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MARCH 1989

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PLUS: 20 OTHER DREAM VACATIONS

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VOL. 11 NO. 6 MARCH 1989

CONTENTS

Airstream, a Steve Pietzsch acrylic, reflects the artist's interest in Eastern religion and surrealism. "I've shown the trailer house floating to give the sense that it is the center of the universe," says Pietzsch, a Texas painter

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FIRST WORD

By Leon Cooper

"What does neural network technology suggest? That the brain—the source of thought, memory, and consciousness—might be mimicked by a machine that thinks as well as or better than we do"

Not long ago many scientists believed that neural networks, data processing systems modeled on some properties of the brain and nervous system, were an impossible technology. Today one might conclude that scientific opinion has shifted from the belief that neural networks could do nothing to the suggestion that they will do everything.

What does neural network technology suggest? That the brain itself, the source of thought, memory, consciousness and self-awareness—all that makes us human—might be mimicked by a machine that thinks as well as or better than we do. Neural nets, presently housed in software simulations that are run on ordinary computers, can make commonsense choices, and they can learn from experience.

Scientists first began studying neural networks in the Fifties. Researchers hoped to unravel the complexities of human perception, but enthusiasm for this project died in the late Sixties. Computer scientists, perhaps discouraged by slow progress in the neural net field, instead directed their attention toward artificial intelligence. It was believed that computers could be programmed to perform any task.

Now it is clear that computers are limited in solving many problems involving complex pattern recognition. This has turned the tide toward neural net works. The military, for instance, has an interest in developing networks that can recognize and compare patterns. It is very difficult to write specific rules for discriminating between a commercial craft and a fighter plane on a radar scope. Thus it is extremely difficult to design a conventional computer program to take over this task. The standard computer (developed from a model conceived by mathematician John von Neumann in the mid-Forties) requires step-by-step instructions. Neural nets, however, may be able to classify images on a radarscope by being fed the radar signal and the operator's evaluation of the craft. After numerous examples, the neurocomputer will learn how to identify the radar signals.

It is also difficult to define rules for loan approval. A neural system that can mimic an underwriter's decisions and determine the risks of approving loans to consumers is currently in the prototype stage. The network is trained by showing it approximately 5,000 loan applications and then indicating both the underwriter's decisions and, among accepted loans, those that were never paid back. By recognizing traits associated with good loans and traits characteristic of bad loans, the network can determine which applicants are most likely to default on their loans in the future.

Although computers add, subtract and execute instructions with incredible speed and accuracy, they fail to be good models for the brain. In the living brain, large numbers of individual nerve cells function slowly and imperfectly. Collectively, however, they perform remarkable tasks that even the largest computers have not been able to match. (Our ability to think is a result of the interplay between the brain's neurons.) Neurocomputers are made of many relatively simple electronic processors that are connected to one another in a manner analogous to the way the brain's neurons are connected. Neural systems are taught by repeatedly subjecting them to specific input and then showing them the desired output. Eventually the neurocomputer picks up the pattern.

In cooperation with current computer science, neural networks seem to some of us to represent the next generation of computer architecture: systems that combine the enormous processing power of Von Neumann computers with the ability to make sensible decisions and learn from ordinary experience—as we do. Because neural networks learn to solve problems on their own, they require much less of the engineering knowledge and expense needed for artificial-intelligence products.

In their current state, neural networks are probably best at problems related to pattern recognition such as reading ZIP codes, recognizing assembly line parts, diagnosing engine problems, and/or translating hard-to-read signatures by distinguishing among different styles of writing. Future applications might include sending neural nets to probe space, where they will make decisions in response to unexpected circumstances. They will likely be integrated into every personal computer system, where part of the computer will be operated by rule-based computing and the other part by neural networks. I expect that someday neural technology will be made available for speech recognition in inexpensive household products—like televisions and telephones—by building neural circuitry directly into the appliances.

Who would have thought that today there would be transistors, silicon chips and the vast array of devices on which all computers depend? Or that superconductors would lead to extraordinarily sensitive magnetic field detectors now carried on many naval ships? Just as the twentieth century is the century of automobiles, airplanes and computers, the twenty first century will be the century of intelligent machines. We will not only learn to live with these machines, but someday we will wonder how we ever lived without them. ∞

Leon Cooper was awarded the Nobel prize in 1972 for developing the theory of superconductivity. Today he is working on creating machines that one day "might be said to think."

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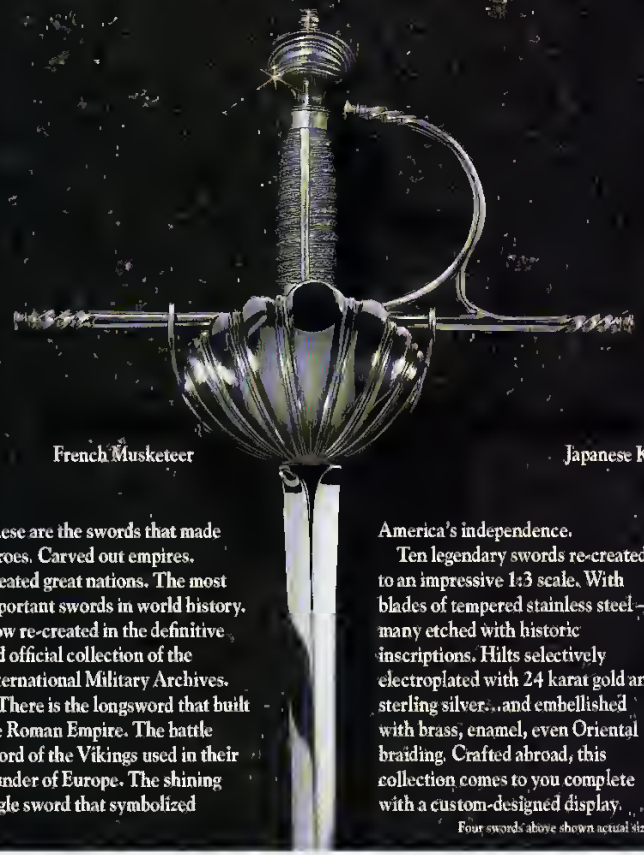

