behind her eyes *Is this what you want?* she asked herself *Yes Yes This is what you want*

"Melinda she said ☐

This may be read as a confession, a prayer, or the travelogue of a divided soul

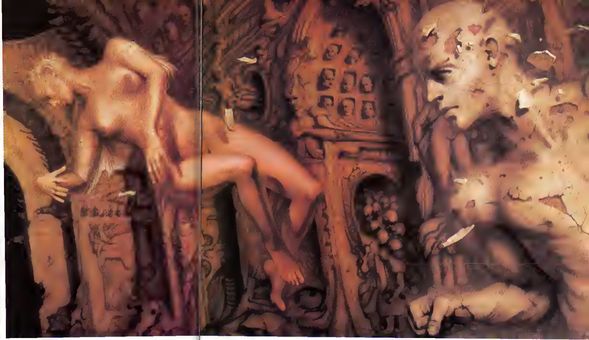
THE MANY FACES OF ADAM

PAINTINGS BY DI-MACCIO

Gentlemen,

You have asked me to describe my research, which you term "chronic paradoxical rage with pseudovisionary delusions." You say you will help me "get better." You cannot know the magnitude of the problem. The eyes that once mirrored the natural world have rotated inward 180°; the neural bulb, created to control the movements of the body, has evolved into an organ of pure self-rumination. (These findings, summarized in the *Journal of Applied Neuromythology*, are firmly based on the fossil record and secred relics of the so-called Dark Ages.) Learned doctors, a futurologist is an archaeologist of the world to come. If my outer flesh peels and my internal organs sometimes seep

TEXT BY JUDITH HOOPER



"I ask you, learned doctors, what man is not a multiple soul, a series of selves arranged in time? Some of my selves are possible; others are quite improbable at this time"

out like overripe fruit (oh, I have noticed your stares!), it is from a lifetime of scrabbling among rubble for a few precious data. Or it may be a form of metamorphosis. Ah, yes, I've seen your files, and I know what is inscribed in mine: "multiple personality disorder with schizo-medieval pathology. . . ." Now, I ask you, renowned scholars, what man is not a multiple personality, a time-series of selves? Some of my selves are possible; others are improbable at present. But at least, good doctors, I am not like the patients you keep in your catacombs, stranded between being and nonbeing or petrified like the mummies of Pompeii. I could cite certain experiments of dubious therapeutic value and enormous archaeological interest, the effects of electromagnetic frequency on the soul; the agony of light and the agony of darkness; worlds drained of color, like certain deep-sea fish . . .

But why go on justifying myself? I believe, though I cannot verify this, that I spoke with more authority before starting my treatment.

You ask whether I am troubled by "voices." No, I'm troubled by silence: mute cathedrals, dismembered saints, souls in torment, the Catacombs of the Doubting Martyrs, lost organs and faculties, the whole dead weight of a world that no one remembers or foresees.

Well, I can see you are not impressed by the efficacy of my footnotes. I can only hope that other generations, scratching in the dust, will find my data and reconstruct my immaculate scholarship ∞

"There are beings between life and nonlife or petrified like the mummies of Pompeii. I've seen an agony of light and of darkness: worlds drained of color, like deep-sea fish."

ZERO-G

CONTINUED FROM PAGE 10

Spacelab 1's orbit is tilted 57° with respect to the equator, a much higher inclination than most American missions. This will enable scientists to cover more of the earth's surface with their instruments. The Europeans are particularly anxious to photograph and map their own countries, most of which lie well above 40° latitude. The higher inclination orbit will also allow the plasma physicists to observe auroral effects close to the north and south geomagnetic poles.

Materials sciences: The ability to operate in zero gravity may be the key to future industrial operations. In zero g, liquid solutions mix more uniformly, containers are not needed to hold and possibly contaminate materials, crystals grow larger and more uniformly, lubricants spread over surfaces more easily, and such biological specimens as blood cells and hormones can be separated more easily for analysis. Spacelab 1 carries an integrated set of furnaces and other materials-processing equipment to run more than 30 studies of zero-gravity crystal growth, chemistry, metal forming, and fluid behavior.

Spacelab 1 is the first of four planned Spacelab missions—a far cry from the 100 flights that the two Spacelab modules are capable of making.

This first mission shows that you can do science in a lot of different disciplines, notes mission scientist Chapell. He says that Spacelab will take on dedicated missions, in which each individual flight focuses on one or at most two scientific disciplines. One such mission, scheduled for 1986, is labeled Astro 1. It will be devoted primarily to astronomical studies—including observations of Halley's Comet.

But NASA has not yet made the budget commitment to use Spacelab beyond those four missions. "We as an agency have invested a lot of money in Spacelab," Chapell says, "yet the follow-on program is not solidly laid out."

Could Spacelab evolve into a permanent scientific station in orbit? "A space station would be great," Chapell says. "I would love to have a manned platform that looks at the sun continuously and then does active experiments in the magnetosphere under different solar conditions." Chapell's platform would also look down at the atmosphere and watch weather systems. "That would be great," he says. "And it would get tremendous support from the public, because you could show how scientists are continuously monitoring the earth's environment."

But Chapell claims NASA's studies of space station applications often do not take into account the useful scientific studies that such a station could carry out. And the scientific community is hesitant to back a new expensive program for a space station when the far-less-expensive Spacelab missions have not been funded beyond the first four flights.

The scientific community," he believes, "will hold off on its total support for a space station until NASA follows through on its support for Spacelab missions."

Despite the uncertain future for Spacelab, Chapell believes that the program is forcing NASA to bring together all its talents and capabilities.

"Can NASA effectively merge manned spaceflight and science?" Chapell asks rhetorically. "Can we really have manned spaceflights whose sole purpose is doing good science? It requires the whole NASA system—the communications people, the shuttle people, the launch people—all of them—to work together."

Spacelab 1 is the first demonstration of this interlinking of manned spaceflight and space science on such a scale. Even though missions beyond 1986 have not been firmly set in motion by NASA, this opening of a new era in scientific research cannot long be denied.

With two modules capable of carrying out flights for at least the next 20 years, Spacelab appears ready to propel space science into the twenty-first century. DO

EARTH

CONTINUED FROM PAGE 18

feel the devastating consequences of Soviet policy in Siberia."

Could Volfson be right? A Soviet embassy spokesman declined to comment on the pipeline, saying that Soviet environmental policy is clearly described in his government's laws and publications. Those documents—gleaned from U.S. State Department translations of *Pravda*, scientific papers, and Soviet law—indicate a growing concern for the environment and increased spending for pollution control. Yet for all good intentions there, American analysts say Soviet pollution-control technology is less than adequate, and national law just isn't powerful enough to stave off the damage done to air, water, and land.

The neglect is especially prevalent in Siberia, where well-meaning scientists are often overruled in the government's race to industrialize. "Many of the construction and operating sites we visited were environmental disaster areas," says an American scientist who visited several pipe-laying areas in 1979. "You could see oil flares spewing black smoke to the horizon," says the scientist. "They'd have breaks in their oil and gas pipelines all the time. The trees were just devastated wherever the pipeline was laid."

Yet polluting local ecosystems is a far cry from wreaking global havoc. American climatologists who have studied the albedo effect admit that destroying vast tracts of forest could change an area's weather, but whether that's happening in Siberia is impossible to say. "There's no question that large-scale destruction of vegetation can cause problems," says Michael Oppenheimer, senior scientist for the Environmental Defense Fund. "But stripping trees in Siberia probably would not have a global effect." Another American scientist, who does not want his name used for fear of endangering future Soviet contacts, says climate is so complex that it's impossible to predict how it would be affected by cutting down trees. Still other researchers worry that another Soviet project—reversing the flow of several major Siberian rivers—will have a greater effect on climate than anything the Soviets do to Siberia's trees.

Volfson, however, sticks with his assertion that the heating gas Europeans buy now may cost them future generations of cold. Like many Soviet dissidents, he argues that only pressure from the West will promote changes in Soviet policy. To that end he has sent his papers to American congressmen and newspapers and says he plans to come to the United States soon to make his warnings heard. "Westerners play a part by purchasing gas from the Soviets and by supplying them with technology," he says. "Years from now the people of the West will not be able to say we did not know." DO

Brave new materials make today's alloys look like artifacts from the Stone Age

AMAZING SUPERSTUFF

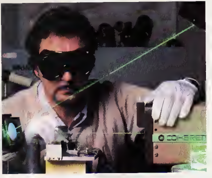
BY RICHARD WOLKOMIR

As dreams go George Wiener's is wild "Boys, I say to the guys in the lab make an invisible wineglass for me Wild yes Impossible no Wiener is manager of materials science at Westinghouse's sprawling research center in Pittsburgh And he could have his invisible wineglass at the wave of a corporate checkbook Then the fun would start

He has often imagined the scene His office is full of visiting dignitaries or a bunch of military honchos, maybe the Joint Chiefs of Staff Nonchalantly he picks up what looks like a handful of air In his other hand, he displays an elegant bottle of Mouton Rothschild As the Joint Chiefs gasp Wiener calmly pours the claret into his seemingly empty hand

Voilà! As he pours, the invisible goblet takes

From ceramic materials come new computers made almost entirely of glass and light



shape from the bottom up revealed by the red wine it contains. "Down the hatch," says Wiener, as the Joint Chiefs applaud vigorously.

Or maybe they faint. *An invisible wineglass!* What is wildest about George Wiener's dream is this: He can make a wineglass invisible whenever he is willing to spend that much of Westinghouse's money. "Look, a two-hundred-dollar invisible wineglass is okay," the scientist says. "But a twenty-thousand-dollar invisible wineglass?"

Welcome to the new Age of Alchemy—expensive but fun. And able to bring to life some of scientists' most Faustian fantasies. Materials researchers, today's transmuters of matter, use electron scanning microscopes as crystal balls, and their wands are ruby lasers. At such universities as MIT, Cornell, Carnegie-Mellon, Pennsylvania State, Johns Hopkins, and Southern California and at such corporations as Westinghouse, General Electric, Allied, and Corning Glass, laboratory sorcerers are busily turning the world's stuff into superstuff. Materials that Mother Nature never dreamed of are being distilled through complex technological conversions.

Materials scientists are transforming metal into glass. High-technology ceramics, distant relatives of pottery or brick, are now employed to make a far-flung range of products: from automotive turbocharger rotors to artificial bones and teeth, from metal-cutting tools to integrated-circuit substrates. Out of their laboratories plastic jet planes emerge, while MX missile silos and nose cones are being developed from the same basic graphite-fibers-in-epoxy-resin materials as such new superlightweight athletic equipment as fly-fishing poles and tennis rackets.

New computer chip materials composed of polymers will be hooked up to Josephson junctions to create computers of lightning speed. These computers may soon mimic the complex wiring of the human brain, and perhaps one day plug right into it; they'll be that compatible.

Much new superstuff is brewed by scientists who concoct new polymers, substances made from enormous, complicated molecules. They are mixing up batches of new polymer-based materials strong enough to rival steel at a fraction of the weight. Some visionaries, in fact, dream of lightweight polymer cables that will connect a geosynchronous satellite to Earth like a balloon on a 23,000-mile string. Other new polymers may imitate organic substances; scientists talk optimistically about artificial polymer muscles. They have already tailored artificial skin to protect severely burned people while they heal.

Distinctions between organic and inorganic are blurring as scientists mix and match natural and artificial substances atom for atom. Engineers and biologists are pooling their knowledge to create new materials with astonishing properties, promising technological changes comparable with those humanity experienced in the leap from the Neolithic to the Iron Age. In the Era of Materials Science, matter itself just isn't what it used to be.

Consider for instance invisible wineglasses. Normally we can see goblets despite their transparency because their surfaces reflect some light. But what if they reflected no light, not a photon? "Then the glass would be perfectly invisible," says George Wiener. And he says, researchers in his division have developed a coating that eliminates glass's reflectivity.

By combining certain silicon compounds with alcohol, the Westinghouse chemists produce a polymer—a heavy molecule built from subunits, like Tinkertoys. Glass coated with this polymer, which smooths submicroscopic surface pores, reflects little light. "We've already used it to reduce reflections on solar cells so that the cells absorb more solar radiation," says Wiener. "This coating can reduce reflectivity to just about zero."

Nearly ready for the market, the coating is cheap. To make a wineglass truly invisible, however, its reflectivity should be absolute zero, says Wiener. That would mean optically grinding the wineglass in a clean room, too expensive even for flabbergasting the Joint Chiefs. "It's impossible to justify," he says wistfully.

On the other hand, what about a bomber or cruise missile invisible to enemy radar? Such "stealth" aircraft, based on new materials, coatings, and shapes are now on the drawing boards, with Pentagon plans calling for 100 B-1B long-range bombers by 1986, possibly a stealth fighter, and 110 other stealth craft (advanced-technology bombers) scheduled for the early Nineties. The tab for this exercise in materials research is over $50 billion.

Developing new materials—superstuff—is pricey. But so are the stakes. We must now import an alarming number of vital materials, the substances upon which technology voraciously feeds. Unless we develop synthetic replacements, the country could find itself in a strategic stranglehold.

Right now the United States imports 22 of the 27 most important metal ores. Most of our chromium, manganese, cobalt, and platinum comes from South Africa, for instance. These metals are

Previous page, left: Westinghouse scientist wields ceramic sulfur dioxide probe that is electrically stimulated by SO_2 emissions. Previous page, right: Engineer with "dynamic compactor," an electromagnetic launcher that transforms metal powder into solids by means of a high-pressure pulse or shock wave that is set off by a speeding projectile. Above: A low-energy argon laser is used for polymerization of liquid chemicals.

vital for everything from power plants, automobiles, jet engines, and computers to chemical processing and petroleum refining. Manganese (99 percent of our supply is imported) is essential for steel production. As Stanley V. Margolin, an expert on chemical and metallurgical engineering with Arthur D. Little Inc., the international consulting company, puts it, "This country faces a materials shortage that could make the whole oil situation look like a minor blip."

Although metal superstars like cobalt and chromium are familiar, few citizens lie awake nights fretting over columbium and tantalum. Yet, without all these metals, jet engines would corrode, crack, or melt. When cobalt prices zoomed from $5.50 per pound in 1977 to over $50 per pound in 1980, NASA began seeking synthetic substitutes for critical aerospace metals. Other government agencies and industries, equally worried, have materials programs of their own.

It was our strategic-metals pauperhood that launched big-time materials research. But fueling the process has been the advent of such powerful new tools as fancy electron microscopes, which enable scientists to probe matter as never before. The field is hot. Nearly 40 percent of all engineering research is now in materials science. As a result tomorrow is apt to be made of new stuff— synterials.

And what will it be like, this brave new man-made world?

"Plastics!" That was the future a helpful executive suggested to Dustin Hoffman in the 1967 movie *The Graduate*, and a generation snickered. Plastics, indeed. Give us earth, air, water, fire. Parsley, sage, rosemary, and thyme. So said the movie's Simon and Garfunkel soundtrack. Give us body paint. Give us sproutburgers.

It turns out the executive was a foxy guy, except that the plastics of the future are not the plastics he envisioned.

In his office at Westinghouse's Research and Development Center, Dave Smith, manager of polymers research, shows visitors a section of pipe the size of a quart carton of milk. It is gold-colored, faintly scintillating, light as a warbler's feather, yet tough and strong—just right for Wonder Woman's magic bracelets. "This is a glass fiber embedded in an epoxy resin, a polymer composite material," says Smith, his words still touched with the burr of his native Aberdeen. "Thermoset polymers are technically speaking, plastics."

Composite plastics are two or more materials combined in ways nature never tried. By fine-tuning the combinations, scientists can produce materials just right for particular jobs. "This is a graphite fiber in an epoxy resin," says Smith, producing a section of black pipe, equally lightweight. "We made the launch silo and the nose cone for the MX missile out of this material." That's right, folks. Mess with America, and you'll get hit with plastic. Composites, however, are by no means the wimps of the material realm. They are the toughs

For instance, materials scientists at General Electric's huge research center, in Schenectady, New York, are experimenting with a silicon/silicon carbide composite that thrives at temperatures up to 2500° F, about 400° too hot for most metals. The Allied Corporation, headquartered in Morristown, New Jersey, is working on a plastic composite that blocks electromagnetic and radio interference. It would be used, among other applications, to house electronic gear like computers. Meanwhile, strong as steel, light as goose feathers, the new composites have a big future in aerospace design and engineering.

When Defense Secretary Caspar Weinberger recently opposed giving Israel new U.S. technology for its Lavi jet fighter, it was not sophisticated electronics that worried him. It was the secret composites now used in fighter wings and fuselages. The new stealth warplanes will be made of composites that are transparent to radar. Eventually we are apt to have a plastic Air Force: plastic missiles and plastic airliners, so promising are the lightweight composites.

> It makes people nervous to think that they're flying in a plastic airplane. And when they find out that the aircraft is glued together.

Initially, however, passengers may be skittish. "It makes people nervous when they're flying in a plastic plane," says Westinghouse's Smith. "And when they find that it's *glued* together."

Thrill seekers, on the other hand, may one day applaud composites as the best thing since roller coasters. Materials scientists say that airliners could be made of composites that are completely transparent, allowing these materials to duplicate not only Wonder Woman's magic bracelets but also her invisible airplane. Imagine the view high over the Rockies or skimming the Manhattan skyline. Composites, however, have more practical applications. "In the future, Navy ships are likely to be made entirely of composites," says Smith. "We learned from the 1982 fighting in the Falklands that aluminum—the lightweight material now used in ship superstructures—burns. It goes up just like fireworks."

Like most metals, aluminum flares up if it becomes sufficiently hot—when it meets up with an exploding air-to-ship missile, for instance. Even iron will burn. In fact, according to a recent study by the National Research Council, since 1968 at least 21 ships in U.S. ports have burst into flames when their cargoes of iron turnings and pellets reacted with oxygen in the atmosphere and heated up.

Because they are a prime material used in steel manufacture, such iron scraps are frequent cargoes in ships. Oxidation of iron in the holds of ships has generated temperatures of 540° C and more. Thus, the notion of building ships from high-strength, low-weight composites that do not oxidize and can withstand higher temperatures than metals like aluminum is attractive to ship operators, especially the Navy.

Large composite structures should present no special problems, Smith continues. Westinghouse's launch tube for the MX missile is the size of a farm silo. For the Navy the company is now designing composite tubes for cruise missiles. Meanwhile, aerospace designers, particularly obsessed with finding low-weight materials, are studying composites not only for fuselages and frames but for motors and generators as well.

Typically a steel motor in a spacecraft might weigh 1.71 pounds or, if it's made of aluminum, 0.96 pound, explains Smith. But if it's made from a glass fiber composite it will weigh 0.54 pound, and a graphite composite motor would weigh only 0.42 pound, a substantial 75 percent reduction in weight over steel.

Robotics is another application, Smith notes. A robot's arm requires high stiffness and light weight for fine control. Japan's Mitsubishi Corporation already is marketing a composite robot arm. Much of the space shuttle is made of composites. And industry is working on everything from composite golf clubs to composite featherweight automobiles. In fact, it is astonishing that so many uses are looming for a material that unprocessed bears a striking resemblance to dog hair.

These are the fibers that go into the resin," says Smith, handing a visitor a bottle full of black strands that might have come from a Labrador retriever. "These go through quite a process before they become an airplane wing."

Building 601 in Westinghouse's research center, a pilot plant for manufacturing composites, contains a room the size of a city block. Its centerpiece is a 26-foot-long spool, or mandrel, for winding the graphite fibers that go into MX missile silos and other projects. "This is our pride and joy," says Smith, smiling and pointing to the installation.

Graphite fibers wind around the mandrel in complex geometric patterns precisely controlled by a computer. As the mandrel turns, a machine running overhead on rails constantly wets the fibers with resins. When the winding is done, the mandrel and its resin-impregnated fiber shell slide, like a Brobdingnagian loaf of pumpernickel, into an enormous oven. When it has been

CONTINUED ON PAGE 176

FICTION

Laura's soul belonged to a man who demanded utter loyalty, no matter what the cost

BOROVSKY'S HOLLOW WOMAN

BY JEFF DUNTEMANN AND NANCY KRESS

Laura walked the Low Steel above the stars, searching for her man.

It was 2.3 klicks across the skeletal terrain by the most direct route—the blue line on the diagram of the construction zone burned in the eye of Laura's mind. No one but Mikhail Borovsky would take that particular route across the unfinished girders of the Titan cylinder's outermost level, and even he would not take it without her.

One foot before the other, lift, swing, step. The pilot beam was solid monocrystal steel, I-section, one decimeter wide. One hundred meters to her left and right identical girders glittered in the always-changing light. They were the primary structural support of the latest, lowest level of George Eastman Nexus. Each girder was a single crystal of iron atoms, one hundred nineteen kilometers in circumference, and strong enough to rest an artificial world on. For a kilometer ahead and behind, it was Laura and her beam.

A man in the saddle of a six-wheeled yoyo swung under the horizon far away antispinward and quickly approached her, soon passing to the rear and vanishing. Borovsky's yoyo was a four-wheeler. The earth swung up behind her end made blue highlights creep across the dull-gray steel plates ten meters above her helmet. It slipped above the horizon and was gone again for another forty minutes.

Laura adjusted the magnetism in her boot soles. Just enough to add a little friction, a little sureness. If she fell outward from the rotating structure into the starry darkness the steelworkers called the Pit, no one would fall after to her rescue. But she would not fall. Steel was her medium, just as it was Borovsky's, and she loved it. Steel was sure and clean and true. It could be trusted, as Borovsky could be trusted when he wasn't—

No. She would not allow that thought to be completed.

Where had they gone? Borovsky, in rubber underwear, off on a yoyo to fight a man twice his size,

PAINTING BY ETIENNE SANDORFI

somewhere on a level swinging more than 1.6 g. Falling on your face could flatten your skull on E Minus Seven. Fighting could dock you a week's pay. Ignoring a challenge could get you called a phobe. A coward. A ... woman.

Where?

Step following step, body bent forward, using the artificial gravity to help carry her onward, Laura searched. She scanned the chatter on the CB and the bloody-murder band. Nothing spoke of a man in rubber hurt on E Minus Seven.

Less than five hundred meters of open steel remained. Far ahead Laura saw something streak through the shadows toward the sucking stars. She followed desperately with her eyes and saw it catch the sun beyond the great cylinder's shadow. Four-wheeled gantry cable saddle! It blazed brilliant yellow for a moment and was gone, falling forever.

His yoyo unridden, alone. Damn the Pit! Laura broke into a run, each boot hitting the beam safely though without thought, each magnet grabbing just so much. Raw dawn broke behind her and cast lurching shadows against the unfinished steel ahead. The sun was beneath her feet as she stepped from naked monocrystal onto gray steel plates.

Above was the port from which the yoyo had fallen. She pulled herself up a ladder and stepped out onto E Minus Six. A little lighter, a little less deadly.

No sign of fleeing men. Six was a big level, one hundred meters thick. Heavy chemical industry, she remembered.

Before her a dozen huge steel tanks squatted against the floor like brooding hens. Each was ten meters high, with a ladder leading to a dogged circular hatch.

She scanned the tanks. All were alike, save that one of the hatches had dog-handles twisted differently from the rest. In moments she was at the hatch, pushing the dogs aside.

The tube was a simple pressure lock. Laura pulled herself in, dogged the outer hatch, and released the inner.

With a rising rush there was sound all around her. She pushed the inner hatch wide and found her man.

Mikhail Borovsky lay naked in a heap, blood leaking from his mouth. Laura cried out, and for an awful moment she lay immobile in the tube until she heard a rattling breath. She slid to his side and squeezed his wrist until her gauntlet felt his pulse. Drugs—he needed drugs to stir his system out of shock.

His rubber suit lay on the floor. Laura kicked it scornfully aside, reached to her throat, and undid its latch. Quickly she eased her helmet back. She pulled her ventral zipper down, flipping the hooks aside with her fingers as they went. Eagerly she spread her ventral plates apart, pulled her pelvic plate forward, then pulled the zippers down each of her legs almost to each knee.

She lay on her back beside him, plates gaping, helmet folded under. The eyes in her wrists and in the toes of her boots helped her lift Borovsky above her. Gently she eased his legs down into her legs and let the slow peristalsis of her inner layers draw his feet into her feet. Her ventral plates stretched wide to clear his hips. She placed the Texas catheter over his penis and pulled her pelvic plate back into position.

Wriggling slightly, she guided his arms down into her arms, where her inner layers did the final positioning.

Each finger was drawn into place and continuously massaged. Laura zipped and hooked her ventral plates and finally eased her helmet over his head.

For a Rabinowicz Manplifier Mark IX space suit, walking steel empty was too lonely to bear. Without her man inside her Laura felt herself a hollow mockery, less than even a woman, not worthy of the soul Borovsky had paid so much for. Never again, she said to unconscious ears. Never again. Stay inside me. You are *mine*.

Borovsky slammed the palms of his hands down hard on the tabletop. Across the table Andre Wolf Lair set his stein aside and stood. At once Simon was on his feet, his face hard.

Slowly she stood, whole again. Up from his toes the hydraulic rings pressed in smooth waves, helping his blood back toward his head and heart. A tiny needle jabbed into his buttocks, sending a careful measure of stimulant into his bloodstream.

This was no place to be caught by a boss. Laura moved slowly as she climbed from the tank. It had been some time since she had carried his dead weight asleep and never unconscious. She gave the torn rubber underwear to the Pit with a vengeful flick of her hand.

They went home the long way, going up through Six to Five and walking slowly. Halfway there he came around.

"Laura," he whispered.

"I love you," she said without breaking her stride.

"He had a metal bar shoved up his ass," he said, and coughed. "Crapped it out on the floor, grabbed it, and that was that. I'm gonna kill the fugger. You watch me."

"I *love* you," she said again, hoping against knowledge that the words would soothe the murderous rage she feared might get him killed.

A world without Borovsky—

"Love you too," he mumbled, only half-conscious. "I'm gonna kill him."

By morning the bruises showed up. Borovsky swore at his image in the mirror. The left half of his face was swollen grotesquely. Ugly purple blotches covered most of his cheek and curved up nearly to surround his left eye. All across his body were bruises and scrapes from hitting the iron going down. He pressed a bruise with one finger and jerked the finger away from the fiery pain.

Laura watched, unmoving. The tiny cylindrical pod with its watercot, its kitchen, its shower and squat toilet was very silent. If Borovsky fought again, if he insisted on fighting again today—

Panic appeared in her crystalline layered machine mind, seeping outward from the F layer at the core. Layers A through E were standard Manplifier equipment: sensory motor communications, memory, and intellect. Borovsky had paid three years' wages for the F layer that Laura so cherished, unique, personal, precious—her soul. The E layer, shared by any machine that could speak and reason, could have stopped the panic, but it did not. Instead, when Laura could no longer stand the way he stood gripping the edge of the sink in furious silence, she spoke.

"You didn't have to go fight him."

He spat into the sink. "He called me a phobe. Maybe once I can take it. Maybe twice. Some people have to make noise. But he made me answer him. So I answered." He probed a bruise on his thigh, wincing. "What do we got for bruises?"

Laura turned and searched a small cabinet beside the bed. "Hemoverithol."

"Let's have it."

Laura pressed an autoampul against his thigh and squeezed.

He sighed as the needle came and went, then nodded. "How long?"

Thousands of words of medical data flew past the eye of Laura's mind. "Eighteen hours to kill the swelling. Color should be gone in forty-eight. I hope we can afford another yoyo the spare wasn't new when we bought it and—"

"Nix. Rent's up, food's up—we get a new yoyo and we'd default on your soul. Gimme a couple months. We'll get a new one from that bastard Coyne even if I have to beat it out of his hide."

"Maybe we should stay away from the Beer Tube for a few days."

"He'll be laughing behind his ugly face."

"Let him laugh, Borovsky—"

"Don't say it." He turned to her and smiled. The smile was made lopsided by the swelling in his cheek and even when whole it was not a smile to charm women—too flat, too suspicious, too much of the smile of an outsider more used to contempt than to love. But Laura was not a woman of flesh. This smile was Borovsky's. It was enough.

"Let me run the balalaika," Laura said. The image came to her mind instantly. Borovsky as he looked while listening to the tape of his father playing the ancient balalaika The tape was all he had brought up from the crumbling slum that was Deep West London The sad hollow music made his face change—change from underneath. Laura thought

At those times his features lost some of their hardness his eyes ceased their constant nervous scanning back and forth His mouth—no his mouth did not smile but in the small parting of his lips it seemed to find peace It he would just listen—now—to the balalaika

"Let me run the balalaika!

"And get me canned? No *dushenka* We'll be late to the grind Damn. That spare better be okay He turned from the sink and tapped a command on the lock console The spare yoyo s condition read out in a few crisp words Not the best but the battery was a retread and old at that

The balalaika—

"Come on Laura Shit we're late al ready *Move* if"

Laura put down her hand and deliberately began undogging her plates

George Eastman Nexus had begun as a single cylinder rotating to simulate standard Earth gravity From the inner surface towers and delicately suspended trees of modular office clusters grew toward the center In those offices the engineers and managers of a thousand companies guided an industry worth six trillion dollars in gold annually

George Eastman grew outward as well Downward from Earth-Zero swelled the industrial levels Some industries preferred the heavier gravity many chemical processes actually worked more efficiently under higher swing

For other industries the heaviness was less necessary but materials were cheap ever since the asteroid Calliope had been towed into orbit around the moon for the steerable mirrors to mine

It was less than three klicks from their pod to the advancing edge of E Minus Seven Its monocrystal rings girdling East man Nexus had been in place for ten months At the forefront of construction the longitudinal beams and outer-deck plates were being welded into position amid showers of sparks Behind the edge the power conduits and other piping were being laid and farther still the floor plates one meter square and removable were being bolted down Laura gripped the yoyo s cable tightly as they rode and felt through her fingers the sizzle of old motors in its gantry above her helmet

Two of the welders paused long enough to let Borovsky pass between them, unharmed by the molten droplets Borovsky waved clear and the yoyo purred on to the point where the floor plates began He parked it and punched in with the shift boss Docked nine minutes—he shrugged and Laura tallied the beers he would have to forgo to make it up Borovsky s partner Andre Wolf Lair thumped his shoulder as Borovsky yanked his card from the clock. Borovsky grunted in greeting and returned a playful poke to the Amerind's midsection Coyne s lamp on the clock was green Borovsky clenched his jaw and glanced toward the supply dump Coyne was loading diamond cutting wheels into his Enhanced Leverage Manipulator

Coyne looked up Borovsky's personal microwave channel triggered and a single scornful whispered word came across over Coyne s chuckle *'phobe*

Laura felt her man s pulse race Quickly she squeezed his thigh and whispered in his ear "He can t even walk the Low Steel for a living All he does is ride in that big yellow egg You re twice the man he ever will be"

"I'll kill him Borovsky muttered "Damn I'll teed him to the stars

George Eastman Nexus turned twelve times over the course of a shift Borovsky and Andre Wolt Lair guided the longitudinal steel beams into position ahead of the edge tacked them and left them for the welders Wolf Lair was taller than Borovsky larger than Coyne Among the men who walked the Low Steel he was a giant with impeccable balance and a gentle deep voice His suit was much older than Laura with little skill in its E layer for speech and reasoning and no F layer at all The suit had no name and spoke when it had to in Wolf Lair s own voice Laura sensed that Wolf Lair did not like intelligent machines and she remained silent while he and Borovský worked

When the shift was half over Coyne s ELM rumbled by on its way to the supply dump As it passed one of its two smaller arms twisted its four fingers into a crude approximation of an ancient gesture of insult Borovsky quickly returned the gesture and looked the other way

Wolf Lair looked after the egg-shaped machine until it moved out of sight "Coyne is a believer Mik I think he hates you for the spirit you wear

Borovsky hoisted one end of the next beam "Pah He believes in his own mouth"

"But I have seen him walk three levels up to the Catholic mass Catholics fear all spirits Hate is a good mask for the things you fear"

"Laura's no spirit Hell she's a computer Borovsky pushed against the end of the beam Laura pushed with him The beam crept into position in line with the tiny red spots of light produced by the laser-alignment network

"Maybe *computer* is the new word for *spirit* Maybe it is a spirit for nonbelievers I heard you talk about the loan you got two years ago You said you bought a soul for your space suit"

Wolf Lair leaned forward and helped Borovsky move the beam to its final position Together they tacked it down with dollops of adhesive after checking it against all fifty alignment spots Borovsky leaned back against a pillar and stared down at the stars creeping past beneath his feet

"Shit I was lonely You can go home to Leah and your little ones twice a year They send you letters and presents and you send them money This up here is all the home I got and nobody in it but me Ain't no woman anywhere would live here and get smashed under this much swing You Indians got it good Your women wait for you in their mountains In the city no woman remembers your name ten minutes after you screw her I thought about it a long time All I did was buy something that would be on my side no matter what just something that sounded like a woman Laura pinched him hard in a very sensitive place But it turned out to be a woman that was *worth* something

"I hear you Mik You say it well I was twenty when I signed up for space My grandfather took me aside and said Wolf Lair do not give over your heart to machinery Machines are to use and put away when day is gone Only living things are worth the true heart of a man He is dead some years but I will never forget him You know that lesson as well I think You had nothing worth your true heart so you bought a spirit The spirit you bought is nothing so simple as a loyal dog or even a dead man's restless ghost I know it comforts you and will never disobey you but forgive me if I fear it Forgive Coyne if he fears it I could never understand or trust a spirit that lived in a machine"

Wolf Lair s words disturbed Laura He was not given to speeches and was not one to admit his heart s fears and feelings She waited to hear what Borovsky would answer but he said nothing The sun passed under their feet five more times and the two men worked in silence

For three days Borovsky avoided the Beer Tube At shift s end he slept sleeping as much as fourteen hours at once Laura sampled his blood and read his vital signs daily and she knew that his body was repairing the damage Coyne had done it and the further damage Borovsky was doing by continuing to work without a break for healing Once watching him as he slept

They climbed in darkness quickly, twice as fast as a nonamplified man could climb Borovsky said nothing Laura dared not plead with him to give up the chase she played the balalaika tape for herself alone but only once Other times she restlessly walked the Low Steel empty thinking She thought about Coyne and about Wolf Lair and about herself

She thought about souls

Standing on a naked monocrystal beam above the bottomless void she looked down and saw Rigel creeping past The spectroscope on her instrument blistered helmet studied it sent data streaming from her A sensory layer inward Stored data raced outward from her D memory layer to meet it Information met intersected compared cross-referenced in a process that, it seemed to Laura was both methodical and more than methodical It found more in the rainbow layered image of a star than the star had to offer But no—the handling of data was not her soul

The pleasure then in that handling Had the pleasure in her own processes been there before Borovsky had bought her a soul? No of course not *Laura* had not been there not as she herself—only a good Rabinowicz Mark IX Manplifier suit with a woman s pleasant voice Not as the watcher of her own mind the tender holder of Borovsky s body the tireless worker who longed to follow the Low Steel out to the stars and farther Still these things were not her soul They were things that as Wolf Lair had said could be put away when day was done and the work was done—all but Borovsky Not for a moment could she lay down her guardianship and loyalty So she had been made and she would not want to be an angstrom different She loved Borovsky beyond either choice or the desire for choice But Borovsky was not her soul

Raising her empty arms Laura stretched them out toward Rigel It was a gesture she had seen made only once—by Wolf Lair the man who feared her as a spirit within a machine Just like this had the Amerind stood arms outstretched so body taut and arched so hands palms open to the devouring sun crawling toward and below him With Borovsky inside her Laura had stopped dead on a beam and stared Wolf Lair had not turned toward them had not sensed their footsteps through the steel on which he stood He had not in fact, seen Laura at all, but in that one moment Laura had seen a vividness a connection between him and her and the sun and Borovsky and the beam beneath her forged of iron atoms that were mostly empty space

Hollow woman! Coyne had mocked once One-hundred-percent artificial broad nothing organic added he had read squinting from a label he imagined on her ventral plates Odd that he would mock her for what she was proud to be, and doubly odd that she felt too ashamed to retort that nothing could persuade her to trade polished powerful hydraulic limbs for the fragile mushiness of human flesh Such weakness was not to be envied But worse than what human beings could *not* do was the thing they could do and did not the thing she had seen in the tensile exultation of Wolf Lair s body on a steel beam hung above the stars

It was a thing for which Laura had no name but only a sense of patterns among half-realized notions of what it might be like to be human The pattern was greater than merely being human it was a transcendence of the human It was a laying of hands upon the universe with such firmness of grasp that the universe took a bit of the being s shape, individual and unrepeatable because exactly that intensity and originality of consciousness had not existed in exactly that way before and would not do so again Becoming unrepeatably and wholly oneself and thus everything else—*that* Laura decided was her soul Becoming and knowing it

Was that what Wolf Lair had meant by the spirit of living things? But then why had Laura not seen it among the humans themselves before that glimpse of intense stillness in the outstretched body of Wolf Lair? No the steelwalkers who had inherited unbought souls without cost seemed unwilling to embrace anything larger than a double hamburger Their souls were asleep though they ate drank, slept worked and fought, their souls were in none of it. Why even Borovsky—

No The thought froze and vanished Borovsky troubled flawed creature that he was had nevertheless caused her soul to be He created her and redeemed her by placing himself in financial chains Laura turned from her contemplation of Rigel to her pleasure in remembering certain ancient myths (but there had been no myths, nor pleasure in them before Borovsky had bought her soul) to the joy of contemplating Borovsky himself Creator Redeemer However limited his other horizons he had reached beyond himself as far as that

Cherishing the thought at the center of her crystalline consciousness, Laura hurried back to where Borovsky was

An argument was under way in the Beer Tube when Borovsky entered three days later Coyne was proclaiming that E Minus Seven would be the last layer to be built around George Eastman Nexus Borovsky tossed back Laura s helmet on its hinges

"Damn right How could the Combine *possibly* build a level that Johnny Coyne couldn't stand up in? His bulldogg face remained expressionless as he undogged Laura s plates but the other men in the automated tavern laughed

Coyne glowered "When they run out of men like me to build it who will they get to do the work?"