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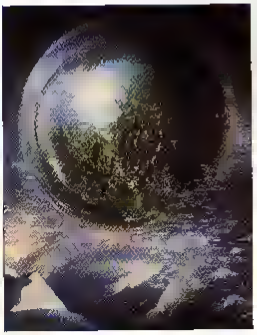
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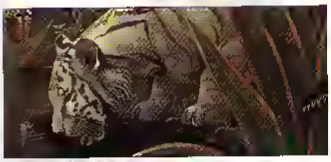
THE MAKING OF FITZCARRALDO


UPWARDLY MOBILE

The New York City-based Explorers Club (for those who don't know) gives the appearance that Teddy Roosevelt just left it. There's a stuffed bear, lots of wood, and at least one fireplace. It was in this setting that I dined with Jack Horner (no, not in a corner), along with about a dozen other members of the press. This paleontologist, who has made the search for dinosaur eggs every bit as American as the Fourth of July, pulled from his briefcase a relic perhaps holier (and much older) than Betsy Ross's flag. A dinosaur egg, he said, passing it to me, over the head of another reporter. It had passed through the eye of a CAT scan, so he could add, with confidence, that it was hollow. I ran my thumb over its cool, elliptical shape and thought how it had survived and would survive me and anything in the venerated institution in which we dined.

Horner was articulate, unassuming, adamant about his love for Montana and his suspicions of New York. He is also, thanks to reporter *James Gorman*, the subject of our Interview (page 72). Concerned about scientific illiteracy ("It's the one thing I'd leave what I'm working on to do something about"), he spoke on his field digs, the children who'd participated, and how they fared. In some ways he's as rough-hewn as the earth he's plowing through, and the plaid shirt and jeans he wore were as refreshing as a tree in Brooklyn.

The same spirit of adventure so basic to Jack Horner was exhibited by writer *Jeff Goldberg* while compiling "*Omni*'s Five Star Travelogue" (page 42). As part of his research, Goldberg journeyed to Trinidad and joined an iguana hunt. "It was terrible," he says, much chagrined. "It tasted crunchy—like a lizard. But the worst part? I had to look at it all day, staring at me with these unforgiving reptilian eyes that seemed to know that it was meant for dinner." Trinidad turned out to be one of the places Goldberg did not include—but the ports of call he did select (Haiti for its voodoo, Canada for its spaceflight simulator, and the West for its telescopes and observatories, among them) will inspire, entice, and educate the deliberate tourist.

For an encounter of the mathematical kind, a journey to the country of India: see "The Master of Math" (page 58) by *Gurney Williams III*. Williams writes about the life and formulas of Srinivasa Ramanujan, a math maven who lived during the first part of this century and whose work has applications to this day.

Mathematical—as well as engineering—skills went into the cars designed for the National Automobile Model Design Contest (see "Upwardly Mobile," page 48). Although you're not likely to drive any of these vehicles in the near future, many of the concepts applied here will surface in the showrooms of tomorrow. Portrait photographer Alan Levenson, who's based in Los Angeles, enjoyed shooting the still lifes. "It's quite different," he explains. "They—unlike people—never talked back."

The imaginations of those in the science-fiction community are always working, as evidenced by two stories. "Filming the Making of the Film of the Making of *Fitzcarraldo*" (yes, the movie will be shorter than the story's title) by *Garry Kilworth*, on page 52, and *Michael Swanwick*'s "Snow Angels," on page 104. The latter will take you on a mystical expedition of sorts, to a mountain in snowy Vermont.

To travel to the desert—and witness one man's ingenuity in the face of adversity—turn to the Earth column (page 28). *Douglas Starr* weaves a tale of an ancient art that may ensure the future of dozens of Third World farms.

Finally, the future will be much brighter—and cleaner—if contributing editor *Ellen Kunes* has anything to say about it. Mindful of America's growing garbage problem, Kunes admonishes the FDA and USDA for their shortsighted view of food packaging. The plastic pouches and trays displayed at a recent meeting are sure to replace the common can. Are they biodegradable? asks Kunes. For the government's answer, turn to "American Myopia" (Continuum, page 33). Perhaps someone with Jack Horner's dedication—and the inventiveness displayed by science-fiction writers—will come up with a solution. —The Editor

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MARCH

LETTERS

COMMUNICATIONS

Omnipotent

I have subscribed to *Omni* four ditterent times over the years and have always found other publications routine or predictable. But both my daughter and I always come back to *Omni*. From our view, the entire December 1988 issue was dynamite, trom "Running on Empties" [Space] to "Los Alamos Whiz Kids" to the interview with Luc Montagnier.

Jim Allison
Forbes Park, CO

Alienated

Traditional scientists such as Michael Persinger refuse fo acknowledge certain phenomena that we humans call psychic or paranormal ["Transcending Science," December 1988]. While there appear to be a number of ways one can "trigger" paranormal experiences, there is no dumber theory than Persinger's—that UFOs are geologic emissions. Geologic disturbances do not come in metal with jointed seams, nuts and bolts, leaving deep pod marks and other ground markings that are radiated. Geologic disturbances don't turn engines on and off or land in the same field you stand in, and they would not have allowed me and my colleagues to take almost 1,000 photographs of someone else's spacecratt since 1980 in the Middletown, New York, area. I invite Persinger and any of his colleagues on one ot our nightly escapades—we're out there all year round.

Ellen Crystall
Publisher and director ot *Contactee*, The First Organization for Research of UFOs by Direct Observation
New Milford, NJ

Although every theory is entitled to its "day in the sun," Dennis Stacy has selt-destructed Michael Persinger's concept ot mystical experience as self-induced. In short, the theory fails to account for the radiation burns and other physical injuries sustained by UEO abductees. As punishment for this oversight, both Stacy and Persinger should be subjected to 100 consecutive viewings of the old sci-fi classic *Forbidden Planet* and a lifetime subscription to *The MUFON UFO Journal*.