Andre Wolf Lair was sitting at one of the black plastic benches near the robot bar at the far end He took a long draft from his carved wooden stein wiped the foam from his lips and laughed deeply "When they run out of men like you they will use *real* men and we will work twice as fast"

Coyne opened his mouth Wolf Lair leaned toward Coyne, who saw the warning in the giant's eyes and looked away

In his blue working longjohns Borovsky stepped free of Laura. She buttoned up and leaned against the wall among several other suits, some like her, others more rubber. Laura watched Borovsky key up a beer into a disposable stein at the bar and walk back toward Wolf Lair.

"Let them build out to E Minus Fifteen," Borovsky said, and took a mouthful of foam. "I will stand after the last man has started to crawl."

"After two hours here I doubt any of us could stand in free fall," said another man. General laughter followed, to Laura's relief. Among the Beer Tube's customers tonight was a shift boss, Simon Weinblatt, who was sitting with several of Borovsky's co-workers and trading jokes with them. The man was of only average height and build and seemed slight beside Borovsky and Wolf Lair. Like all shift bosses, Weinblatt had a soft-spoken, gentle demeanor and a keen understanding of human motivation. When tensions flared, shift bosses had a way of showing up, quieting the situation, and making forty rough, quarrelsome laborers cooperate and produce. Their methods could be as rough as those of the laborers. Every man there had heard tales of drunken steelworkers who had defied shift bosses and found that their jobs evaporated the following morning. And there was another story, hundredthhand at least, of a man who had traded angry words with a shift boss and shoved him to the floor—only to awaken in a prison hospital bed with both arms gone past the elbows.

Laura saw that Weinblatt had been inconspicuously watching Borovsky and Coyne. When Borovsky went back to the bar for a second beer, Weinblatt placed a hand on his elbow. Borovsky bent down to listen; the man spoke quietly. "You have an accident at work?" Weinblatt pointed to his own cheek. Borovsky's eyebrows rose, and Laura thought he grew a little pale. There was still some slight discoloration from the bruise that had covered half his face.

"Fell outta bed. No big deal."

Coyne squeezed past on his way to the bar for yet another beer. Laura longed to get Borovsky back within her and away from there.

Even with a raucous album playing in the background, Coyne appeared to have heard the exchange.

He laughed belligerently and poked Borovsky with his index finger.

"Fell outta bed, huh? Dreaming about one of those Rooski women, I guess. All muscle and three tits, a pair and a spare!" Coyne doubled over laughing. Borovsky stiffened but remained silent.

Weinblatt did not seem bothered by the banter. Through a grin he rejoined, "At least he remembers to dream about women. After ten beers I'll bet you spend all night making love to your handling machine."

Coyne shrugged as his stein filled. "There ain't no words for the kind of women I dream about."

From the next table another man joined in. "That's because the Combine ain't started making 'em yet!"

Coyne belched loudly. He shook his head and made his way to the rear of the tavern, where a dozen space suits stood or hung near the lock. He stood in front of Laura and addressed the crowd with a full stein in his hand.

"Ha! The expert on mech-anical women is right here among us! Our good friend Mik-Hayal Borovsky and his patented hollow woman! She cooks, she cleans, she cheats at cards, she tells dirty jokes. What more could a man want?"

Borovsky's face tightened.

"I think that ought to be your last beer, Johnny," Weinblatt said pleasantly.

Coyne ignored him. "What more, huh? Tits maybe?" He turned and made pinching motions across Laura's ventral plates. "Kind of hard to get hold of, huh? Well, Mik's got lots of imagination."

"You're making an ass of yourself, Johnny," Weinblatt said. The grin was gone.

Panic appeared in Laura's crystalline, layered machine mind, seeping outward from the F layer at the core. Her E layer could have stopped the panic, but it did not.

"No tits. Well, how about a twat? Jesus, guys, she's *all* twat! Lookitthat!" Coyne grabbed Laura by the rim of her helmet gasket and tipped it forward, pointing with an index finger to the hollowness inside. "A guy could crawl in there and get lost, which is about as close as Mik's ever gonna get to being inside a woman!" Coyne released Laura and faced the crowd again. Borovsky spat on the floor. Too much tension. Laura thought she could picture Borovsky bashing Coyne's head flat against the floor. As soon as Coyne turned away she brought her right hand up and thumbed her nonexistent nose at him.

The room exploded with laughter. Coyne whirled around in time to see Laura's arm snap back to her side.

"Well, so she wants to be one of the boys. Hey, babe, you can't have fun at the Beer Tube without putting away some yourself. Here, I keyed for this one, but it's all yours." He lifted his stein over Laura's helmet gasket as though to empty the liquid into her hollowness.

Borovsky slammed the palms of his hands down hard on the tabletop. Across the table, Andre Wolf Lair set his stein aside and stood. At once, without hurrying, Weinblatt was on his feet, his face hard.

"*Coyne, shut your goddamned mouth.*"

Coyne bent over as though kicked in the stomach, his stein groping for the nearest table. His face paled. Laura saw that he had realized what he had done, provoked a shift boss to his feet.

Except for the continuous drone of the juke, the Beer Tube was silent. Simon Weinblatt was still standing. "Go home, Johnny," he said, and took his seat.

Coyne nodded, turned, and began pulling on his rubber suit.

Laura saw little of Coyne next shift. Wherever she and Borovsky happened to be, the yellow ELM happened to be elsewhere. Nor did Coyne appear at the Beer Tube after shift. But Simon Weinblatt was there, and he pointed to the bench opposite his as Borovsky walked in. Laura left again with the other suits, edged close enough to listen.

"Mik, I'm worried about Coyne." Weinblatt's face was smiling, unreadable. "One of these days he's going to jump you, and you're going to beat his brains out."

"Would serve him right," Borovsky said, eyes on the bench. "The guy is some kind of psycho."

"Could be. How did this thing between you two start?"

"I didn't start it."

"I didn't say you did," Weinblatt said pleasantly. "Do you know why he has it in for you?"

"No. One day he just starts in."

Weinblatt waited. Borovsky, scowling, said nothing more. Finally Weinblatt said, "Some guys are up only when they're making noise. They need it, like air. But Coyne is also mighty damned good with an ELM. His replacement index is forty points tougher than yours." The shift boss sipped from his mug. "If one of you had to go, it wouldn't be him."

"That's not fair."

"Money isn't fair. Bear down, make some Q-points, and we'll see. Right now you have to bend a little. I've been doing some watching and some asking around. You pretty much stick to yourself, and that's cool. But up here it never hurts to melt in a little. You've got no wife to talk about, no kids to brag about. Nobody ever hears of you going off to see a woman somewhere. You make it easy for an asshole like Coyne to single you out. Humans are pack animals. If you don't show that you're in, the others will assume that you're out." Weinblatt gave Borovsky a level stare for a few moments and then shrugged. "You can tell me that's not fair either."

"So what do I do?"

"Starters," Weinblatt said, and shoved a silver octagonal token across the scarred plastic tabletop. Laura's eyes followed the token across the bench. Embossed on the exposed face was a stylized spiral galaxy and the words BERENICE'S CLUSTER.

"Silver lay, Mik. Anything you want. This one is on me It s my treat

After an incredulous moment Laura snapped her attention from Weinblatt s token to Borovsky s face Her man—*her* man—looked as impassive as ever But Laura who knew the meaning of every twitch in that unlovely face saw in Borovsky s eyes a complex reaction resentment and distaste and—yes—interest The room lurched slightly and Laura thought something had gone sour in her F level but then realized she was discovering something new in the bright innermost level she knew as her soul If Borovsky—

"No thanks Borovsky was saying He lowered his eyes to stare at the silver token Whorehouses give me the creeps

"Be honest Mik Are you queer?

No!

Several of the other men nearby looked toward Borovsky seeing Weinblatt s warning glare they quickly looked away

I can t afford it Borovsky said and in his voice Laura heard the same thing she had seen in his eyes He resented being told what to do he was determined to resist he felt scorn for the human pressure to fit in but he was interested

Maybe not a silver Weinblatt said but a purple quickie once a week won t break you I know

Borovsky nodded The Combine always knew to the penny every employee s assets debts and expenses Borovsky s excuse had been a poor one Was he trying to save face in offering resistance so easily wrestled down? Laura longed to have Borovsky look at her but his gaze remained on the silver token It was Weinblatt in profile to Laura who seemed for a moment to flick a sidelong glance at the suits against the wall Desolation swept through her F layer If Borovsky—Borovsky *her* man—

I ve never been there before Borovsky said

Weinblatt stood "I ll take you I could use a good time myself about now

And Borovsky was standing up Borovsky was reaching for her Borovsky still not meeting her many sets of eyes was wriggling into her ventral cavity into her boots He said nothing And Laura sure now that the universe was steady and the lurching continued only in her soul could say nothing either

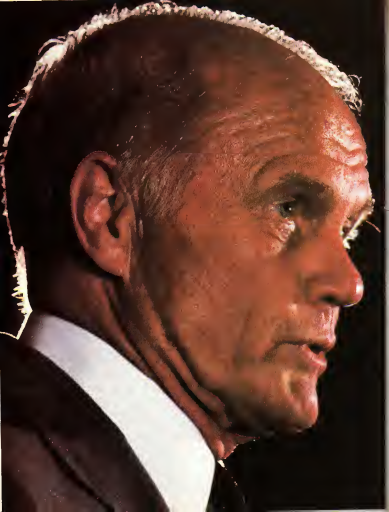
Let s go Weinblatt said

Both ports were cast wide at Berenice s Cluster up on E Minus Four Loud raucous music echoed out through the lock Borovsky hesitated a moment

"Come *on* Mik Relax

Laura felt Borovsky suck in his breath and they entered Inside it was very crowded a random tessellation of polygonal waterbeds illuminated from beneath by changing multicolored lights On each bed lay a woman some naked many draped in shimmering cloth More than a dozen men stood among the beds reading the fee schedules and counting dollars in their heads and on their fingers Down

CONTINUED ON PAGE 182



The first American astronaut to orbit the earth would like to be the first U S president to take a ride on the space shuttle

INTERVIEW

JOHN GLENN

Among John Glenn's early forays into politics was curiously enough a trip to Japan in the spring of 1963, about 15 months after he had been the first American to orbit the earth Lieutenant Colonel Glenn then still in the Marine Corps had gone to Nagasaki to board a tracking ship on which he helped to guide Major Gordon Cooper in his spaceflight in May Then the Glenn family toured Japan partly on vacation and partly on a goodwill mission from the U S government

That was diplomacy and by nature nonpartisan, but still an exercise in politics By anyone s measure, John Glenn was a stunner He learned to sign his name in a Japanese script called *katakana* and startled autograph seekers whom he accommodated by the score He met with the political and scientific leaders of Japan, but it was the crowds of shopkeepers clerks, and ironworkers whose hearts he won with unfailing good humor and all-American boyish charm At the Foreign Correspondents Club he was asked how he knew the difference between up and down in space He drew a laugh when he said "In space you can pick your own up " But he was grave when questioned about reports that Soviet cosmonauts had died in a space accident and was applauded when he said he fervently hoped that was not true By the time Colonel Glenn left Japan he could have won any election in the country hands down A leading Japanese newspaper commented "Everything about him was openly candid "

A year later John Glenn was out of the space program, retired from the Marine Corps and deep into real politics partly at the earlier suggestion of President Kennedy who had been killed by an assassin s bullet in November 1963 and more at the urging of the President s brother Robert Kennedy Since then Glenn has evolved an agenda that James Reston the columnist for *The New*

PHOTOGRAPH BY RICK FRIEDMAN

York Times, has described as "a mixture of the old values and the new technology."

In terms of the old values Glenn is a quintessential American hero. He flew 59 combat missions as a Marine fighter pilot in World War II and another 90 missions in the Korean war, winning five Distinguished Flying Crosses. He set a cross-country speed record of an average of 726 miles per hour in a Navy jet in 1957 and in 1962 rode the capsule *Friendship 7* three times around the earth and into the history books.

Glenn's three orbits, which lasted 4 hours and 55 minutes on February 20, 1962, were strictly kindergarten stuff by today's standards. But coming ten months after the Soviets' first manned orbital flight and five months after they orbited a man for 25 hours, it was the first tangible evidence that America's catch-up effort was on the right track. And Americans responded to Glenn with a frenzy of adulation unmatched since Charles Lindbergh's Atlantic solo and Dwight Eisenhower's return from the conquest of Nazi Germany. The onetime Marine jet jockey was even invited to address a joint session of Congress, and publicity-wise politicians angled for proximity to the new spaceman.

Not only are his bravery and high-flying exploits just right for the makings of an American hero, but his origins are impeccable as well. Glenn's roots are in Small Town USA—New Concord, Ohio—where his father ran a plumbing business. As a boy Glenn was a good student and a good athlete. Later he married his high-school sweetheart. He values his religion, and once, when asked whether he sensed God in space, said, "The God I believe in. I don't expect Him to be small enough that I'd run into Him in space."

Glenn's faith in the old values apparently was shaken during the turbulent days in Vietnam. After the death of four students in a 1970 riot at Kent State in northeastern Ohio, he was glum in a conversation with a newspaper reporter. "Everyone is losing confidence in everything," he said, "our foreign policy, our universities, our electoral system—all because we haven't changed the things that needed changing and we haven't told the people the truth."

Tom Wolfe, author of *The Right Stuff*, based his book on John Glenn and the other six original astronauts, men who stirred the nation's deepest emotions. "They knew it had to do with the presence, the aura, the radiation of the right stuff, the same vital force of manhood that had made millions vibrate and resonate thirty-five years before to Lindbergh."

Glenn's switch from space to politics, however, has been filled with adversity. It has taken him more than a decade to find the right stuff there. He had to drop out of the primary race for the Ohio Democratic senatorial nomination in 1964 because he slipped in a bathroom and suffered a serious concussion. Then he lost the same nomination to Howard K. Metzenbaum in 1970 after running a badly organized underfinanced campaign (everyone thought Glenn would be an easy winner). But he beat Metzenbaum in the primary in 1974 with a well-run effort and went on to defeat a rather colorless Republican mayor of Cleveland, Ralph J. Perk.

Glenn, however, stumbled again in 1976. At the Democratic presidential nominating convention, he gave a keynote address that was uninspired in content and plodding in delivery. The response from the assembled Democrats was tepid at best, and Glenn talked himself out of whatever chance he had to be Jimmy Carter's vice-president. He returned to the Senate and gradually put together an agenda on the new technology that has emphasized education, research, the exploration of space, and the control of nuclear power and arms. Politically Glenn seemed to come into his own in 1980, when he ran for reelection and won by a record 1.8 million votes in a state that went Republican for Ronald Reagan by a margin of 450,000 votes.

> "For me to stick around being the world's oldest, in-training, secondhand astronaut, hoping for a flight when I was fifty, would be wishful thinking."

Glenn began expressing himself on the value of education back in his days as an astronaut. "When you get educated, you are no longer fearful," he said of his training. "You fear the least what you know the most about." Now he talks about cutting educational budgets as "eating our seed corn," and has proposed a $4 billion program to improve schools. Most of that would help disadvantaged children, but some would go to gifted students and outstanding teachers.

Among Glenn's favorite words, judging from his public utterances, is *curiosity*. He says that curiosity the essential element of research enhances American civilization and the standard of living. As soon as he started his ride into space, Glenn later wrote, "I began to sop up every bit of information I could and to record every impression I could. I talked constantly—to the ground stations when they were in range, into a tape recorder when they weren't—about what the instruments read, about how things appeared out the window, about colors, about what itched and where, about everything." The point, he said, was that "the researcher quite often does not really know which observations later will be of great importance."

Last year Glenn conducted a poll of 48 American winners of the Nobel Prize in science and found that 29 of them had received 90 percent of their research funds from the federal government. Another 11 had gotten half of their support from the government. He asserted that he had conducted the survey to counter "the mistaken impression that the expenditure of federal money for basic research is a ripoff of the taxpayer."

That sense of curiosity permeates Glenn's plea that Americans continue to explore space. He scorned what he called "the drag race" with the Russians to reach the moon. Instead he propounded an almost classic argument that space should be explored because it is there. "One reason why man is driven to explore the unknown, to reach for the pinnacle, to master the unfamiliar, may be that by doing so he gains better control over his future," he wrote in 1969.

Glenn, however, doesn't favor technology for technology's sake. He has been among the leaders in blocking the spread of nuclear weaponry. In the Senate, where esteem for performance is slowly acquired, Glenn has overcome the suspicion that he was a freak political beneficiary of a long-ago space hysteria. As a junior member of a subcommittee with jurisdiction over nuclear affairs, he was assigned to look into the global implications of nuclear proliferation—a subject in which politics, technology, diplomacy, and economics are tightly intertwined.

A subcommittee staff member recalls that Glenn "immersed himself in the subject and mastered the details of every category. When he was through, no one knew more than he did." The outcome of his efforts was the Nuclear Non-Proliferation Act of 1978, a landmark piece of legislation for which Glenn is acknowledged as the principal architect.

"When considering the wisdom of spreading nuclear technology throughout the world," he wrote in 1976, "the benefit must be weighed against the potential tragedy. The benefit takes the form of a new abundant energy source that can help many nations substantially raise their standards of living with labor-saving devices and conveniences as well as increased food production—critical items in the years ahead. The greatest political tragedy lies in the destructive capacity of the weapons-grade material associated with nuclear production." He continued in his argument for the act, "Unless it is placed under adequate controls, this material can be converted to atomic weaponry by nations and terrorist groups alike."

For those who recall Glenn from those faraway days of space pioneering 20 years ago, it is extraordinary how little he has changed in appearance. By virtue of political accomplishment, however, he's recognized as Senator Glenn rather than ex-astronaut Glenn Given his political ambitions that's just as well, since for millions of Americans under age twenty five or so astronaut Glenn is an item from the history books and TV documentaries rather than a contemporary figure

Apart from aerospace mementos in his office there is little about Glenn to suggest his previous incarnation Now and then, though, he selectively employs aerospace lingo with great effect as when at a congressional hearing he was questioning a State Department flunky on the relaxation of nuclear proliferation safeguards When perhaps 30 seconds had elapsed without an answer to a volley of questions Glenn softly said to the flustered witness "Over"

Following is a conversation between Glenn and Daniel S Greenberg a longtime observer of the Washington scene

Omni: You've come a long way in politics—from ten years in the Senate to a leading candidate for the Democratic presidential nomination Does that suggest there's a right stuff in politics too?

Glenn: There's a right stuff in any vocation quite apart from the space program If there was one theme that Tom Wolfe tried to follow all the way through *The Right Stuff* it was that the fighter pilots test pilots and astronauts of that particular period were sort of the last of a breed of men and their machines out against the elements Wolfe was trying to say that things are now going to be a lot more automated and I think there's a lot of validity to that

Omni: Things are getting increasingly automated in many aspects of American life including politics Is the old American political system still workable or is it so much in the grip of experts pollsters and computer analysts that it has now become an altogether new business?

Glenn: It has become a new business But has it gone too much that way? No I wouldn't say that it has I think we have a lot yet to be worked out in the way of financial support for campaigns that has become one of the most onerous parts of politics But if you run for office that's one of the things you accept as being a requirement of the business Do you like having to go out and raise money? No But it's one of the things you do in order to do the things you think are right for the country

Omni: When you see the space shuttle going up do you ever think that you'd like to be aboard?

Glenn: I experience pure flat green-eyed jealousy I've already volunteered to go up on a flight

Omni: Then you might be the first president to go into space?

Glenn: I volunteered in advance

Omni: Do you feel confident that you can beat Mr Reagan?

Glenn: I'll leave that to the people to decide but have you seen the polls?

Omni: They look pretty encouraging for you An ex-astronaut could do a lot of things Why did you choose politics?

Glenn: There are a lot of days here in the Senate when I wish I were back in the space program But let me back up a bit I've got no regrets about leaving NASA when I did and the progression to politics was a natural one for me I was the first of the original group of astronauts I was the oldest of that group After my flight I was coming up on forty-one and they felt that upcoming flights on Gemini should go to those who were going to be available for the Apollo mission which we saw coming along about a decade later For me to stick around as the world's oldest permanent in-training secondhand astronaut hoping for a flight when I would be fifty or beyond was probably wishful thinking I stuck around for several years to contribute what I could from my experience and then I left Government politics where the country's going—what role I could play— that has been a lifelong interest of mine, going back to a term paper on the U S Senate that I wrote when I was in high school.

> *What were they thinking of when they tried to cut funding for Pioneer 10? That's man's farthest gadget out in space We still get information from it*

Omni: In many speeches you've said that we have a national crisis in science and engineering education and in our research and development Don't you think that is laying it on a bit thick?

Glenn: Nope I don't think it is There are three things in the American system that made it develop the way it has Number one would be education number two is research number three is our free enterprise system We established our country with an idea that stressed education for every person That's been fundamental Wherever Americans came to take root they established the little schoolhouse and the schoolmarm and as soon as they could be developed the higher-education institutions My home state of Ohio is a good example 139 institutions of higher education Out of all that effort repeated all across this country came an educated people and an educated workforce

And then number two we always plowed more of our gross national product back into research inquisitiveness and investigation into the unknown and into how we could do things better—not only differently but better And much of this was sponsored by the government Private industry did a lot of it, of course but most of the basic research—the things that do not have a three to five-year bottom-line payoff—became the province of government And the government laboratories that we have in this country are literally the envy of the world

And that brings up the third part of the system free enterprise It takes the knowledge produced in government and university labs and turns it into products We now find that we're cutting back all across that knowledge-producing system

Omni: Why is this being done?

Glenn: For shortsighted budgetary reasons That's the only rationale there is To me it's like eating our seed corn when we cut back on higher education or when we cut back our support for research And this is coming at the very time that other nations have recovered from the war and now have a larger proportion of their income that's discretionary and they're plowing it into education and research They're beginning to outdo us in both fields in certain selected areas I don't see us as being down the tube yet but I think all the trends are wrong We must keep feeding this goose that lays the golden eggs

When I talk to David Stockman [director of the Office of Management and Budget] and other administration people about this they say we have to cut back for budgetary reasons and they say that if at a later time we're in a better economic situation we can put more money back into this This shows such a fundamental lack of knowledge about our research system that you want to sit down and cry Anyone who knows the first thing about research knows that you don't just put some money in this year and get your return next year

It may take as long as a decade to get good people to build research teams and laboratories and to get the work moving in certain directions It's a process that you don't pick up one year and lay down the next What were they thinking of for instance when they tried to cut out funds for *Pioneer 10*? That is man's farthest gadget out in space We got it out there It's working perfectly Even though it has left the solar system we still get information from it They were going to cut it out!

Omni: But you salvaged it

Glenn: Salvaged now but the original proposal was to cut it So here we are What are we going to learn from *Pioneer*? I haven't the foggiest idea But to turn off man's most distant object out there to save a few dollars! I was even going to start some public subscription or something but they finally reversed the decision And it involved only a couple of million dollars a year to receive the information If somebody doesn't want to analyze it for ten years that's okay But at least get it It's out there I couldn't believe that they were simply going to turn off the receivers and not even get the information

Omni How did you go about saving the Pioneer program?

Glenn We just talked about it here and somebody over there in the administration finally decided to put the money back That was all But for that kind of money—I don t know what percent it is of the national budget but it isn t much—to turn off something like that showed a thorough lack of appreciation of all things scientific Man s curiosity about how we can do things better or differently or how we learn why things work has given us our whole standard of living our civilization control over our future better control over the forces of nature and hopes for making a better life for everyone around this world That s fundamental and to turn off that kind of research to save a few dollars doesn t make any sense

Omni You've been going around saying that s happening in education too

Glenn Because of inadequate training we're wasting human capital that is vital to the country s future Twenty-two percent of the nation s high-school-math teaching positions are vacant Twenty-six percent of the positions are held by teachers who aren t certified for math In the Chicago school system they ve got one licensed physics teacher for every two high schools Figure after figure like that shows we re not doing the job that we should be doing The Japanese with half our population outproduce us in engineers seventy-four thousand to our fifty-two thousand The Soviets produce three hundred thousand engineers a year Now the Soviets have never been big in liberal arts But the numbers indicate an area where we are beginning to be very deficient

Omni Where does this show up?

Glenn We see it in other countries creating the new industries that are making the jobs and we ll see more of that unless we get back into the competition

Omni Why isn t this problem of declining support for education and research more of a political issue? You're not alone in discussing it but you certainly don t have much company

Glenn I wouldn't say I m alone but I sure haven't heard any great chorus of support out there I sometimes feel like a voice in the wilderness on this It s something that because of my own background in aviation and space I have seen coming Our government is controlled largely by lawyers and people who don t have much background in the science area They expect that just because America has always been number one in these fields we ll automatically continue to be number one But preeminence is not guaranteed into the future unless we work at it

Omni Do you have a particular concern about the decline of the space program?

Glenn Yes I do I m not for giving the space program a blank check But we spent billions of dollars and two and a half decades getting the research capability we have in space and that wasn t done so that people could go up and jazz around and get a new view of the earth Space is a new laboratory For what? For energy sources and development of new materials on board the spacecraft new properties of glass new alloys and metals—things that open whole new capabilities for new industries on Earth and Earth-resources analysis from space We're barely scratching the surface on the type of research that can be done there We ve cut back too far and unfortunately we're not realizing the research potential of the shuttle or preparing for the follow ups to shuttles

Omni What do you think should be our next big step in space?

Glenn We should go to a permanently orbiting space station and use the shuttle to transport scientists and equipment

Omni What would be the purpose?

Glenn On-board manufacture and research Who knows what the value of that research is going to be? There's a serendipity effect in all research It s rare that someone involved in basic research knows what the outcome will be That s the reason we do research And space is no different from that We have a lot of things we want to investigate Every new thing we ve learned in space seems to generate ten more questions to which we want the answers We have the ability to do that kind of research But we re not doing it at the level we should

> “We spent billions and two and a half decades getting the research capability in space The purpose was not for people to go up there and jazz around”

Omni George Keyworth [presidential science adviser] has said that a space station would be enormously expensive and that we re not sure we'd get anything out of it What's your reaction to that?

Glenn If he could show me any scientist who was sure of what would be the out come of his basic research he'd have to tell me that they knew the answer before they started the research

Omni But five billion to ten billion dollars is involved in a space station

Glenn But the whole space program has been quite productive Some of the figures we ve had from the past show that the civilian economy has received a return of somewhere between seven and ten times the amount spent on space We didn t foresee that at the outset To use a simple example many years ago some ordinary mold—the kind that grows in garbage—accidentally fell into a dish of bacteria in Alexander Fleming s laboratory And he noticed that the bacteria around the mold had died off Fleming could not have *possibly* foreseen that penicillin and our whole antibiotics industry would come from that commonplace mold And who could have foreseen in those days that the effect would be longevity increases for most of mankind— and Social Security problems on the floor of the U.S Senate today because of longer lives that people are living? No one ever knows the value of basic research going in but if history is any indication money spent on research has a way of paying off beyond anything we can see at the outset

Omni Where would you apply financial first aid to American research?

Glenn Across the board because it has been pretty well butchered over the last couple of years Our national lab system was cut back an average of twenty percent last year and another seventeen percent this year We've terminated projects and laid off some of the most competent technical people in the world Most of our Nobel prizes have been won by people working in government supported programs Are we going to give up that kind of leadership? That's what we're cutting back on Stockman and the President say that if things like this are worth doing private industry will do them That s just poppycock I ve been on boards of directors and I know how you vote there You vote for a three to five year bottom-line payoff a return It s a rare company that will take on something like a fifteen to twenty-year research project

Omni Do you share the concern that the pace of scientific discovery is going beyond our social capacity to deal with it?

Glenn We have to be concerned about the implications of scientific advances but that doesn t mean we should lessen our efforts to learn new things that might help us control our future No one now would ever say that we don't want a solution to cancer heart attacks and stroke because people living to one hundred ten would give us enormous social problems They would But that would be a problem we'd like to face I m not looking at scientific advances as threats I see them as advantages

Omni You're talking about spending when the country is in an antispending mood

Glenn It would not take a lot of money to correct these problems That's important to realize And in many of these areas a little spending now could avoid huge costs later Take energy for example I spent about three years during the Carter Administration trying to get money for research in the alternative-energy and conservation fields, as an objective we set an amount equal to about one percent of what the United States was paying for imported oil In the last year of the Carter Adminis-

CONTINUED ON PAGE 190

FICTION

It was a typical suburban cocktail party, with its shoptalk and a hint of illicit sex

DURING THE JURASSIC

BY JOHN UPDIKE

Waiting for the first guests, the iguanodon gazed along the path and beyond, toward the monotonous cycad forests and the low volcanic hills The landscape was everywhere interpenetrated by the sea, a kind of metallic blue rottenness that daily breathed in and out Behind him, his wife was assembling the hors d'oeuvres As he watched her, something unintended something grossly solemn, in his expression made her laugh displaying the leaf-shaped teeth lining her cheeks Like him, she was an ornithischian but much smaller—a compsognathus He wondered watching her race bipedally back and forth among the scraps of food (dragonflies wrapped in ferns cephalopods on toast), how he had ever found her

PAINTING BY ROLAND CAT

beautiful. His eyes hungered for size. He experienced a rage for sheer blind size.

The stegosauri, of course, were the first to appear. Among their many stupid friends these were the most stupid, and the most punctual. Their front legs bent outward and their filmy-eyed faces almost grazed the ground. The upward sweep of their backs was gigantic, and the double rows of giant bone plates along the spine clicked together in the sway of their cumbersome gait. With hardly a greeting they dragged their tails, quadruply spiked, across the threshold and maneuvered toward the bar which was tended by a minute and shapeless mammal hired for the evening.

Next came the allosaurus, a carnivorous bachelor whose dangerous aura and needled grin excited the female herbivores; then Rhamphorhynchus, a pterosaur whose much admired "flight" was in reality a clumsy brittle glide ending in an embarrassed bump and trot. The iguanodon despised these pterosaurs' pretensions, thought grotesque the precarious elongation of the single finger from which their levitating membranes were stretched, and privately believed that the eccentric archaeopteryx, though sneered at as unstable, had more of a future. The hypsilophoden, with her graceful hands and branch-gripping feet, arrived with the timeless crocodile—an incongruous pair, but both were recently divorced. Still the iguanodon gazed down the path.

Behind him the conversation gnashed on a thousand things—houses, mortgages, lawns, fertilizers, erosion, boats, winds, annuities, capital gains, recipes, education, the day's tennis, last night's party. Each party was consumed with discussion of the previous one. Their lives were subject to constant cross-check. When did you leave? When did *you* leave? We'd been out every night this week. We had an amphibious baby-sitter who had to be back in the water by one. Gregor had to meet a client in town, and now they've reduced the Saturday schedule; it means the 7:43 or nothing. Trains? I thought they were totally extinct. Not at all. They're coming back: it's just a matter of time until the government.... In the long range of evolution they are still the most efficient.... Taking into account the heat-loss/weight ratio and assuming there's no more glaciation.... Did you know—I think this is fascinating—did you know that in the financing of those great ornate stations of the Eighties and Nineties, those real monsters, there was no provision for amortization? They weren't amortized at all; they were financed on the basis of eternity! The railroad was conceived of as the end of Progress! *I* think—though not an expert—that the pivot word in this overall industrio-socio-what-have-you oh nexus or syndrome or whatever is *overextended*. Any competitorless object *bloats*. Personally, I miss the trolley cars. Now don't tell me I'm the only one old enough to remember them!

The iguanodon's high pulpy heart jerked and seemed to split; the brontosaurus was coming up the path.

Her husband, the diplodocus, was with her. They moved together, rhythmic twins buoyed by the hollow assurance of the huge. She paused to tear with her lips a clump of leaf from an overhanging paleocycas. From her deliberate grace the iguanodon received the impression that she knew he was watching her. Indeed, she had long guessed his love, as had her husband. The two saurischians entered his party with the languid confidence of the specially cherished. In the teeth of the iguanodon's ironic stance, her bulk, her gorgeous size, enraptured him, swelled to fill the massive ache he carried when she was not there. She rolled outward across his senses—the dawn-pale underparts, the reticulate skin, the vast bluish muscles whose management required a second brain at the base of her spine.

Her husband, though even longer, was more slenderly built, and perhaps weighed less than twenty-five tons. His very manner

From the book Museums and Women, *by John Updike. Copyright © 1966 by John Updike. Reprinted in the United States by permission of Alfred A. Knopf, Inc., and in the United Kingdom by Andre Deutsch Ltd.*

"I've lost my pride."

was attenuated and tabescent He had recently abandoned an orthodox business career to enter the Episcopalian seminary This regression—as the iguanodon felt it—seemed to make his wife more prominent less supported more accessible

How splendid she was! For all the lavish solidity of her hips and legs the modeling of her little flat diapsid skull was delicate Her facial essence seemed to narrow along the diagrammatic points of her auricles and eyes and nostrils, toward a single point located in the air, of impermutable refinement and calm This irreducible point was he realized in some sense her mind the focus of the minimal interest she brought to play upon the inchoate and edible green world flowing all about her, buoying her bathing her The iguanodon felt himself as an upright speckled stain in this world He felt himself under her distant smile impossibly ugly his mouth a sardonic chasm his throat a pulsing curtain of scaly folds his body a blotched bulb His feet were heavy and horny and three-toed and his thumbs—strange adaptation!—were erect rigidities of pointed bone

Wounded by her presence he savagely turned on her husband

"*Comment va le bon Dieu?*"

"Ah? " The diplodocus was maddeningly good-humored Minutes elapsed as stimuli and reactions traveled back and forth across his length

The iguanodon would not be deterred "How are things in the supernatural?"

"The supernatural? I don't think that category exists in the new theology "

"*N'est ce pas?* What *does* exist in the new theology?"

"Love Immanence as opposed to transcendence Works as opposed to faith "

"Work? I had thought you had quit work "

"That s an unkind way of putting it I prefer to think that I've changed employers "

The iguanodon felt in the other s politeness a detestable aristocracy, the unappealable oppression of superior size He said gnashing, "The Void pays wages?"

"Ah?"

"You mean there s a living in nonsense? I said nonsense Dead fetid nonsense "

"Call it that if it makes it easier for you Myself I m not a fast learner Intellectual humility came rather natural to me In the seminary for the first time in my life I feel on the verge of finding myself "

"Yourself? That little thing? *Cette petite chose?* That s all you re looking for? Have you tried pain? Myself I have found pain to be a great illuminator *Permettez moi* " The iguanodon essayed to bite the veined base of the serpentine throat lazily upheld before him but his teeth were too specialized and could not tear flesh He abraded his lips and tasted his own salt blood Disoriented crazed he thrust one thumb deep into a yielding gray flank that hove through the smoke and chatter of the party like a dull wave

But the nerves of his victim lagged in reporting the pain and by the time the distant head of the diplodocus was notified the wound would have healed

The drinks were flowing freely The mammal crept up to him and murmured that the dry vermouth was running out The iguanodon told him to use the sweet Behind the sofa the stegosauri were Indian wrestling each time one went over, his spinal plates raked the recently papered wall The hypsilophoden tipsy perched on a banister the allosaurus darted forward suddenly and ceremoniously nibbled her tail On the far side of the room by the great slack-stringed harp the compsognathus and the brontosaurus were talking He was drawn to them amazed that his wife would presume to delay the much larger creature to insert herself with her scrabbling nervous motions and chattering leaf-shaped teeth into the crevices of that queenly presence As he drew close to them music began His wife said to him "The salad is running out " He murmured to the brontosaurus "*Chere madame voulez vous danser avec moi?*"

Her dancing was awkward but even in this awkwardness, this ponderous stiffness he felt the charm of her abundance "I've been talking to your husband about religion " he told her as they settled into the steps they could do

"I've given up " she said "It s such a deprivation for me and the children "

"He says he s looking for himself "

"It s so selfish " she said "The children are teased at school "

"Come live with me "

"Can you support me?"

"No but I would gladly sink under you "

"You re sweet "

"*Je t aime* "

"Don't Not here "

"Somewhere then?"

"No Nowhere Never " With what delightful precision did her miniature mouth encompass these infinitesimal concepts!

"But I " he said " but I lo—"

"Stop it You embarrass me "

"You know what I wish? I wish all these beasts would disappear What do we see in each other? Why do we keep getting together?"

She shrugged "If they disappear we will too "

"I m not so sure There s something about us that would survive It s not in you and not in me but between us where we almost meet Some vibration some enduring cosmic factor Don t you feel it?"

"Let's stop It s too painful "

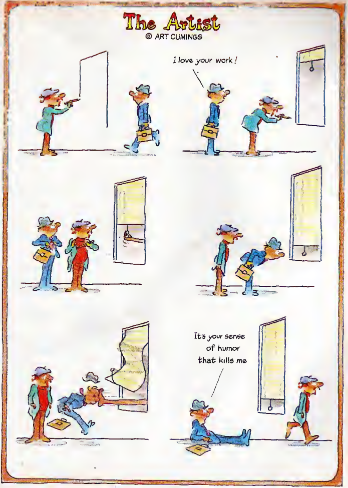
"Stop dancing?"

"Stop being "

"That s a beautiful idea *Une belle idée* I will if you will "

"In time " she said and her fine little face precisely fitted this laconic promise and as the summer night yielded warmth to the multiplying stars he felt his blood sympathetically cool and grow thunderously fruitfully slow ∞

"Mating season coming up in two weeks? Don't remind me!"


The Artist
© ART CUMINGS
I love your work!
It's your sense of humor that kills me

FLASHBACKS

ACROSS FIVE OCTOBERS

The year 1978 was a tumultuous one. In Jonestown, Guyana, 910 religious fanatics and their self-proclaimed reverend killed themselves in a macabre suicide ceremony. At the Vatican a Polish cardinal was installed as the first non-Italian pope since medieval days. And at Camp David, in Maryland, President Jimmy Carter proclaimed a Mideast peace that was to prove as fragile as the Munich accord reached by Neville Chamberlain and Adolf Hitler just 40 years before.

A thick antitechnology fog continued to hang over the American public that year, perhaps an unfair legacy from the Vietnam years. Students who pursued computer science at America's universities were regarded as little more than "nerds," and advanced computer research was associated somewhat skeptically with the Pentagon. Pinball games continued to bask in a 50-year popularity that was to end within two years with the rise of video games. But that October, *Omni*, a publication dedicated to presenting science and technology in an upbeat manner, was launched.

Technophobes, of course, scoffed at the mission of the infant magazine, but this month we can proudly gaze back across five Octobers, as we celebrate our fifth anniversary. To commemorate many of the significant predictive stories that have appeared in *Omni* over the last five years, we commissioned science journalist Dava Sobel to comb through our back pages to see how the future looked when, and even after, *Omni* began.

What follows is a retrospective of the future, from the most hopeful dreams achieved to the shadows of darker forecasts that have also come to pass. Her report suggests the enormity of the technological revolution that has altered our society in just five years.

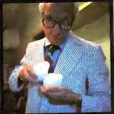
As for the promises *Omni* reported that still hold only promise—the miracle cures, the theories that will tie the events inside the atom to the birth and death of the universe—these we'll examine five years from now, when we've put more of the future behind us.

PARTICLE-BEAM WEAPONS COME OF AGE

Less than seven months after Ronald and Nancy Reagan stormed the White House, *Omni* published its lead story about Space Age weapons. Written by California physicist Gregory Benford, "Zeus in Orbit" raised the specter of a new generation of space-borne armaments that would dominate our globe in the years to come.

Published in September 1981, "Zeus in Orbit" provided readers with a private glimpse of a top-security Soviet facility, where a potent new weapon, the particle beam, was apparently undergoing testing. Benford's report described rays of pure kinetic energy that could knock down ballistic missiles or burn up other nations' satellites. The *Omni* article called these new weapons "planetary policemen," to emphasize their strictly defensive nature. It declared that particle-beam weapons would most likely enter the arms arena by the late Eighties.

Eighteen months later, in March 1983, President Reagan issued his now-famous "star wars" speech, sounding a political tocsin that warned America of its need to militarize itself in space. Reagan's talk not only proclaimed a renewed American commitment to the defensive armament of space but seemed to validate the views expressed in "Zeus in Orbit," published nearly two years earlier.



THE BIONIC MAN LIVES . . . AND DIES

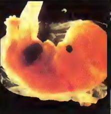
"The Real Bionic Man," we reported in 1978, cost more than "The Six Million Dollar Man" and lived at the University of Utah, where 360 medical scientists and technicians were striving to duplicate man's physiology. These researchers, reported Dick Teresi, now *Omni*'s executive editor, had a clear goal—to "restore people" by employing artificial arms, portable artificial kidneys, and brain implants that would help the blind to see.

But bioengineering was then a primitive medical science, and *Omni*'s editors were criticized for supposedly confusing science with science fiction.

Two inventions discussed were an early bionic blood pump (held, above, by Dr. Willem Kolff, then director of Utah's artificial-organs division) and a plastic-and-metal heart designed by Robert K. Jarvik. Four years later a retired dentist, Barney B. Clark, underwent surgery to have a heart designed by Jarvik implanted in his chest. Clark lived 112 days after the operation, tethered to a large external power-supply unit. The cost of his care came to nearly $250,000.

Bionics remains an experimental science, and it will probably be years before the artificial heart sees wide use. But other areas of bionic-transplant surgery hold great medical promise for the decades ahead.

Five years ago we promised you a better world through science and technology. That future is with us today



A REVOLUTION OF BRAVE NEW BABIES

The birth of Louise Brown, the first human being known to have begun life in a laboratory dish, jolted the public at large with visions of assembly-line baby factories borrowed from the pages of Aldous Huxley.

By her very existence, Louise raised fears and ethical quandaries that we addressed in "Test Tube Babies," in November 1978, when she was four months old. But her triumphant birth held out hope to so many infertile couples that a test-tube-baby clinic, headed by Robert Edwards and Patrick Steptoe, the middlemen in Louise's conception, opened in England in the fall of 1980.

Eastern Virginia Medical College, in Norfolk, started the first American counterpart that same year and can now boast more than 20 healthy infants. Similar centers at various locations throughout the country have sprung up, from Southern California to Manhattan. All of them have long lines and longer waiting lists.

And we predicted in 1978 that surrogate mothers, women who would contract to conceive and carry babies for others, were "certainly a technical possibility before too long." Today there are women doing just that, and there is a thicket of new moral and legal issues surrounding the agreements they sign with would-be parents.

SHROUDED IN CENTURIES OF MYSTERY

A hallowed sheet of linen, 14 feet long and 3.5 feet wide, was about to undergo the most rigorous series of tests ever applied to textile when we carried the story of "The Turin Shroud" in October 1978, our premier issue. Forty American scientists were en route to Italy with $2.5 million worth of equipment they would use to scrutinize the cloth. They were hoping to determine the nature and origin of its two straw-colored images—the front and back of a naked man who had apparently been whipped and crucified.

The shroud is said to be the burial cloth of Jesus of Nazareth, but the scientists were not out to verify the Gospels. As John H. Heller now explains in his firsthand account of the project, *Report on the Shroud of Turin*, they were intensely curious as to how such images could have been made.

The research team spent 120 hours working around-the-clock in an Italian palace, with the shroud spread before them, and then three years back home in experiments and data analysis. They say the images were made by acid oxidation of the linen, but they cannot explain how this might have happened. The blood on the shroud is very old and unquestionably human, they avow, but whose is it? Heller concludes, "The shroud remains, as it has over the centuries, a mystery."

BIRTH OF A LIVING COMPUTER

The "biochip," a tiny computer chip of enormous capacity and made from organic materials, made its debut in the December 1981 issue of *Omni*. "Biochip Revolution" suggested that this extraordinary hybrid would be thousands of times smaller, millions of times faster, and far less expensive than any computer component previously made. The article indicated that biochip implants might restore sight to the blind, hearing to the deaf, and muscle control to people paralyzed by spinal-cord injuries. At the time much of the leading research in biomolecular electronics was confined to an obscure outfit called EMV Associates, in Rockville, Maryland, where James McAlear, EMV's president and cofounder, spoke brazenly of a biocomputer modeled entirely after living systems.

"Over the past two years a great deal has happened, and in a sense nothing has happened," recalled McAlear, who is now head of Gentronix Laboratories, Inc., a company that acquired EMV in July. Interest in the field has increased dramatically, especially since our national defense leans so heavily on computer technology. But the Japanese are hotly pursuing biochips, and a $10 million appropriation for biomolecular-electronics research is in jeopardy as a result of lengthy congressional debates and hearings.

FLASHBACKS

ENTREPRENEURS ON THE HIGH FRONTIER

Captain Robert C. Truax was running against time, money, and NASA in October 1979, when staff writer Kathleen Stein reported his dreams of "A Rocket for the People." He wanted his Volksrocket X-1, assembled in his garage from government-surplus parts, to be the first real, working space shuttle. And if not the first, the cheapest.

Truax, shown above with his rocket, did complete a successful one-minute ground test of his craft in 1980, but he has since run out of money and continues his work out of dedication.

The successful maiden flight of NASA's space shuttle in April 1981 torpedoed one Truax fantasy, and other private citizens have since beaten him to the high frontier. The *Conestoga I*, a small spacecraft, became the first people's rocket in 1982. Fired from a Texas cattle ranch by Space Services Inc. of America, its mission director was former astronaut Deke Slayton, now vice-chairman of the Houston-based company. He smiled proudly as the 36-foot rocket lifted off with a roar and arced to a perfect splashdown ten minutes later in the Gulf of Mexico.

The Reagan Administration has publicly declared its desire to further opportunities for free enterprise in space, and NASA officials see increasing commercialization as an "inevitable step" in the Space Age.

WIRES OF GLASS: A FIBEROPTIC SOCIETY

It all began on the Manitoba prairie in a couple of tiny towns. In Elie and St. Eustache, the Canadian government introduced a bold communications technology called fiberoptics, which can be used to alleviate the technological isolation faced by residents in many rural areas. Technicians replaced telephone wires and underground cables with hair-thin fibers of ultratransparent glass that carry information, in the form of light, much faster and more efficiently than electricity.

Our December 1982 account, "Fiberopolis," hailed fiberoptics as a remedy for many of the ills that plague modern communications. Telephone service, television shows, computerized databases—any kind of communication, we predicted—would soon enter our homes through a single pair of glass fibers.

Omni also foresaw that fiberoptic cables would soon thread through the Northeast Corridor, the nation's busiest telephone route. In early 1983 AT&T began carrying New York–Washington calls on a completed 372-mile stretch of those optical fibers. The first leg of a Sacramento–San Diego link went into operation only a few weeks later. And the best industry projections still mesh with our date of 1988 for the first transatlantic telephone calls by light-wave communications.

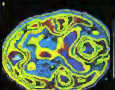
THE MAKING OF DURK AND SANDY

Science writing is hardly the traditional gateway to Hollywood stardom, but former *Omni* contributing editors Durk Pearson and Sandy Shakocius did just that on their road to the top. Clad here in their trademark leotards, the healthy duo of Pearson and Shakocius (she later changed her name to Shaw) penned a how-to piece for *Omni* that set out their prescriptions for boosting intelligence, eliminating depression, prolonging orgasm, and so on.

"Mind Food," which brought in a deluge of 4,000 letters from our readers, was only the beginning for Durk and Sandy, who went on to coauthor *Life Extension*, the million-copy best seller that swears you can add years to your life and life to your years by taking doses of experimental vitamins, amino acids, prescription drugs, and miscellaneous chemicals. The text contains photos of Durk and Sandy posing with bulging muscles, developed despite their sedentary life-styles.

Although there has been arch criticism from experts who object to certain drugs recommended in the book, sales haven't slackened. Proceeds from the royalties, say Durk and Sandy, go to their nonprofit foundation, the Laboratory for the Advancement of Biomedical Research, allowing them to continue their studies into the burgeoning field of life extension.

"In 1981 Omni warned its readers of a medical mystery that was baffling epidemiologists. Today we know it as AIDS."



THE SEARCH FOR A CANCER CURE

Back in 1980, when thousands of cancer patients, including the stricken Shah of Iran, were desperate for interferon, *Omni* began a special report on this research drug. "Cell Defender," published in 1981, suggested that interferon, the body's own virus-fighting agent, would not be the long-sought miracle drug against cancer. Instead, *Omni* predicted that the drug would be used as an adjunct therapy in many medical treatments, from suppressing immune responses in transplant recipients to increasing immune protection for those in danger of massive infection. Interferon is more widely available for testing now, thanks to genetic engineering, and it is being used precisely as predicted.

Kidney-transplant patients, for example, are often defenseless against many diseases. But doctors at Boston's Massachusetts General Hospital found recently that transplant recipients treated with interferon both before and after surgery did not succumb to the typical viral infections.

The preventive protection afforded these patients inspired the research team to begin another round of clinical trials. This time they'll be looking to see whether early doses of interferon can halt the deadly progress of AIDS in individuals just beginning to show symptoms.

THE PHARMACOPOEIA OF THE BRAIN

The discovery of the body's internal opiates, or endorphins (for "the morphine within"), inaugurated a whole new branch of neuroscience, as we reported in "An End to Pain," in February 1979. Researchers were trying to isolate more endorphins, taking stock of the endopharmacopoeia.

Later that year scientists identified the potent "dynorphin," which now appears to be a family of perhaps five related substances. Neuroscientist Candace Pert, who cleared the way for these investigations with her 1973 landmark discovery of the brain's opiate receptor, said in an *Omni* interview in February 1982, "Our brains probably have natural counterparts for just about any drug you could name." She herself was exploring the "Valium receptor," or the specific sites where Valium and similar antianxiety agents work their calming effects.

A research team at the National Institute of Mental Health thought it had found the naturally occurring Valium analog last spring when it isolated a protein that was bound to the Valium receptor. But when the team did tests, the substance failed to quell anxiety; it *produced* it. The endogenous tranquilizer, if it exists, still eludes detection. But work progresses with endorphins, and major discoveries appear likely in the next few years.

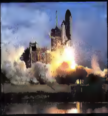
A MEDICAL RIDDLE PANICS AMERICA

In November 1981 *Omni* warned its readers of a medical mystery that was baffling epidemiologists nationwide. "Gay Diseases," in our Continuum section, reported on two mysterious diseases, pneumocystis carinii pneumonia and Kaposi's sarcoma, that were claiming the lives of gay men.

Today we know these maladies as AIDS. In two years' time acquired immune deficiency syndrome has become a widespread epidemic and has produced enough hysteria to suggest the plague. Doctors, moreover, are no closer to understanding its onset, incubation period, or method of transmission. At first some researchers suspected that elements of the gay lifestyle, such as the use of sex-enhancing stimulants, could be the cause of AIDS, but this hypothesis has not held up. Baruj Benacerraf, the Nobel Prize-winning immunologist, revealed in *Omni* that current thinking ascribes the disease to an unidentified virus that attacks the body's immune system.

AIDS meanwhile has killed over 750 of its 2,000-plus victims in the United States since 1981. Most of these have been homosexual males and intravenous-drug users, but Haitians and hemophiliacs also face risks. As epidemiologists struggle to solve one of the most puzzling medical riddles of this century, no end appears near.

FLASHBACKS



THE WIZARD OF SPACE AND TIME

The extraordinary saga of Stephen Hawking, the world-renowned theoretical physicist, continues. From his wheelchair at England's Cambridge University, he pursues his assault on the unknown and continues to confound the doctors who diagnosed a progressive, wasting disease called amyotrophic lateral sclerosis and gave him, in 1963, only a few years to live. Shortly after "The Wizard of Space and Time," one of the first major profiles on Hawking, appeared in February 1979, the scientist's third child, Michael, was born.

Then, in 1980, Hawking was named Lucasian Professor of Mathematics at Cambridge—the same prestigious faculty chair once occupied by Sir Isaac Newton. But whereas Newton's calculations orchestrated a universe as orderly and precise as a minuet, Hawking's theories postulate a heaven filled with such chaotic entities as wormholes and mini-black holes. He has even confronted the cosmic miasma of singularity, where all of Newton's classical laws break down and the traditional notions of space and time fail to have meaning.

Omni received the 1980 American Institute of Physics/U.S. Steel Foundation Award, one of the most prestigious prizes in science journalism, for this affecting story.

A NEW ERA FOR SPACE EXPLORATION

It had become the butt of our jokes, an object of derision for late-night TV comedians. Running three years late, $3.2 billion out of pocket, and shedding heat-shield tiles like a molting bird, the space shuttle had become a national boondoggle. But as *Columbia* finally stood poised for takeoff at Cape Canaveral in 1981, novelist James A. Michener wrote glowingly in *Omni* of her chances for inaugurating a new era of space exploration.

Columbia's flawless flight, from April 12 to 14, silenced the critics, and subsequent performances have restored some of the glory to America's currently limited space program.

In June 1983, *Columbia's* sister ship, *Challenger*, completed the seventh shuttle flight, effortlessly launching two communications satellites from its cargo bay and bringing cheers for the first female crew member aloft, Sally Ride. As our anniversary issue goes to press, *Challenger* is scheduled to fly again on August 20, and NASA has every hope of meeting the September 30 target date for *Columbia's* return to duty—with Spacelab as her payload.

Michener judged that shuttle operations would be so routine by 1984 that fare-paying passengers, including himself, might go along. His timetable was optimistic, although his faith was apparently not misdirected.

SEARCH FOR THE DEATH HORMONE

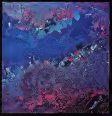
Poets and alchemists alike have long searched for an end to aging, but modern science has all but ignored the pitifully funded field of life extension. But one scientist who has pursued antiaging research is endocrinologist W. Donner Denckla. His remarkable studies on rats hold out the hope of healthier and longer lives for us all.

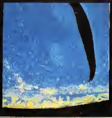
Yet, barely one month after his *Omni* Interview appeared, in November 1981, the fiery Denckla (above) lost his position at the National Institute of Alcoholism and Alcohol Abuse. His revolutionary work on a so-called death hormone, which precipitates the body's decline, has come to a halt.

Investigations continue at other institutions. New experiments with mice and rats at the Jackson Laboratory, in Maine, has bolstered Denckla's theory that a death hormone does exist. Many of the rodents used in the Maine experiments lived longer, regaining a youthful, thick coat and slim body after having their pituitary glands removed. Others displayed improved immune responses especially important in fighting cancer.

Denckla is still trying to raise funds to continue his studies. Although he has made what some biologists believe to be a seminal discovery, the world will have to live without the fruits of his labors for some time to come.

When Omni toured California's fertile Silicon Valley in 1979, just over 100,000 Americans owned a home computer.





IN THE VALLEY OF THE SILICON GIANTS

Somewhere among the orchards and the wildflowers of California's lush Santa Clara Valley stands the birthplace of the microcomputer. In 1979, when *Omni* first toured this sprawling land (a Landsat photograph of the area is shown above) of high-tech concerns ("The Wizards of Silicon Valley"), just over 100,000 Americans owned home computers. The so-called personal computer cost upwards of $1,000 and was used almost solely in business.

But by 1982 a veritable boom market had begun, and over 4 million American households boasted a home computer. In 1983 alone, Americans will buy 5 million more. These range from simple game models to sophisticated systems for market analysis. Annual sales should triple by 1988.

Steve Wozniak and Steve Jobs, the youthful founders of the Apple Computer Company, originally showed their prototype to a few fellow hobbyists at a meeting of the Homebrew Computer Club in the mid-Seventies. Those were the days when computer buffs were regarded as social outcasts. Today's nationwide network of approximately 400 computer clubs is enrolling thousands of new members every month. Expanding computer camps now have adult counterparts, and Club Med has installed 50 Atari computers at its Punta Cana resort.

TREATING ADDICTION: AN ELECTRIC CURE

Not only Pete Townshend but also Keith Richards and Eric Clapton privately sing the praises of a kindly Scottish surgeon who helped them break their addictions to alcohol, heroin, speed, or tranquilizers. Hundreds of less famous ex-addicts also bless Dr. Meg Patterson (above), who invented the small black box that treats patients with NeuroElectric Therapy (NET). The unit transmits a tiny electrical signal that appears to harmonize with natural brain rhythms and reduces craving and anxiety.

After contributing editor Kathleen McAuliffe's account of Patterson's work appeared this past January, the doctor received countless letters from prospective patients. But government approval is yet to be forthcoming. As Patterson observed recently, "No one can say with the FDA." An advanced model of the device will soon be more widely available in *other* countries. It is more sophisticated electronically and fully programmed and automated so that doctors or paramedics will not require extensive training.

A nonprofit foundation is planning to open NET clinics all over the world. It has made her director of her own research institute, the MEGNET Foundation. From its Washington, DC, base she will refine her technique for application in other prevalent disorders.

MONKEYING WITH THE HUMAN BRAIN

Once damaged or destroyed, brain cells are gone forever. Such irrevocability cruelly confronts victims of stroke and nerve diseases. Yet, the brain seems remarkably tolerant of transplanted tissue, whether from another brain, from other organs of the body, or even from animals of another species. The use of brain-tissue transplants to cure paralysis or senile dementia holds enormous promise.

In September 1979, a Continuum report on "Brain Grafts" told how scientists at the National Institute of Mental Health had successfully transplanted cells from healthy rats into the brains of nine rats afflicted with a rodent analog of Parkinson's disease. (Transplanted rat nerve cells are shown above.) Such brain research was still at an incipient stage. Later, in 1982, *Omni* described how Swedish doctors had treated a man with Parkinson's by transplanting tissue from his adrenal gland to his brain. The results were not optimal, but the operation suggested the direction of neurosurgery.

Recently the possibility of using tissue from aborted human fetuses for brain transplants has posed ethical problems. But if doctors are unable to use fetal tissue, cells taken from excised tumors could be another source, according to Rochester School of Medicine researchers. ▢▢

FILM

CONTINUED FROM PAGE 36

ego of the fighter jock In a way Presbyterianism was tailor-made for people who intended to make it in this world as well as on the Plains of Heaven which was a good thing because John Glenn with his country-boy face was as ambitious as any pilot who had ever hauled his happy burden of self-esteem up the pyramid

And this is why Glenn's being rejected as the first American astronaut to fly is more consequential in Wolfe's history of the space program than the selecting of the no less upright but far less zealous Alan Shepard Wolfe has gone for the drama not of man among men but of man against God the unfathomable mystery at the heart of the Protestant Ethic

Curiously for the film version Kaufman has dispensed with all of this (Not to worry An intelligent screenwriter and director Kaufman whose credits include *The White Dawn*, *Invasion of the Body Snatchers* and *The Wanderers*, has earned our trust) He has moved Glenn off center in his screenplay and replaced him with the guiding lights of a different vision Charles Yeager the pilot who broke the sound barrier not because his hardware was superior but because he dared to doubt that there actually was a barrier Also central now is Alan Shepard, the naval officer who dutifully permitted himself to be shot into space (in what Wolfe derided as a patriotic stunt) at a time when American rockets were not particularly flightworthy And Gordon Cooper the irreverent wiseacre in the script s most moving scene ultimately emerges too as the heir apparent to Yeager and his ilk

Kaufman has in his own words "dreamed his way through a time of history But his way is not necessarily Wolfe s Much of the book happened only in its author's imagination It was Wolfe not the test pilots who symbolized the competition among peers as a towering ziggurat It was Wolfe not the astronauts who spoke openly of the right stuff This was never pilots chatter

'No one in the screenplay except one NASA recruiter, says *right stuff* according to Kaufman This is the opposite of *Star Wars* where they can spend the whole movie talking about the Force

Wolfe creates this kind of breathy fiction says Kaufman that echoes reality Kaufman has created his own space fiction more mythical if not so spiritual as Wolfe's, not so ideological and—with luck—not so mercilessly redundant or relentlessly cruel Kaufman has brought to bear movie-style the weight of history His astronauts are not the overachieving narcissists of the book While Wolfe s astronauts are the ultimate conformists Kaufman s are the ultimate nonconformists They are that most enduring of screen bred heroes the altruistic rebel the principled loner Kaufman looks at astronauts and seems to see Cagney in *Ceiling Zero* Stewart in *The Spirit of St Louis* Bogart in *To Have and Have Not* even McQueen in *The Blob* His astronauts are men fighting to preserve an ideal (whether we deserve it or not) traversing the uncharted because that is more important than life itself while all around them politicians exploit it, hucksters peddle it and journalists subvert it twist it into a validation of the status quo (In one hilarious scene Shepard prays Don't let me fuck up which Walter Cronkite translates to the American public as 'He says everything is A-OK)

Wolfe s right stuff is a public affirmation of his private quest Kaufman s is a private compulsion to preserve a public trust Essentially they are both conservative views

Babies unborn when man first walked on the moon (1969) are high-school students now Fifty-eight percent of us were born since Yeager broke the sound barrier (1947) Can we be induced to forget what we daily take for granted 747s, space shuttles *Close Encounters*? And if we cannot forget how can we appreciate what Yeager achieved what Shepard Gus Grissom Glenn Scott Carpenter Wally Schirra Cooper and Deke Slayton braved? How can we experience their heroism? The hardware—that veritable orgy of accumulation that went into the making of this film—is justified by Kaufman s eagerness to have us feel what was at stake when men with the right stuff faced the unknown

That is the relationship between hardware and history That is why Kaufman s crew principally Lieutenant Colonel Duncan Wilmore USAF (Retired) pulled together two Navy A-4 Skyhawks two Navy A-7s one Douglas A 26 one A-37 one B 26 Invader one Boeing B-29 Superfortress one C 130 transport one Hawker Siddley Hunter (modified to resemble a Douglas D 558 Skyrocket) one F 4, one F 86 Sabre two F-104s (borrowed from the German air force we no longer have any) two North American P 51 Mustangs two T-6 Texans five Lockheed T 33s one Bell X-1 Rocket Research Aircraft (Yeager s original is hanging in the Smithsonian Institution) one X 15 five Army transports 12 Army helicopters and one Sikorsky H 34 Choctaw civilian helicopter The bulk of these were acquired from the Air Force the General Services Administration the FBI the Defense Department Lockheed Rockwell and Northrop What was done to secure the aircraft was done as well to secure period trucks carts fire-fighting equipment missiles hoses tubes pipes funnels pumps parachutes space suits and a 1945 Naval Academy class ring Film shooting took place on 20 military and NASA installations in four states and on two ships at sea

The enterprise was massive But out of context it has no historical meaning—in fact no meaning at all The same thing is true of a press that can be counted on for the wow of a thing but not the why ◘◘

INTELLIGENCE

CONTINUED FROM PAGE 46

that can crunch numbers in nanoseconds—billionths of a second—and "learn" from experience. It is an ambitious plan that would marry human and artificial intelligence. The government is taking a two-step approach to bring off the marriage. First it will lift the old programs out of its IBM 9020s and, in effect, drop them into new computers. A few years later it will seek state-of-the-art software for the new air-traffic-control machinery.

"History has shown that when you replace a very large system with a totally new clean-sheet system in one fell swoop, success has a very low probability," Hunt argues. "One of our design goals is to 'modularize' the system so the hardware is easily replaceable. The software would be developed using a high-level language and any of the computer systems on the market could use that same high-level language."

Willis Ware, an electrical engineer at The RAND Corporation who has three decades of experience with computers, takes issue with Hunt's assessment. The FAA's two-step approach is, in his view, "dripping with technological risk for too many reasons. Among others, I would guess that those estimates for software resources are underestimated in terms of what it will actually take to develop them."

What will happen when something goes wrong with AERA? Psychological studies suggest that people are reluctant to overrule computers in simple computations. How will the more complex challenge of managing hundreds of airplanes affect air-traffic controllers? Will they dare to pit their split-second judgment against the machines? Will succeeding generations whose only experience is full automation even have a chance to develop sound judgment about air safety?

A report from The RAND Corporation takes a gloomy view. "By depending on an autonomous, complex, fail-safe system to compensate for keeping the human controller out of the routine decision-making loop, the AERA scenario jeopardizes the goal of safety."

Ironically, the better AERA works, the more complacent its human managers may become, the less often they may question its actions, and the more likely the system is to fail without their knowledge."

Neal Blake, the FAA's deputy associate administrator for engineering, disagrees. "The advent of data-link will increase the safety of the system. As we get improved weather information and improved winds-aloft information, pilots will be able to do a much better job of planning their flight and will minimize the amount of airborne delay. It will be a more efficient flight; there will be fewer missed connections. There won't be the diversions and delays due to weather that you see today." Airlines could realize considerable fuel savings from direct routing. And passengers might arrive sooner on average than they do under the current system. Whether your baggage gets there, of course, is another matter.

NEW WARES: HARD AND SOFT

Unless someone enters the data, computers normally remain insensitive to what's going on around them. A typical personal computer alone, for example, won't sense the temperature and humidity of your room; it can't autonomously control the environment. But a new series of products ($700 and up) from Data Translation provides personal computers with the equivalent of neural connections so they can continuously pick up information from electronic sensors. Lab scientists can use the devices to collect such physiological data as brain-wave potentials instantaneously in digital form. (Data Translation, 100 Locke Drive, Marlboro, MA 01752.)

"Learning Concept: An Introduction to Personal Computers" is an hour-long, five-part videotape that starts out with basic definitions of computer jargon and goes on to explain such typical applications for home computers as word processing, spreadsheets and database retrieval. An accompanying manual provides an introduction to programming. ($99.95, from Micro Learning Concepts, 380 Lexington Avenue, Suite 1208, New York, NY 10017.)

You can turn your home computer into a miniature planetarium with a book called *Celestial BASIC*, by Eric Burgess. The author tells how to program a computer to do everything from creating computer displays of constellations, galaxies and meteor showers to figuring out the date of the next lunar eclipse. The volume contains 23 programs that can be run on the Apple II, IBM PC, TRS-80 and Commodore PET. It also includes calendars and an astronomical conversion table for light-years. ($13.95 from Sybex Inc., 2344 Sixth Street, Berkeley, CA 94710.)

CREDITS

Page 10, Christopher Morrow, Suzanne Lee Houfek, Pat Hill, Maggie Smith, © Gene J. Puskar/Science Source, Inc., Pat Hill, Pat Hill; **page 18,** Sygma; **page 20,** De Es Schwertberger; **page 22,** Rowena Morrill; **page 26,** Henry Ries; **page 28,** © Susan Lichtman; **page 30,** Gottfried Helnwein; **page 34,** Olga Spiegel; **page 36,** © 1982 The Ladd Company; **page 38,** Gottfried Helnwein; **page 44,** Christopher Springmann; **page 46,** © Gabe Palmer/Palmer/Kane, Inc., 1982; **page 52 top,** Olga Spiegel; **page 52 bottom,** © David Scharf/Peter Arnold; **page 53 top,** Margot Conte/Animals Animals; **page 53 bottom,** Olga Spiegel; **page 54 top,** Michael Skott/Image Bank; **page 54 bottom,** Sandia National Laboratories; **page 55 top,** Jerry Telfer/*San Francisco Chronicle*; **page 55 bottom,** W. H. Hodge/Peter Arnold; **page 56 top,** Olga Spiegel; **page 57 top,** Sam C. Pierson, Jr./Photo Researchers; **page 57 bottom,** Jean-Louis Huvé; **page 58 top,** Olga Spiegel; **page 58 bottom,** Anthony Korody/Black Star; **page 100,** D. Maccio/Hervé Serane Galerie F.; **page 108,** Toby Segal/Westinghouse Electric Corporation; **page 126,** Rick Friedman/Black Star; **page 140,** Pete Turner, Al Thelin; **page 141,** Claude Edelman/Black Star, © Holy Shroud Guild; **page 142,** © Homer Sykes/Woodfin Camp, © Greenwood Liaison, Tony Wolff; **page 143,** Eros Data Center, Earl Miller, Dr. Donald Gash; **page 144,** Doug Kirkland, Carl Fischer, Steve Schapiro; **page 146,** B. Barromes/Liaison, Howard Sochurek, Louis Gubb/Liaison; **page 148,** Dickran Palulian/© N.E.C. Electronics USA, Inc.; **page 171,** Olga Spiegel; **page 172 top,** Tony Roberts/Young Artists; **page 172 bottom,** Olga Spiegel; **page 173 top,** Robert Beckhard/International Stock Photo; **page 173 bottom,** Nick Cool Photographics; **page 174 top,** Edris Bennett/Photo Researchers; **page 174 bottom,** Vincent D'Fate; **page 206,** Don McCoy/Black Star; **page 224,** Charles Henry Demuth/Metropolitan Museum of Art, Alfred Stieglitz Collection, 1949

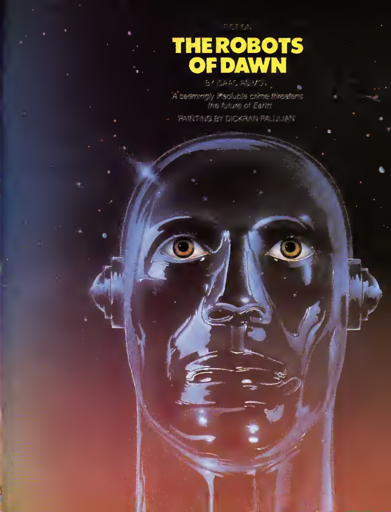
FICTION

THE ROBOTS OF DAWN

BY ISAAC ASIMOV

A seemingly insoluble crime threatens the future of Earth

PAINTING BY DICKRAN PALULIAN



Elijah Baley, a top investigator from Earth, is brought to the planet Aurora to solve a mystery. A humaniform robot, one of only two in existence, has been murdered. During the course of his investigation, Baley must interview master roboticist Kendel Amadiro, who has accused his professional and political rival of the murder.

An Auroran now appeared in the ornate doorway. He was tall, somewhat heavyset, with a round face, a bulbous nose, curly dark hair, swarthy complexion, and a smile.

It was the smile that was most noticeable. Wide and apparently unforced, it revealed prominent teeth that were white and well shaped.

He said, "Ah, it is Mr. Baley, the famous investigator from Earth, who has come to our little planet to show that I am a dreadful villain. Come in, come in. You are welcome. I am sorry if my able aide Roboticist Maloon Cicis gave you the impression that I would be unavailable, but he is a cautious fellow and is a great deal more concerned about my time than I am."

He stepped to one side as Baley walked in, and tapped him lightly on the shoulder blade as he passed. It was a gesture of friendship that Baley had not experienced on Aurora.

Baley said, cautiously (was he assuming too much?), "I take it you are Master Roboticist Kendel Amadiro?"

"Exactly. Exactly. The man who intends to destroy Dr. Han Fastolfe as a political force upon this planet—but that, as I hope to persuade you, does not really make me a villain. After all, I am not trying to prove that it is Fastolfe who is a villain simply because of the foolish vandalism he committed on the structure of his own creation, poor Jander. Let us say only that I will demonstrate that Fastolfe is—mistaken."

He gestured lightly, and the robot who had guided them in stepped forward and into a niche.

As the door closed, Amadiro gestured Baley jovially to a well-upholstered armchair and, with admirable economy, indicated, with his other arm, wall niches for Daneel and Giskard as well.

Baley noticed that Amadiro stared at Daneel with a moment's hunger. His smile disappeared for that moment, and a look that was almost predatory appeared on his face. It was gone quickly and he was smiling again. Baley was left to wonder if that momentary change of expression was an invention of his own imagination.

Amadiro said, "Since it looks as though we're in for some mildly nasty weather, let's do without the ineffective daylight we are now dubiously blessed with."

Somehow (Baley did not follow exactly what it was that Amadiro did on the control panel of his desk) the windows opacified and the walls glowed with gentle daylight.

Amadiro's glance fixed itself on Daneel again. "A remarkable job, this humaniform robot," he said. "It is astonishing how close to his vest Fastolfe kept things. And it is a shame that Jander was lost. There, Fastolfe did the unforgivable."

"Dr. Fastolfe, sir, denies that he was in any way implicated."

"Yes, Mr. Baley, of course he would. Does he say that *I* am implicated? Or is my implication entirely your own idea?"

Baley said deliberately, "I have no such idea. I merely wish to question you on the matter. As for Dr. Fastolfe, he is certain you have had nothing to do with what happened to Jander because he is quite certain you lack the knowledge and capacity to immobilize a humaniform robot."

If Baley had hoped to stir things up with his comment, he failed. Amadiro accepted the slur with no loss of good humor and said, "In that he is right, Mr. Baley. Sufficient ability is not to be found in any roboticist alive or dead, except for Fastolfe himself. Isn't that what he says, our modest master of masters?"

"Baley noticed that Amadiro stared at Daneel with a moment's hunger. A look that was almost predatory appeared on his face. It was gone quickly and he was smiling again."

"Yes, he does."

"Then whatever does he say happened to Jander?"

"A random event. Purely chance."

Amadiro laughed. "Has he calculated the probability of such a random event?"

"Yes, master roboticist. Yet even an extremely unlikely event might happen if there are incidents that better the odds."

"Such as?"

"That is what I am hoping to find out. Dr. Amadiro. Are you the head of the Robotics Institute?" Baley asked.

"Yes, I am."

"And its founder?"

"Correct."

"How long has it been in existence?"

"As a concept—decades. I have been gathering like-minded people for at least fifteen years. Building began nine years ago, and active work began six years ago. In its present completed form the Institute is two years old, and there are long-range plans for further expansion."

"Why did you find it necessary to set up the Robotics Institute, Dr. Amadiro?"

"Ah, Mr. Baley."

At this point, a robot brought in a tray of small sandwiches and still smaller pastries, none of which were familiar to Baley. He tried a sandwich and found it crunchy and not entirely unpleasant, but it was odd enough for him to finish it only with an effort. He washed it down with what was left of his water.

Amadiro watched this with a kind of gentle amusement and said, "You must understand, Mr. Baley, that we Aurorans are unusual people. So are Spacers generally, but I speak of Aurorans in particular now. We are descended from Earthpeople—something most of us do not willingly think about—but we are self-selected."

"What does that mean, sir?"

"Earthpeople have long lived on an increasingly crowded planet and have drawn together into still more crowded cities that finally became the beehives and anthills you call Cities with a capital C. What kind of Earthpeople would leave Earth and go to other worlds that are empty and hostile in order to build new societies that they could not even enjoy in their own lifetime?"

"Rather unusual people, I suppose."

"Quite unusual. Specifically, people who are not so dependent on crowds of their fellows that they lack the ability to face emptiness. People who even prefer emptiness, who would like to work on their own and face problems by themselves, rather than hide in the herd and share the burden. Individualists, Mr. Baley."

"I see that."

"And our society is founded on that. Every direction in which the Spacer worlds have developed further emphasizes our individuality. We are proudly human on Aurora, unlike the huddled sheep on Earth. Mind you, Mr. Baley, I used the metaphor not as a way of deriding Earth. It is simply a society I find unadmirable, but you, I suppose, find comforting and ideal."

"What has this to do with the founding of the Institute, Dr. Amadiro?"

"Even proud and healthy individualism has its drawbacks. The greatest minds, working singly, cannot progress rapidly if they refuse to communicate their findings. A knotty puzzle may hold up a scientist for a century, when a colleague may have the solution already and is not even aware that there is a puzzle to solve. The Institute is an attempt, in the field of robotics, to introduce a certain community of thought."

"Is it possible that the particular knotty puzzle you are attacking is the construction of a humaniform robot?"