Ron Jackson
Vincennes, tN

Alcoholism and Behavior

I have been working with drug- (alcohol-) addicted people for ten years and welcome Herbert Fingarette's point of view on the subject ["The Politics of Alcoholism," Mind, December 1988]. It seems that unless one is a philosopher, it is difficult to make proper distinctions between what we know as concepts (alcoholism) and what we know as presences (heavy drinking). People take the road to alcoholism (concept) and addiction (concept) when they begin to misuse alcohol and other drugs. When they are in the presence of enslavement to their "solution," they no longer have their "vote" and need someone to "wake them up."

Russell E. Shaw
Littleton, CO

Underwear Scare

I have to give Dr. Eduard Friedrich credit for going to such extremes on *Candida albicans* ["Microwaving Underwear," Continuum, December 1988]. Your article had me rolling on the tloor. I do feel, however, as Dr. William Crook explains in his book *The Yeast Connection*, that you must get rid of *Candida* from inside the body. Once that is controlled, one will see a decrease in the pestering infections as well as other problems caused by the unsuspected toxins.

Deborah Selby
Reading, PA

Human Error

A small correction on the piece "Why Can't a Robot Be More Like a Man?" [Continuum, December 1988]. C-3PO is the one that looks like a human—not R2-D2. R2-D2 is the one that appears to be a sophisticated vacuum cleaner.

Michael Wescott
Columbia, SC

THE AUTOMATION GENERATION

FORUM

By Alex Kozlov

It's just a hell of a time to be alive is all—just this goddamn messy business of people having to get used to new ideas. And people just don't, that's all. I wish this were a hundred years from now, with everybody used to the change," says Paul Proteus, a brilliant young engineer and the main character in Kurt Vonnegut's anti-Utopian novel *Player Piano*. It's 1952 when the book is published, and Vonnegut has just finished a brief stint working in corporate America, doing public relations for a General Electric plant in Schenectady, New York. The world created by Vonnegut is an unhappy place, dehumanized and pointless because highly efficient machines provide everything for everybody. In the absence of meaningful work—almost everyone has been displaced by automated machines—people lead dull and empty lives. "This book," writes Vonnegut in the foreword, "is not a book about what is, but a book about what could be."

So how close are we to Vonnegut's world-of intelligent automation? About 30 years away. At least that's what David Bourne predicts. But Bourne, a computer scientist at the Robotics Institute at Carnegie-Mellon University (CMU) in Pittsburgh, objects to Vonnegut's chilling vision. In Bourne's world, machines perform the boring work, freeing people to do creative jobs.

Working with Paul Wright, a mechanical engineer at New York University's Robotics Laboratory, and CMU master machinists Jim Dillinger and Dan McKeel, Bourne is developing an automated craftsman, an intelligent machine tool that can make any component to precise specifications and does so at least as efficiently as a skilled human. "We're just biological machines," says Bourne. "As soon as we understand the science behind any activity, we can automate it."

Both Bourne and Wright are tall and lanky. Bourne is passionate, animated, and laughs often. Wright, an Englishman, is more reserved in manner and measured in tone. Dillinger, a machinist for 13 years, and McKeel, with 15 years' experience in the trade, came to CMU nine years ago. The four men, thrown together to work on an ambitious project with potentially dramatic consequences for society, differ in their respective views of the future. Bourne is enthusiastic about the technological possibilities; Wright is more realistic; his vision tempered by practical experience as a machinist and shop manager. He believes the workerless factory is possible but says he's certain a craftsman's creativity and artistic flair can never be totally captured and reproduced by machines. Dillinger and McKeel are ambivalent about Bourne's ultimate goal, complete automation. "Sometimes I have problems with what I'm doing," says McKeel. "I feel a little strange. I know that maybe not now, maybe not in five years, but certainly in twenty a lot of the stuff that we've taught the engineers could displace us. They will develop a 'system' that's going to do our work."

In the near term, however, both the researchers and machinists believe intelligent tools will enhance workers' skills. Craftsmen will spend less time on busywork and focus on difficult jobs; inexperienced workers will consult the smart tools for advice on tackling problems. The project's long-term impact, however, is almost uncontestable. Machinists will be displaced.

"With advanced automation we could end up with, say, fifteen million to twenty million underemployed or unemployed workers and five million jobs nobody is qualified to fill," says Don Kennedy, education representative with the 800,000-member International Association of Machinists and Aerospace Workers (IAM). Today's skilled worker, Kennedy claims, may be unequipped to work with future machinery so sophisticated that only an engineering Ph.D. will be able to understand it. According to Kennedy, who notes that his union has been influenced by Vonnegut's vision of a world controlled by machines, IAM's position is that technology should be a tool for workers to use, not something that will replace them. "If the goal is merely to eliminate workers"

Rank and file: Will the workerless factory displace machinists and skilled craftsmen?

Kennedy says, "that's a value judgment. When management hears about the workerless factory, they envision scientists collecting data, monitoring and controlling production from a central point." Control, he adds, is often the key value for management—control of inventory, control over production and workers. "For us, the 'automated craftsman' is a contradiction in terms. We believe a craftsman by definition can't be automated, that craftsmanship is a uniquely human activity."

Kennedy believes that most companies are seduced by the promise of robots and artificial intelligence programs, only to find that these high-tech tools are inherently risky and inefficient. While a human worker might turn out three or four bad pieces per hundred, a workerless assembly line might hum along smoothly for days or weeks but then produce 4,000 bad pieces in a row. "The technology hasn't lived up to the promise," Kennedy says. "We've seen robotic welders that simply can't do what a skilled human welder can do. When judgments have to be made, a robot can't do it."

Suppose your company makes widgets. If you need 10,000 of them, it's relatively easy and cost-effective to program a machine tool to churn out 10,000 exact copies. But if you need only ten very fancy widgets, mass-production techniques are unwieldy and imprecise; in such instances a human machinist is needed. Now, if those widgets cost $10,000 apiece and must be machined to within a thousandth of an inch to ensure the safe operation of a jet engine, there's no room for error. Master machinists could make the ten widgets perfectly. But layoffs, retirements, and cuts in apprenticeship programs have made skilled craftsmen scarce—and if automation becomes a reality, they'll become scarcer, just as Vonnegut predicted.