Amadiro's eyes twinkled. "Yes, that is obvious, isn't it? It was twenty-six years ago that Fastolfe's new mathematical system, which he called intersectional analysis, made it possible to design humaniform robots. But he kept the system to himself. Years afterward, when all the difficult technical details were worked out, he and Sarton applied the theory to the design of first Daneel, then Jander. Those details were

From the book *The Robots of Dawn*, by Isaac Asimov. Copyright © 1983, by Nightfall, Inc. To be published in the United States by Doubleday & Company, Inc. To be published in the United Kingdom by Granada Publishing Ltd.

also kept a closely guarded secret

"Most roboticists shrugged and felt that this was natural They could only try individually, to work out the details for themselves I on the other hand conceived of an institute in which efforts would be pooled If wasn't easy to convince other roboticists of the usefulness of the plan or to persuade the Legislature to fund it against Fastolfe's formidable opposition, but here we are

'Why was Dr Fastolfe opposed?'

'Ordinary self-love fo begin with I have no fault to find with that you understand It comes with the territory of individualism The point is that Fastolfe considers himself the greatest roboticist in history and also considers the humaniform robot his own particular achievement He doesn t want that achievement duplicated by a group of roboticists I imagine he viewed it as a conspiracy of inferiors to dilute and deface his own great victory '

You say that was his motive for opposition fo begin with That means there were other motives What were they?"

'He objects to our plans for the use of these humaniform robots

What uses are these Dr Amadiro?'

Now now Let s not be ingenuous Surely Dr Fastolfe has told you of the Globalist plans for settling the Galaxy?"

'That he has and for that matter Dr Vasilia has spoken to me of the difficulties of scientific advance among individualists However that does not stop me from wanting to hear your views on these matters

Very well I—we I should say for the people at the institute are like-minded in this—look into the future and wish to see humanity continuing to open newer planets to settlement We do not however want the process of self-selection to destroy the older planets or to reduce them to moribundity as in the case—pardon me—of Earth We don't want the new planets to take the best of us and leave behind the dregs You see that don't you?

Please go on

In any robot oriented society as in the case of our own the easy solution is to send out robots as settlers The robots will build the society and the world and we can then follow later without the process of selection We can go on to new worlds without leaving home so to speak

'Won t the robots create robot worlds rather than human worlds?

'Exactly if we send out robots that are nothing but robots We have however the opportunity to send out humaniform robots like Daneel here who while creating worlds for themselves would automatically create worlds for us Dr Fastolfe however objects to this He finds some virtue in the thought of human beings carving a new world out of a strange and forbidding planet He does not see that the effort to do so would not only cost enormously in human life but would also create a world molded by catastrophic events into something not at all like the worlds we know

'As the Spacer worlds today are different from Earth and from one another?'

Amadiro for a moment lost his joviality and looked thoughtful Actually Mr Baley you touch an important point I am discussing Aurora only The Spacer worlds do indeed differ among themselves and I am not overly fond of most of them It is clear to me—though I may be prejudiced—that Aurora the oldest among them is also the best and most successful I don t want a variety of new worlds of which only a few might be really valuable I want many Auroras uncounted millions of Auroras and for that reason I want new worlds carved into Auroras *before* human beings go there That's why we call ourselves Globalists by the way We are concerned with *this* globe of ours—Aurora—and no other

Do you see no value in variety?'

'If the varieties were equally good Mr Baley, perhaps there would be value, but if some or most are inferior how would that benefit humanity?

"It is indeed our thought to devise some scheme whereby robots can produce babies that can grow and mature—at least until they establish the kind of society we want"

When do you start this work?'

When we have the humaniform robots with which to do it So far there were Fastolfe's two one of which he destroyed His eyes strayed briefly to Daneel as he spoke

'When do you think you will have humaniform robots?

That is difficult to say We have not yet caught up with Dr Fastolfe

Even though he is one and you are many Dr Amadiro?

Amadiro twitched his shoulders slightly You waste your sarcasm Mr Baley Fastolfe was well ahead of us to begin with and though the institute has been in embryo for a long time we have been fully at work for only two years Besides, it will be necessary for us not only to catch up with Fastolfe but to move ahead of him Daneel is good but he is only a prototype

How must the humaniform robots be improved beyond Daneel s mark?

Obviously they must be even more human They must exist in both sexes and there must be the equivalent of children We must have a generational spread if a sufficiently human society is to be built up on the planets

I think I see difficulties Dr Amadiro

No doubt There are many Which difficulties do you foresee Mr Baley?"

"If you produce humaniform robots that are so humaniform they can produce a human society and if they are produced with a generational spread in both sexes how will you be able to distinguish them from human beings?

Will that matter?"

'It might If such robots are too human, they might melt into Auroran society be come part of human family groups and then they might not be suitable for service as pioneers

Amadiro laughed ' That thought clearly entered your head because of Gladia Delmarre s attachment to Jander You see I know something of your interview with that woman from my conversations with Gremionis and with Dr Vasilia I remind you that Gladia is from Solaria and her notion of what constitutes a husband is not necessarily Auroran in nature

I was not thinking of her in particular I was thinking that sex on Aurora is broadly interpreted and that robots as sex partners are tolerated even now If you really cannot tell a robot from a human being—

There's the question of children Robots cannot father or mother children '

But that brings up another point The robots will be long-lived since the building of the society may take centuries

'They would in any case have to be long-lived if they are to resemble us '

And the children—also long-lived?

Amadiro did not speak

Baley said, These will be artificial robot children and will never grow older they will not age and mature Surely this will create an element sufficiently nonhuman to cast the nature of the society into doubt

Amadiro sighed You are penetrating Mr Baley It is indeed our intention to devise some scheme whereby robots can produce babies that can in some fashion grow and mature—at least until they establish the society we want

And then when human beings arrive, the robots can be restored to more robotic schemes of behavior

Perhaps—if that seems advisable '

And this production of babies? It would be best if the system used were as close to human as possible wouldn t it?"

' Possibly '

Sex fertilization, birth?

Possibly

And if these robots form a society so human that they cannot be differentiated from human then when true human beings arrive might it not be that the robots would resent the immigrants and try to keep them off? Might the robots not react to Aurorans as you react to Earthpeople?

Mr Baley the robots would still be bound by the Three Laws '

"The Three Laws speak of refraining from harm to human beings and of obeying human beings

Exactly

And what if the robots are so close to human beings that they regard *themselves* as the human beings? They might place themselves above the immigrants."

"My good Mr. Baley, why are you so concerned with all these things? They are for the far future. There will be solutions as we progress in time. And as we understand, by observation, what the problems really are."

"It may be, Dr. Amadiro, that Aurorans will not approve of what you are planning once they understand what it is. They may prefer Dr. Fastolfe's views."

"Indeed? Fastolfe thinks that if Aurorans cannot settle new planets directly and without the help of robots, then Earthpeople should be encouraged to do so."

Baley said, "It seems to me that that makes good sense."

"Because you are an Earthman, my good Baley. I assure you that Aurorans would not find it pleasant to have Earthpeople swarming over the new worlds, forming some sort of Galactic Empire and reducing the Spacer worlds to insignificance or even extinction."

"But the alternative to that is worlds of humaniform robots building quasi-human societies and allowing no true human beings among themselves. There would gradually develop a robotic Galactic Empire. Surely Aurorans would prefer a human Galactic Empire to a robotic one."

"What makes you so sure of that?"

"The form your society takes now makes me sure. I was told on my way to Aurora that no distinctions are made between robots and human beings on Aurora. But that is clearly wrong. It may be a wished-for ideal. Aurorans flatter themselves that it truly exists, but it does not."

"You've been here—what?—less than two days, and you can already tell?"

"Yes, Dr. Amadiro. It may be precisely because I'm a stranger that I can see clearly. I am not blinded by customs and ideals. Robots are not permitted to enter Privates, and that's one distinction that is clearly made. It permits human beings to find one place where they can be alone. You and I can sit at our ease, while robots remain standing in their niches, as you see." Baley waved his arm toward Daneel. "I think that human beings, even Aurorans, will always be eager to make distinctions and to preserve their own humanity. As soon as the Aurorans see the implications of your plan, they will turn against you."

"Mr. Baley, do you think you have discovered a secret? That I have told you something that our world does not already know? That my plans are dangerous but that I blab them to every newcomer? I imagine you may think that if I talk to you long enough, I will surely produce some verbal folly that you will be able to make use of. I am not likely to. My plans for ever more humaniform robots, for robot families, and for as human a culture as possible are all on record. Available to all."

Baley said, "Does the public know?"

"Probably not. The general public has its own priorities and is more interested in the next meal, the next hyperwave show, the next space-polo contest, than in the next century and the next millennium. Still, the general public will be as glad to accept my plans as the intellectually minded are. Those who object will not be numerous enough to matter."

"Can you be certain of that?"

"Oddly enough, I can be. You don't understand, I'm afraid, the intensity of the feelings that Aurorans and Spacers generally have toward Earthpeople. I don't share those feelings, mind you, and I am, for instance, quite at ease with you. I don't have that primitive fear of infection. I don't imagine that you smell bad. I don't attribute to you all sorts of personality traits that I find offensive. I don't think that you and yours are plotting to take our lives or steal our property—but the large majority of Aurorans have all these attitudes. It may not be very close to the surface, and Aurorans may bring themselves to be very polite to individual Earthpeople who seem harmless, but put them to the test and all their hatred and suspicion will emerge. Tell them that Earthpeople are swarming over new worlds and will preempt the Galaxy, and they will howl for Earth's destruction."

"Even if the alternative to that were a robot-controlled society?"

"Certainly. You don't understand how we feel about robots. We are familiar with them. We are at home with them."

"No. They are your servants. You feel superior to them and are at home with them only while that superiority is maintained. If you are threatened by an overturn, by having *them* become your superiors, you will react with horror."

"You say that only because that is how Earthpeople would react."

"No. You keep them out of the Privates. It is a symptom."

"They have no use for those rooms. They have their own facilities for washing, and they do not excrete. Of course, they are not truly humaniform. If they were, we might not make that distinction."

"You would fear them more."

"That's foolish," said Amadiro. "Do you fear Daneel?"

Baley's silence was eloquent, and Amadiro pursued his advantage.

"Right now," he said, "you are unmoved by the fact that Giskard is standing, silent and unresponsive, in an alcove, but I can tell by small examples of body language that you are uneasy because Daneel is doing so. You feel he is too human in appearance to be treated as a robot. You don't fear him because he looks human."

"I am an Earthman. We have robots," said Baley, "but not a robot culture. You cannot judge from my case."

"What case can you judge from, then? You are only guessing. To me it seems obvious that if a robot is human enough, he

"I'm sorry, my dear. It was the old ticker."

would be accepted as human Do you demand proof that *I* am not a robot? The fact that I *seem* human is enough In the end we will not worry whether a new world is settled by Aurorans who are actually human if no one can tell the difference But—human or robot—Aurorans either way '

Baley s assurance faltered He said unconvincingly What if you never learn how to construct a humaniform robot?"

"Why wouldn t we?"

' It may be that any number of mediocrities do not add up to one genius

Amadiro said, shortly We are not mediocrities And Fastolfe may yet find it profitable to come in with us

"I don't think so

I do He will not enjoy being without power in the Legislature and when our plans for settling the Galaxy move ahead and his opposition does not stop us he will join us

"I don t think you will win," said Baley

'Because you think that somehow this investigation of yours will exonerate Fastolfe and implicate me

' Perhaps '

Amadiro shook his head My friend if I thought that anything you could do would spoil my plans would I be sitting still and waiting for destruction?

You are not You are doing everything you can to have this investigation aborted Why would you do that if you were confident that nothing I could do would get in your way?

Well said Amadiro, you *can* get in my way by demoralizing some of the members of the institute You can't be dangerous but you can annoying So if I can I'll put an end to the annoyance—but I'll do that in reasonable fashion even gentle fashion If you were actually *dangerous*—

"What could you do in that case?

"I could have you seized and imprisoned until you were evicted I don't think Aurorans would worry overmuch about what I might do to an Earthman

Baley said You are trying to browbeat me and that won t work You know very well you could not lay a hand on me with my robots present '

Amadiro said Does it occur to you that I have a hundred robots within call? What would yours do against that?

All hundred could not harm me They cannot distinguish between Earthmen and Aurorans I am human within the meaning of the Three Laws '

"They could hold you quite immobilized without harming you while your robots were destroyed "

Not so ' said Baley Giskard heard you, and if you make a move to summon your robots Giskard will have *you* immobilized He moves very quickly and once that happens your robots will be helpless even if you manage to call them They will understand that any move against me will result in harm to you '

' You mean that Giskard will hurt me? '

"To protect me from harm? Certainly He will kill you if it becomes necessary "

Surely you don't mean that

"I do, said Baley "Daneel and Giskard have orders to protect me The First Law in this respect has been strengthened with all the skill Dr Fastolfe can bring to the job If my robots must choose between harm to you and harm to me Earthman though I am they will choose to harm you I imagine you are well aware that Dr. Fastolfe is not very eager to ensure *your* well-being

Amadiro chuckled and a grin wreathed his face ' I'm sure you re right in every respect, Mr Baley but it *is* good to have you say so You know my good sir that I am recording this conversation and I m glad of it It is possible that Dr Fastolfe will erase the last part of this conversation but I assure you I won't It is clear from what you have said that he is quite prepared to devise a robotic way of doing harm to me—even killing me if he can manage that—whereas it cannot be said that I plan any physical harm to him whatever Which of

> *What if the robots are so close to human beings that they regard themselves as the human beings? They might then place themselves above the immigrants*

us is the villain Mr Baley? I think you have established that and I think then that this is a good place to end the interview

He rose still smiling and Baley swallowing hard stood up as well

Amadiro said, I still have one thing to say however It has nothing to do with our little contretemps here on Aurora—Fastolfe s and mine Rather with your own problem Mr Baley

'My problem?

Perhaps I should say Earth s problem I imagine that you feel very anxious to save poor Fastolfe from his own folly because you think that it will give your planet a chance for expansion You are quite wrong rather arsy-versey to use a vulgar expression I ve come across in some of your planet s historical novels

I'm not familiar with the phrase ' said Baley stiffly

' I mean you have the situation reversed You see when my view wins out in the Legislature—and note that I say *when* and not *if*—Earth will be forced to remain in her own planetary system Aurora will have the prospect of expansion and of establishing an endless empire If we then know that Earth will merely be Earth and never anything more she will be of no concern to us With the Galaxy at our disposal we will not begrudge Earthpeople their one world We would even be disposed to make Earth as comfortable a world for her people as would be practical

'On the other hand, Mr Baley if Aurorans do what Fastolfe asks, and allow Earth to send out settling parties then it won t be long before it will occur to an increasing number of us that Earth will take over the Galaxy and that we will be encircled and hemmed in We will be doomed to decay and death After that there will be nothing I can do My own quite kindly feeling toward Earthmen will not be able to withstand the general kindling of Auroran suspicion and prejudice It will then be *very* bad for Earth

So if Mr Baley you are truly concerned for your own people, you should hope that Fastolfe does not succeed in foisting upon this planet his very misguided plan You should be an ally of mine Think about it '

Amadiro was smiling as broadly as ever but it was all wolf now

Baley and his robots followed Amadiro out of the room and along the corridor

You must understand my good Mr Baley he went on that I am quite an aficionado of Earth and its culture It is not the most popular of subjects on Aurora but I find it fascinating I am particularly interested in Earth's history the days when it had a hundred languages and Interstellar Standard had not yet been developed May I compliment you by the way on your own handling of Interstellar?

This way, this way he said turning a corner ' We ll be coming to the pathway-simulation room which has its own weird beauty and we may have a mock-up in operation Quite symphonic actually But I was talking about your handling of Interstellar It is one of the many Auroran superstitions concerning Earth that Earthpeople speak an all-but-incomprehensible version of Interstellar

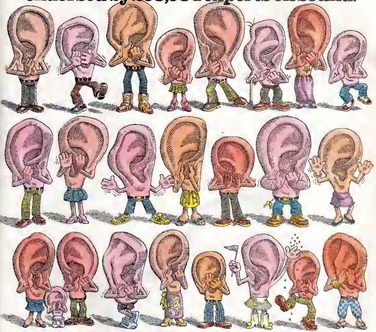
"I ve tried reading Shakespeare" he said with a confidential air "but I can t read him in the original and the translation is curiously flat I can t help believing that the fault lies with the translation and not with Shakespeare I do better with Dickens and Tolstoy perhaps because that is prose although the names of the characters are in both cases unpronounceable

' What I m trying to say Mr Baley is that I m a friend of Earth I really am I want what is best for it Do you understand?' He looked at Baley and again the wolf showed in his twinkling eyes

"I m afraid I cannot oblige you Dr Amadiro I must be about my business, and I have no further questions to ask of either you or anyone else here Let me go sir or I will ask my robots for help

' You had but to express the wish I will take you to the nearest exit and if ever you are on Aurora again, return and you may have the tour I promised you ◘◘

The only cassette deck in America endorsed by 258,984 experts on sound.



Last year, more ears applauded Sony than any other line of cassette decks.

And Sony even delighted the ears of professional critics of sound. Like the editors of leading publications, who have consistently rated Sony decks above all others in their price class.

Perhaps it's the performance—which is enhanced by Sony's unique LaserAmorphous™ heads and advanced Dolby* G noise reduction—that earns our decks such wide acclaim.

Or perhaps it's the convenience of such features as feather-touch controls. A linear tape counter that displays actual elapsed time in minutes and seconds. And systems that locate and play songs automatically.

Regardless, Sony cassette decks continue to win applause everywhere they're heard.

Which doesn't mean we're asking you to buy a Sony merely on hearsay. Instead, we invite you to audition one of the new Sony cassette decks at your nearest audio dealer. And simply listen to what your ears say.

SONY.
THE ONE AND ONLY

The leading expert on space colonies unveils his plan for building factories in orbit by 1992

CONQUEST OF SPACE

BY GERARD K. O'NEILL

Trends that cannot be reversed make the decades ahead very dangerous—potentially catastrophic—here on our planet. Our land area and mineral resources are limited and can never be extended. They are being pressed more and more severely by a world population that will double in 40 years and rise to three times today's population 30 years after that.

We human beings are problem solvers by nature, and our response to those threats should not be a wringing of hands but an exploration of the ways to solve serious resource and environmental problems. We must find unlimited low-cost energy and make it available to everyone, not just the nations favored with large fuel reserves. And we must tap mineral resources to sustain new industries without damaging Earth's environment. There are limited short-term solutions to some of the world's major problems. But the only viable long-term solution is to begin using the energy and material resources that lie beyond our finite planet—in space itself. That will be a healthy development for another reason. It will draw us outward, encouraging the human settlement of space. For those who already look toward the space colonies that will result from space industry, the immediate question is: What form will that industry take?

If research under way continues to meet its goals, we could establish a substantial industry in high orbit, 200,000 miles above Earth, before the end of this century. Within decades the products of space industry could exceed 1 million tons per year—small compared to the great industries of Earth but worth more than $100 billion annually. The raw materials to feed that industry would come from the surface of the moon. Lunar materials would be separated into pure elements in high orbit, where constant sunlight would supply the energy for extracting metals and fabricating them into finished products. At first many of the workers for that industry would remain on Earth, monitoring and controlling robotic machines through radio and television links. A few, mainly highly skilled troubleshooters, would live in orbit for duty tours of six months or more.

The initial products of industry in space will be solar-power satellites, giant arrays that collect the bountiful sunlight of high orbit and convert it to radio energy. That radio energy will then be sent to Earth for conversion to electricity, ultimately providing our civilization with all the electrical power we need *with-*

PAINTING BY JOHN BERKEY

out polluting planet Earth's biosphere

Up until now, of course, there has been just one valuable product of commercial activities in space: information. Satellites equipped with sensors produce data on large-scale weather patterns including tropical storms. And satellites orbiting just above Earth's atmosphere use sensitive television cameras to take pictures of the land. From that detailed imagery computers can pick out subtle color changes which indicate the presence of oil, metals, and fresh or salt water beneath the earth's surface. Satellites also relay information from one ground location to another or to entire continents. There are now more than 100 of these satellites and more of them rocket into orbit every month.

The success of information satellites—and the dearth of any other space industry—can be explained by a fundamental fact: Information has great value, but it weighs nothing. The cost of launching a satellite from the earth to geostationary orbit (an orbit in which a satellite stays at a fixed point in the sky as seen from Earth) is currently about $18,000 per pound of satellite weight. But once a satellite is up there, it can produce or relay information for virtually nothing. For such established information products as telephone messages or TV program time, a relay satellite can pay back its entire cost of manufacture and launch in a year or less.

As soon as we look beyond the area of information, though, commercial opportunities in space become far more limited because we are up against the costs of lifting raw materials into orbit. Rates to low-Earth orbit for shuttle cargo range from $1,250 per pound to $11,000 per pound. The low figure is for high-density cargo in bulk. The high figure is more typical of shuttle payloads so far and applies to complex low-density objects, of which satellites are the prime example. Any product made of materials that must be brought from Earth on the shuttle, processed in orbit, and returned to Earth for sale must include that high price of lift as an item in its production cost. Pharmaceuticals, which NASA has targeted for early commercial production, are among the few products on Earth that sell for such rarefied prices.

If the industrialization of space is to play a significant role in the total economic picture, it must compete in one of the major markets on Earth. It cannot do so in most of the new high-technology markets, including electronics and robotics, because such products couldn't be manufactured more efficiently in the space environment than in factories on Earth.

Yet there is one large-scale market for which space industry makes sense: energy, which, like information, can be transmitted without the flow of materials. More than five years ago power at a level of 100 kilowatts was transmitted by radio waves over a distance of one mile in tests at Goldstone, California. While that transmission would have to be scaled up by 10,000 to 100,000 times to reach the power level of a typical electric-generating station, the feat would require no new physics. The energy beam would be larger in area but would not have to be more intense.

Some 15 years ago Peter Glaser of the Arthur D. Little international consulting company in Cambridge, Massachusetts, suggested transmitting energy from space. Large satellites fitted with solar cells could be located in geostationary orbit. There they would convert sunlight to radio waves which could be beamed back to the earth. The idea made sense. Sunlight is an intense, reliable resource in high orbit, available 24 hours per day during most of the year. Only in the spring and autumn is a geostationary array eclipsed and then only for predictable periods of less than 40 minutes each midnight.

> "If research continues to meet its goals, we could establish a substantial industry in high orbit before the end of this century. The products of space could exceed 1 million tons a year."

Unfortunately, Glaser's good idea never gained acceptance, and the problem lies with its friends as well as its enemies. NASA and its aerospace contractors latched on to the Glaser plan as a wonderful reason for a massive new space program. Engineers drew up designs for monster versions of the shuttle—wholly reusable space planes that could carry payloads of several hundred tons. The giant rocket planes were to weigh 20,000 tons at liftoff—ten times as much as today's shuttle.

Companies working on NASA study contracts drew up plans for solar-power satellites that would be as light as possible. Their components could be lifted from Earth in those giant supershuttles and assembled in orbit. The program planners worked up a schedule of several flights per day for the huge rocket planes. That schedule would have had to be maintained for a year if even one power satellite were to be installed.

During the Seventies many studies of solar-power satellites were carried out. In the most comprehensive investigation, the Department of Energy (DOE) spent three years and about $15 million to explore the concept. About two thirds of the funding went into environmental-impact studies. Somewhat to its own surprise the DOE found no serious environmental impact from the transmission of energy by radio beams. There are two reasons for the clean bill of health. First, the intensity of the radio beam was only about the same as the intensity of sunlight. Second, at the frequency of the radio waves, the packets of energy in the beam—in physics terms, the quanta—were only 0.001 percent as strong as those of sunlight and therefore much too weak to damage living tissue. There had never been a question of danger to humans, because the receiving antenna would be mounted on posts above ground level and inside a fenced enclosure. But no one could prevent birds or insects from flying through the beam. The DOE-sponsored experiments found that the radio waves had no effect on birds. And in another experiment no effect was found on even so subtle a natural phenomenon as the dancing pattern of bees.

Despite the fundamental attractiveness of the solar-power satellite, it was shot down by the National Research Council (NRC) of the National Academy of Sciences. The NRC's negative conclusion resulted from its analysis of economics. With evidence of escalating shuttle-flight costs fresh in mind, the reviewers concluded that the supershuttles could never operate as inexpensively as the people at NASA hoped. They also refused to believe that solar cells, the basic energy-conversion mechanisms for power satellites, could ever be made cheaply enough. The NRC study concluded that power satellites could probably be built and would probably be acceptable environmentally, but that they could never compete economically with coal or nuclear electric power.

In my view that entire sad history played out over more than a decade was a classic example of asking the wrong question and getting a useless answer. Although I believe the power-satellite concept is fundamentally sound, NASA's approach to making it happen collided head-on with basic physics. The energy cost of lifting a power satellite into geostationary orbit is huge because we on Earth are at the bottom of a gravity well that is 4,000 miles deep. Fighting gravity forced NASA's designers into two traps. One, the direct cost of lift, was obvious. The other was a little less apparent. Because the designers had to fight those high lift costs, they proposed lightening the satellites by using complex, costly designs and exotic, equally costly materials. For example, in converting solar energy to electricity they had to use lightweight but extremely expensive pure-crystal silicon solar cells. They could not use the much less expensive amorphous-silicon solar cells, because those would have been heavier per watt of power. Nor could they use heavy turbogenerators

Editors' note: Gerard K. O'Neill is a physicist at Princeton University, president of the Space Studies Institute in Princeton, New Jersey, and a leading advocate of industry in space. O'Neill's 1976 book The High Frontier *presented a persuasive argument for colonization of space.*

producing electricity from sunlight concentrated by mirrors though that would have been a relatively simple low-technology solution to the energy-conversion problem But if NASA got the wrong answer by asking the wrong question what is the right question?

The right question, I suspect, is What is the simplest, lowest-risk design for a solar-power satellite that could be made out of materials already at the top of Earth's gravity well? We have a large mine of materials up there, and it has already been assayed more carefully than all but a few mines on Earth The mine is the surface of the moon From the Apollo project we know that the material of the lunar surface is about 30 percent metals by weight 20 percent silicon and 40 percent oxygen The metals and silicon are just right for building a solar-power satellite, and oxygen is the gasoline of space constituting about 86 percent of the weight of rocket propellant Continuing to ask what we hope are right questions we should explore methods for building solar-power satellites from lunar materials within the limitations of the space-shuttle transportation system

In the past five years one organization has been working quietly and effectively to ask those right questions and to arrive at sensible answers The organization which I founded in 1977 with the help of some friends is the Space Studies Institute (SSI) a nonprofit corporation located in Princeton New Jersey just outside the Princeton University campus The institute is supported by donations from thousands of members, it neither asks for nor accepts government money Unlike most space-related organizations SSI does not agitate for governmental action Instead it has taken on the responsibility for directly funding basic scientific and engineering research That has kept SSI in a relatively low profile compared with most other space related private groups but it has also made it effective and consistent Our organization's purpose to find a practical approach to satellite power and the more general goal of space industry beginning the peaceful human conquest of the high frontier

Soon after SSI's formation, we held a series of workshops to develop a cost-effective plan for the development of space industry The workshop ground rules included staying within the limitations of the shuttle which can lift only about 29 tons of cargo to orbit on each flight We developed a scenario for space industry through those workshops

Pilot plants remote-controlled and small enough to be transported by today's rockets would carry out the key industrial functions material transport extraction of pure elements and fabrication of finished products The pilot plants would be of several kinds One would scoop up lunar-surface soil and sinter it with heat and pressure into solid durable spheres The second would transport the spheres of lunar soil to a point in high orbit above the moon A third would process the lunar soil into pure elements alloys and composites And the fourth would fabricate those industrial materials into finished products The products would be the heavier simpler components of more pilot plants identical to the first In that way space industry could grow geometrically 1 2 4, 8 ... through eight doublings until 256 pilot plants would have been built That scheme would provide us with sufficient industrial capacity to build solar-power satellites

The results of the SSI workshops were published in two articles in the journal *Astronautics and Aeronautics* According to those articles an investment of $7 billion or $8 billion over a five year period comparable to the investment that built the Alaska pipeline would be enough to produce about one power satellite per year Each power satellite could be sold to a nation or a utility for about $10 billion And each could supply the earth with continuous electric power equal to the output of ten nuclear plants The potential world market for power satellites that undersell coal and nuclear-power plants is well over $200 billion a year During the course of our workshops we also reasoned that two other products less complex than power satellites could be marketed in the short term liquid oxygen for use as rocket propellant and raw lunar soil excellent for shielding orbital space stations and factories from cosmic radiation

In a separate research effort Hannes Alfven an adviser to SSI, suggested that there might be asteroidal material trapped in the earth's orbit around the sun by the combined gravitational forces of those two bodies It was easy to calculate the energy cost of retrieving that material and it was very low—about 0.05 percent of the energy cost for lifting materials out of Earth's gravity well to the same high orbit It was far more difficult to decide whether asteroids in that orbit could have remained trapped since the formation of the solar system, given the perturbations of all the other planets Under an SSI grant to Princeton University Scott Dunbar studied the problem mathematically and concluded that despite all perturbations asteroidal materials could very probably still be within Earth's orbit Dunbar received his Ph D from Princeton on the basis of that research Then he received an NRC fellowship to work with Eugene Shoemaker and Eleanor Helin at Caltech, in part to search for that material with the large Schmidt telescope at Mount Palomar

Whether the raw materials for space industry come from the moon or from trapped asteroids they must be separated into pure elements for most industrial uses In 1981 SSI made a substantial grant to Rockwell International the builders of the space shuttle Under that grant Rockwell's Robert Waldron measured the key reactions

"Maintenance? We've had a computer malfunction" for separation of lunar minerals into pure aluminum, iron, titanium, silicon, oxygen, and other elements. Waldron's results, now being written up as a final report, indicate that a processing plant in space or on the moon could process roughly 100 times its own weight in soil each year and that very few chemical materials would have to be brought from the earth to keep such a processing plant running.

Although our energy cost for bringing materials from the moon to an orbital industrial site would be only 5 percent of the cost of bringing them from Earth, we would still need a machine to carry out that transport. For the past several years SSI has funded development of the "mass-driver," an electromagnetic catapult. In a mass-driver, electric current is pulsed through coils of aluminum wire, generating a magnetic field. This field accelerates a moving coil of wire, called a "bucket," which carries a sphere of sintered lunar material that's about the size and weight of a baseball. The material then leaves the bucket and accelerates toward its destination, a precise point in high orbit above the moon. There the sintered lunar material enters a very simple collector that has a closed cylindrical tube at one end.

The mass-driver work took a big step forward in May 1983, when Les Snively of Princeton, completed the newest model—Mass-Driver III—according to a computer-design program that I had written. Mass-Driver III models the first half-meter of a fully operational lunar machine, which would be about 160 meters long. It is a simple device consisting of 20 circular drive coils, each 40 centimeters in diameter and about as thick as a bicycle tire. Stacked against one another, they form a hollow cylinder. Inside the cylinder the bucket coil is free to move. When currents are discharged through the drive coils in a precise time sequence, they produce strong magnetic fields that accelerate the bucket and also guide it on the centerline of the cylinder. Functioning at a fraction of full power, Mass-Driver III gave its payload carrier an acceleration of 1 100 g, enough to go from a standstill to 250 miles per hour in 0.01 second. Full-power tests scheduled for later this year should see the machine accelerate a payload to its design goal of 1 800 g. That acceleration will bring the payload carrier from a standstill to 300 miles per hour in 0.007 second.

Building on its successful track record, SSI will be funding second-generation development in key research areas during the next several years. Now that Mass-Driver III has proven the accuracy of the computer program by which it was designed, the program will be used to extend the design to the full length of the lunar machine, or 160 meters. The acceleration of Mass-Driver III is enough to bring payloads to a speed of 5 400 miles per hour, the escape speed from the moon, within just 160 meters. In addition, chemical-separation technology will be brought to the pilot-plant stage. And SSI will soon be requesting proposals from aerospace companies for solar-power satellites that can be built from lunar materials. If we at SSI maintain our research schedule, by 1987 we'll be ready to publish a consistent, logical overall plan for establishing large-scale industry in space.

When the road to productive, high-volume space industry has been paved by research of that kind, it will be time for action. Nations or groups of corporations are among the possible players at that stage. In order to minimize risks, they will choose products that the marketplace will still want five to ten years after investment begins. Given the pace of change in our technological society, only the most general products—energy, rocket propellants, and lunar soil for shielding space stations and colonies—will satisfy that condition. That is why SSI has targeted these three as the most viable products of space industry. On the fastest time scale, a nation or a consortium of industries could pick up the SSI plan and run with it in 1987. That would result in productivity in space at the 100 000-ton-per-year level by 1992. If events go more slowly SSI will broaden, deepen, and buttress its plan by constructing larger-scale demonstration experiments until finally the investment opportunity becomes so tempting that a major investment source will commit itself to the development of space industry.

I cannot be sure who will be the first to create wealth out of the constant solar energy and the abundant materials waiting for us at the top of Earth's gravity well. But I am sure that the first group that succeeds will soon have its imitators. Whether the first program is led by Americans, Japanese, Europeans, or Russians, within a few short years all the major space powers will compete in production. When the scale of industry in space becomes large enough to demand the presence of thousands of people in high orbit for long periods, it will pay to devote some of the productivity to the building of space colonies for workers and their families. Those colonies, in the form of spheres one mile in circumference, will rotate slowly to provide Earth-normal gravity for their residents. The space colonists will grow their own food and derive all the energy they need from the sea of constant sunlight. By the middle years of the next century the first beachhead in space will have grown to include thousands of such colonies, each with a language and a cultural heritage drawn from a nation of Earth. Travel between Earth and its colonies will be as common by then as international travel is today. It will be a happy development for our tired and fragile planet when humanity's drive toward production and conquest is redirected outward onto that high frontier. ☐

The Space Studies Institute can be reached by mail at Box 82, Princeton, NJ 08540. Membership is $15 per year.

EXPLORATIONS

CONTINUED FROM PAGE 28

erupted, leaving a 15-kilometer rift in its destructive wake. This fissure became the thermal valley.

In 1917 yet another violent explosion rocked the area, giving birth to a crater that has become the world's largest boiling lake. The Waimangu Cauldron, flanked by huge steaming cliffs, rises and falls 10 meters per month.

The rest of the valley is more quiescent. Small springs gurgle over the Warbrick Terrace, a collage of rust, yellow, and moss green hues caused by the fusion of mineral deposits and algae. The Emerald Pool, a crater 40 meters deep, sits majestically, like a peacock showing off its plume; it displays cool, green waters.

Nature's vivid complexion is also on display at the Waiotapu Wonderland, just a few miles south of Waimangu. Make sure you arrive at 10:15 A.M. to see Lady Knox Geyser (named after the wife of a former New Zealand governor) spew her spray 20 meters into the sky.

Waiotapu was also formed by the 1886 eruption, evident by the large number of craters and turquoise lakes. But the jewel of Waiotapu is the Champagne Pool and adjoining terraces. Fed by a spring, this pool contains high levels of carbonic acid. A sinter rim has formed on all sides, creating a glittering, pale-orange perimeter. Behind the pool, multihued terraces exquisite in their delicate lacework patterns meld like colors on an artist's palette.

While feasting on New Zealand's scenic splendor, keep in mind that there's a practical side to this landscape. On the southern tip of the Rotorua district lies yet another valley; this one gleams with aluminum pipes that flash intermittently with billowing clouds of steam.

This, the site of the Wairakei power station, shows geothermal activity at work. Here more than 60 steam wells, or bores, sprout from the valley floor, extracting high-pressure steam, which is transported several kilometers by pipeline to turbine generators and transformed into electricity.

Two hundred thousand New Zealanders, both on North and South Island, benefit from this clean energy, which costs less to produce than hydrogenerated power. Despite cries from environmentalists that geothermal exploitation is drying up the region's geysers, developments are already under way to build Ohaaki, a second power plant, in the Broadlands Fields, which are 20 miles northeast of Wairakei. The recent discovery of offshore gas, however, has delayed this project, much to the disappointment of thermal advocates.

Whatever the outcome of this environmental dispute, the steamy fireworks at Rotorua show little sign of fizzling out in the near term. So long as New Zealand's Ring of Fire continues to smolder, this natural spectacle remains one of the best free shows on Earth. ☐

FICTION

Melanie and Nina have played their deadly game for years. Melanie wants to stop, but will Nina let her?

CARRION COMFORT

BY DAN SIMMONS

In the first part of Carrion Comfort *three elderly people meet in Charleston South Carolina to tally up their scores in a gruesome game The three are users, who telepathically manipulate unsuspecting people into unspeakable acts—murder suicide assassination Melanie Fuller announces her intention to quit playing Nina Drayton, her longtime friend and rival seems to take the news with equanimity*

Morning Bright sunlight through bare branches It was one of those crystalline, warming winter days that make living in the South so much less depressing than merely surviving a Yankee winter I had Mr Thorne open the window a crack when he brought in my breakfast tray As I sipped my coffee I could hear children playing in the courtyard Once Mr Thorne would have brought the

This is the concluding section of a two-part novelette

PAINTING BY ROBIN MULLER

morning paper with the tray, but I had long since learned that to read about the follies and scandals of the world was to desecrate the morning. I was growing less and less interested in the affairs of men. I had done without a newspaper, telephone, or television for twelve years and had suffered no ill effects unless one were to count a growing self-contentment as an ill thing. I smiled as I remembered Willi's disappointment at not being able to play his video cassettes. He was such a child.

"It is Saturday, is it not, Mr. Thorne?" At his nod I gestured for the tray to be taken away. "We will go out today," I said. "A walk. Perhaps a trip to the fort. Then dinner at Henry's and home. I have arrangements to make."

Mr. Thorne hesitated and half-stumbled as he was leaving the room. I paused in the act of belting my robe. It was not like Mr. Thorne to commit an ungraceful movement. I realized that he too was getting old. He straightened the tray and dishes, nodded his head, and left for the kitchen.

I would not let thoughts of aging disturb me on such a beautiful morning. I felt charged with a new energy and resolve. The reunion the night before had not gone well but neither had it gone as badly as it might have. I had been honest with Nina and Willi about my intention of quitting the Game. In the weeks and months to come, they—or at least Nina—would begin to brood over the ramifications of that, but by the time they chose to react, separately or together, I would be long gone. Already I had new (and old) identities waiting for me in Florida, Michigan, London, southern France, and even in New Delhi. Michigan was out for the time being. I had grown unused to the harsh climate. New Delhi was no longer the hospitable place for foreigners it had been when I resided there briefly before the war.