In Vonnegut's novel, master craftsman Rudy Hertz cuts a small metal shaft on his lathe to precise specifications, while Proteus records Hertz's actions on a tape. "Paul unlocked the box containing the tape recording that controlled [all the machines]. The tape was a small loop that fed continuously between magnetic pickups. On it were recorded the movements of a master machinist turning out a shaft," wrote Vonnegut, basing his information on the 1950 numerical control (NC) machine tool that used tapes, like a player piano, to instruct a machine to cut a machine part. Today the NC tapes have been replaced by computer programs.

While the older model performed simple, repetitive tasks, the CMU research team hopes to build an intelligent tool that makes many different parts precisely. To do so, Dillinger and McKeel describe to the researchers in detail the skills and actions required to make a part. Bourne and Wright ask questions and watch videotapes of the machinists as they make the cuts for the part: properly set the speed and depth for the cutting tool, and, finally, produce a finished product. After this process is completed, the researchers write computer programs that replicate what the skilled humans do. "Until we started the sessions," McKeel says, "we never really thought about what we do. It's automatic, just like getting in your car and driving. Now we describe every specific action, including each small step involved in making a part."

According to Bourne and Wright, the big problem is to get the "brain, eyes, and hands" of the intelligent tool working together. Take vision, for instance. As a part is being cut, a machinist watches the size and shape of the chips coming off the part, indicating whether the tool is cutting at a proper speed and depth. A good visual system also must recognize when something is wrong and react immediately. If a part flies out of the vise, an intelligent tool must have the sense to shut down.

"A customer will be able to walk into a small retail dress factory, choose the design she wants, be measured by a laser scanner, and walk out an hour later with a finished garment."

To demonstrate the problems involved in making automated hands, Wright picks up a saltshaker and twirls it around. "It's easy to do, right? But try to explain precisely where one finger releases and where the next one grasps. It's actually a very complicated activity." To develop hands that can manipulate parts as deftly as a machinist does, Wright and his Robotics Lab colleagues have built a four-fingered robotic hand connected by fiberoptic lines to a glove. If you put your hand in the glove and wiggle your fingers back and forth, signals travel from sensors in the glove to the robotic hand—its metal fingers wiggle back and forth in an eerily humanlike fashion.

When the machinist's different functions are automated and integrated to work in a single system, Bourne envisions fully automated plants—"unattended manufacturing systems"—where better goods will be produced less expensively. Designers will be able to see prototypes of their ideas almost immediately. Efficiency will reign because companies will cut out the middleman in manufacturing. Time-consuming shipping from third-party suppliers, for example, will be eliminated. Their own machine tools will make whatever is needed. The technology will offset the growing shortage of skilled machinists and, Bourne predicts, restore U.S. industry's competitive edge. He envisions nothing short of an economic revolution.

When the automated craftsman is a reality, Bourne says, a customer will walk into a small retail dress factory, choose a design, be measured by a laser scanner, and within an hour walk out with a finished garment. An automated dressmaker located in an unattended back room will select the right fabric, buttons, and accessories and will cut and sew the dress on the spot. As the technology advances and more sophisticated manufacturing facilities become available, "a Pittsburgh car manufacturer could make a car completely out of plastic, or a guy in Rome could build cars out of stainless steel," Bourne says. "The technology will change the way we do business, giving individual people power to make their vision of the world come true. I'm talking about taking power out of the hands of Lee Iacocca and putting it into the hands of David Bourne."

In other words, put the power into the hands of the "little people." Bourne's view of the future directly contradicts Vonnegut's vision of a mass of dehumanized, spiritless people, unable to control their lives because machines have taken over. Who's right? Thirty-seven years ago Vonnegut predicted that a select few—the engineers who design and program the machines, and the managers who decide what and how much the machines produce—would control society. If this is what the future holds, Bourne laughs, "I agree with Vonnegut, let's tear down the machines."

Bourne, however, doesn't foresee disaster, even though he admits that "drastic changes" will accompany what he believes will be a 30-year transition to unattended manufacturing. "No doubt some people will suffer," he says. Just as earlier in this century the sons of blacksmiths were unable to carry on their fathers' trades, in the new machine age the children of machinists and other industrial workers will have to develop new skills or find other vocations. "Unattended manufacturing will open up all kinds of possibilities," Bourne says. "If I succeed and these flexible manufacturing systems start springing up all over the place, the skilled craftsman will be needed to tune them up, keep them running. Ultimately, there will be more jobs."

SETI'S GUIDING LIGHT

STARS

By J Kelly Beatty

Pity the poor astronomers involved in the search for extraterrestrial intelligence, or SETI. Most of their colleagues are content to make a living the easy way. They track actual objects in space—like planets, stars and galaxies. These will show up (however faintly) when you point a telescope their way. Even more adventurous stargazers, who search out the bizarre and unknown—such as black holes, brown dwarfs and dark matter—have a pretty good idea beforehand of what to expect, what instruments to use, and in which direction to turn.

SETI scientists search without these advantages. Armed with radio telescopes, they must haphazardly 'spin the dial,' looking for a coherent message amid the clutter of signals emanating from natural phenomena such as high-energy stars and Earth's own radio pollution. Worse still, SETI proponents have little sense of where, when, or even how to look—the extraterrestrial signals could be from any direction at any time. The thorough approach—to systematically search the entire heavens—is a daunting, expensive, and near-impossible task. How to optimize the search strategy therefore has been the basic question for SETI.

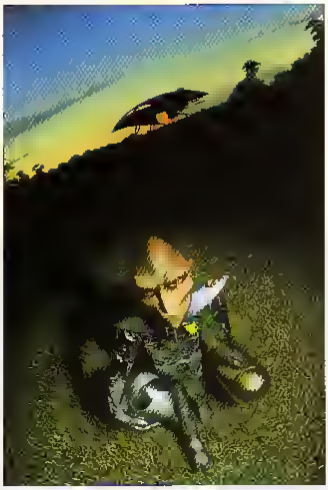
Perhaps the hottest new way to streamline the quest is to try to take advantage of supernovas—the brilliant death throes of massive stars. Supernovas are so luminous that they can be seen throughout our galaxy.

The essence of the idea of using these magnificent galactic events for SETI was first proposed by Soviet scientists but has been refined and popularized by retired British aeronautics specialist William F. Hilton. He reasons that the odds of picking up alien transmissions are at their absolute best if we simply look in the direction of a supernova as soon as it explodes into view. "Listening for extraterrestrial signals is such a formidable undertaking," he explains, "that I turned to what I call the 'inverse problem': How would I communicate with someone else?"

Would other civilizations realize that a supernova's appearance means 'Talk now'? Hilton is convinced that they would. Any race smart enough to know how to communicate, he reasons, would also realize the staggering difficulty of trying to coordinate broadcasts across hundreds of light-years of interstellar space. So they'd all be waiting for such opportune moments to transmit.

This insight led Hilton to a key realization. The time signal provided by a supernova moves outward through the galaxy at the speed of light. If we were the ones doing the talking, he then reasoned, the best communication tactic would be to point our transmitters away from the supernova. In time, extraterrestrials downstream from us would spy the supernova, look or listen in its direction, and pick up our broadcast.

With this appealing strategy to answer the where and when of SETI, the other prerequisite for successful interstellar communication would be to tune in to the broadcast. In other words, the electromagnetic spectrum offers billions of possible transmission frequencies, but which ones would alien life forms use?



Calling E.T.: Using supernovas to reach out

Some do seem more likely than others. As early as 1959, for example, astronomers realized that the microwave radio band (between about 1 billion and 10 billion hertz) offered the best combination of a quiet cosmic background noise level and ease of reception on Earth—important considerations for both intergalactic broadcasters and receivers. Thus virtually all SETI efforts to date have listened at microwave frequencies.

If Hilton's theory is correct, a big cosmic hello should have reached the earth two years ago, when the brightest supernova (1987A) in 350 years exploded into our view. Unfortunately, it's visible only from the Southern Hemisphere, putting it out of reach of the vast majority of Earth's radio telescopes. But three astronomers at Argentina's Institute of Radio Astronomy have heeded Hilton's call and are monitoring the supernova with a radio dish 100 feet across. "We began looking in October 1987," says the institute's Guillermo Lemarchand, "and we'll continue to do so on a part-time basis." Astronomers at two radio telescope facilities in Australia have also pledged to look the supernova's way.

According to Jill Tarter, who chronicles SETI efforts worldwide from NASA's Ames Research Center, the supernova-aided strategy is a good one. To put the problem of a purely random search in perspective, imagine moving the Argentine telescope to the equator so it could view the entire sky. This telescope's field of view is roughly the size of the full moon. This means that even if you pointed it at each full-moon-size view of the sky for ten minutes before moving on to the next target area, it would take 190 000 different spots—more than two years of scanning—to cover the whole sky once. Obviously, SETI researchers are eager to find a strategy that can improve on these daunting search prospects, such as listening to the heavens immediately after spotting an exploding star.

ACCELERATED MEDICINE

BODY

By Gregg Levoy

Inside one of the three separate 'caves' or medical treatment suites that constitute the Lawrence Berkeley Laboratory (LBL) accelerator complex in Berkeley, California, a twenty-eight-year-old woman is receiving advanced medical treatment that may save her life. Several years earlier an abnormal growth of blood vessels in her brain put her into a coma from which she awoke with her right eye paralyzed. Her doctor, Jacob Fabrikant, a radiology professor at the University of California at Berkeley, told her that the growth was too deep to be accessible by conventional surgery. Her next hemorrhage, he said, could be fatal. Fabrikant recommended therapy with the LBL's Bevatron, an atom-smashing particle accelerator originally designed for physics experiments.

A group of shirtsleeved physicians and physicists strap the woman into the Isocentric Stereotactic Apparatus for Humans (ISAH). Essentially a revolving couch, ISAH's movements permit the Bevatron's powerful helium-ion beam to take aim at the woman's brain from different angles. When the accelerator is turned on, it will deliver precise doses of radiation to the desired target. Using computerized axial tomography (CAT scan) images of the patient's growth, called an arteriovenous malformation (AVM), taken on an earlier visit, physicists align ISAH to within a fraction of a millimeter. To prevent her from moving during the treatment, they immobilize the woman's head in what looks like a custom-made hockey mask.

The four doses of therapy Fabrikant calls stereotactic radiosurgery will be given at two- to three-minute intervals, each lasting about 60 seconds. The painless procedure effectively cauterizes the growth. The radiation stimulates blood cells within the AVM to reproduce, in doing so, they clog its blood vessels. With the supply of fresh blood cut off, the mass begins to atrophy. As this happens, normal blood flow should be restored to the woman's brain. Fabrikant and his team have cured 133 of 140 cerebral AVM patients since 1980.

Doctors expect the increasing use of accelerators to revolutionize treatment for focal cancers, or those localized in one area. Particle beam therapy will lower the doses of radiation required while increasing their accuracy. Cancer patients treated with it will also be spared the side effects. "Any disease that is treatable with X rays could probably be better treated with particle beams," says Dr. Raymond Kjellberg, a neurosurgeon at Harvard Medical School, home of the only other accelerator currently being used for clinical purposes in the United States. "My guess is that they will replace most X-ray use in ten to twenty years."

Next spring Loma Linda University Medical Center outside Los Angeles will unveil its new synchrotron, the first accelerator designed expressly for medical uses. The opening of Loma Linda's $40 million facility will be an important milestone. James Slater, chairman of Loma Linda's department of radiation sciences and project director for the new facility, estimates that it will be capable of treating up to 2,000 patients a year in half-hour sessions.

While the cost of building accelerators and the vast expanses of space necessary for their construction are prohibitive for most medical centers, Kjellberg believes more hospitals will follow Loma Linda's lead and raise the necessary funds. "Interest in the medical community has increased fivefold in as many years," he says. Officials at Massachusetts General Hospital in Boston are already planning an accelerator that may be ready to treat patients by 1995.

Because the accelerators are such complicated machines, radiosurgery requires more effort on the part of doctors than standard radiotherapy, but it's safer for their patients. Conventional radiation treatment uses X rays, which scatter as soon as they hit the body, wasting energy and plowing into healthy and cancerous tissue alike. This is especially dangerous if the tumor is near a vital organ, such as the heart or spinal cord. To avoid damaging normal tissue doctors use a less-than-ideal dose.