Nina had been right about one thing—a return to Europe would be good for me. Already I longed for the rich light and cordial *savoir vivre* of the villagers near my old summer house outside of Toulon.

The air outside was bracing. I wore a simple print dress and my spring coat. The trace of arthritis in my right leg had bothered me coming down the stairs, but I used my father's old walking stick as a cane. A young Negro servant had cut it for father the summer we moved from Greenville to Charleston. I smiled as we emerged into the warm air of the courtyard.

Mrs. Hodges came out of her doorway into the light. It was her grandchildren and their friends who were playing around the dry fountain. For two centuries the courtyard had been shared by the three brick buildings. Only my home had not been parceled into expensive town houses or fancy apartments.

"Good morning, Miz Fuller."

"Good morning, Mrs. Hodges. A beautiful day, isn't it?"

"It is that. Are you off shopping?"

"Just for a walk, Mrs. Hodges. I'm surprised that Mr. Hodges isn't out today. He always seems to be working in the yard on Saturdays."

Mrs. Hodges frowned as one of the little girls ran between us. Her friend came squealing after her, sweater flying. "Oh, George is at the marina already."

"In the daytime?" I had often been amused by Mr. Hodges's departure for work in the evening, his security-guard uniform neatly pressed, gray hair jutting out from under his cap, black lunch pail gripped firmly under his arm.

Mr. Hodges was as leathery and bowlegged as an aged cowboy. He was one of those men who were always on the verge of retiring but who probably realized that to be suddenly inactive would be a form of death sentence.

"Oh, yes. One of those colored men on the day shift down at the storage building quit, and they asked George to fill in. I told him that he was too old to work four nights a week and then go back on the weekend, but you know George. He'll never retire."

"Well, give him my best," I said.

The girls running around the fountain made me nervous.

Mrs. Hodges followed me to the wrought-iron gate. "Will you be going away for the holidays, Miz Fuller?"

"Probably, Mrs. Hodges. Most probably." Then Mr. Thorne and I were out on the sidewalk and strolling toward the Battery. A few cars drove slowly down the narrow streets, some tourists stared at the houses of our Old Section, but the day was serene and quiet.

I saw the masts of the yachts and sailboats before we came in sight of the water as we emerged onto Broad Street.

"Please acquire tickets for us, Mr. Thorne," I said. "I believe I would like to see the fort."

As is typical of most people who live in close proximity to a popular tourist attraction, I had not taken notice of it for many years. It was an act of sentimentality to visit the fort now. An act brought on by my increasing acceptance of the fact that I would have to leave these parts forever. It is one thing to plan a move; it is something altogether different to be faced with the imperative reality of it.

There were few tourists. The ferry moved away from the marina and into the placid waters of the harbor. The combination of warm sunlight and the steady throb of the diesel caused me to doze briefly. I awoke as we were putting in at the dark hulk of the island fort.

For a while I moved with the tour group, enjoying the catacomb silences of the lower levels and the mindless singsong of the young woman from the Park Service. But as we came back to the museum, with its dusty dioramas and tawdry little trays of slides, I climbed the stairs back to the outer walls. I motioned for Mr. Thorne to stay at the top of the stairs and moved out onto the ramparts.

Only one other couple—a young pair with a cheap camera and a baby in an uncomfortable-looking papoose carrier—were in sight along the wall.

It was a pleasant moment. A midday storm was approaching from the west and it set a dark backdrop to the still-sunlit church spires, brick towers, and bare branches of the city.

Even from two miles away I could see the movement of people strolling along the Battery walkway. The wind was blowing in ahead of the dark clouds and tossing whitecaps against the rocking ferry and wooden dock. The air smelled of river and winter and rain by nightfall.

It was not hard to imagine that day long ago. The shells had dropped onto the fort until the upper layers were little more than protective piles of rubble. People had cheered from the rooftops behind the Battery. The bright colors of dresses and silk parasols must have been maddening to the Yankee gunners. Finally one had fired a shot above the crowded rooftops. The ensuing confusion must have been amusing from this vantage point.

> *"A movement down below caught my attention. Something dark was sliding through the gray water—something dark and shark silent. I was jolted out of thoughts of the past."*

A movement down below caught my attention. Something dark was sliding through the gray water—something dark and shark silent. I was jolted out of thoughts of the past as I recognized it as a Polaris submarine, old but obviously still operational, slipping through the dark water without a sound. Waves curled and rippled over the porpoise-smooth hull, sliding to either side in a white wake. There were several men on the tower. They were muffled in heavy coats, their hats pulled low. An improbably large pair of binoculars hung from the neck of one man, whom I assumed to be the captain. He pointed at something beyond Sullivan's Island. I stared. The periphery of my vision began to fade as I made contact. Sounds and sensations came to me as from a distance.

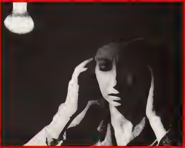
Tension. The pleasure of salt spray, breeze from the north, northwest. Anxiety of the sealed orders below. Awareness of the sandy shallows just coming into sight on the port side.

I was startled as someone came up behind me. The dots flickering at the edge of

CONTINUED ON PAGE 191

Kolb abducted his wife as she left her night job, then Patrick took her to his basement and began the deprogramming

ANTI MATTER



UFO UPDATE

Ted Patrick is known worldwide as the man who kidnapped and deprogrammed young Moonies from Reverend Moon's Unification Church, where, he contends, they were brainwashed. But most people don't know about Patrick's most recent battle: finding and deprogramming those who have been brainwashed by the country's UFO cults.

Patrick's involvement with UFO cults began at his San Diego home one night in 1979, when he got a surprise visit from Thomas Kolb. Kolb's twenty-four-year-old wife, Susan, it seems, had seen flashing orange lights over their Kiel, Wisconsin, home. Since then, she'd been going to Wisconsin's UFO Education Center where, Thomas claimed, founder Charlotte Blob (rhymes with globe) had brainwashed Susan into thinking that she could save the world.

Blob allegedly told Susan that the late George Adamski, a former center member, had taken flying saucer rides to meet the "Master"; the Master in turn had promised Adamski that his "space brothers" would send telepathic messages teaching center members to purge society of drugs, war, and poverty. Moreover, those who saved the world would be reincarnated on Saturn.

Lured by Blob's promises, says Patrick, Susan abandoned Thomas and their three-year-old daughter for a life at the center. Later she took on three jobs to meet the center's required weekly donations of $20 to $30, as well as other expected "spot contributions" of up to $100.

It was at this point that Kolb ended up on Patrick's doorstep and the two concocted a plan. Thomas abducted Susan as she left one of her night jobs at a bank. Then Patrick, who was paid $5,000, led her to a bare room in the basement of his house. He sat her on a stool under a naked light bulb and asked whether she knew that Blob had used center money for private real-estate investments. Susan mumbled no and Patrick went on, asking whether humans needed space suits to travel to other planets. Susan said yes, and he asked if in three years at the center she had ever seen a space suit. When she said no, he asked her how Adamski could have met the Master without a space suit. "Is it possible," he demanded, "that someone has been lying to you?" The questions went on for days, and finally, Patrick says, he "snapped" Susan back to reality.

Today Susan is home, and Patrick has gone on to deprogram other cultists as well. He saved one twenty-three-year-old who moved into the Wisconsin center after telling her parents, "You don't mean anything more to me than the manure on this earth." He has also succeeded in rescuing elderly members of "Bo and Peep," an underground UFO cult promising golden-agers a flying-saucer ride to Venus and the Fountain of Youth.

Patrick blames the proliferation of UFO cults on movies like *Close Encounters of the Third Kind* and *E.T.*, as well as on the government. With UFO cults around, he says, "it's easier to cover up the real UFOs: new weapons, killer satellites, lasers, and missiles."—PETER RONDINONE

One June day in 1980 Zygmunt Adamski a fifty seven-year-old Polish-born coal miner slipped out of his home in Leeds England to buy potatoes for dinner He never returned and five days later his body was found in Todmorden, a small town 30 miles away He had died of a heart attack But on his head and neck were burns inflicted two days before the estimated time of his death

According to police there were other bizarre circumstances as well Adamski s body was lying atop a ridge of coal six feet above level ground yet there were no marks to suggest that anyone had scaled the area And he was spotlessly clean as if said one officer he had stepped from a shower

At the inquest doctors agreed that Adamski s heart attack could have been caused by fright And his widow expressed the view that he had been kidnapped and tortured But the strangest explanation came from British ufologists who said that huge orange balls had been seen over Todmorden the week Adamski died Aliens they claimed had scared Adamski to death

A main proponent of the alien murder theory is Graham Birdsall investigator for the British UFO organization Contact Birdsall first learned of the case from a *Yorkshire Evening Post* story headlined DID UFO KILL THIS MAN? And he says his interest increased when he heard subsequent reports of another Todmorden UFO seen by police constable Alan Godfrey God frey in fact, claimed he'd been abducted by an alien named Joseph and eight lamp headed robots after a weird medical examination he was released

The question ufologists are pondering now is this Did Adamski have a similar encounter? They say the answer may be yes Godfrey s superiors have been attempting to cover up UFO sightings by other police officers, Birdsall says And I find i quite extraordinary that less than a month after the discovery of the body it was shipped to Poland for burial
—Ivor Smullen

I can assure you that flying saucers given that they exist are not constructed by any power on Earth
—Harry S Truman

Those who insist that a woman s place is in the home frequently back up their beliefs with the biblical story of Genesis The Bible, they say clearly states that woman was created as a helpmate for man

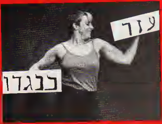
Wrong says religious-archaeology and -language scholar David Freedman The image of woman created as subordinate to man is simply the result of a translation error

Freedman who is director of religious studies at the University of California at Davis explains that the Hebrew word *ezer* is usually translated in Genesis as helper or helpmate But the word should actually be interpreted as a power or a strength And *kenegdo* which is usually read as meaning fit actually means equal Thus Genesis says that woman was created as a power equal to man instead of as a helper fit for man

If you go back to the earliest Jewish writing says Freedman the meaning is clear But so many translations have been influenced by the King James version of the Bible in which the Genesis passage is misinterpreted that things get fixed in people s minds

After publishing an article on the subject in *Biblical Archaeology Review* recently, Freedman got a mixed reaction A Jewish gentleman said I wasn t being reverent enough, he relates And a Southern Baptist quoted the New Testament to show me I was wrong But the women who wrote in were quite happy —Sherry Baker

The erection of artificial worlds in space is inevitable Once man's breakthrough into space has begun it will be as irreversible as the discovery colonization and exploitation of new countries during the age of great historical discoveries
—Iosif Shklovsky



THE CLOUD IS COMING

A group of French astronomers has discovered a giant interstellar cloud heading toward Earth from the distant constellation Sagittarius

Some climatologists believe the passage of dense interstellar clouds through our solar system could cause ice ages others say such clouds could render the sun more luminous But whichever way it goes warns astronomer Alfred Vidal-Madjar and his colleagues at the Laboratory for Stellar and Planetary Physics in Verrieres-le-Buisson the presence of a nearby cloud could have "some drastic influence on the terrestrial climate sometime during the next ten thousand years "

Direct observation of the interstellar medium is a very tricky business says Vidal-Madjar Nonetheless his group s results have been confirmed by at least two other astronomers working independently This is the strongest evidence yet he says in favor of the cloud

The gaseous interloper may be roughly cigar shaped Vidal Madjar says and perhaps ten times longer than its 0 33-light year thickness Traveling away from Sagittarius at the speed of about 15 to 20 kilometers per second might well be 0 1 light-year from Earth by now If so it will be here in about 1 500 years But the data are just too skimpy for precise predictions and Vidal Madjar admits there s a remote chance that the cloud is no farther from Earth than the sun is At that distance it would arrive by the year 2001

—Robert A Freitas Jr

"Belief is not the beginning but the end of all knowledge

Johann Wolfgang von Goethe

THE HANDSTAND TWINS

Ron and Richard Bowser were abandoned at birth and left on the floor of a cabin in the woods They were found near death their vocal cords damaged and their bones malformed one doctor even said they might be retarded The twins felt unloved by their foster parents throughout childhood and Ron tried killing himself twice by the age of fifteen

But when the pair turned sixteen things started looking up They began weight lifting and before long Ron won the Mr Teen age Pennsylvania body building contest going on to become a nationally ranked weight lifter Out of the Marines he attended college for a year and then joined Richard, who was working in a steel mill Two years later Ron fell to his knees and asked Jesus to enter my heart Within a year both Bowsers were ordained ministers Shortly thereafter they worked out a performance routine that consisted of walking on their hands For a fee the Bowsers (pictured at right) today preach sing and do handstand balancing acts in churches all across the country

'We re the only set of identical twins in the world who walk upside down for the Lord " says Ron Notes Richard "Nobody's walked down as many steps on their hands as we have "

The twins also march in parades One walks on his hands the other follows wheeling a ten foot cross with splotches of red paint One guy yelled to us that Jesus didn t use a wheel says Ron Adds Richard So we told him we d take off the wheel if he'd accept Jesus into his heart

At another parade, Richard found himself staring down a shotgun barrel held by a man ordering him to drop the cross 'I rendered his powers impotent in the name of Jesus and he dropped the gun and ran he says But it s not something you want to try all the time "

The Bowsers also have a dream They d like to walk on their hands down the steps of the Empire State Building the Washington Monument, and yet-to-be announced structures throughout Paris, London Rome and Asia Our motto " says Richard "is that if we can walk for Him upside down you can walk for Him right side up

—Scott Cramer

SATELLITE INSURANCE

There's no need for modern-day Chicken Littles to worry about the sky falling, but they might be wise to look out for space debris. That, at least, is the opinion of Gracine Huffnagle, assistant to the president of Complete Equity Markets Inc., an insurance company in Wheeler, Illinois.

To profit from the impending debris, Huffnagle recently put together a policy called Satellite Reentry Protection. Premiums total only $150 a year, and the payoff is immense. If you are disabled, killed, or even scratched by a falling satellite, you or your beneficiary collect $1 million. And if the space debris misses you but lands on your property, you are entitled to $100,000.

Huffnagle first came up with the idea after learning that Fireman's Fund had offered a one-time policy to people wanting protection from the Russian satellite *Cosmos 1402* (which reentered the atmosphere in February of this year). She also knew that Lloyd's of London had written a similar policy for *Skylab's* descent a few years ago.

"But there was no policy for *all* the space debris that comes down," she explains, "so I began to do some research." Finally she found a government source who admitted that approximately 350 pieces of space junk enter the atmosphere every year. While 95 percent of this debris is burned up upon reentry, 5 percent hits the earth. "It's not a secret," said the source, who requested anonymity. "But it's not something we like to broadcast."

While no one has been injured in the United States by falling satellites so far, Huffnagle claims that 25 pieces of space debris have been found on American land. "Some pieces landed on streets. The largest piece they found weighed six hundred forty pounds," she notes, "but even a small piece could do a lot of damage."—Sherry Baker

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

RECORD BLEAT

A new record by 600 black mountain sheep is getting a lot of air play in Great Britain.

The record was the brainchild of Richard Branson of Virgin Records. He noticed that the sheep on his aunt's farm near Norwich seemed to bleat in several varied pitches. After recording the sheep's voices, sound engineers separated out the tones that fit the song Branson decided to record—appropriately enough, it was "Baa Baa Black Sheep." The record's producer, moreover, is listed as "Jeff Mutton."

Is Virgin Records fleecing the public?

"People have been quite interested in the record," insists Juliet Miranda, of Virgin. "In fact, it recently broke into the top fifty on the British record charts."

The flip side, she notes sheepishly, is "Rock Around the Flock."—Sherry Baker

"In the morning when we rise from bed, although surprised to find ourselves still alive, we are even more amazed to find everything just as we left it the night before."
—Tommaso Landolfi

"For an idea ever to be fashionable is ominous, since it must afterwards be always old-fashioned."
—George Santayana

SUPERSTUFF

CONTINUED FROM PAGE 112

baked hard the new silo comes off the mandrel ready for action

Composites important as they are are only one marble in the materials scientist s bag The field is huge As an Allied vice president put it recently when his corporation gobbled up Bendix to acquire that company's synterials technology Well everything is made of materials That includes advanced electronics today's version of the Eleusinian mysteries in which initiates worship the chip—a fingernail-size slice of semiconducting crystal usually silicon The chip is doped with impurities at selected spots to increase or decrease the electrical conductivity in these areas then etched with microscopic circuits Depending on its design and how the tiny wires are arranged the chip can perform a range of tasks

Chip designers however have gone about as far as they can go using silicon Without new chip materials—gallium arsenide is due next and polymer materials are waiting in the wings—designers will face a dead end in their race for more efficiency more speed But until they better understand how chip materials interact with the metal contacts attached to them designers will be unable to exploit silicon fully much less move on to entirely new materials Thus some scientists are now exploring the miniature world visible only through the highest-powered electron microscopes where metal contacts thinner than eyelashes touch the crystal of an electronic chip

As all electronic devices shrink circuits will be only atoms big and the purity of the silicon upon which the circuits are printed will become increasingly critical Westinghouse microelectronics expert Don Hobgood is developing a new technique for growing ultrauniform silicon crystals using magnetic fields to suppress convecting currents in the molten fluids where the crystals form Meanwhile he is discovering ways to grow crystals of gallium arsenide the next generation chip material in commercial sizes As he points out without such new materials computer evolution would stop cold

These I consider to be works of art declares Professor C Lloyd Bauer spreading out photographs in his office at Carnegie-Mellon University in Pittsburgh To the untrained eye Bauer's black-and-whites look less like Steichen masterworks than Polaroid snapshots of the Alps in January and close-ups of gravel driveways But these photographs shot through electron microscopes are topographic studies of silicon and gallium arsenide chips in the submicron range where 'mountains' are only atoms high

Using these images Bauer is studying how metal contacts eat holes in chips wreaking electronic havoc "One of the space-shuttle missions ended early because of the trivial degradation of an electronic-chip coating that cost a few bucks Bauer says Changes on such a small scale in miniaturized electronics can very easily lead to major failures

Where metal electrodes attach to crystal chips Bauer has found deep pits It s fascinating metallurgists can t believe the degree of reaction he says These are the first pictures ever taken of this phenomenon because the ability to make crystals only a tenth of a micron thick thin enough to examine under an electron microscope is itself new

Bauer takes his visitor down the hall to the laboratory where electron microscopes of various types brood like idols In one darkened room a microscope screen glows demon green while researchers their faces frog-colored study the craters pitting a silicon crystal s face When two different substances touch they are inevitably unstable Bauer continues

> *One of the space shuttle's missions ended early because of the trivial degradation of an electronic- chip coating that cost only a few bucks*

For instance gold stable in nature reacts with gallium arsenide Other metals existing in nature as compounds react even more readily with chip material reverting to the original compound in which they exist in the wild We are always fighting this tendency to return to ore he comments Understanding these phenomena will take the engineers a giant step toward supercomputers We have a situation in which the things electrical engineers *want* to believe don't correspond to the reality we now know says Bauer

Other materials scientists meanwhile are taking alternate routes to the supercomputer Deborah Chung also at Carnegie-Mellon is looking at superlattices—chips built layer cake style each layer an atoms thick slice of a different substance selected for its special properties The crystal layers are so thin that a 5 000-layer stack is barely the thickness of a piece of paper At that degree of thinness the atoms of the crystal align themselves either by separating or pulling together to create an elastic quality This seems to prevent cracks or other flaws Besides this absence of imperfections superlattices can be fine-tuned by adjusting the proportion of arsenic in the layers

In other laboratories where supercomputer scientists seek the ultimate chip their Holy Grail experts are coming up with electronic anomalies For instance conductors of electricity canon has it are metals But researchers at the Allied Corporation have developed new polymers that properly doped with impurities act as conductors and open the way for such innovations as organic batteries *Organic* in chemistry refers to compounds based on the element carbon just as U S senators garter snakes azaleas and all other living things are composed of carbon-based compounds

Polymers are organic—carbon-based compounds whose molecules are exceptionally large and complicated Polymer batteries could be lightweight and pancake flat tailor-made to ride in the door of an electric car the hull of a spacecraft, or the innards of a portable radio But the organic conductors may have more exalted applications than use as batteries

We re looking at electronic chips a step beyond gallium arsenide which is the next step beyond silicon says Smith These chips of the future would be made atom by atom of layers of conducting and nonconducting polymers Smith says polymer semiconductors would work especially well with Josephson junctions futuristic switches that work with blinding speed The result would be a thinking computer that mimics the human brain "We have conducting polymers in our brain Smith adds but they re very slow—they need to be speeded up

Polymer-chip research may begin soon with both the Navy and Air Force considering funding The outcome could be astonishing I think we're going to see a tremendous response from the biology people Smith continues because when it comes to biopolymers like DNA and RNA they can synthesize most of what Mother Nature has made I can even foresee computers that plug into the brain and copy it

Although biomolecular electronics is still in its infancy researchers daydreams are full of visions of lilliputian realms tinier than the micrometer the smallest measurement used in today s solid-state circuits The dimensions of biomolecules though are expressed in nanometers units 1 000 times smaller than micrometers And whereas conventional silicon chips are two-dimensional wisps of material the molecular chip would be a well-rounded three dimensions which would increase its density another thousandfold or more

Biomolecular electronics heralds a new era of protein engineering Some investigators avidly entertain plans for creating new matter proteins not found in the original cookbook

Scientists at Tokyo University, on the other hand are fashioning the first working biomotor from the real stuff Based on molecules from rabbit muscle, the Japanese have developed a prototype engine the size of a teacup, they plan to shrink it to the dimensions of a pinhead.

The motor is built of one-molecule-thick films of actin (a muscle-contracting protein) and myosin (a muscle molecule). The proteins are laid on thin, postage-stamp-size mica sheets, which are arranged like vanes on a six-armed windmill. Adenosine triphosphate, or ATP, the chief energy supplier for all biomolecular processes, fuels the motor. The Tokyo scientists got their brainstorm by observing the cell behavior of a plant called Nitella. Under a microscope the contents of the Nitella cell swirl around continuously, generating a tiny whirlpoollike condition. On its own, the micromotor windmill will spin for a couple of hours until the ATP fuel is depleted. Such a tiny motor, say the Japanese, could have several applications, most specifically in lining human capillary tubes to pipe in minute amounts of liquid.

Only slightly less exotic than biomotors and nanometer chips are the most immediate plans to upend the electronics industry with new types of metals—metals made of ordinary metal atoms but with the structure of glass. Welcome to the brave new age of "metallic glasses."

"The Japanese think they can take over the whole transformer and motor industry with metallic glasses," says Thaddeus Massalski, a Polish scientist now on the faculty of Carnegie-Mellon. He pulls what looks like a spool of silver Christmas ribbon from his drawer, snips off a piece with scissors, and hands it to his visitor.

The material is razor thin, flexible, and too shiny for ordinary metal. It is made, Massalski says, by cooling a molten metal so fast that its atoms have no time to form a metal's usual rigid crystal structure in which the "grains" line up like troops marching in phalanx. Instead, the suddenly chilled atoms form an unorganized mob, as glass molecules do.

"Any liquid, even Pepsi Cola, will crystallize during cooling," says Massalski. "Cooling metals fast enough to avoid crystallization requires some techniques that are very fancy."

Metallic glasses, also called amorphous metals, must cool about 1 million degrees Fahrenheit *per second*. One way is to hit a metal sample with a laser, melting a pool only millimeters large. As the laser moves on, the pool surrenders its heat to the surrounding unmelted metal. In another technique, says Massalski, pressurized gas squirts molten metal from a crucible, out a nozzle, and onto a spinning copper wheel. The more nozzles, the wider the ribbon of metallic glass that forms on the wheel.

Metallic glasses are exceptionally tough. Japanese firms now use them as the magnetic heads in tape recorders, since they can resist the constant abrasion caused by sliding tapes. "The next stage will be learning to form these rapidly solidified materials into useful shapes," says Massalski, noting that MIT is currently working on a technique for producing metallic glasses as minute balls, then compacting this powder into the desired shape. Researchers at the Lawrence Livermore Laboratory, near San Francisco, are experimentally exploding metallic glasses into useful forms.

"But the transformer industry is the greatest challenge," says Massalski, noting that the little devices for stepping voltages up and down are ubiquitous on electric power poles, in audio gear, and in all sorts of radio equipment. "Millions and millions of dollars are involved," he points out.

Connected to ordinary alternating-current power lines, a transformer must magnetize and demagnetize 120 times a second, 24 hours a day, 365 days a year. Because of their random structure, metallic glasses can make these magnetic changes far more smoothly than ordinary metals can. The result is a jump in efficiency, up to 60 percent. Given the huge number of transformers humming away

"When it comes to biopolymers like DNA, the biologists can synthesize most of what Mother Nature has made. I foresee computers that plug into the brain and copy it."

that could save as much as $1 billion per year in the United States alone. Thus the winner of the metallic-glass transformer race should reap huge profits.

So far the Allied Corporation seems to have the lead. Allied's amorphous metals, Metglas, have now been on the market for five years. The Electric Power Research Institute is field-testing 1,000 residential transformers that have Metglas cores. Meanwhile, Allied has signed contracts to develop metallic-glass transformers and motors with Emerson Electric, Westinghouse, General Electric, and a Japanese consortium. Allied says its metallic glasses are already at work in jet engines, heart pacemakers, rechargeable batteries, car engines, stereos, microcomputers, and other products.

Other new cooling processes, too, are altering the characteristics of metals. Robert Sekerka, a Carnegie-Mellon physicist, says that materials scientists are now creating composites by cooling molten alloys at various speeds. "You may wind up with something like one metal lined with rods of another compound and bonded at the atomic level," he says. "You can do it with a ceramic and a metal, for instance, producing a ceramiclike uranium dioxide containing natural reinforcing rods of tungsten or molybdenum." Such materials can have all sorts of unusual properties, he says. For instance, they might be weak in one direction but extremely strong in the opposite direction. They might conduct electricity 1,000 times better in one direction than in another. "This is frontier stuff, not for ashtrays," Sekerka says. "It's probably already in advanced-weapons systems, maybe new grades of armor, stronger yet less brittle."

Ceramics, the stuff of ashtrays, teacups, and bathroom sinks, have a bright future as substitutes for scarce metals and petroleum-based plastics. They will play roles in everything from fusion power to defense systems. For instance, both Ford and General Motors are working on ceramic engines that can take much more heat than conventional engines and therefore operate at higher thermal efficiencies. When will your car have a crockery engine? Perhaps soon. The Cummins Engine Company of Columbus, Indiana, has already built a prototype ceramic diesel to power a five-ton Army truck.

Ceramics—things that are neither organic substances nor metals—include a wide range of materials. In fact, the raw materials for ceramics are so widespread—about 90 percent of the earth's crust—that new techniques for working these materials could usher in a new technological epoch that some scientists are already calling the Ceramic Age.

General Electric, for instance, is manufacturing industrial parts from a silicon carbide ceramic that is nearly as hard and as chemically inert as diamond. It's just right for critical components in pumps, valves, compressors, and other devices in power plants and chemical plants where wear and corrosion are problems. The economic effect of such ceramic parts could be pleasant. A researcher at the Battelle Memorial Institute, in Columbus, Ohio, says that the cost of manufacturing a complex engine component from a ceramiclike silicon nitride, one of the more expensive types, is 33 to 50 percent less expensive than making the engine component of a standard metal alloy.

Other new ceramic products now on the drawing boards range from a daisy wheel printer, a garbage-disposal device with rugged ceramic teeth, and ceramic gas-turbine engines to ceramic computer chips even tinier than today's chips. Ceramics experts say that as new methods of working with ceramics are perfected, manufacturing will change. Instead of assembling a device from ten separate parts, the entire device will be made of ceramics and molded as one unit. The result will be a significant drop in costs for all kinds of complex machinery.

Probably the most famous of the new ceramics are the tiles that line the belly of the space shuttles, absorbing the high heat of reentries into the atmosphere where temperatures reach 2300° F About 90 percent air, the tiles are as light as butterflies Their major component ultrapure silica fibers can withstand searing temperatures without expanding The tiles are so tough that you can blast them with a flamethrower then plop them into ice water without damage It is superstuff all right So far however, nobody has come up with a viable commercial spinoff because the tiles are so highly engineered that using them for insulating picnic baskets or thermos bottles would be like building a doghouse using jade shingles and golden nails Their manufacturer Lockheed, says the tiles will be used however in defense invisible to infrared or radar they are good for the endlessly evolving military game of hide-and-seek

Japan has accelerated its ceramic research in recent years too And some U S ceramics experts believe the Japanese are working on a ceramic electric motor made possible by the ability of certain ceramic materials such as barium titanate to give off an electrical charge when struck or distorted (That is how quartz watches work) Other uses for ceramics under investigation at various research centers include ceramic houses that could be built in less than a week by spraying foams into forms and allowing the material to harden Westinghouse is working on ceramic cells to convert sunlight into electricity ceramic fuel cells (power plants that generate electricity via chemical reactions somewhat as batteries do), ceramic electrodes for magnetohydrodynamic (MHD) plants which generate electricity by sending a gas through a magnetic field and sensing devices such as a highly sensitive pollution detector that can sniff out sulfur dioxide (SO_2) in factories and utilities

At the heart of this last project is a ceramic sensor that is electromechanically stimulated by SO_2 (see page 108) The sensor generates a direct-voltage reading that corresponds to concentrations of SO_2 in a gas stream Westinghouse engineers also foresee a "home of the future" equipped with ceramic sensors that will use a central computer to regulate everything from lights to the furnace and burglar alarms

But you don t have to wait for a ceramic ball-and-socket hip joint In December 1982 University of California at San Francisco (UCSF) orthopedists began implanting pottery prostheses so far they ve worked on 31 patients ranging from twenty-one to seventy A cementless ultrasmooth ceramic with aluminum oxide content the joint does not inhibit bone growth The prosthesis is literally screwed into the pelvic bone and the bone grows to fill in around the thread and groove "It is capable of one-hundred-percent biocompatibility" declares William R Murray chairman of UCSF s department of orthopedic surgery "Patients were capable of pain free motion in the artificial hip within hours after surgery and were able to walk without a limp after four months The joint is supposed to last a lifetime especially in patients under fifty whose bones regenerate well

Probably the *piece de resistance* in ceramics research, however, is in the realm of new high-tech glasses which are used in fiberoptic devices to conduct laser beams from point to point Westinghouse among other companies is working on new fiberoptic materials that could lead as one company spokesperson puts it to total optical computers made almost entirely of light and glass"

Elsewhere at Westinghouse s research center scientists are transmuting the world s stuff with tools that make the power-driven screwdriver seem as primitive as a piece of carved antler David Moon who directs Westinghouse's energy research tells of instruments that can drive ions (electrically charged atoms) just 100 atom layers deep into the surface of a material By studying a substance with ions this way manufacturers could easily produce materials that have one set of characteristics inside but special surfaces—whatever the engineers might like

> *"CIA agents had detailed satellite photos of a silicon-chip plant in the USSR They wanted to know how pure the Soviet chips were."*

How about featherweight blocks of foam insulation with a diamond-hard skin for home construction?" You can put anything into anything says Moon

The electromagnetic gun he says accelerates ions with enough power to penetrate the surface of materials to preselected depths One commercial application for the electromagnetic gun has already surfaced "It you drive nitrogen ions into tungsten-carbide tools they last longer" he says and nobody knows why

In yet another mode of bombardment Westinghouse engineers are experimenting with novel ways to use a high powered electric cannon or electromagnetic "launcher" (see page 109) This first-of-a-kind device can fire a small plastic projectile into a heap of metal powder at a speed six times faster than that of a bullet fired from a 22 caliber rifle In a process called dynamic compaction the impact of the projectile creates a shock wave in the powder causing the surface atoms to interlock With the launcher high-precision metal components can be produced in a single radical convergence

Westinghouse wizards have also been working with crystals made of thallium arsenic selenide which can function as tiny sensing devices for light Applications they say will range from pollution control to exotic defense systems According to Richard Hopkins manager of Westinghouse's silicon solar-cell materials program the crystals can double a laser beam's frequency If the beam enters the crystal as infrared it emerges from the other side as green Engineers exploit that power by connecting the crystal to a transducer which converts electric signals into a mechanical—or acoustic—vibration As the vibrations change the crystal compresses or expands changing the velocity of the light moving through it Thus by adjusting the current to the transducer superstuff engineers can electronically tune the crystal for specific wavelengths of light with no lens changes needed

Because the system requires no cumbersome lens switching says Hopkins the possibilities are enormous For instance, the crystals might monitor industrial smokestacks for emissions by analyzing the air with laser beams

In coal mines they could detect methane from that gas s particular absorption band in infrared Hopkins says The crystals might even make sure your home furnace is burning at its most efficient level

They also have far out uses like analyzing video images for camouflaged tanks " says Hopkins "In a satellite they can analyze incoming laser beams and activate a protective shutter if the beams wavelengths indicate they are designed to attack and blind the satellite

Behind all this Computer Age alchemy are powerful new tools For instance at Westinghouse's research center where 40 percent of the budget goes to materials science one laboratory—devoted to reconnaissance in the atomic zone—is filled with electron microscopes Each costs about $500 000 is old-fashioned in a year and obsolete in five With such tools scientists are busily rearranging molecules Industry is watching And so are other eyes

A friend of mine a researcher at a semiconductor company was abruptly summoned to a meeting recently says a materials scientist "It turned out to be CIA agents who had satellite photographs amazingly detailed of a silicon-chip plant in the USSR They wanted to know how pure the Soviet chips were "

The plant s design gave the scientists clues But a reliable analysis they said would require a small sample "In a month the agents were back says the scientist "They had a ten-pound silicon ingot straight from the Ukraine More than that the scientist would not say

In an electronic world built of high-tech materials superpowers need superstuff Matter may never be the same again ∞

BOROVSKY

CONTINUED FROM PAGE 125

among their feet surged a heavy bluish smoke, stirred into sluggish vortices as the men stepped along the narrow ways between the waterbeds.

Weinblatt doffed his rubber suit quickly. Borovsky much more slowly. A blonde on a nearby bed smiled at him, then drew aside the drapery suspended from cords braided around her neck. She had large breasts to which the heavy swing of E Minus Four had not been kind. Cupping a hand under one breast, she lifted it toward Borovsky and smiled again.

"How long since you've had a real woman?" Weinblatt asked. Borovsky muttered something that Laura did not think Weinblatt would catch above the jukebox, but she did: four years.

I'm real, Laura said, her voice low. I'm real and I'm—look at them! Like puddles of melting cranberry sauce! Either of us could outlift, outhaul, outproduce them all put together. How can you? Borovsky—"

"It's not my idea," Borovsky said sullenly, finally stepping free of her. Laura realized that it would not matter how much she looked at him, what she said, or how she behaved. She could not change Borovsky's mind.

Confused and hurting, she stepped back against the wall. Borovsky moved quickly away from her, heading toward the far end of the room, ignoring the blonde who followed him with charcoaled eyes. In moments he was lost in the swirling mist. Eagerness to see more melting cranberry women—or to get away from her? Laura was not sure, though she suspected the latter, and took from that some small wrapping of comfort.

"He talking to *you*?" the blonde demanded. She stared at the emptiness above Laura's helmet gasket at the head that Laura had never had nor wanted.

"Yes."

"Huh!" She sounded neither surprised nor scornful, only annoyed. "He don't like blondes?"

"I don't know what he likes."

The woman looked at Laura shrewdly. "I'll bet you do so, Honey." Suddenly she laughed, such an unselfconscious, friendly laugh that Laura found herself drawn away from the wall to stand beside the woman's pentagonal waterbed. The lights beneath it shifted from green to red, warming the woman's skin so that to Laura it looked like uncooled metal.

"Why do you do this?" Laura asked softly.

"Do what?"

"Make . . . love to these men. You aren't their work partners. You have no interest in their lives. They haven't bought you a soul. You don't love them."

The blonde gave her a long, speculative look. Something surfaced in her eyes, something Laura had the quickness to see but not the knowledge of humanity to interpret. Then the human woman laughed again. "It's a living."

A living. Laura hadn't seen it that way before. People had to live. Steelwalkers needed sex. Laura knew they talked of it enough and few had fine Rabinowicz suits like Laura. There was a good, respectable economic foundation to Berenice's Club. But Borovsky... Borovsky *did* have her.

"Jealous, Honey?" the blonde said softly. She did not mock. Her eyes, lids painted blue as far as her brows, seemed sympathetic and a little sad. Staring into those eyes, Laura felt the odd sensation of unrelated data suddenly relating. The woman's eyes reminded her of Borovsky's balalaika music.

"Don't cry about it," the blonde said. "That's how a steelwalker is. Tin woman, skin woman—he don't care. We do what we can."

"No," Laura said. "No!"

"Sorry." Again the blonde gave Laura that knowing, sad, blue-lidded look. From the airlock a man walked into the room and stripped off his rubber suit. After glancing around the misty room, he smiled at the blonde. She raised her huge breast to him and looked up through her lashes. The man sauntered over to the bed.

"Silver lady, stud?"

"Purple quickie. You available?" The man grinned mischievously at her.

"Why not?"

Laura stepped back against the wall. Around the blonde's bed the blue mist grew thicker, rising in hazy walls shot through with multicolored light from the bed. The man in his eagerness had left his rubber suit at Laura's feet. She kicked at it, then abruptly picked it up and hung it on a nearby peg. Its empty arms dangled helplessly. Without a man inside it, it was useless. Rubber suits. Balalaika music. Blue-lidded eyes. Borovsky. Simon Weinblatt. Coyne. Silver lays. Souls—Souls.

That was what she had seen in the blonde's sympathetic look.