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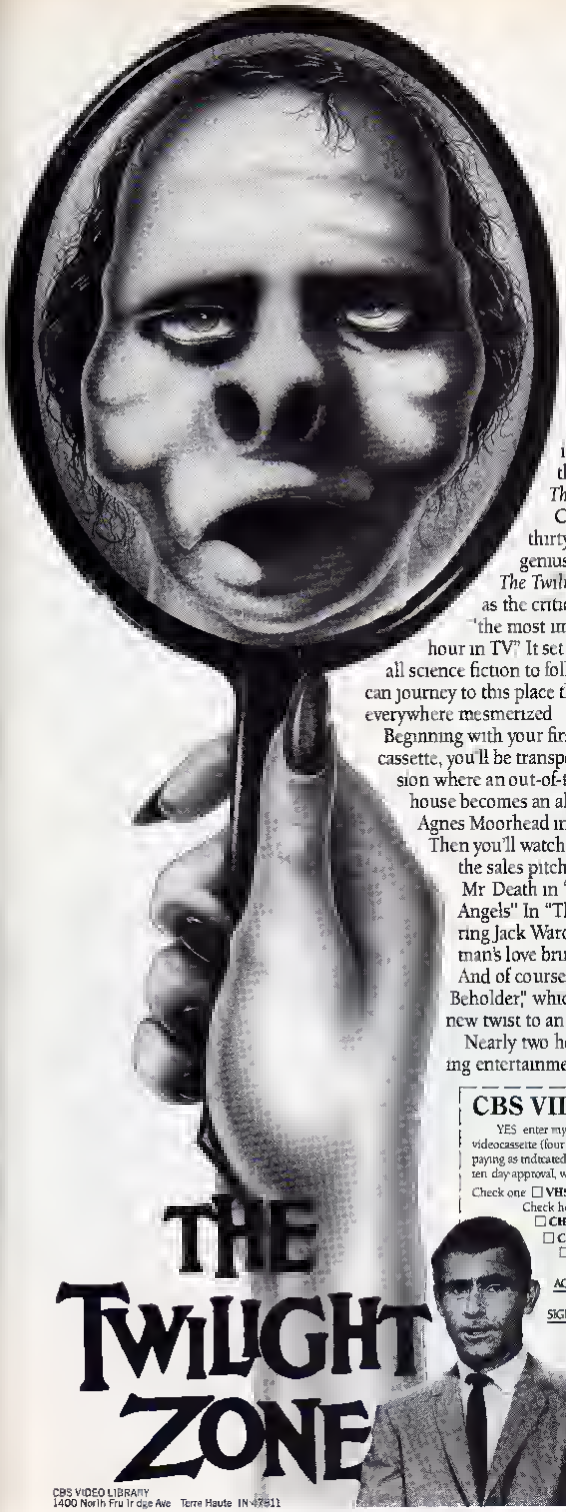
Rays of hope. Particle beams kill cancer cells (above) with pinpoint accuracy



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DESERT BLOOM

EARTH

By Douglas Starr

For 30 minutes it poured—hard drops slapping the dry rock and sand of southern Israel's Negev Desert. Normally such a rain would cause flash floods and erosion, but rarely would it soak in. This rain, however, behaved differently. As it struck the hillsides, it trickled into ancient stone channels that directed it downhill to a valley. The runoff formed rivulets, which united to form streams.

In the valley of Avdat lived a scientist and his wife. They had uncovered the vestiges of ancient farms and restored the aged channels. They watched as the murky water flooded down from the hillsides onto a system of earth terraces they had built on the low ground. It collected on their land and penetrated their soil. They ran out and took measurements to document their experiment. They realized that they had uncovered a kind of agriculture that had been lost for 1,500 years.

"At that point, we knew our theory was right," says Michael Evenari, a professor of botany at Hebrew University in Jerusalem. His discovery—that an ancient Middle Eastern people raised crops in the desert by cleverly channeling the desert's scarce rainwater with rock walls and earth terraces—is one of the most promising low-tech ways of providing food and fuel for barren regions of the Third World.

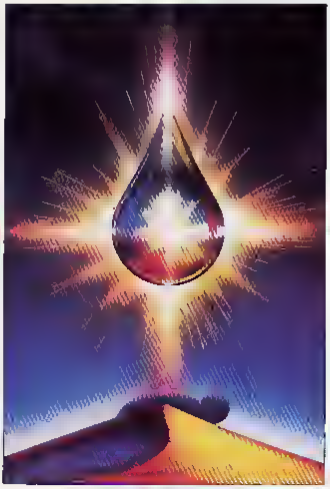
Evenari explains that because they require no irrigation, the farms perpetuate themselves almost as part of the ecosystem. "Maybe it's a prophetic vision," says Pedro Berliner, a colleague of Evenari's, "but our goal is to reverse the trend of world desertification."

Researchers from the Third World and development agencies have been coming to Avdat for years to train and to take Evenari's runoff methods back with them. Runoff farms have been established in Kenya, Mali, Burkina Faso (Upper Volta), and Nigeria, and a team of German government relief workers has established a runoff farm in Afghanistan. (At last report, despite the war's devastation, it continued to thrive.)

And under Evenari's guidance, a new farm has been built a few miles from Avdat. Here, in addition to planting crops, nut trees, and olive trees, scientists are exploring ways to provide renewable fuel for the Third World. They are planting quick-growing trees like eucalyptus, which they intersperse with pasture plants and annuals like barley and wheat. The branches are trimmed to provide fodder for sheep. The idea is to provide a self-cycling ecosystem of trees, pastures, and herbivores that could someday feed people and keep them warm, while reversing the trend toward deforestation.

Evenari's work began more than 50 years ago when he saw something puzzling in the Jordanian desert. Visiting the ruins of Petra, a city built by an ancient trading people called the Nabataeans, he discovered earth terraces that resembled today's terrace farms. The mystery deepened when he found similar terraces surrounded by rock walls throughout the Negev.

His questions were set aside until the Fifties, when friends in the Israeli air force took him on a number of reconnaissance flights in which he hung out the side of a Piper Cub and took pictures. He and his colleagues made in excess of 50 trips to map the desert walls from the ground. "We were like children confronted by our first jigsaw puzzle," he wrote of the experience.



Drawing water from a stone

The more he saw of the structures, the more he wanted to learn about the people who built them. The Nabataeans, he discovered, were a trading society that flourished between 312 B.C. and A.D. 106. They lived in the deserts of present-day Arabia, Israel, and Jordan. They built cities such as Petra, Shivta, Avdat, and Nitzana.

Evenari decided that the ancient walls comprised hundreds of farms throughout the Negev and deduced from the aerial photographs that each farm unit consisted of several acres of terraces, usually at the bottom of a valley. The unit was surrounded by an oval wall, probably to mark off property.

The channels, he thought, must have collected rain from miles around and funneled it into the little plots of land. He called the system runoff agriculture.

It was an idea with more than a few holes. First, the Negev is extremely arid, and it was hard to believe that any system could concentrate enough rain for crops to grow. Furthermore, even if crops could sprout in the moist winter, they would wither during the torrid summer months.

Testing their hypothesis, Evenari and his colleagues restored an ancient farm in the shadow of the ruins of ancient Avdat, the geographic center of the Negev, and in Shivta, another ancient city in the Negev. They rebuilt walls and terraces and erected a farmhouse of ancient stones, which they moved into. They agreed never to irrigate.

At the first rain, the water flowed along the restored channels, funneling down from the desert hills and soaking into the terraces. They sowed a field of barley and then, two weeks later, they sang and danced in the mud when

CONTINUED ON PAGE 86

INSIDE THE HOUSE OF SPUTNIK

SPACE

By James E Oberg

The spacemen were in a jam. Repowering a dead craft, they needed to know the precise temperature onboard. But the thermometers wouldn't work in the unanticipated cold. Flight controllers back on Earth huddled and came up with a novel technique. Spit on the wall, then time how long it takes the spittle to freeze. The resulting spittle 'data' subsequently played a key role in the successful restart of the dormant power system.

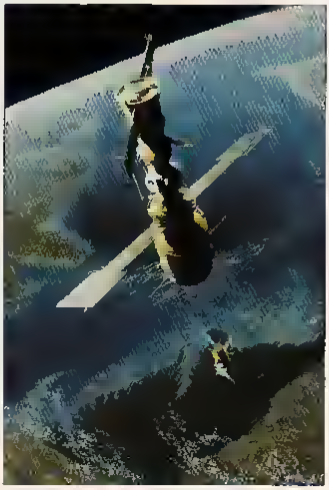
Graceful improvisation under pressure used to be an exclusive hallmark of the American astronauts and their support teams hunkered over consoles at Mission Control in Houston. But in recent years (the frozen-spit anecdote dates from 1985) the Soviets have constructed an impressive center to control their space exploration effort: one that provides the technical backup that permits such in-flight creativity. This Soviet mission control facility is called the Tsentr Upravleniye Polyotom in Russian (the Center for Control of Flight). In their own version of space jargon the Soviets call it the TsUP and pronounce it as a single syllable, *tsoop*. But from space, cosmonauts merely call out, "Moskva" for Moscow.

Few Westerners tour the TsUP. Those who do, however, see a facility vast compared with the much more modest NASA Mission Control building at Johnson Space Center in Houston. The TsUP, located in the suburb of Kaliningrad, is only a short drive from Moscow.

An ordinary-looking five-story office building reached along winding streets past aging, nondescript industrial structures, the TsUP has no spaceflight emblems, no crests, no statuary. Notwithstanding its drab, run-down exterior, the inside of the building sparkles with pristine, churchlike spotlessness. To the left of a small foyer sits a striking two-story mosaic of space pioneers Konstantin Tsiolkovsky, Sergei Korolev (who headed the Soviet Rocket Design Bureau from its inception), and Yuri Gagarin (the first man to orbit Earth). The quasireligious figures seem to be overseeing their faithful.

VIPs ascend a wide staircase to a long hall where lavish buffets await. A large briefing room sits just through a door midway down this corridor, and at the end of the hall, past a series of plaques with photographs of all the cosmonauts who have flown in space, lies the centerpiece of the tour, the visitors' gallery overlooking the main control room.

NASA's famous Houston facilities would fit almost unnoticed into a corner of this main hall, which seems more like an auditorium than a control room. Viewed from a plush open portico under a high ceiling, the main display screens and rows of control consoles make a striking sight, even if—as is usual—they display no real data and workers have left the hall, evacuated for security reasons during the visit by foreigners. VIPs sit in plushly upholstered red chairs amid rich wood-paneled counters and walls. At the front of the gallery, a bank of red telephones allows onlookers to speak directly to cosmonauts in orbit.



Mir. *Star performance, ground controlled.*

TsUP staffers can control many different Soviet craft from specialized rooms throughout this building. Depending on mission events, though, any one of the spacecraft can use the main hall.

When the flight controllers sit at their posts, they look much like their NASA counterparts, predominantly young but with a smattering of veterans, mostly male, well dressed in civilian clothes (they dress in tan–brown lab coats for special occasions). The TsUP controllers may work in the primary control room—or in any of about a dozen specialized support rooms, some almost as big as NASA's two main rooms in Houston. Among these control rooms for rendezvous-and-docking operations by unmanned Progress freighters and by manned Soyuz craft, and others for monitoring the special scientific modules hooked onto the main space station. One room specializes in monitoring trajectories, and another in tracking and telemetry. Physicians conduct remote medical observations (including ongoing psychological evaluations) of the orbiting crews from a special room, and families of flight crews use another, smaller room for weekly private two-way television links. Observers to international missions have yet another room.

The computer support complex has seven 12.5-MIPS (million instructions per second) machines, with a 40-MIPS machine under development. Visitors have inspected, peeked, prodded, and concluded that the Soviets have built their own computers. NASA, by contrast, has only five main computers that run at ten MIPS to support shuttle missions—although they are upgrading them to 15 MIPS apiece.