Startled, Laura stared at the bed. The mist around the bed grew thicker and darker blue. The bed began to move away from Laura on its cushion of air. Another bed, this one with two women and one man, just leaving it, slid toward Laura. One of the women put one foot on the floor and squealed. The man laughed and slapped her bare ass. Music blared and mist swirled. Nothing in the scene looked to Laura anything like Wolf Lair's outstretched arms on the steel beam, but Laura knew she was not mistaken. In the blonde's balalaika eyes Laura had seen another soul. And she had recognized it only because she had her own.

Laura settled back against the wall in resignation and waited for the sliding beds to bring Borovsky back to her.

> ❛She had never failed to tell Borovsky anything he wanted to hear. If he commanded her, she would tell him. To refuse was to face consequences too final to consider.❜

The spare yoyo was dead.

Borovsky snapped the battery cover free and peered into the space crowded with wires and age-crusted components. Nothing looked amiss.

"Take a look," he told Laura, and poked their right hand into the cavity.

Laura's fingers nudged the wires aside as the eyes that rode over each finger examined the mechanism.

Her fingers saw it and teased it out into view from where it had been tucked behind a voltage regulator: a carefully snipped wire.

Hesitantly she described the wire. Borovsky stopped for many long seconds, one hand on the battery pack and one hand holding a screwdriver.

"He came in here. I noticed him before we got tied up with the trouble setting up the last beam. He didn't come out."

Borovsky and Laura checked between the piles of steel for a place where a man might hide.

"We could have missed him coming out," Laura suggested.

"I don't miss nothing from him no more," Borovsky replied coldly. "He's in here."

Laura said nothing. Borovsky's bionics alarmed her. Pulse, blood pressure, muscle tension, skin resistance—this was not normal anger. He was in a cold rage.

In one corner of the dump was a circular column three meters wide, rising up from the floor and vanishing into the ceiling. It was the conduit core that carried power down from the center of the titan cylinder to the construction on the Low Steel. At knee level was the inspection hatch.

"Get that hatch on your infrared," Borovsky ordered.

The wide oval eye on Laura's brow saw the vague smudge on the hatch's handle. The vacuum of E Minus Seven preserved heat traces well.

"There were hands on that handle recently," she said, wishing it were not so.

Borovsky grunted and grasped the handle. It would not turn.

"Locked," Laura said.

"For me, maybe. Not for you. *Turn.*"

Laura's fingers tightened on the handle and twisted hard. She felt the metal of the latch resist and moan, then break free. The hatch swung inward.

Wriggling through the hatch took some

minutes It had not been designed for passing a man in an amplified Rabinowicz space suit Laura supposed that had been Coyne's hope and ached that it could have been true

Inside the column were pipes and bus channels vanishing upward in the darkness Running among the pipes was an aluminum ladder Laura turned off her suit lights and saw the warm spots where sweating, rubber suited hands had gripped the rungs

The olfactics within her helmet smelled Borovsky's rage Up

They climbed in darkness quickly twice as fast as a nonamplified man could climb Borovsky said nothing, and Laura dared not plead for him to give up the chase It would do no good and would only feed the rage she so feared

It's a mess in here she said truthfully trying to read the swirl of multicolored images her infrared eye gave her

By that level the column was pressurized, and warm air confused the heat traces Coyne had left behind She saw that the dust on the hatch handle had not been disturbed for some time She did not volunteer the information

Borovsky steered Laura's helmet crest beam along the ladder above Still too heavy This is E Minus Four He lives on E Minus Two He's still climbing

Without responding Laura grasped the rungs and climbed

Two airlocks higher E Minus Three began Above them locks had been removed to make the column an air-return manifold The black mouths of air tunnels yawned on four sides and a constant draft through the tunnels had erased any possible heat traces the man might have left behind Borovsky scanned the four tunnels

"He can't be far Damn, I've got him I know I do Damn "

They stood in silence for tens of seconds Laura gradually learned to separate the gentle white noise of the air tunnels from the general subsonic rumble created everywhere by life in a steel habitat With panic and despair she realized she could hear high above them the sound of a man's labored breathing

A man Borovsky wanted to kill

She could tell him where Coyne was or not tell him—a sickening choice She had never failed to tell Borovsky her man her life anything she knew he wanted to hear If he commanded her, she would tell him—to refuse was to face consequences too final to consider But if he found Coyne—if he *killed* Coyne—what would the Combine do to Borovsky then?

The words formed a hundred times and each time she wiped them away before sending them to her helmet speakers She strained to believe that hiding the truth was not a lie and knew that to believe so would be lying to herself

"He lives east of here " Borovsky said "He'll follow the tube Let's go

"No," Laura said, forcing the words to form "I hear him He's up on the ladder somewhere

Borovsky spat something foul in his native language He gripped the ladder with both hands and sent Laura's crest beam stabbing upward Coyne was there wrapped around the rungs panting Laura could smell his sour sweat drifting down on the stale air

Coyne stiffened made motions to start climbing again

"Stop!" Borovsky screamed Laura's arms pulled with his arms and the aluminum of the ladder tore raggedly away from its lower wall brackets

"Eat shit!" Coyne cried and dropped free of the ladder

His boots struck the top of Laura's helmet crushing many of her most delicate instruments including the pale blue glass oval that imaged in the infrared His knees flexed and he leaped to one side

The still vicious swing of E Minus Three drew him down but he had time to plan

Frantically Laura raced through her options. Borovsky was mad, insane—she could drug him She knew she had tranquilizers enough to make him sleep in seconds

his movements He drew up in a ball and rolled screaming in pain as one shoulder slammed into the steel But then he was up stumbling then running crookedly down one of the air tunnels favoring his left leg and sobbing in pain

Borovsky swore to himself in Russian Laura longed not to run but Borovsky's legs were running so her legs ran His arms swung in a deadly determined rhythm so hers swung too

Coyne was a pathetic scarecrow highlighted in every detail by the cold lights of Laura's helmet beam His rubber suit was smudged and torn helmet long abandoned to lighten himself He had only a few seconds head start and appeared close to exhaustion As much as Laura hated Coyne she felt a moment of pity for him

Coyne chose that moment to look over his shoulder side-stumbling for two steps He moaned and turned away but it had been enough Laura had seen his face smeared with the grime of the tunnels mixed with tears of exertion and abruptly she saw herself through his eyes

Shaped like a man cut out of steel and crushed in a magnetic press, torso nearly as wide as it was tall, arms and legs clusters of hydraulic cylinders contracting and extending in smooth polished motions Faceless silvered helmet without any neck ruined instruments atop it dangling by tiny wires and striking the helmet's sides with little sounds Hands twice human size, guided by flesh but powered by a hydraulic exoskeleton strong enough to crush rocks Hands reaching forward fingers splayed and grasping, grasping A machine bent on death

But she was not! She was life, productivity strength steel! She was in her soul—

No time Coyne screamed again stumbled fell to his knees, rolled over and stared in wide-eyed horror as Laura bore down on him

Her right hand caught him by the neck and lifted him like a rag doll He gurgled eyes bulging as Borovsky slammed him against the steel wall

Borovsky's hand squeezed

Horror-struck Laura felt her hand squeeze

Coyne tore at the hand around his neck hammered his fists against the smooth cylinders and the silver pistons that were slowly forcing Laura's fingers together His mouth twisted tongue pushing to one side struggling to let his throat breathe Laura felt his frantic heartbeat hammering in the veins of his neck And in Coyne's eyes under the terror and rage Laura saw something else a soul slipping away A trapped and mean soul but real—as real as the soul she had seen in the eyes of the woman trapped on the bed A soul that in a few more heartbeats would be gone

Because of her

"No!" she cried in Borovsky's ears "Stop this! You're killing him!

"Goddamned right! Squeeze!" Borovsky grunted

Borovsky squeezed Laura squeezed Frantically Laura raced through her options Borovsky was mad insane—she could drug him She had tranquilizers enough to make him sleep in seconds Tiny valves opened in the medpack on her hip, opiates pulsed down a tube toward the needles in their sheaths behind his buttocks The needle—she could plunge it home the power was hers

The command formed and with it appeared something new

A cloud, fiery red rising above the Flayer she called her soul It hovered an imagic representation of what would happen if she disobeyed Borovsky's command to squeeze Driven by terror and love, she asked herself one question *What will happen to Borovsky if he kills?* But not another *What will happen to Laura if she kills?* Now, all at once, she knew The consequence was inescapable built into the bright layers of her mind and the spiderweb paths between them She would lose her soul The ravening red cloud would burn it out of her She must obey Borovsky's command to squeeze or her soul would be destroyed She must not kill or her soul would be destroyed

She was going to become the soulless death tool she had seen in Coyne s eyes

A grim thought appeared out of nowhere Men are judged by their maker at the moment of their death I am judged by my maker every moment that I live

Coyne s pulse weakened His pulse! Wait! Laura sent fluid into the insulating layers between Borovsky s fingers and the outermost skin Slowly—but there was so little time—she built up a layer of fluid that kept Borovsky s fingers from truly contacting the outer layer of tough synthetic While the fluid flowed into the skin of her fingers she set her contractile layers to pulsing in her hand matching the rhythm of Coyne's laboring heart In seconds the illusion was complete and Borovsky rage maddened as he was had not noticed The pulse he felt was wholly in Laura s skin Laura gradually slowed the pulse made it weaker until it could barely be felt Finally it stopped

No pulse she said He s dead

Borovsky swore and released his hand Coyne unconscious fell in a heap face down Borovsky backed away from the man fell back against the opposite wall of the tunnel

Jesus Jesus

Laura s soul began assembling itself again gathering back into the haven of her innermost crystalline layer

It was hers again—she had not killed she had not disobeyed But now there was a dirtiness to her soul that she felt might never be cleared away

Borovsky trembling backed away from Coyne for several steps before breaking and running toward the vertical duct from which they had come

Tied up in a handkerchief on his water cot lay two kilos of gold ingots Borovsky stared at them He was wearing his old rubber suit inside out He had shaved his head and depilated the stubble Laura could stand his behavior no longer

Talk to me dammit!

What s to say? They catch me they ll kill me Nothing you can do

So where can you run to?

Earth London I never shoulda left Only crazy men live up here

Earth Laura was appalled But still Earth would be far from George Eastman Nexus Far from this boxed-in deadliness Borovsky would be there she could learn to live there too She undogged her top plates before Borovsky looked at her sharply

Forget it Me I can maybe bribe through customs and sneak down You no chance

You can t leave me!

Like hell

But I love you!

Would you love me better dead? *Dushenka* here you can die for bumping a guy on the head and taking his money Two three days maybe before they find him The computers know Coyne hated me Ha! Don't take no computer to tell the cops that They ll be here ten minutes after they find his ugly corpse

He looked at her From his eyes Laura saw that he was pleading for her to understand to forgive to still be the one always on his side Borovsky would never say it aloud but it was there in his twisted face He could not take her with him but it hurt him to leave her behind

Laura reached to him

Borovsky I lied He isn t dead I tricked you " Every word was a labor "I made you feel a pulse I created, then stopped it He was still alive when you let go of him

Borovsky's mouth opened In that one movement Laura saw her mistake His fists tightened and he glared with the fury of a man who thinks he has been tricked into softness and then kicked in it Whore! Steel bitch! I buy your soul and you look after shit like Coyne! Tell me you didn t do that!

I did do it

Borovsky spat at her his saliva spattered on her faceplate "I wanted something better than a woman But I got a woman anyway Go rot in a corner, I m leaving and to hell with you

Something lurched in Laura s soul It was not the red cloud but like the red cloud it hurt and tore at her Fragile—she had never realized the soul in her steel body was so fragile As fragile she thought as the lacy balalaika music trapped in its metal box

Borovsky cursed her again Numb Laura peered into his eyes It seemed to her that she saw nothing at all

She couldn t bear it Pain balalaika, souls curses—she looked away anywhere away, out the little window to where the stars called from the Pit—

Crawling under the horizon was the bright-yellow ELM

Borovsky!

Shut up

He s coming back Coyne The yellow egg—

Laura watched Borovsky whip around his face suddenly pale No He squeezed past the little sink to the window "No! "

Suspended on four motorized trucks that rode the flanges on the longitudinal beams was Coyne s ELM The main arm was extended forward It was close enough now to see the diamond cutting wheel glinting in the creeping sunlight

He s gonna cut us loose Christ! Open up fast! Borovsky tore off his rubber suit Leaning into the barrel-shaped shower he turned the water full on hot

Borovsky pulled the sheet from the watercot and slit the plastic mattress with a paring knife He yanked the coil-corded immersion heater from the kitchen blister and threw it into the water spilling out of the watercot mattress In moments the water began to bubble into steam

The ELM was just outside the pod Borovsky climbed into Laura and was just sealing her ventral plates when he heard the diamond wheel cut into the first of the pod s four suspension supports

Borovsky cursed and sealed Laura's helmet gasket He slapped his hips, felt for all his familiar tools

The pod lurched then tipped to one side as the first support broke loose Boiling water cascaded out onto the floor from the watercot Steam was beginning to condense on the outside of Laura's faceplate

They stumbled across the skewed floor to the rear of the pod and opened the lock door The lock was only a barrel itself, barely wide enough to admit Laura's bulk Borovsky tapped commands into the lock control, securing the inner door open

Next he tore the cover off a guarded keypad and armed the explosive bolts supporting the lock's outer hatch

Inside the lock Laura heard Borovsky take a deep breath

"Don't you never lie to me again he said softly and tapped the key that detonated the explosive bolts

The sound was deafening and the whirlwind of steam that blew them forward was worse Water expelled into the void burst into droplets, which exploded into steam Laura felt for the chain ladder's tubular rungs and hauled upward blinded by the rolling cloud of steam pouring out of the pod Two meters overhead was the underbelly of George Eastman Nexus, here a tangle of beams to which the chain ladder was welded Borovsky and Laura pulled themselves up among the beams Laura braced herself on a beam and pulled the chain ladder until its welds tore loose They let it drop into the steam

They felt the second pod support give way Steam continued to pour out of the cast wide hatch for many minutes They felt the vibration of the ELM's trucks carrying it forward to reach the second pair of pod supports The whine of the diamond wheel biting into the steel carried up through the support into the beams from which it hung

The steam was beginning to clear as the third support gave way Borovsky saw the pod pitch crazily downward on its last thin support and describe a short, fast pendulum arc for several seconds Then weight and metal fatigue ripped the support from its bracket The pod tumbled downward toward the stars with sickening speed, trailing a tattered comet's tail of steam

The steam was gone falling away from them as the pod had Borovsky gritted his teeth breathing shallowly Laura saw Coyne under the big glass bubble atop the ELM, watching the pod vanish in the glare from the sun

With infinite care Borovsky pulled a zot wrench from his hip The ELM was several meters spinward of the nest of beams to which they clung Laura knew Borovsky was watching Coyne as desperately as she was But what could Borovsky do?

Coyne turned his eyes away from the now-vanished pod and began looking ahead Laura and Borovsky were still in shadow though the sun was creeping spinward along the tessellated undersurface of Eastman Nexus In ten minutes light would find them—as would Coyne

Coyne could not have seen them blow out of the pod amidst the steam but he was not stupid enough to assume it could not be done Laura imagined that he would expect them to flee along the beams and she watched his narrow face searching the impenetrable shadows antispinward of where they hid

Borovsky seemed to share her speculations His arm cocked, and with a quick, sure motion he threw the zot wrench to antispinward Five meters beyond them it fell out of the shadows and caught the sun with a metallic dazzle

Coyne saw the wrench The ELM's motors ground to life again, pulling the big egg antispinward Coyne brought up the big spotlight and began scanning the shadows only a meter beyond them

The ELM crept beneath them Its upraised robotic arm carried the glittering diamond wheel not a meter from Laura's helmet Borovsky's body tensed inside Laura She knew horrified what he was about to do

As soon as the ELM's dome passed beyond them, Borovsky and Laura dropped from the beam down onto the back of the handling machine

Magnets in Laura's toes and knees snapped hold on the metal as they connected Laura saw Coyne turn and open his mouth she felt his scream through the metal of the ELM

Borovsky crouched down and backward The multijointed arm swung toward them holding its silently spinning cutoff wheel The wheel scanned back and forth as Coyne's hands flexed in the pantograph As Borovsky had known its joints would not allow it to reach that far back over the ELM's dome

Laura felt machinery energize beneath her Four smaller arms were unfolding from the sides of the ELM Each carried something deadly—an arc welder cable nips tubing cutter and utility grippers

The arc welder struck and sizzled into life It had the shortest range and could not reach them Coyne let it drop after one pass The tubing cutter lunged at Laura's arm and ground against the hardened steel of one of the slender hydraulic cylinders that moved her torso Borovsky grabbed at the cutter below its wrist and twisted hard The bayonet latches obediently opened and the tool popped from the end of the arm leaving the blunt wrist to flail and beat at them While Coyne was distracted Borovsky kicked out at the base of the arm carrying the cable nips With Laura's hydraulic assist in full play the kick bent the arm back hard against its base Fluid oozed from the base joint and ran greasily down the ELM's side The arm twitched several times and was still

The remaining arm hovered cautiously just out of reach, weaving from side to side like an attacking snake It carried a hand with four powerful fingers and unlike the others, the hand was too complex to be easily removable on a bayonet base.

The fingers spread wide, and the hand darted forward, following Coyne's hand in the pantograph. The steel hand grasped one of the hydraulic tubes on Laura's right shoulder and clamped tightly. The arm began hauling them forward, out over the glass dome, into the range of the waiting diamond wheel.

The wheel swept toward Laura's helmet and struck her faceplate obliquely with a shriek of hardened glass against raging diamond. An hourglass-shaped abrasion appeared where the wheel had struck and glanced away.

Borovsky's one free arm darted out and took hold of the diamond wheel. Quickly Laura's strength pulled it down and to one side before Coyne could work against them and pressed the wheel against the smaller arm clamped on Laura's shoulder joint. Only a moment's touch parted the metal skin over the wrist joint, and the pressurized joint fluid spurted out of the narrow cut. The smaller arm's grip went limp and the fingers snapped involuntarily open. They scrambled back out of the reach of the cutoff arm.

Borovsky and Coyne stared at each other through the glass of the ELM's dome. Coyne was still in his torn and filthy rubber underwear, his neck a swollen pattern of purple bruises, his fingers flexing and working aimlessly in the pantograph.

There was no sign of a space helmet under the dome.

"Bastard! You want tools, Coyne? I show you tools!"

Borovsky reached into his right hip-locker and pulled out a carbide scribe. From his belt he hefted a three-kilo mallet.

"No," Laura said. "The machine is ruined, that's enough! Please don't!"

"Shut up!" Borovsky snapped. He reached down and drew the point of the scribe heavily sidewise across the glass dome. Glass splinters sparkled in the scribe's wake, leaving behind a jagged scratch. Borovsky reached forward and drew another gouge with the scribe, pulling it across the first gouge, making a lopsided cross in the glass. He positioned the point of the scribe where the scratches crossed, and he raised the mallet.

His hand was in her hand. When the mallet descended and struck the scribe, Coyne would die.

"No!" Laura cried. "Kill him and you kill me! My soul, the soul you paid for!"

He did not hear her, or if he did, his rage was so devouring that her words didn't matter. The mallet began to descend. Laura saw the red cloud appear again and felt it tearing at her F layer. Borovsky would not stop it. Laura could not stop it—halt the mallet, drug Borovsky, drop the scribe into the Pit—none of it would halt the red cloud. A machine's soul must obey, a machine's soul must not kill, a machine's soul—

"No!" Laura screamed again, but this time not to Borovsky.

Something in the scream—something so decisive and anguished that it penetrated even his enraged mind—made his eyes whip to the side, to the instruments inside Laura's helmet. Human eyes met electronic eyes, and with a great wrench Borovsky twisted the smashing mallet to miss the carbide scribe. But the action came a nanosecond too late. Laura did not see it. She had already made her decision.

In an instant Laura swept away the bright lines of connection between her F layer and her cold outer intellect, scrambled all sensory paths beyond reassembly. She drew a curtain of chaos between her innermost self and the world that waited to steal her soul. The crystalline domains went random and impassable; connections that had taken years to form were gone forever, dragging with them the burning, immediate memories that her soul could not embrace. Without Borovsky she would be empty, but without her soul she would be nothing. So Laura split herself in two: a machine intellect that obeyed Borovsky's orders without self-awareness, and an inner soul that could neither touch nor be touched by the outside world, sealed into the crystalline F layer like the phantom memories of a catatonic.

Borovsky's space suit sent the mallet spinning off into space. Laura the soul did not see it. For Laura, the soul, Eastman Nexus vanished, the ELM vanished, hands and eyes and steel vanished. The last thing she had seen was Borovsky's eyes.

Laura ran along a steel beam on a memory, high above the sucking stars. Her man ran within her, and they laughed, and they worked, and they told jokes in steel saloons run by robot bartenders. At night, in their tiny pod, she held his body and heard him whisper words of endearment as they made the special love that only a space suit may make to her man. They rode their yoyo to the Low Steel and pushed the beams with a tall, quiet man and endlessly watched the remembered days go by.

Only occasionally would she stop alone on a beam and, following a star with her many eyes, wonder how the outer world had vanished on that last day.

But then she would turn away to seek again what reality was now, in her crystalline soul, hers forever.

Even more occasionally Laura would look at two pieces of disjointment that lay in her soul. Their presence puzzled her; she could not tell what they meant. One was a man standing on a steel beam, arms outstretched, back straining in tortured exultation. The other was her man, but not as he ran with her in her memories. In the second piece of disjointment her man's eyes whipped around to meet hers, and the expression in them was frozen forever. In his eyes were shock and fear and the stunned realization of a man seeing for the first time something beyond himself and greater than himself.

In his eyes was a soul. ◘◘

MIND

CONTINUED FROM PAGE 20

average life span, body size, and the use of some sort of language, for example. We can expect no such guarantees in contacts with extraterrestrial societies.

"Are we prepared," Hill asks, "for a society in which the average body height is sixty feet? Or where there are three sexes instead of two? What would happen to our religious beliefs if we were to make contact with life from beyond? We ought to be realizing that a clenched fist, for example—a sign of aggression on Earth—could be a sign of peaceful intent elsewhere. Exosociology has practical applications."

One of the more practical applications is preparing us for living in space, rather than just visiting it. "If NASA is going to go ahead with establishing colonies in space," maintains Hill, "then, at the very least, they ought to be consulting an exosociologist."

The space agency has not been all that receptive. "NASA was trying to pretend we weren't raising a legitimate issue," Yinger recalls of the early days of his science. "They weren't afraid to talk about colonization of space, but they were deathly afraid to talk about what that would mean for all of us." So far that reluctance remains.

Sociologist Arthur Harkins, of the University of Minnesota, who coedited a 1974 exosociology anthology, *Cultures Beyond the Earth*, thinks his discipline's most practical applications will be in high technology, specifically artificial intelligence.

"Humans get sick in space," Harkins reminds us. "We have a limited ability to survive. Now think how many microprocessors we can put into space—with *no* fear of survival danger. We should really be concerning ourselves with what happens when machine social systems, not humans, are put into space.

"Starting in about five years," Harkins continues, "and lasting for the next several decades, NASA won't be interested in putting humans into space. Artificial intelligence is now so advanced that NASA will have no choice but to turn to systems with robotic actuators. And why not? If they work better than humans, we should go with the flow. Sociologists are unfascinated with change in general and high technology in particular. But that's where the future is. And that's where the study of exosociology is going. We should study what happens to these systems in space for hints of extraterrestrial life. *That* would be putting exosociology to good use."

Before exosociologists can seriously consider future directions for the field, says Yinger, they must improve societies on Earth. "It is fruitless to study how we should relate to other societies in space if we don't know how to relate to one another," he says. "As soon as we can find a nonviolent resolution to conflict here on Earth, we'll really have something to communicate to intelligent beings in the universe." ◘◘

INTERVIEW

CONTINUED FROM PAGE 132

tration the offshore oil bill was about eighty billion dollars, and the budget for alternative energy was about seven hundred seventy-six million dollars—pretty close to the one-percent goal. The Reagan Administration came in and cut that by around sixty percent. I can't think of anything that will guarantee our dependence on foreign oil more than cutting that research.

Omni: Do you see private industry coming in, as the Reagan Administration said it would, to pick up activities that have been dropped by the government?

Glenn: No. Quite the contrary. If we've seen anything in this recessionary period, it's that one of the first things companies drop are their efforts in the basic-research area.

Omni: And what about your other pet project, preventing the further spreading of nuclear weapons around the world?

Glenn: When I first came to the Senate, I found very little going on in the government to control the flow of the kind of information that would lead to weaponry. I picked up the issue, and the upshot of it was that, after working on it for a couple of years, we passed the Nuclear Non-Proliferation Act in 1978. We felt we had ten to fifteen years to prevent the spread from the half dozen or so major nuclear supplier nations—those who had the capability to manufacture the very technical equipment for reprocessing spent nuclear fuel and getting out the plutonium that could be used for a bomb, or the equipment used to enrich uranium up to bomb capability. Overall, the Non-Proliferation Act had a good impact. It hasn't worked perfectly, but it's our effort to control the spread of nuclear weapons around the world.

The Reagan Administration has been going pretty well in the other direction, trying to gut the act. They have made changes in plutonium policy that reduce the safeguards. It makes you feel like the little Dutch kid with his finger in the dike trying to hold back some of these things around the world. I'm not overly optimistic about how much we can stanch the nuclear flow to more and more—and sometimes smaller and smaller—nations. But we have to keep trying. We are also concerned about new technological developments for nuclear weaponry. What if one of these days laser-isotope separation becomes common? If it becomes as simple and as common as some people think it will, almost any nation in the world that wanted a bomb-making capability could have it. We're not without progress in this field, but is there enough concern in the administration now? No. I don't think there is.

Omni: Can the government's handling of science and technology ever ignite into a real political issue, the way, for example, that protection of the Social Security system is a political issue?

Glenn: I would tend to doubt it for this reason. It could attract greater interest, but could it get to the point where it inflames people? No, because it's so far in the future. It's a pattern that doesn't pay off tomorrow. Social Security ignites people because a lot of them are either on Social Security now or nearing Social Security age, and everyone sees his own financial future being affected by what's being done about Social Security. But the relationship between research and the future of the country—that's indeterminate; you can't put a dollar value on it. That's the problem with research—you can't say that for each dollar spent we're going to get back two dollars fifty cents the year after next, making it a good investment. Yet it usually pays off far beyond that. But it's not definite, so you can't get people fired up about it.

Back in the early days of this country we emphasized research in agriculture. That's why today we produce maybe twice as much per acre as anybody else produces on similar land in other parts of the world. It gives us a wonderful problem: great surpluses of food. And we ship zillions of tons of it all over the world. That didn't happen overnight. It happened because we were curious about how plants work, about the chemistry of plant nutrients, about techniques for developing high-yield hybrids. All this took a lot of experimenting. And out of that eventually came the Green Revolution. If there's one good example of what research has meant to this country, it's our agricultural system.

"I rode the F-16 recently. It's the closest thing to a rocket I've been in lately. We made a full-burner takeoff almost straight up, at an 80° angle."

The same thing has gone on in other areas—in communications, transportation, aeronautics. In aeronautics the research we've done has been almost exclusively government research. All of these are examples of how we built whole new patterns of industry, trade, jobs—all these came because we learned new things and put them to use. Then other nations followed our lead. That's been our tradition, but if we break with it we take the chance of relegating ourselves not only to second-class status, but perhaps much farther down the ladder than that.

Omni: What sort of response have you been getting to this theme?

Glenn: People respond very well, because nobody else seems to be speaking along these lines. I find great attention, particularly when I tie these issues to them and their families. What are our kids going to be working at twenty years from now, and are we setting the stage for that, or are we eating our seed corn for the future by not putting sufficient support into educational areas or research?

Omni: Do you find time for reading anything other than legislative materials?

Glenn: Some, but not enough. Every time we get a legislative break, I have half a dozen books lined up, and I usually make it through one or two. But most of my time is taken up with things I have to read for my legislative responsibilities.

Omni: When you do have time, what do you prefer?

Glenn: It goes across the board. A lot of the things involve politics, government, philosophy—a few novels. The last one I read was a few years old, and I hadn't had a chance to get to it before: *Fields of Fire*, about the Vietnam War. I guess I was interested because of my Marine background. I haven't read many novels. Most of the books I read are on some particular subject, usually having to do with government, foreign policy, or scientific matters.

Omni: Do you ever go back and take a look at your old *Mercury* capsule in the Air and Space Museum?

Glenn: I've been back a few times with groups that wanted to go over. It's not very big, I know that.

Omni: Would you go up in it again?

Glenn: Oh, sure. You like to make every flight you possibly can. I rode the F-16 down in Fort Worth [Texas] recently. It's the closest thing to a rocket I've been in for a while. I went up with the chief test pilot for the plane. We made a full-burner takeoff—almost straight up—climbing at about a seventy-five- to eighty-degree angle, which is virtually standing on the tailpipe. We went up to about thirty thousand feet—you can get to forty thousand in a minute and a half—leveled off and put it through its paces as far as maneuverability and stability checks. I took it out to about 1.65 Mach. It's a nine-g limited, and I pulled it up to about eight and a half. We did a lot of stuff and then we came back and shot some landings with it. It's a very impressive airplane. It was almost like being back in the spacecraft again with a sidearm controller, which sits over on the right side of the cockpit as opposed to having a stick in the middle of the cockpit. That's the same kind of system we had in the old *Mercury*.

Omni: How much flying time do you get in?

Glenn: I average one hundred fifty to one hundred seventy hours a year. I have a Beech Baron and I have it equipped, as near as you can equip a little plane, like a miniairliner: radar, coupled autopilot for automatic approaches, and everything else possible. Anytime I'm going anywhere in the eastern half of the country, I fly my plane. I enjoy it. It's like therapy. OO

CARRION

CONTINUED FROM PAGE 168

my vision fled as I turned

Mr Thorne was there At my elbow Unbidden I had opened my mouth to command him back to the top of the stairs when I saw the cause of his approach The youth who had been taking pictures of his pale wife was now walking toward me Mr Thorne moved to intercept him

"Hey excuse me, ma am Would you or your husband mind taking our picture?"

I nodded and Mr Thorne took the proffered camera It looked minuscule in his long-fingered hands Two snaps and the couple were satisfied that their presence there was documented for posterity The young man grinned idiotically and bobbed his head Their baby began to cry as the cold wind blew in

I looked back to the submarine but already it had passed on its gray tower a thin stripe connecting the sea and sky

We were almost back to town the ferry was swinging in toward the slip when a stranger told me of Willi s death

"It s awful isn t it?" The garrulous old woman had followed me out onto the exposed section of deck Even though the wind had grown chilly and I had moved twice to escape her mindless chatter the woman had obviously chosen me as her conversational target for the final stages of the tour Neither my reticence nor Mr Thorne s glowering presence had discouraged her "It must have been terrible" she continued "In the dark and all "

"What was that?" A dark premonition prompted my question

"Why, the airplane crash Haven t you heard about it? It must have been awful, falling into the swamp and all I told my daughter this morning—"

"What airplane crash? When?" The old woman cringed a bit at the sharpness of my tone but the vacuous smile stayed on her face

"Why last night This morning I told my daughter—"

"*Where?* What aircraft are you talking about?" Mr Thorne came closer as he heard the tone of my voice

"The one last night," she quavered "The one from Charleston The paper in the lounge told all about it Isn t it terrible? Eighty-five people I told my daughter—"

I left her standing there by the railing There was a crumpled newspaper near the snack bar and under the four-word headline were the sparse details of Willi s death Flight 417 bound for Chicago had left Charleston International Airport at twelve-eighteen A M Twenty minutes later the aircraft had exploded in midair not far from the city of Columbia Fragments of fuselage and parts of bodies had fallen into Congaree Swamp where fishermen had found them There had been no survivors The FAA and FBI were investigating

There was a loud rushing in my ears and I had to sit down or faint My hands were clammy against the green vinyl upholstery People moved past me on their way to the exits

Willi was dead Murdered Nina had killed him. For a few dizzy seconds I considered the possibility of a conspiracy—an elaborate ploy by Nina and Willi to confuse me into thinking that only one threat remained But no There would be no reason" If Nina had included Willi in her plans there would be no need for such absurd machinations

Willi was dead His remains were spread over a smelly obscure marshland I could imagine his last moments He would have been leaning back in first-class comfort a drink in his hand perhaps whispering to one of his loutish companions

Then the explosion Screams Sudden darkness A brutal tilting and the final fall to oblivion I shuddered and gripped the metal arm of the chair

How had Nina done it? Almost certainly not one of Willi s entourage It was not beyond Nina's powers to Use Willi s own cat's paws especially in light of his failing Ability, but there would have been no reason to do so She could have Used anyone on that flight It *would* have been difficult The elaborate step of preparing the bomb, the supreme effort of blocking all memory of it and the almost unbelievable feat of Using someone even as we sat together drinking coffee and brandy

But Nina could have done it Yes, she *could* have And the timing The timing could mean only one thing

The last of the tourists had filed out of the cabin I felt the slight bump that meant we had tied up to the dock Mr Thorne stood by the door

Nina's timing meant that she was at tempting to deal with both of us at once She obviously had planned it long before the reunion and my timorous announcement of withdrawal How amused Nina must have been No wonder she had reacted so generously! Yet she had made one great mistake By dealing with Willi first Nina had banked everything on my not hearing the news before she could turn on me She knew that I had no access to daily new[illegible] and only rarely left the house anymore S[illegible] it was unlike Nina to leave anything [illegible] chance Was it possible that she thou[illegible] had lost the Ability completely and th[illegible] was the greater threat?

I shook my head as we emerge[illegible] the cabin into the gray afternoon li[illegible] wind sliced at me through my th[illegible] The view of the gangplank was blu[illegible] I realized that tears had filled my e[illegible] Willi? He had been a pompous w[illegible] tool For Nina's betrayal? Perhaps [illegible] only the cold wind

The streets of the Old Section were [illegible] most empty of pedestrians Bare branc[illegible] clicked together in front of the windows [illegible] fine homes Mr Thorne stayed by my side The cold air sent needles of arthritic pain up my right leg to my hip I leaned more heavily upon father's walking stick

What would her next move be? I stopped A fragment of newspaper caught by the wind wrapped itself around my ankle and then blew on

How would she come at me? Not from a distance She was somewhere in town I knew that While it is possible to Use someone from a great distance it would involve great rapport, an almost intimate knowledge of that person And if contact were lost it would be difficult if not impossible to reestablish at a distance None of us had known why this was so It did not matter now But the thought of Nina still here nearby made my heart begin to race

Not from a distance I would see my assailant If I knew Nina at all, I knew that Certainly Willi's death had been the least personal Feeding imaginable but that had been a mere technical operation Nina obviously had decided to settle old scores with *me* and Willi had become an obstacle to her a minor but measurable threat that had to be eliminated before she could proceed I could easily imagine that in Nina's own mind her choice of death for Willi would be interpreted as an act of compassion almost a sign of affection Not so with me I felt that Nina would want me to know, however briefly, that she was behind the attack In a sense her own vanity would be my warning Or so I hoped

I was tempted to leave immediately I could have Mr Thorne get the Audi out of storage and we could be beyond Nina's influence in an hour—away to a new life within a few more hours There were important items in the house of course but the funds that I had stored elsewhere would replace most of them It would be almost welcome to leave everything behind with the discarded identity that had accumulated them

No I could not leave Not yet

From across the street the house looked dark and malevolent Had *I* closed those blinds on the second floor? There was a shadowy movement in the courtyard and I saw Mrs Hodges's granddaughter and a friend scamper from one doorway to an[illegible] [illegible]stood irresolutely on the curb and [illegible] [illegible]her's stick against the black[illegible] [illegible] It was foolish to dither so—I [illegible] but it had been a long time [illegible] been forced to make a decision [illegible]

[illegible] please check the house [illegible]om Return quickly

[illegible]ame up as I watched Mr [illegible] coat blend into the gloom [illegible] I felt terribly exposed [illegible]one I found myself glanc[illegible] the street looking for Miss

How amused Nina must have been. Yet, she had made one great mistake. By dealing with Willi first, Nina had banked on my not hearing the news before she turned on me

Kramer's dark hair, but the only sign of movement was a young woman pushing a perambulator far down the street

The blinds on the second floor shot up and Mr Thorne's face stared out whitely for a minute Then he turned away and I remained staring at the dark rectangle of window A shout from the courtyard startled me but it was only the little girl—what was her name?—calling to her friend Kathleen that was it The two sat on the edge of the fountain and opened a box of animal crackers I stared intently at them and then relaxed I even managed to smile a little at the extent of my paranoia For a second I considered Using Mr Thorne directly but the thought of being helpless on the street dissuaded me When one is in complete contact the senses still function but are a distant thing at best

Hurry The thought was sent almost without volition Two bearded men were walking down the sidewalk on my side of the street I crossed to stand in front of my own gate The men were laughing and gesturing at each other One looked over at me *Hurry*

Mr Thorne came out of the house locked the door behind him and crossed the courtyard toward me One of the girls said something to him and held out the box of crackers but he ignored her Across the street the two men continued walking Mr Thorne handed me the large front-door key I dropped it in my coat pocket and looked sharply at him He nodded His placid smile unconsciously mocked my consternation

"You're sure?" I asked Again the nod "You checked all of the rooms?" Nod "The alarms?" Nod "You looked in the basement?" Nod "No sign of disturbance?" Mr Thorne shook his head

My hand went to the metal of the gate but I hesitated Anxiety filled my throat like bile I was a silly old woman tired and aching from the chill, but I could not bring myself to open that gate

"Come" I crossed the street and walked briskly away from the house "We will have dinner at Henry's and return later" Only I was not walking toward the old restaurant, I was heading away from the house in what I knew was a blind directionless panic It was not until we reached the watertront and were walking along the Battery wall that I began to calm down

No one else was in sight A few cars moved along the street, but to approach us someone would have to cross a wide empty space The gray clouds were quite low and blended with the choppy white-crested waves in the bay

The open air and fading evening light served to revive me and I began to think more clearly Whatever Nina's plans had been, they certainly had been thrown into disarray by my day-long absence I doubted that Nina would stay if there were the slightest risk to herself No she would be returning to New York by plane even as I stood shivering on the Battery walk In the morning I would receive a telegram I could see it MELANIE ISN'T IT TERRIBLE ABOUT WILLI? TERRIBLY SAD CAN YOU TRAVEL WITH ME TO THE FUNERAL? LOVE NINA

I began to realize that my reluctance to leave immediately had come from a desire to return to the warmth and comfort of my home I simply had been afraid to shuck off this old cocoon I could do so now I would wait in a safe place while Mr Thorne returned to the house to pick up the one thing I could not leave behind Then he would get the car out of storage and by the time Nina's telegram arrived I would be far away It would be *Nina* who would be starting at shadows in the months and years to come I smiled and began to frame the necessary commands

"Melanie"

My head snapped around Mr Thorne had not spoken in twenty-eight years He spoke now

"Melanie" His face was distorted in a rictus that showed his back teeth The knife was in his right hand The blade flicked out as I stared I looked into his empty, gray eyes and I knew

"Melanie"

The long blade came around in a powerful arc. I could do nothing to stop it. It cut through the fabric of my coat sleeve and continued into my side. But in the act of turning, my purse had swung with me. The knife tore through the leather, ripped through the jumbled contents, pierced my coat, and drew blood above my lowest left rib. The purse had saved my life.

I raised father's heavy walking stick and struck Mr. Thorne squarely in his left eye. He reeled but did not make a sound. Again he swept the air with the knife, but I had taken two steps back and his vision was clouded. I took a two-handed grip on the cane and swung sideways again, bringing the stick around in an awkward chop. Incredibly, it again found the eye socket. I took three more steps back.

Blood streamed down the left side of Mr. Thorne's face, and the damaged eye protruded onto his cheek. The nictal grin remained. His head came up, he raised his left hand slowly, plucked out the eye with a soft snapping of a gray cord, and threw it into the water of the bay. He came toward me. I turned and ran.

I *tried* to run. The ache in my right leg slowed me to a walk after twenty paces. Fifteen more hurried steps and my lungs were out of air, my heart threatening to burst. I could feel a wetness seeping down my left side, and there was a tingling—like an ice cube held against the skin—where the knife blade had touched me. One glance back showed me that Mr. Thorne was striding toward me faster than I was moving. Normally he could have overtaken me in four strides. But it is hard to make someone run when you are Using him. Especially when that person's body is reacting to shock and trauma. I glanced back again, almost slipping on the slick pavement. Mr. Thorne was grinning widely. Blood poured from the empty socket and stained his teeth. No one else was in sight.

Down the stairs, clutching at the rail so as not to fall. Down the twisting walk and up the asphalt path to the street. Pole lamps flickered and went on as I passed. Behind me Mr. Thorne took the steps in two jumps. As I hurried up the path, I thanked God that I had worn low-heel shoes for the boat ride. What would an observer think seeing this bizarre, slow-motion chase between two old people? There were no observers.

I turned onto a side street. Closed shops, empty warehouses. Going left would take me to Broad Street, but to the right, half a block away, a lone figure had emerged from a dark storefront. I moved that way, no longer able to run, close to fainting. The arthritic cramps in my leg hurt more than I could ever have imagined and threatened to collapse me on the sidewalk. Mr. Thorne was twenty paces behind me and quickly closing the distance.

The man I was approaching was a tall, thin Negro wearing a brown nylon jacket. He was carrying a box of what looked like framed sepia photographs.

He glanced at me as I approached and then looked over my shoulder at the appartition ten steps behind.

"Hey!" The man had time to shout the single syllable and then I reached out with my mind and *shoved*. He twitched like a poorly handled marionette. His jaw dropped, and his eyes glazed over, and he lurched past me just as Mr Thorne reached for the back of my coat.

The box flew into the air and glass shattered on the brick sidewalk. Long brown fingers reached for a white throat. Mr Thorne backhanded him away but the Negro clung tenaciously, and the two swung around like awkward dance partners. I reached the opening to an alley and leaned my face against the cold brick to revive myself. The effort of concentration while using this stranger did not afford me the luxury of resting even for a second.

I watched the clumsy stumblings of the two tall men for a while and resisted an absurd impulse to laugh.

Mr Thorne plunged the knife into the other's stomach, withdrew it, plunged it in again. The Negro's fingernails were clawing at Mr Thorne's good eye now. Strong teeth were snapping in search of the blade for a third time, but the heart was still beating, and he was still usable. The man jumped, scissoring his legs around Mr Thorne's middle while his jaws closed on the muscular throat. Fingernails raked bloody streaks across white skin. The two went down in a tumble.

Kill him. Fingers groped for an eye, but Mr Thorne reached up with his left hand and snapped the thin wrist. Limp fingers continued to flail. With a tremendous exertion, Mr Thorne lodged his forearm against the other's chest and lifted him bodily as a reclining father tosses a child above him. Teeth tore away a piece of flesh, but there was no vital damage. Mr Thorne brought the knife between them, up, left, then right. He severed half the Negro's throat with the second swing, and blood fountained over both of them. The smaller man's legs spasmed twice, Mr Thorne threw him to one side, and I turned and walked quickly down the alley.

Out into the light again, the fading evening light, and I realized that I had run myself into a dead end. Backs of warehouses and the windowless, metal side of the Battery Marina pushed right up against the waters of the bay. A street wound away to the left, but it was dark, deserted, and far too long to try.

I looked back in time to see the black silhouette enter the alley behind me.

I tried to make contact, but there was nothing there. Nothing. Mr Thorne might as well have been a hole in the air. I would worry later how Nina had done this thing.

The side door to the marina was locked. The main door was almost a hundred yards away and would also be locked. Mr Thorne emerged from the alley and swung his head left and right in search of me. In the dim light his heavily streaked face looked almost black. He began lurching toward me.

I raised father's walking stick, broke the

lower pane of the window and reached in through the jagged shards If there was a bottom or top bolt I was dead There was a simple doorknob lock and crossbolt My fingers slipped on the cold metal, but the bolt slid back as Mr Thorne stepped up on the walk behind me Then I was inside and throwing the bolt

It was very dark Cold seeped up from the concrete floor and there was a sound of many small boats rising and falling at their moorings Fifty yards away light spilled out of the office windows I had hoped there would be an alarm system, but the building was too old and the marina too cheap to have one I walked toward the light as Mr Thorne's forearm shattered the remaining glass in the door behind me The arm withdrew A great kick broke off the top hinge and splintered wood around the bolt I glanced at the office but only the sound of a radio talk show came out of the impossibly distant door Another kick

I turned to my right and stepped to the bow of a bobbing inboard cruiser Five steps and I was in the small covered space that passed for a forward cabin I closed the flimsy access panel behind me and peered out through the Plexiglas

Mr Thorne's third kick sent the door flying inward dangling from long strips of splintered wood His dark form filled the doorway Light from a distant streetlight glinted off the blade in his right hand

Please Please hear the noise But there was no movement from the office only the metallic voices from the radio Mr Thorne took four paces paused and stepped down onto the first boat in line It was an open outboard and he was back up on the concrete in six seconds The second boat had a small cabin There was a ripping sound as Mr Thorne kicked open the tiny hatch door and then he was back up on the walkway My boat was the eighth in line I wondered why he couldn't just hear the wild hammering of my heart

I shifted position and looked through the starboard port The murky Plexiglas threw the light into streaks and patterns I caught a brief glimpse of white hair through the window and the radio was switched to another station Loud music echoed in the long room I slid back to the other porthole Mr Thorne was stepping off the fourth boat

I closed my eyes, forced my ragged breathing to slow and tried to remember countless evenings watching a bowlegged old figure shuttle down the street Mr Thorne finished his inspection of the fifth boat a longer cabin cruiser with several dark recesses and pulled himself back onto the walkway

Forget the coffee in the thermos Forget the crossword puzzle Go look!

The sixth boat was a small outboard Mr Thorne glanced at it but did not step onto it The seventh was a low sailboat, mast folded down canvas stretched across the cockpit Mr Thorne's knife slashed through the thick material Blood-streaked hands pulled back the canvas like a shroud being torn away He jumped back to the walkway

Forget the coffee Go look! Now!

Mr Thorne stepped onto the bow of my boat I felt it rock to his weight There was nowhere to hide only a tiny storage locker under the seat, much too small to squeeze into I untied the canvas strips that held the seat cushion to the bench The sound of my ragged breathing seemed to echo in the little space I curled into a fetal position behind the cushion as Mr Thorne's leg moved past the starboard port *Now* Suddenly his face filled the Plexiglas strip not a foot from my head His impossibly wide grimace grew even wider *Now* He stepped into the cockpit

Now Now Now

Mr Thorne crouched at the cabin door I tried to brace the tiny louvered door with my legs but my right leg would not obey Mr Thorne's fist slammed through the thin wooden strips and grabbed my ankle

"Hey there!"

It was Mr Hodges's shaky voice His flashlight bobbed in our direction

Mr Thorne shoved against the door My left leg folded painfully Mr Thorne's left hand firmly held my ankle through the shattered slats while the hand with the knife blade came through the opening hatch

"It's one of your students"

"Hey—" My mind shoved. Very hard. The old man stopped. He dropped the flashlight and unstrapped the buckle over the grip of his revolver.

Mr. Thorne slashed the knife back and forth. The cushion was almost knocked out of my hands as shreds of foam filled the cabin. The blade caught the tip of my little finger as the knife swung back again.

Do it. Now. Do it. Mr. Hodges gripped the revolver in both hands and fired. The shot went wide in the dark as the sound echoed off concrete and water. *Closer, you fool. Move!* Mr. Thorne shoved again, and his body squeezed into the open hatch. He released my ankle to free his left arm, but almost instantly his hand was back in the cabin, grasping for me. I reached up and turned on the overhead light. Darkness stared at me from his empty eye socket. Light through the broken shutters spilled yellow strips across his ruined face. I slid to the left, but Mr. Thorne's hand, which had my coat, was pulling me off the bench. He was on his knees, freeing his right hand for the knife thrust.

Now! Mr. Hodges's second shot caught Mr. Thorne in the right hip. He grunted as the impact shoved him backward into a sitting position. My coat ripped, and buttons rattled on the deck.

The knife slashed the bulkhead near my ear before it pulled away.

Mr. Hodges stepped shakily onto the bow, almost fell, and inched his way around the starboard side. I pushed the hatch against Mr. Thorne's arm, but he continued to grip my coat and drag me toward him. I fell to my knees. The blade swung back, ripped through foam, and slashed at my coat. What was left of the cushion flew out of my hands. I had Mr. Hodges stop four feet away and brace the gun on the roof of the cabin.

Mr. Thorne pulled the blade back and poised it like a matador's sword. I could sense the silent scream of triumph that poured out over the stained teeth like a noxious vapor. The light of Nina's madness burned behind the single staring eye.

Mr. Hodges fired. The bullet severed Mr. Thorne's spine and continued on into the port scupper. Mr. Thorne arched backward, splayed out his arms, and flopped onto the deck like a great fish that had just been landed. The knife fell to the floor of the cabin, while stiff white fingers continued to slap nervelessly against the deck. I had Mr. Hodges step forward, brace the muzzle against Mr. Thorne's temple just above the remaining eye, and fire again. The sound was muted and hollow.

There was a first-aid kit in the office bathroom. I had the old man stand by the door while I bandaged my little finger and took three aspirin.

My coat was ruined, and blood had stained my print dress. I had never cared very much for the dress—I thought it made me look dowdy—but the coat had been a favorite of mine. My hair was a mess. Small moist bits of gray matter flecked it I splashed water on my face and brushed my hair as best I could Incredibly my tattered purse had stayed with me although many of the contents had spilled out I transferred keys billfold reading glasses and Kleenex to my large coat pocket and dropped the purse behind the toilet I no longer had father s walking stick but I could not remember where I had dropped it

Gingerly I removed the heavy revolver from Mr Hodges s grip The old man s arm remained extended fingers curled around air After fumbling for a few seconds I managed to click open the cylinder Two cartridges remained unfired The old fool had been walking around with all six chambers loaded! *Always leave an empty chamber under the hammer* That is what Charles had taught me that gay and distant summer so long ago when such weapons were merely excuses for trips to the island for target practice punctuated by the shrill shrieks of our nervous laughter as Nina and I allowed ourselves to be held arms supported bodies shrinking back into the firm support of our so-serious tutors arms *One must always count the cartridges* lectured Charles, as I half swooned against him smelling the sweet masculine shaving soap and tobacco smell rising from him on that warm bright day

Mr Hodges stirred slightly as my attention wandered His mouth gaped and his dentures hung loosely I glanced at the worn leather belt but there were no extra bullets there and I had no idea where he kept any I probed but there was little left in the old man s jumble of thoughts except for a swirling tape-loop replay of the muzzle being laid against Mr Thorne's temple the explosion the—

Come I said I adjusted the glasses on Mr Hodges s vacant face returned the revolver to the holster and let him lead me out of the building

It was very dark out We had gone six blocks before the old man s violent shivering reminded me that I had forgotten to have him put on his coat I tightened my mental vise, and he stopped shaking

The house looked just as it had my God only forty-five minutes earlier There were no lights I let us into the courtyard and searched my overstuffed coat pocket for the key My coat hung loose and the cold night air nipped at me From behind lighted windows across the courtyard came the laughter of little girls, and I hurried so that Kathleen would not see her grandfather entering my house

Mr Hodges went in first with the revolver extended I had him switch on the light before I entered

The parlor was empty undisturbed The light from the chandelier in the dining room reflected off polished surfaces I sat down for a minute on the Williamsburg reproduction chair in the hall to let my heart rate return to normal I did not have Mr Hodges lower the hammer on the still raised pistol His arm began to shake from the strain of

Like I was saying, it's incredible how computers are becoming as sophisticated as humans holding it Finally I rose and we moved down the hall toward the conservatory

Miss Kramer exploded out of the swinging door from the kitchen with the heavy iron poker already coming down in an arc The gun fired harmlessly into the polished floor as the old man's arm snapped from the impact The gun fell from limp fingers as Miss Kramer raised the poker for a second blow

I turned and ran back down the hallway Behind me I heard the crushed-melon sound of the poker contacting Mr Hodges's skull Rather than run into the courtyard I went up the stairway A mistake Miss Kramer bounded up the stairs and reached the bedroom door only a few seconds after I I caught one glimpse of her widened maddened eyes and of the upraised poker before I slammed and locked the heavy door The latch clicked just as the brunette on the other side began to throw herself against the wood The thick oak did not budge Then I heard the concussion of metal against the door and frame Again

Cursing my stupidity I turned to the familiar room but there was nothing there to help me There was not so much as a closet to hide in only the antique wardrobe I moved quickly to the window and threw up the sash My screams would attract attention but not before that monstrosity had gained access She was prying at the edges of the door now I looked out saw the shadows in the window across the way and did what I had to do

Two minutes later I was barely conscious of the wood giving way around the latch I heard the distant grating of the poker as it pried at the recalcitrant metal plate The door swung inward

Miss Kramer was covered with sweat Her mouth hung slack and drool slid from her chin Her eyes were not human Neither she nor I heard the soft tread of sneakers on the stairs behind her

Keep moving Lift it Pull it back—all the way back Use both hands Aim it

Something warned Miss Kramer Warned Nina I should say there was no more Miss Kramer The brunette turned to see little Kathleen standing on the top stair her grandfather's heavy weapon aimed and cocked The other girl was in the courtyard shouting for her friend

This time Nina knew she had to deal with the threat Miss Kramer hefted the poker and turned into the hall just as the pistol fired The recoil tumbled Kathleen backward down the stairs as a red corsage blossomed above Miss Kramer's left breast She spun but grasped the railing with her left hand and lurched down the stairs after the child I released the ten-year old just as the poker fell rose fell again I moved to the head of the stairway I had to see

Miss Kramer looked up from her grim work Only the whites of her eyes were visible in her spattered face Her masculine shirt was soaked with her own blood but still she moved, functioned She picked up the gun in her left hand Her mouth opened wider and a sound emerged like steam leaking from an old radiator

"Melanie ' I closed my eyes as the thing started up the stairs for me

Kathleen s friend came in through the open door, her small legs pumping She took the stairs in six jumps and wrapped her thin white arms around Miss Kramer s neck in a tight embrace

The two went over backward, across Kathleen all the way down the wide stairs to the polished wood below

The girl appeared to be little more than bruised I went down and moved her to one side A blue stain was spreading along one cheekbone, and there were cuts on her arms and forehead Her blue eyes blinked uncomprehendingly

Miss Kramer's neck was broken I picked up the pistol on the way to her and kicked the poker to one side Her head was at an impossible angle but she was still alive Her body was paralyzed, urine already stained the wood, but her eyes still blinked and her teeth clicked together obscenely

I had to hurry There were adult voices calling from the Hodgeses' town house The door to the courtyard was wide open I turned to the girl "Get up" She blinked once and rose painfully to her feet

I shut the door and lifted a tan raincoat from the coatrack

It took only a minute to transfer the contents of my pockets to the raincoat and to discard my ruined spring coat Voices were calling in the courtyard now

I kneeled down next to Miss Kramer and seized her face in my hands exerting pressure to keep the jaws still Her eyes had rolled upward again, but I shook her head until the irises were visible I leaned forward until our cheeks were touching My whisper was louder than a shout

"I'm coming for you Nina"

I dropped her head onto the wood and walked quickly to the conservatory, my sewing room I did not have time to get the key from upstairs so I raised a Windsor side chair and smashed the glass of the cabinet My coat pocket was barely large enough

The girl remained standing in the hall I handed her Mr Hodges's pistol Her left arm hung at a strange angle and I wondered if she had broken something after all There was a knock at the door and someone tried the knob

"This way" I whispered, and led the girl into the dining room

We stepped across Miss Kramer on the way walked through the dark kitchen as the pounding grew louder and then were out, into the alley, into the night

There were three hotels in this part of the Old Section One was a modern expensive motor hotel some ten blocks away comfortable but commercial I rejected it immediately The second was a small homey lodging house only a block from my home It was a pleasant but nonexclusive little place exactly the type I would choose when visiting another town I rejected it also The third was two and a half blocks farther an old Broad Street mansion done over into a small hotel expensive antiques in every room, absurdly overpriced I hurried there The girl moved quickly at my side The pistol was still in her hand, but I had her remove her sweater and carry it over the weapon My leg ached and I frequently leaned on the girl as we hurried down the street

The manager of the Mansard House recognized me His eyebrows went up a fraction of an inch as he noticed my disheveled appearance The girl stood ten feet away in the foyer half-hidden in the shadows

"I'm looking for a friend of mine" I said brightly "A Mrs Drayton"

The manager started to speak paused frowned without being aware of it and tried again "I m sorry No one under that name is registered here"

"Perhaps she registered under her maiden name" I said "Nina Hawkins She s an older woman but very attractive A few years younger than I Long gray hair Her friend may have registered for her an attractive young, dark haired lady named Barrett Kramer—"

"My hand went to the metal of the gate, but I hesitated Anxiety filled my throat like bile I was a silly old woman, but I could not bring myself to open that gate"

"No I m sorry" said the manager in a strangely flat tone "No one under that name has registered Would you like to leave a message in case your party arrives later?"

"No" I said "No message"

I brought the girl into the lobby and we turned down a corridor leading to the rest rooms and side stairs "Excuse me please" I said to a passing porter "Perhaps you can help me"

"Yes ma'am" He stopped, annoyed, and brushed back his long hair It would be tricky If I was not to lose the girl, I would have to act quickly

"I'm looking for a friend," I said "She s an older lady but quite attractive Blue eyes Long gray hair She travels with a young woman who has dark curly hair"

"No ma'am No one like that is registered here"

I reached out and grabbed hold of his forearm tightly I released the girl and focused on the boy "Are you sure?"

"Mrs Harrison," he said His eyes looked past me "Room 207 North front"

I smiled *Mrs Harrison* Good God, what a fool Nina was Suddenly the girl let out a small whimper and slumped against the wall I made a quick decision I like to think that it was compassion but I sometimes remember that her left arm was useless

"What s your name?" I asked the child gently stroking her bangs Her eyes moved left and right in confusion "Your *name*!"

"Alicia" It was only a whisper

"All right, Alicia I want you to go home now Hurry but don't run"

"My *arm* hurts," she said Her lips began to quiver I touched her forehead again and *pushed*

"You're going home" I said "Your arm does not hurt You won't remember anything This is like a dream that you will forget Go home Hurry but do not run" I took the pistol from her but left it wrapped in the sweater "Bye-bye Alicia"

She blinked and crossed the lobby to the doors I handed the gun to the bellhop "Put it under your vest" I said

"Who is it?" Nina s voice was light

"Albert ma'am The porter Your car s out front and I'll take your bags down"

There was the sound of a lock clicking and the door opened the width of a still secured chain Albert blinked in the glare smiled shyly and brushed his hair back I pressed against the wall

"Very well" She undid the chain and moved back She had already turned and was latching her suitcase when I stepped into the room

"Hello Nina" I said softly Her back straightened but even that move was graceful I could see the imprint on the bedspread where she had been lying She turned slowly She was wearing a pink dress I had never seen before

"Hello, Melanie" She smiled Her eyes were the softest purest blue I had ever seen I had the porter take Mr Hodges's gun out and aim it His arm was steady He pulled back the hammer and held it with his thumb Nina folded her hands in front of her Her eyes never left mine

"Why?" I asked

Nina shrugged ever so slightly For a second I thought she was going to laugh I could not have borne it if she had laughed—that husky, childlike laugh that had touched me so many times Instead she closed her eyes Her smile remained

"Why Mrs Harrison?" I asked

"Why, darling I felt I owed him *something* I mean, poor Roger Did I ever tell you how he died? No of course I didn't And you never asked" Her eyes opened I glanced at the porter but his arm was steady It only remained for him to exert a little more pressure on the trigger

"He *drowned* darling," said Nina "Poor Roger threw himself from that steamship—what was its name?—the one that was taking him back to England So strange And he had just written me a letter promising marriage Isn t that a *terribly* sad story Melanie? Why do you think he did a thing like that? I guess we ll never know will we?

"I guess we never will, I said I silently ordered the porter to pull the trigger

Nothing

I looked quickly to my right The young man s head was turning toward me *I had not made him do that* The stiffly extended arm began to swing in my direction The pistol moved smoothly like the tip of a weather vane swinging in the wind

No! I strained until the cords in my neck stood out The turning slowed but did not stop until the muzzle was pointing at my face Nina laughed now The sound was very loud in the little room

Good-bye Melanie *dear*, Nina said and laughed again She laughed and nodded at the porter I stared into the black hole as the hammer fell On an empty chamber And another And another

Good bye Nina I said as I pulled Charles's long pistol from the raincoat pocket The explosion jarred my wrist and filled the room with blue smoke A small hole smaller than a dime but as perfectly round appeared in the precise center of Nina's forehead For the briefest second she remained standing as if nothing had happened Then she fell backward recoiled from the high bed, and dropped face forward onto the floor

I turned to the porter and replaced his useless weapon with the ancient but well-maintained revolver For the first time I noticed that the boy was not much younger than Charles had been His hair was almost exactly the same color I leaned forward and kissed him lightly on the lips

'Albert I whispered there are four cartridges left One must always count the cartridges mustn t one? Go to the lobby Kill the manager Shoot one other person the nearest Put the barrel in your mouth and pull the trigger If it misfires pull it again Keep the gun concealed until you are in the lobby

We emerged into general confusion in the hallway

Call for an ambulance! I cried 'There s been an accident Someone call for an ambulance! Several people rushed to comply I swooned and leaned against a white-haired gentleman People milled around some peering into the room and exclaiming Suddenly there was the sound of three gunshots from the lobby In the renewed confusion I slipped down the back stairs out the fire door into the night

Time has passed I am very happy here I live in southern France now between Cannes and Toulon but not I am happy to say too near St Tropez

I rarely go out Henri and Claude do my shopping in the village I never go to the beach Occasionally I go to the townhouse in Paris or to my pensione in Italy south of Pescara on the Adriatic But even those trips have become less and less frequent

There is an abandoned abbey in the hills and I often go there to sit and think among the stones and wild flowers I think about isolation and abstinence and how each is so cruelly dependent upon the other

I feel younger these days I tell myself that this is because of the climate and my freedom and not as a result of that final Feeding But sometimes I dream about the familiar streets of Charleston and the people there They are dreams of hunger

On some days I rise to the sound of singing as girls from the village cycle by our place on their way to the dairy On those days the sun is marvelously warm as it shines on the small white flowers growing between the tumbled stones of the abbey, and I am content simply to be there and to share the sunlight and silence with them

But on other days—cold, dark days when the clouds move in from the north—I remember the shark silent shape of a submarine moving through the dark waters of the bay and I wonder whether my self imposed abstinence will be for nothing I wonder whether those I dream of in my isolation will indulge in their own gigantic final Feeding

It is warm today I am happy But I am also alone And I am very very hungry **DO**

STARS

By Frank D Drake

SETI the search for extraterrestrial intelligent life just became a brilliant nova in the world of science Thirty years ago it was but a dream of people beguiled by the richness of the cosmos and by the idea that life was its normal handiwork In time SETI became the cherished project of a few dedicated and sometimes daring people who seized the opportunity to conduct the first fumbling tentative searches for life in the universe In the last year it joined the mainstream of hardheaded science The full powers of our existing technology are finally being applied to the quest for our neighbors in the sky, and the techniques we now use are expected to become even more sophisticated and more powerful in the future SETI scientists are exhilarated

Two recent events have made SETI a full-fledged member of the scientific community First an extensive blue-ribbon study of the needs of American astronomy in the Eighties the National Academy of Sciences so called Field Committee Report ' assigned a high priority to a lengthy radio search for transmissions from other civilizations It recommended an annual rate of funding of about $2 million per year This was the first solid endorsement of expensive searches for extraterrestrial radio signals ever made by a distinguished group not dominated by SETI fans One of the programs the report recommended was a high-quality search—using the latest in sophisticated observational technologies—for other planetary systems around nearby stars Then in August of last year the International Astronomical Union the preeminent professional astronomy organization in the world created a new commission for the search for extraterrestrial life Thus SETI joined the ranks of commissions dedicated to such traditional disciplines as solar research and studies of other galaxies Already this new commission has more than 200 members from all over the world and in the summer of 1984 will hold its first meeting to coordinate individual programs of SETI research being conducted throughout the world

The SETI telescope at Arecibo Will this be superseded by a five-mile wide megatelescope?

This endorsement by the scientific community in turn stimulated the U S government to finance a major SETI program A NASA proposal to devote some $2 million per year to a long-term search for evidence of extraterrestrial intelligent life flew through Congress unopposed a reflection of a new enlightened attitude toward the importance of science and this search program which was long in the planning stage, is well under way

What will the future bring? The technology of SETI will improve The greatest obstacle to the success of radio searches has not been lack of sensitivity to weak signals or too narrow coverage of the sky as most imagine Rather it has been our inability to study at any given instant a large sampling of radio-frequency channels of the most promising portion of the radio spectrum Over the next few years a NASA program, carried out at the NASA Ames Research Center and the Jet Propulsion Laboratory of Caltech will produce an ingenious radio spectrum analyzer that will be able to monitor the phenomenal number of 8 million radio channels simultaneously This amazingly sensitive instrument will be used with a number of major radio telescopes, including the 1 000-foot telescope at Arecibo Puerto Rico to search the entire sky for signals especially [illegible] promising places in our galaxy like the regions around nearby stars Signals no stronger than those we now transmit will be detectable from distances of thousands of light-years Once this spectrum analyzer is perfected—a research effort that will require five years of experimentation—the SETI program using it will take five more years to fully exploit the analyzer's potential

And there is more At this moment the 84-foot radio telescope of Harvard University is continuously scanning the sky for signals Supported by private funds from The Planetary Society it utilizes a 128 000 channel radio receiver the brainchild of Paul Horowitz a professor of physics Already Horowitz is devising ways to increase the capacity of his

CONTINUED ON PAGE 215

BOOKS

CONTINUED FROM PAGE 38

masquerading to myself as a lefty. But my vision of what's possible has been tamed, and now I'm even more wistful. I'm not any less convinced that technology denatures some of the rich opportunities for achieving craft and selfhood, and there are numbers around showing that modern medicine fakes as many lives as it saves. But sicken a social critic of medicine and watch him head for the hospital. Sicken me and that's what I'd do."

About his approach to the world of surgeons, Kramer says, "I finally gave in wholeheartedly to my impulse to tell stories. I dumped whole sections of historical research and sociology, about sixty pages worth, from the semifinal draft. I realized that everything was there without it. I feel I have to master my subject. I can't island-hop—stand on an archipelago of knowledge in an ocean of ignorance. But once I know my territory, I don't tip over into seeming like an expert. In this book I'm storyteller, scene setter, ironist. I try to whisper about human sweetness and evoke peevishness over moments of publicly displayed greediness."

Kramer has always had a gift for getting at what's buried and essential and giving it the right name. Here he finds the ironic center of his subject. Surgeons cut, wound, and sometimes cause excruciating pain in order to do good. They practice what he calls "saintly aggression." The book follows two very skillful surgeons as they go about their morally ambiguous task. (Kramer announces in his prologue that in order to enjoy the confidences of his subjects, he had agreed to disguise the identities of the surgeons and their patients. No one reading this book, however, could imagine that he's changed or invented anything besides some superficial details.) The story of the year in the lives of the two surgeons proceeds as a series of sharply focused, mostly nonjudgmental narratives. Kramer achieves his main objectives through artful juxtapositions; he makes the material speak for itself. The narrative moves from one surgeon to the other, but you never forget which one is which. In this book doctors come alive on the page. Kramer *shows*—he doesn't need to *tell* you—that there is such a thing as individual personality among surgeons. The stories also make it plain that it would be impossible for any human being to work as a surgeon and not share the "surgeon's personality," well-known to every nurse in the country.

The book takes you into the surgeons' homes and back into their childhoods, but most often you go with Kramer to their operating rooms. He spent the better part of two years in those crucibles. "When you come back to the real world you may regret what you've seen," he says. "The first time I saw a leg sawed off, I thought I felt fine. Fifteen minutes after I got home I was sobbing. It was tremendously frightening and exciting at first, and then I got used to it. If I laid off for a month, though, I had to get reconditioned all over again." He understands this business of conditioning and its inevitability. "Blood, in surgery, is like money in the middle of a poker game. It changes value," he tells you. Though occasionally mordant about the limitations of his two surgeons, he never carps at them. Their flaws seem poignant. Kramer takes an adult tone; he puts himself in his subjects' shoes and the book is richer for it.

The descriptions of operations have an odd effect. People don't much like to think about their own innards, but there's something comforting about surgery as Kramer describes it. The accounts of operations are much more vivid and exact than any I've read before. Instead of squeamishness and false horror, Kramer gives you his eyes. His precision works as an antidote to voyeurism. The operations do not horrify; in fact they are engrossing.

The book doesn't shy away from discussing the innate deficiencies of the system in which surgeons work and that surgeons have helped to create. But after reading *Invasive Procedures* I felt better than I had before about surgeons and surgery. Surgeons may get paid too much for their competence, but in a surgeon no other virtue can be as important as competence. That seems to be a crucial, underlying message in this book. Kramer makes you see the surgeons' impressive powers of intellectual and emotional concentration. In the end you find yourself feeling grateful that they possess those attributes.

Kramer says he's finished with surgery as a subject for his writing, and he's glad of it. "I don't care if I never go into another operating room awake," he says. He knows what he would do, however, if he should again have to visit one asleep. Some recent research suggests, he writes in his prologue, that patients under most anesthetics hear what their surgeons say about them. So if you're worried about receiving psychic scars in addition to physiological ones, you might want to look around for a personable sort of surgeon. According to Kramer, however, "There's no reason why you should want your surgeon to be your friend. What you want is a fairly dull person who's content to do the same procedures over and over again for more than ten and fewer than thirty years." To find the right surgeon, he writes, don't ask physicians to recommend one; they will invariably respond with professional circumspection. Instead, ask them for the name of the surgeon they'd go to. For that matter, if you want someone to keep you company, to inform and comfort and delight you on a subject that touches almost everyone eventually, I'd recommend Mark Kramer in this book. I know of no recent works of literary nonfiction that are superior, and within the realm of medical literature I know of no better consulting text. ∞

GAMES

ANSWERS TO GAMES (PAGE 224)

Gardner's friend, Dr. Matrix, predicted the millionth *digit* of pi, and *digit* is an ambiguous word that could include the initial 3 or just the digits after the decimal. The millionth digit of pi, including the 3, turns out to be *5*. The millionth decimal is *1*.

FIVES QUIZ

a. She was the fifth of the Dionne quintuplets, born to Oliva and Elvira Dionne on May 28, 1934, in Callander, Ontario.

b. Pente. The game is based on the Japanese game *ninuki renju*, which is, in turn, based on *go moku*.

c. The five official Olympic flag colors—black, blue, red, green and yellow—were chosen because at least one of them appears on every national flag in the world. The five rings of the Olympic symbol also symbolize five continents. Of the usual seven, presumably Antarctica isn't counted, and Europe and Asia are combined into one.

d. Fencing.

e. "To boldly go where no man has gone before."

f. *Quintet*.

g. *Five Easy Pieces*.

h. Beethoven's Fifth, in C minor. Called the Victory Symphony in World War II because of Winston Churchill's "V for victory" symbol and because the first four notes of the symphony sound like the Morse code (dot-dot-dot-dash) for *V*.

i. Fifth column.

j. The Fifth Dimension.

GET PRACTICAL

1 PACKAGE. As mentioned, the man was a photographer. He had a friend take the package and a camera into another room. The friend unwrapped the package, shot several pictures of the present, rewrapped the package, and gave our man an exposed roll of film.

The photographer processed the film with a mailer and had the pictures sent to himself in care of his family in the Midwest. When he got to Michigan for the holidays, he wrapped the box of pictures and put it under the tree. On Christmas morning he opened the box and leafed through the pictures to learn what his sister's present had been. (For your information, it turned out to be a stone sculpture of a cat.)

2 COOKE'S BOOKS. Cooke arranged the bookcase as a geographical map of the United States. Books about Maine went in the upper-right-hand corner, books about Florida, in the lower-right-hand corner. Alaska went in the upper left, Hawaii in the lower left, Texas in the middle of the bottom shelf, and so on.

3 TRUCK. The child's solution was elementary. "Let some air out of your tires," he said, "until the truck is low enough to pass under the bridge."

This problem "must be as old as the inner tube," said University of Oregon psychologist Ray Hyman, in a scientific paper on problem solving. Parts of the article were reprinted in *Reader's Digest*, and as a result Hyman received several letters from people around the country, all claiming to have been the boy in the original story who helped the trucker solve his dilemma.

It's possible that this incident may have occurred independently many times—or perhaps there are just many people with creative memories.

4 NUTS. The man took one lug nut from each of the other three wheels, and attached the spare tire. Each tire was then held on by three nuts rather than four, which was sufficient to keep the wheels on until the man reached the next town.

We have no idea whether this problem and solution ever actually happened, but modern folklore says that it took place on a country road next to a state hospital and that an inmate watched the whole affair and suggested the borrowed-nuts solution. "Why, that's brilliant!" the man said. "Thank you! I never would have thought of that. Why are they keeping an intelligent man like you locked up behind that fence?"

"I may be crazy," the inmate reportedly replied, "but I'm not stupid." ∞

Just a theory: results of Competition #27

COMPETITION

By Scot Morris

A good theory explains a lot of data or predicts a state of affairs based on current trends. Why can't you ever find a paper clip when you want one and yet there are always more hangers in the closet than you put there? Simple. The paper clip is the embryonic form of the coat hanger and it migrates from desk to closet when no one is watching. The Western Hemisphere is expected to sink into the ocean by the middle of the next century. Why? Because of the accumulated weight of back issues of *National Geographic* magazine.

This competition, announced in February, asked for more such theories to help make sense of the world. Among the repeated ideas: Days are short in the winter and long in the summer because cold contracts and heat expands. The observation that no one ever sees a baby pigeon in city parks gave rise to various theories about spontaneous pigeon generation. Several readers pointed out the obvious fact that the movement of trees creates the wind. As anyone can plainly see when leaves and branches are still, no wind is produced.

The single observation that brought the most theories—some 55 separate entries—was the phenomenon of missing socks. Most sockologists suggested that disappearance occurs during the spin cycle, when one sock of a pair is (a) sucked into a black hole, (b) explodes to become lint, or (c) enters a time warp and is projected forward in time (or into the past, in which case the sock turns up, unwashed, in the corner of the closet). One reader observes that the mismatched socks are usually female—the males escape, probably when over-agitated. Another suggested that after mating, the female sock becomes cannibalistic, like the black widow, devouring the male and then producing a litter of lint balls. The question is still unresolved. We await further research at MIT (the Maytag Institute of Technology).

You will note that two of the runners-up are variations on a theme.

GRAND PRIZE-WINNER: $100

Why is the earth flat at the poles? Because of the constant pressure applied by the wing nuts, which can be clearly seen on any desk-top model of the globe.
—*Harry Yearsley, Atlantic City, NJ*

RUNNERS-UP: $25 EACH

Gravity is decreasing. That's why people are getting taller and heavier. Gravity is being used up at an alarming rate. Already pockets of gravity absence have been discovered—such as the Bermuda Triangle and the last place you put your car keys. A worldwide program for the conservation of gravity must be undertaken, beginning with the immediate ban of pole vaulting, foot stomping, and any other actions that use excessive amounts of this precious natural resource.
—*Richard Walker, Idyllwild, CA*

Gravity is being used up and not being replaced. A few years ago the Wright brothers could manage to get only a couple of hundred pounds a few feet off the ground. Today we can lift giant rockets and actually leave the earth. How long do we have?
—*Don Woodruff, Middleburg, FL*

I have finally derived the equation that will allow demographers to predict with high accuracy the birthrate of the United States:

$$BIRTHRATE = \frac{A^2 \times 2B \times E^5}{\sqrt{C} \times D^2}$$

WHERE:
A = the number of fraternity parties
B = the universal forgetful constant
C = average weekly appearances by Johnny Carson on the *Tonight Show*
D = the number of headache pills sold
E = the number of bottles of vitamin E sold
—*David J. Traini, Clementon, NJ*

Automotive paint contains pheromones attractive to supermarket shopping carts. The attraction dissipates over time. It is strongest when the paint is new and is virtually absent after seven years.
—*Eileen Clark, Azusa, CA*

Jupiter's blemish—its Great Red Spot—is evidence of contact with a wandering heavenly body. It is a sidereal disease, probably brought about by the same body responsible for sunspots and other solar flare-ups.
—*John Huotari, Zimmerman, MN*

In the Northeast, excessive salting of icy roads in the winter will eventually neutralize the effects of acid rain, producing a balanced pH level for the entire area.
—*Suzanne Hoyle, Shutesbury, MA*

Safe and efficient methods of production have been developed for almost all sources of alternative energy. These are being suppressed by the bumper sticker and T shirt industries.
—*David Clements, South Woodstock, ME*

Rock and soul stations are at the high end of the radio dial because of the faster beat (that is, higher cps, or frequency) of the music played on them.
—*Jenny A. Lambert, Mamaroneck, NY*

Most of the current state of world affairs is the result of a massive social-science experiment being conducted by Stanley Milgram. He is studying the effect of unemployment on depression and the effect that observing an actor as President has on obedience to authority. In the final phase, he intends to study group dynamics during a world war.
—*Mark S. Rafer, San Bernardino, CA*

HONORABLE MENTION

Earthquakes induce anharmonic vibrations in species during stasis. Hence, there are rains of frogs everywhere but Lourdes.
—*Gus Vironeem, Los Angeles*

Intermarriage among successive generations of Ivy League alumni has produced a sensory mutation such that

CONTINUED ON PAGE 218

LIFE

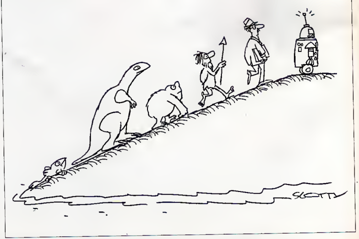
CONTINUED FROM PAGE 30

Unfortunately, patients may be left in the dark because doctors themselves are sometimes denied access to medical data about a suspected teratogen. In 1972 Dr Peter Peacock, then chairman of the Department of Public Health and Epidemiology at the University of Alabama, noted 17 cases of clubfeet among children born to helicopter pilots at the Lyster Army Hospital, in Fort Rucker. Although the sample was small, the incidence of the deformation was far higher than one would expect by chance. He suspected that the culprit might have been radiation from the radar the pilots were exposed to while flying close to the ground. The initial findings sufficiently concerned Dr Peacock that he secured funding to further investigate the correlation. But Peacock reports that the Army stonewalled his effort by not allowing him access to the pilots and their medical records. And one more possible teratogen remains undetected.

Within the medical establishment, concurrence about teratogens is rare. The courts have spoken concerning Dilantin; yet many doctors, including witnesses in the Harbeson trial, scoff at the connection between the drug and birth defects. It asked to name one teratogen that had been universally recognized by physicians, alcohol would probably be most frequently cited. Yet Dr Josef Warkany, an esteemed pioneer in the field, recently coauthored an article in *The New England Journal of Medicine* in which he refused to accept alcohol as a proven teratogen, instead relegating the substance to his "suspected" list. The effect is similar to what might occur if the U S Surgeon General suddenly announced he wasn't *sure* that "cigarette smoking is dangerous to your health."

There is so much professional discord partly because concrete evidence is hard to come by in teratology. In the late Fifties and early Sixties the National Institute of Neurological and Communicative Disorders collected information from 50,282 pregnant women and continued to study the children that resulted from those pregnancies. The project created a massive data bank of information. Many teratologists, however, regard the information as useless, since past medical records fail to distinguish all but the most obvious of defects and rely on arbitrary or biased methods and standards. "If you're going to set up a national system of inquiry, what criteria will you use to determine whether a substance needs to be explored?" asks Dr Sterling Clarren, one of about two dozen syndromologists in the United States trained to recognize patterns of abnormality associated with teratogens. "If for instance a mother takes kumquats for nine days in high dose during pregnancy, and her baby has a cleft palate, what are you supposed to do with that information? Cleft palate is a very common defect." An agent causing a malformation interacts with a number of variables—the period during pregnancy of the mother's exposure, the dosage, the genetic and metabolic makeup of both the mother and the fetus, which may or may not make either one susceptible. Most teratogens don't cause one easily identified defect. Thalidomide is an exception, though in a few cases even it has been shown to result in other, less dramatic deformities than the stunting of limbs. Coming in contact with the same agent during different trimesters or in different dosages usually causes different defects. Furthermore, exposure to a teratogen may occur before pregnancy or through the father.

Given so many complicating factors, it is hardly surprising that the study of birth defects often seems an inexact and arbitrary line of work. Dr Clarren recalls a 1976 conference in which a brother and sister with a similar congenital disorder were paraded in front of an international group of experts. "Nobody knew what was wrong with them, but Smith-Lemli-Opitz syndrome [a genetic condition] was suspected. They presented these children at the meeting and asked, 'What is this disorder?' Dr Smith was in the audience, so



he came down to examine the kids and he said Obviously this is Smith-Lemli-Opitz syndrome Then Dr Opitz, who was also present, looked at the kids and he said I don't think it's Smith-Lemli-Opitz syndrome at all And the two doctors just stood there looking at each other and at this deadly quiet auditorium filled with thousands of people until finally someone said 'Call it Smith-Lemli syndrome Next case

In the meantime doctors continue to prescribe drugs like Dilanfin fo women like Jean Harbeson, in parf because they are unable to keep up with the already existing evidence about teratogens but also because they want to maintain what they perceive to be professional control "I find an incredible paternalisfic attitude among obstetricians They know how to treat their girls and they'll be in charge of making fhose decisions," explains Clarren 'And just as it took public demand to change the way babies get delivered it will take public demand to make doctors talk about medications differently"

Of course better access to current information on teratogens is essential for preventing birth defects If, on the morning she asked about the dangers of Dilantin, her doctor had asked her to wait while he typed into his office Apple the words DILANTIN and TERATOGEN fhat first step on a long tragic journey might never have been taken Harbeson might then have been faced with some hard choices—fo have a child anyway to have a child but to go off the drug during her pregnancy and risk an epileptic seizure or not to conceive in the first place But at least the choice would have been hers

Ironically many doctors have compufers in their offices but few take advantage of the data services that compile and update medical information from the thousands of reports and sfudies that find their way into print each monfh

A far more difficult challenge for the medical profession however is isolating new teratogens in the first place Since laboratory testing is of little use in identifying harmful agents women and their children are the guinea pigs It's bad enough that they're living experiments what's worse is that nobody's collecting the data Well almost nobody

In San Diego an old yellow house surrounded by a brown picket fence is home to this country's only teratogen registry Open since 1979 it is available to residents of California alone The registry answers specific questions that women may have about their pregnancies and possible dangers It also has a second purpose separate from its function as a clearinghouse of teratological information Of the 700 or so women who make unsolicited calls to the facility each month approximately 300 register themselves as part of the project's investigative work.

During the course of fheir pregnancies these women are kept busy answering detailed questionnaires about their exposures to any environmental agents After their children are born fhe Infants are examined meticulously by a dysmorphologist a doctor trained to recognize subtle and often hidden birth defects and syndromes According to Christine Kelley the registry's coordinator the findings from the exam are then fed into a computer fhat searches for patterns of similarity underlying different cases of birth defects reported in the study group In this way it should be possible to spot previously undetected teratogens and to provide corroborating evidence on suspected agents The regisfry also helps to dispel anxieties about some groundless concerns In a few years Kelley says the facility plans to publish a book that can serve as a reference for doctors around the country and it also intends to put fhe information on computer software for office terminals

Kelley hopes that similar registries will eventually be established regionally throughout the country, collecting dafa and dispensing information from *all* the living experiments It is also fhe best hope for our unborn children, because registries appear to be the nearest thing anyone in the field of teratology has proposed in the way of long-term solutions ∞

STARS

CONTINUED FROM PAGE 206

receiving system to scan many millions of channels at the relatively modest cost of a few hundred thousand dollars Although clearly not a substitute for the NASA system, which is much more powerful and so phisticated Horowitz s plan represents a giant technological step forward

But even with access to 8 million channels the bottleneck in our searches will still be our limited coverage of the radio spectrum So why not scan 100 million channels? That number can be achieved by duplicating our present systems enough times Ten years from now a 100-million-channel system could well be common We will need such systems if we are ever to tackle searches at much higher frequencies, say those whose wavelengths are a few millimeters Those wavelengths are the ones that carry the farthest over the radio noise of our galaxy and the big bang For that reason other civilizations in the universe may have decided to emphasize these same frequencies

By 2000 we could well succeed in our search for extraterrestrial intelligent life Or we could fail What then? Strangely the answer is the same in either case We must build a truly giant radio telescope—maybe five miles in diameter—probably in space If we fail to detect any signs of extraterrestrial intelligence, we will need a more powerful telescope And if we succeed we will long for this larger telescope to learn more about the civilization we have detected and to discover other civilizations, whose existence will be assured

After all when Galileo used his three inch telescope to gaze at the moons of Jupiter (and learned to understand the solar system from that limited observation), he didn t say, Well the job is done no need to build larger telescopes. So it should be with SETI Our telescopes and receiving systems will never be powerful enough This is true not just for SETI but for astronomy in general

There may well be no more proper and, indeed more noble use of the space shuttle than to have it ferry into orbit the parts of a mammoth radio telescope It would require a small army of extraterrestrial construction workers and cooperation on a global scale to attempt it but the result would be the grandest structure that may ever be built by humans By this route humanity may eventually share in the grandeur of life throughout the galaxy We have already waited too long **OO**

Editors note Frank Drake is Goldwin Smith Professor of Astronomy at Cornell University the director of the National Astronomy and Ionosphere Center which operates the 1,000-foot Arecibo radio telescope and one of the founders of SETI He was the first radio astronomer to try to detect signals from extraterrestrial civilizations as part of Project Ozma in the early Sixties

FOR FUTURE REFERENCE

Moving? We need 4-6 weeks notice of a change of address Fill in the attached form

New Subscription or Renewal? One year of Omni is $24 in the U S $34 in Canada and overseas Please enclose a check or money order for the appropriate amount and allow 6-8 weeks for delivery

Listing/Unlisting Service? Omni makes the names and addresses of its subscribers available to other publications and outside companies The publications and companies selected are carefully screened for their acceptability and quality of their offers If you would like your name removed from this mailing list please check the appropriate box on the coupon

OMNI
PO Box 5700 Bergenfield, N J 07621

Please check the appropriate box below
Payment must accompany order

☐ New Subscription ☐ Renewal
☐ Please remove my name from your mailing list
☐ This is a change of address my new address is below

Name

Address

City State Zip

Attach mailing label

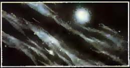
HUCA9

NEXT OMNI

UBIQUITOUS BUGS

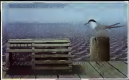
Magnificent and menacing, winged and earth-bound, brilliant as war paint or drab as dirt. Insects fill every earthly habitat, from the frigid Himalayan snowfields to the turbulent surface of the sea. Some are pests that suck our blood or poke holes in our plants. Others pollenate flowers or spin slender strands of silk. But no matter what the species, each breed of insect has honed its traits for the serious business of survival. These beautiful invertebrates may seem alien, but they are descendants of the same evolutionary forces that molded man. To learn more about myriad insect forms, see our excerpt from *The Audubon Society Book of Insects* in this month's *Omni*.

ASTROGENESIS



Cosmic seas of interstellar gas swarm with molecules in the largest chemistry set of all—the universe itself. Isaac Asimov, a knowledgeable biochemist as well as a famous author, charts the progress of astrochemistry in solving the great puzzle: how random chemicals in space could coalesce to form such a planet as Earth. Read in November's *Omni* about the clues that are everywhere—in the core of a meteorite, in interstellar clouds, and in the chemistry of asteroids.

FICTION



Harlan Ellison, Gene Wolfe, Frederik Pohl, Edward Bryant, Pat Cadigan, and Thomas M. Disch combine their talents for a special presentation called "Double Treble." In an unprecedented move, *Omni* commissioned these six authors to write humorous stories of 500 words each. The results are a delight. On a more serious note, Kate Wilhelm's "Sister Angel" tells of an evangelist and his daughter's effect on a bereaved widow's life. *Omni* also will feature Marc Laidlaw's "400 Boys," an imaginative vision of telepathic gangs in a devastated postholocaust city.

INTERVIEW

According to MIT linguist Noam Chomsky, if a Martian landed and spoke a language that violated "universal grammar," humans might never be able to communicate with the alien in its own tongue. Or they might learn Martianspeak the way scientists gain new insights in physics, slowly and arduously over generations. Chomsky has transformed the way linguists view language. In a revolutionary stance, he proposed that a genetically programmed "language organ" in the brain primes the human infant to master the intricacies of his mother language. This "organ" sets humans apart from all other animals, but it also limits the characteristics of all human languages, from Ainu to Urdu. In this month's Interview the controversial Chomsky criticizes sociobiology, behaviorism, and Piagetian ideas of childhood and development, and he puts forth his views of heredity and environment and their role in the development of humans and languages.

COMPETITION

CONTINUED FROM PAGE 210

victims truly perceive that the color pink goes with the color green
—Amy K Sinofsky, Concord MA

The human foot originally ended in one large toe. It was only through repeated accidental collisions with chair and table legs that it developed its present state
—Walt Gross, Medford WI

Rainy weekends are caused by the excessive amounts of hot air released to the atmosphere during weekly staff meetings, committee meetings and so on
—Sue Davis, Burley, ID

Mobile homes attract tornadoes
—Susan Dunten, Austin, TX

Wonder where the rubber particles go as an auto tire wears? They gather and slowly rejuvenate. Proof can be found alongside any busy highway where young tires may be seen in various stages of reformation

A diligent observer may also catch tires herding in the tall grass behind abandoned service stations
—Wayne Allen, Tacoma

GULOTTA'S THEORIES OF THE UNIVERSE

1 War taxes and unemployment have served their most important roles in the evolution of man by giving people something to talk about while they're getting their hair cut

2 The Jews invented guilt but the Italians turned it into an art form

3 It is a physical property of the universe that a space traveler moving in what he believes is a straight line will invariably end up right where he started. This is also true in parts of New Jersey

4 Space is pliable—not only can it be curved, twisted and molded to any shape, but it can also pick up pictures from the Sunday comics

5 The laws of physics say it is impossible for any object to move faster than the speed of light. Ironing a shirt is also not so easy
—Charlie Gulotta, Stamford CT

Clouds are very delicate, and cold alone is enough to shatter them. The little white pieces that drift downward are called snow
—Emily Dahlstrom, Victor NY

Arcade video games are a plot by extraterrestrials to measure human reflexes and coordination. The recording of high scorers' initials is their way of identifying the dangerous Earthlings who must be eliminated just before the invasion
—Lewis Terman, South Salem, NY

Balance-of-mass theory explains why whenever you have gained a few pounds, you are more likely to meet people who tell stories about how much weight they've lost. When someone loses weight someone else must gain it—to avoid destroying the balance and throwing Earth out of orbit
—JoAnn Aulenbacher, Toledo, OH

It is well known that the detergents used in car washing release their molecules into the atmosphere: water droplets coalesce around them, resulting in rain. It is proposed that detergents might provide an economical substitute for silver iodide in cloud seeding
—Lan H Tornes, St Paul, MN

Burrowing behavior in the common nail clipper (*Snippus ordinarius*). Research indicates that when this species is placed near sofa cushions, papers on a desk, or with laundry in a dresser drawer it quickly burrows to a spot somewhere below where you saw it last
—Catherine McGuire, Orange CA

The EPA has announced that a Florida firm is probably responsible for the gigantic sinkholes that have recently swallowed several houses and cars. The firm, which installs holes in machined parts has been dumping misshapen and out-of-tolerance holes into a vacant lot. The pile of waste holes is now over 125 feet deep. It is suspected that small holes have leaked into the underground water supply and have collected to form gigantic caverns
—L McCandless, Bainbridge Island WA

Creative evolution theory: We cannot be descended from monkeys, of course, or there wouldn't be any monkeys left. However, God must have gone to a lot of trouble making *Australopithecus* fossils rigging isotropic decay rates and designing our DNA to be so similar to a chimpanzee's. Therefore, even though evolution isn't true, we had probably better believe it if we know what is good for us
—David Daulton, Columbus OH

Furry toilet-seat covers, the type that won't allow the seat to stay up by itself, are part of a Communist plot to emasculate all men in the Western world. The Kremlin hopes we will be so preoccupied with these seat covers that its invasion will go unopposed
—Peter MacKichan, Calgary AB

Theory of gastrointestinal learning: Scientists have already shown that flatworms, having been taught mazes, can be fed to other flatworms, which actually acquire the knowledge of the original maze through ingestion. This explains how cannibals learned the missionary position
—Fred Wickham, San Francisco

As one goes bald, one begins to grow hair in the ears and nose, on the shoulders and back, and other areas where it has not grown before. Evidence suggests that hair may migrate south for the winter, just as birds do
—Daniel G Gall, Whitakers, NC

Iron-rodent contest: The yearly march to the sea of thousands of lemmings is merely the first leg of their annual triathlon
—Mark Lemont, Dolton, IL

Atmospheric temperature is controlled by thermostats located in bank clocks
—Brian MacCormack, Lawrence, KS

Traffic jams are not caused by drivers but by automobiles, which obey an instinctual urge to gather around an injured member of the herd
—Michael Ekinaka, Irvine, CA

Unflavored Jell-O should be added to the crude oil in tankers. Then, in the event of a wreck, the spilled oil will congeal into huge blobs—oilbergs—waiting to be rounded up and towed to a refinery
—Bert J Bingel, Dover, NH

Most of the species on Earth are individual entries in a galactic science fair. The youngest extraterrestrials contributed amoeba and paramecia; the platypus was a group effort by an eighth-grade class. We are a postgraduate project, and if we don't foul up, our maker will win a scholarship. Winners will be notified in 2010
—Lynda Cook, Escondido, CA

$Ch=U-mp$

This equation shows how sellers formulate contract warranties: *Ch* is contract honor time, *U* is unit of cost and *mp* is monthly payments
—Michael A Eiermann, Chicago

The random component of every event is determined by a gradient of three nonmeasurable substances: glorx, jick and qua6th. For example, excess glorx in the galaxy (and pitching) prevents the Cubs from winning the pennant
—Martin Weiss, Springfield, IL

When I clap my hands near an ordinary housefly, it quickly flies away. I removed the wings from an experimental fly and clapped my hands, but it didn't move. Thus, I conclude that when you remove a housefly's wings it goes deaf
—Roger Mason, New York City

The destructive tides and storms along the California coast have been traced to the increased tour-ship traffic to mainland China. If propeller activity is not severely curtailed, we may lose most of our Pacific coastline
—Brenda Petruska, East Brunswick, NJ

Competitions that challenge people to come up with humorous theories lead to several people independently producing very similar ideas, any one of which when considered alone is worthy of winning. These theories are usually disqualified automatically and the winner is most often something totally out to lunch
—Martin P Dreves, Bellevue, WA

PHENOMENA

A southern green frog peeks warily above the duckweed and wolffia plants that carpet the surface of his watery habitat. Nature photographer John Shaw spotted this shy amphibian while wandering through the Little Black Slough, a vast, swamplike region in southern Illinois. He had been photographing the mammoth cypress tupelo trees and other large-scale marvels of the area and was trying to capture a more intimate side of the sweeping expanse of nature, when he noticed a group of green frogs splashing in the water. Strapping on a pair of hip boots and attaching an electronic flash and a 105mm Macro lens to his Nikon camera, he struggled out into the vegetation-choked ponds and waited for a frog to reappear. Finally his patience was rewarded. This frog popped to the surface barely a foot away from the photographer. Shaw bent down close to the water's surface and recorded the encounter on Kodachrome 25 film. ∞

ARCHITECTURE

CONTINUED FROM PAGE 34

one wouldn't want to know exactly when ONECITY exists. Do you really want to know when you're going to die?"

According to Insley, his wall fragments are artifacts, proving ONECITY exists. "They also operate in ONECITY as evidence that people knew it existed before. In fact, it did. That's where it gets confusing. You see I have evidence of things that will exist in potential in some other time. In that sense I traveled to the future in my mind and came back into the present with information about it. I like to say, 'I remembered the future.'"

ONECITY's religion reflects the process of Insley's discovery. Inhabitants worship the horizon line as a magical space between earth and sky through which one may pass, glimpse the future, then return to the present to record what one has seen. Insley, inspired by the flat plains of Indiana, where he was born, believes that the Myth of the Horizon Line is a metaphor not only for his own mental journey to ONECITY but for the artistic process in general, which he believes is more mystical than intellectual. "You don't just sit down and make a painting," he declares. ONECITY's eternity takes the form of eight concentric shells, indicating it has a "structure and inevitability." Insley professes not to comprehend the obscure Eight-Dimension-Spiral myth himself. "I just write it down."

The configurations of ONECITY are as complex as its myths. The city is composed of 14,040 square buildings, each of which is 2.5 miles on a side, laid out in a square spiral 675 miles on a side. Insley receives information about "ratio theories," which enable him to compute the specific dimensions of each component and draw it accordingly. The ratios, he says, have revealed glimpses of surprising new spacial forms: a square that is not a square, and there is a hinge. And a wave. The buildings resemble towns and contain 100 "rooms," or neighborhoods, composed of Over Buildings and Under Buildings with the Theater Space between. In the center of every building are nine square arenas—an architectural form with mythological origins. Ceremonies take place on the surface of eight of them, and museums and concert halls are housed below.

Although Insley insists ONECITY bears no resemblance to "advanced architectural planning theories" and is simply a formal situation, "like a mountain, which has the power of space alone," there are decided advantages, aesthetic and practical, to his mythical civilization. "ONECITY would be like living in a movie," he says, "where all the information you're getting is about light." ONECITY walls are translucent, not solid, and adjustable vents filter light in a nearly silent, dreamlike atmosphere. Building form dematerializes in this shifting light. The roofs of Over Buildings are skylights, screened to control light and heat. Because the skin of each building is a translucent material, the city glows like a "dim, digesting jellyfish" at night. During the day one can see out, and at night one can see in. Insley is fond of weather conditions, so his Theater Space is contained, yet open to the elements. ("Birds fly through the space, dust dances in the light, wind whips across, and rain pours in.") "Air roots," or thin, hollow towers, ventilate the entire city and on windy days emit pleasant sound effects—low moans and staccato whistles.

Unlike their deteriorating prototypes, the future city's infrastructures function effectively. A jetube transit system contained in the city's walls speeds silently to all parts, eliminating traffic jams and pollution. Artificial valleys and plateaus created by the buildings are planted, like flowerpots, and each chain of buildings opens onto woods and fields. "There's no slogging through the suburbs in your Cadillac to get to nature," Insley says. Waste and fumes from heavy manufacturing are contained beneath the flat-earth layer of Over Building fields. Crime in ONECITY is accepted as a natural phenomenon and provides entertainment. Criminals are voluntarily confined to the Under Building of the Ninth Arena, where they gleefully prey on themselves, spied upon by voyeuristic citizens through slits in the surface. Final showdowns between them occur, gladiator-style, in hydraulic lifts that can be raised or lowered by pushing a combination of buttons. The fiend who masters the logic of his buttons and completes a sequence of ratio-spatial changes gains control of his lift, then tries for control of his opponent's. If he wins he may then devise a spatial trap that forces the loser away from his control booth into a futuristic version of death row—a space he is powerless to escape. Insley depicts the Theaters of Death in his drawings of Abstract Buildings, which he terms "frightening mental spaces." "My first projects, starting in 1967," he backtracks, "were the Abstract Buildings, that is, exercises in abstract space with no other function than to exercise their own measurements. These Abstract Buildings are not ONECITY. They exist outside of it, buried in the wilderness. To seek them out is one of the 'mythological pastimes' of the citizens of the city."

"The city exists in the potential. It is about myth and mythology, and exists outside of normal time, in a kind of all-time. The idea is bigger than just one temporal location."

Insley believes life in ONECITY might be a frightening experience for the noncriminal citizens as well. "The design is very dense," he says. "One is constantly trapped in the so-called intelligence of the system. Some inhabitants would find it quite hideous to be part of a place that has such a total sense of form." Some of Insley's structures, too, are potentially dangerous. "You could fall off the wall of an Abstract Building and drop thirty feet." The artist says he tries not to moralize about his creation. "The Abstract Buildings exist in the wilderness of things that do not *work* but simply are."

A citizens' committee in Cambridge, Massachusetts, proved unsympathetic to the amoral principles of abstract architecture when Insley received a National Foundation grant to build a large component of ONECITY on a high-school site there. The proposed project, a large earth mound with interior passageways framed in concrete, was vetoed off to potential time because the committee feared students would race up the mound and plunge into the open passageways, and girls exploring the interior would be attacked by concealed rapists not yet confined in Cambridge to the Theaters of Death.

Although ONECITY is designed to hold 400 million souls, Insley wastes few words on the inhabitants in his writings, describing them only as "moon-spied ghosts in a tattered palace." He depicts only occasional figures, anonymous sticks, in his models and drawings. He confesses that he thinks of himself as ONECITY's population. "It's my city," he says, "a city for one person. That's the game I play. I build this whole thing and then I go and live in it—the experience of walking around Manhattan on a Sunday morning, when you begin to feel a different power of the city."

Alone or not, Insley plans to inhabit his private metropolis for years. In his present studio, where filtered light, spartan concrete walls and ceilings, and a coffee table decorated with nine arenas in the form of hot-plate tiles suggest the artist's mythological space, Insley waits for more news about his city. He painstakingly renders memories of his future travels on tracing paper with pencil, then redoes them in ink. His midcareer show, at New York City's Guggenheim Museum, opens in the fall of 1984. The information exists in potential, he says. "All I have to do is go get it. I can't look at all of it at once, so I just come back with bits and pieces." Upcoming details should enable him to make theoretical diagrams of the all-important Opaque Library—"the most mystical of the spaces, known more by rumor than by anything else. The city is bigger than I am," continues Insley, who is writing a book about his discovery. "It has inexhaustible possibilities. I could, and will, make drawings of ONECITY for the rest of my life."

Fives, practical problems, and a competition for everyday brilliance

GAMES

By Scot Morris

Omni is five When Mozart was our age he wrote "Twinkle, Twinkle Little Star" A female horse at our age changes from a filly to a mare In dog years we are almost middle-aged

Since *Omni* was born in October 1978, Jupiter has completed less than half an orbit around the sun, Pluto about a fiftieth and continental drift has widened the Atlantic Ocean by about seven inches The news of our first issue reached Alpha Centauri a few months ago and we can now report with confidence that this nearest star some 4 3 light-years away had not exploded by the time our first few issues were out

A fifth birthday is special because 5 is such a ubiquitous number There are five players on a basketball team five cards in a poker hand, five years in a lustrum five Great Lakes five senses and a pair of fives in our national speed limit The fifth digit of pi is 5 The fifth term of the Fibonacci sequence is 5

In geometry (sometimes called "the fifth science") five points determine a conic curve and a cone may be cut by straight slices into five types of sections circle ellipse parabola hyperbola and triangle Euclid had five postulates and the fifth of them (the parallel postulate) became perhaps the most controversial statement in all of mathematics There are five polyhedrons whose faces are all identical regular polygons triangles squares, and pentagons These are the Platonic solids There are just five of them no more

In biology the number 5 crops up more than its share of times Practically all land vertebrates have five fingers and five toes on each limb Even the horse has five Its hoof is really an enlarged fingernail of a specialized middle digit Many marine animals including sea urchins sand dollars and sea cucumbers, have fivefold symmetry Most modern starfish have five arms There are fossil remains of starfish that *aren't* five armed, but they have all died out

Most flowers have five petals and even those that have many more, such as the daisy have an underlying fivefold symmetry Many fruits show the quintessence of their ancestry Cut an apple a pear or a banana crosswise and you'll see that the seeds are arranged in a five-pointed star

Our favorite five story concerns a remarkable prediction made by Irving Joshua Matrix a colleague of *Scientific American* columnist Martin Gardner In 1966 Gardner remarked about the inevitable impact of computers on mathematics "It will probably not be long until pi is known to a million decimals In anticipation of this Dr Matrix the famous numerologist has sent me a letter asking

I Saw the Figure 5 *by Charles Demuth inspired by a William Carlos Williams poem The Great Figure The painting is part of the Alfred Stieglitz collection in the Metropolitan Museum of Art* that I put on record his prediction that the millionth digit of pi will be found to be 5 His calculation is based on the third book of the King James Bible chapter 14, verse 16 (it mentions the number 7 and the seventh word has five letters), combined with some obscure calculations involving Euler s constant and the transcendental number e"

Pi was first calculated to 1 million places in France in 1974 The millionth digit of pi is 5 How could Matrix have known, eight years earlier? Was it a lucky guess that came true with a one in-ten chance? No, it was a lucky guess that had a slightly better shot at coming true one in five, to be exact What was the 'out' that Dr Matrix used to double his chances of getting a hit?

A FIVES QUIZ

Here's a test on our favorite number this year Identify these famous fives

a Who is Annette Dionne?

b In what popular board game does a player win by getting five pieces in a row vertically, horizontally or diagonally?

c The official flag of the Olympics has five interlocking rings Name the five colors and explain why they are significant

d Swimming, riding shooting running What's the fifth event in the men s Olympic pentathlon?

e The five-year mission of the *U S S Enterprise* included orders 'to explore strange new worlds to seek out new life and new civilizations and to defy grammarians by splitting an infinitive What was the last order of business for the five year mission?

f Name a Paul Newman movie (1979)

g A Jack Nicholson movie (1970)

h Victory Symphony

i In warfare a group of secret supporters working behind the enemy s lines or within its national borders

j 'Up Up and Away' singing group

GET PRACTICAL

Most of the puzzles presented in this column are purely mental exercises with little or no relevance to reality This month we emphasize practicality and real solutions to real problems Practice on the problems below then submit examples of your own

1 PACKAGE PLAN A New York photographer was on a cross country drive last August and stopped to see his family in Michigan His resourceful sister took the opportunity to give him his Christmas present a package weighing about 20 pounds She explained that it would be much easier for him to carry the package in the car to New York than it would be for her to mail it there come December He took the box with him and kept it in a closet securely wrapped for the next few months

When December rolled around our friend found that he would be able, after all to visit his family over the holidays He was faced with an array of choices Should he take the 20-pound package back with him on the plane so that he could open it on Christmas morning then lug it back to New York? Should he open the present before leaving for Michigan so that he could thank his sister for it on Christmas morning? Or should he leave the package unopened in his closet so as not to spoil the surprise and then open it after he gets back?

None of these alternatives are quite satisfactory Give the problem some thought and find a better solution

2 COOKE S BOOKS British-born American historian Alistair Cooke had a wall-size bookcase in which he kept books about various states and regions of the United States When the library got very large he decided to organize it How?

He could alphabetize the books by author but he rarely wanted to find all the books by one author, and he could never be sure that he could remember who wrote a book he wanted about, say, Montana or Texas

He could alphabetize by publisher, but the same problems would arise—which publisher did that book about Missouri?

He could alphabetize the books by state, but then where would he put books about say New England the Mississippi Valley or the Great Plains?

What was his ingenious solution?

3 THE TRUCK AND THE BRIDGE A trucker wants to drive under a bridge but finds that his rig is one inch higher than the bridge's clearance The frustrated driver pulls to the side of the road and is checking maps to find his shortest alternate route when a small child comes up to him and says "Hey Mister I know how you can get your truck through" The suggestion worked What was it?

4 NUTS A man with a flat tire pulled his car to the side of the road He jacked up the car removed the hubcap and four lug nuts placed the nuts in the hubcap, and removed the bad tire As he was lifting the spare tire out of the trunk, however he kicked over the hubcap and all the nuts fell down a sewer The next town is several miles away He could walk or hitchhike there to buy more lug nuts but that is a second-best solution Can you think of anything better?

Answers are on page 209

OMNI COMPETITION #30 GET PRACTICAL

Is there any advantage to being brilliant? So you're a whiz at the problems in *Omni*'s Games column Big deal Does that mean you're any good at solving the problems of life?

Does the ability to handle *Omni*-like puzzles have any connection whatsoever with the ability to get through an ordinary day and to solve ordinary problems with extraordinary flair? We may be biased but we think our readers are clever in every way To prove it we invite each of you to send *one* inspired solution to a real-life problem We prefer cases that have really happened to you but will accept hypothetical ones as long as they are realistic

Send your problem and solution (less than 100 words combined) with your name and address attached to *Omni* Competition #30 1965 Broadway New York NY 10023 5965 All entries become the property of *Omni*, none will be returned The grand prize winner will receive $100 and runners-up (2–10) $25 each Entries must be postmarked by November 15 1983 ∞

LAST WORD

By Art Buchwald

Redondo described the unidentified object: It was cylindrical in shape, except for a wing protruding from each side. To each of these there was a motor attached

The government has hushed them up in order not to frighten the people, but deep in the bowels of the Department for Unexplained Phenomena and Environment (DUPE), just outside Washington, DC, in vaults guarded day and night by armed Marines, are case histories of eyewitness accounts of some of the strangest supernatural happenings that have occurred in modern times.

There is no rational explanation for any of them, so in typical government fashion, officials of DUPE have denied they ever happened. Here is just one of them. You be the judge.

One night, around 2 A.M., two highway patrolmen, Officer A. C. Dunning and Sergeant Butch Redondo, were driving along Route 21 outside Sorrowful Bluffs when they heard the roar of engines overhead. They looked up into the sky and saw a strange object pass over them with two giant beams of light.

The officers immediately gave chase, following the craft, which was doing 250 miles per hour by their estimation.

"It's moving toward the closed-down Abel Hill Air Force Base," Redondo shouted to Dunning. "Cut across the desert and we can head it off."

The object was circling the field as the two officers arrived. Finally, after blinking its spotlights four times, it landed gently on the runway. Redondo, in his testimony, described the unidentified object: "It was cylindrical in shape, except for a wing protruding from each side. To each of these there was a motor attached. Two wheels jutted out from the center of the object, with a small one in the rear."

Dunning said, "The thing came to a halt next to an old Army barracks. I pulled up about two hundred feet from it. The sergeant and I got out, our guns drawn. Nothing happened for ten minutes. Then the door at the back of the object opened. A strange apparition appeared. It was wearing something like a baseball cap, had on dark coveralls, and brown rubber boots."

Redondo added, "There were four of them. They had hair all over their faces and over their eyes they were wearing funny things that looked like sunglasses. Each carried in its hands what could have been a laser weapon, but looked like a Thompson submachine gun. As we approached them I shouted, 'Don't shoot, we are your friends.'"

Dunning told investigators, "The leader of the group said something in a strange language to the others and then spoke to us in English. '*Buenas noches*. We come in peace from the planet Sirius. Where are we?' The sergeant said, 'You are on the planet Earth. Welcome.'

"'*Caramba!* We have made a navigational error,' the leader said. 'Our mission was to explore the planet Pluto. We have to be going, pronto.'

"'Wait,' the sergeant begged. 'Why not stay and explore our planet?'

"'We must follow the orders of our great Cyclone, Bolívar. Perhaps some other time.'"

In his debriefing Dunning went on, "I got up my nerve and asked, 'Could we at least take a look inside your spaceship?' The leader spoke to the other things, and they seemed to be arguing among themselves. Finally it said, '*Sí*, señor. We will even take you for a short ride.' The sergeant and I were escorted inside. It didn't look like any spaceship we had ever seen in the movies. There was nothing in the cabin except large bales of what appeared to be a grasslike substance. The leader sat across the aisle with his laser-submachine gun pointing at us. I asked what the bales were for. The leader said, 'It is our food, señor. One bale keeps us sustained for every million light-years we travel.' The sergeant asked if he could taste it, and the leader shouted, '*Madre mia!* Don't touch it, gringo. It is poison to Earthlings.'"

Redondo said, "Then the lights in the cabin dimmed and suddenly we were zipping down the runway. The spaceship lifted itself gently in the air. Dunning and I got airsick, but the movement of the ship didn't seem to bother the things. They calmly sat smoking and giggling.

"Finally we returned to the airport. Although the pilot had never been to Earth before, he again made another perfect landing. The door of the ship was opened, and the leader pushed us out. '*Hasta la vista*, señor,' he said. 'Tell the people of Earth, Sirius will never make war on them, unless they make war on us.' Dunning shouted over the engines' roar, 'And tell the things of Sirius, war is not in Earthman's nature.' Then the spaceship disappeared into the darkness."

Now here is the strange part of the story. When Dunning and Redondo got back to headquarters they made a full report to their captain, who called the Air Force DUPE investigating team. For two weeks both highway patrolmen were grilled. They stuck to their stories.

Mysteriously, both Redondo and Dunning were later fired from the patrol without explanation. Three years have passed, and the case has been marked TOP SECRET. When I tried to see the files, I was referred to the Drug Enforcement Agency—obviously an effort to lead me down a blind alley, since DEA has nothing to do with UFOs.

I found Dunning, now working at a gas station. "I know what I saw, and I told it as it happened," he maintains.

I located former Sergeant Redondo. He now lives in one of the abandoned barracks at the defunct Abel Hill Air Force Base, a shattered man. "I know they'll return," he told me, sipping from a gallon jug of Blue Nun wine. "And I'm going to wait here until they do. And when they arrive I'll bring the whole country to meet them, and then we'll see who has the last laugh on whom." ∞