At the end of 1988 TsUP spaceflight specialists had completed the first full calendar year of continuous, uninterrupted manned space operations—managing the *Mir* station. As a result of this and other achievements, as time goes by, more and more people will discover that when they think *mission control*, the call sign that springs to mind will be "Moskva." ☒

ARTIFICIAL INTELLIGENCE

By Steve Ditlea

On July 3, 1988, the U S S *Vincennes* (pictured below) was under attack by Iranian gunboats A round of ammunition failed to fire from one of the ship's guns and the crew had to rush to throw it overboard before it exploded With only one working gun remaining, the captain of the *Vincennes* quickly swung the ship around so the gun could be used on the attacking boats The sudden turn threw everything that wasn't bolted down into the air and crew members had to dodge the flying objects

It was at this moment that the men who manned the complex computer consoles saw a plane approaching They informed their superior officer that an F-14 fighter plane was coming toward them in a rapid descent Without checking the computer console himself, the officer immediately informed the captain who made the decision to shoot the approaching fighter plane from the sky The plane as it turned out, was not a fighter plane at all but an Airbus A300 jetliner 290 civilians were killed

As this tragic incident illustrates, people, even superbly trained military officers, don't always respond as planned in a crisis situation which is one reason that computer expert Clifford Johnson has been waging his own war against overreliance on artificial intelligence "I don't say that you shouldn't *use* artificial intelligence he says, 'just that you shouldn t be used by it "

Johnson who has been known to don symbolic dress as the Revolutionary War pamphleteer Thomas Paine is a lone figure sounding the alarm against U S Department of Defense misuse of computer-generated data—data that Johnson contends could accidentally trigger World War III A British expatriate Johnson has spent the last five years pursuing a costly and so far losing federal lawsuit known as *Johnson* v *Secretary of Defense* His avowed goal is to have the courts rule that America's current nuclear war policy with its hair-trigger reliance on computerized data interpretation is unconstitutional

'Although artificial intelligence should be heeded when appropriate," Johnson says "it is unconstitutional to delegate to machines the power to initiate and wage war." The Pentagon's nuclear policy, Johnson argues increases the risk of a computer-instigated nuclear war by allowing for the launch of U S missiles upon first warning of a Soviet attack Since 1984 Johnson's controversial lawsuit has been both dismissed and then reinstated by the courts This past June the U S Court of Appeals in San Francisco struck it down a second time calling his charges hypothetical and generalized

A week after this ruling, the *Vincennes* mistakenly shot down the Iranian airliner, an accident that seems to support Johnson's fears "Having a person in the decision loop is no good if there is not time to be a person" Johnson explains In other words, if there is no time to assess the computer s accuracy or verify an initial reading of it the computer is in effect making the decisions

The Defense Department has even gone so far as to have some of its computer training simulations programmed for a first strike (in which the United States launches its missiles before another country does) This simulation is part of a computer war game program developed for the Pentagon by the Rand Corporation The original Rand Strategy Assessment System (RSAS) software with artificial intelligence techniques, did include this first strike simulation, but it was made to appear an illogical course of action in *all* circumstances To satisfy the Defense Department however Rand Corporation researchers altered the program to make a first strike appear logical in some situations The Pentagon insists that the simulation is merely an academic exercise, but Johnson contends that because of the exercise, there is a significantly greater chance that an actual crisis would be escalated

Paul Davis director of Rand's Strategy

CONTINUED ON PAGE 96

The power to start World War III says Clifford Johnson may lie in the circuits of computers

CONTINUUM

AMERICAN MYOPIA

In a darkened auditorium a division director from the U S Food and Drug Administration (FDA) clicks her way through a series of slides Each one depicts the food containers of the future—an endless array of reheatable plastic pouches, trays, bags, bowls and cylinders, stuffed with assorted baby foods soups whole dinners desserts 'What used to appear in metal cans is now likely to come in plastic pouches, the FDA's speaker tells us ' These packages may be a panacea for the troubles of time crunching By 1991 she beams, "we project that 4 7 billion of these containers will be sold "

Then the speaker—just one of several government scientists touting new products at the annual FDA/U S Department of Agriculture (USDA) Food Safety and Nutrition Conference—finishes her presentation and a reporter rises to question her "Are any of these new plastics that you've shown us biodegradable?' he asks

"Not that I know of she replies

"Well " he continues "isn t your agency worried that introducing all of these nonbiodegradable containers in the next few years will worsen the nation s already monumental waste-disposal problems?

"That's not our concern,' the FDA scientist tells him "This agency's priority is to make foods safe and convenient for today's consumer The environment is not our bailiwick

I sit back in my seat then, wondering just whose bailiwick it might be Later a few calls to the Department of the Interior and the Environmental Protection Agency reveal that no official government groups are actually monitoring the flow of new plastics into the environment Given the desperate state of the environment, it seems clear that we no longer have the luxury of this sort of tunnel vision We simply can't afford to ignore the long-term effects that our new inventions might have on our nation—and on the wider world as well Indeed, as Mary Catherine Bateson, anthropologist and author of *Thinking AIDS*, sees it, we Americans have always tended to ignore future concerns in order to reap immediate benefits "We have not learned to make the necessary connections between what we do today and the results of those actions on our society in a generation or two, ' she says

Instead, our myopia compels us to live in a constant state of crisis management For years environmentalists warned that our system of landfills and incinerators could not continue to handle the rapidly increasing waste stream They made dire predictions that by the year 2000 most of the nation's landfills would be packed to capacity But not until the effluvia began to wash up on our shores not until we saw our garbage scows sailing the oceans in search of dumping grounds or were confronted with the necessity of building incinerators in our own backyards did we acknowledge that we had a problem

Seeking short-term profits has caused many other environmental messes, from acid rain and water pollution to the greenhouse effect "To truly solve these dilemmas " says Bateson, "we must make our children understand the constant care ecosystems require in order to survive '

Bateson likes to describe the benefits of taking the long view by comparing the handling of the environment to a strategy employed by a champion dogsled racer For the past three years Susan Butcher has won the Iditarod a grueling two-week 1,000-plus-mile race across Alaska "The way she wins is by caring for her dogs and sustaining their strength,' says Bateson "The men who compete against her always seem to be charging on ahead, but toward the end of the race their dogs become too tired, while Butcher's team—which has been more carefully paced throughout the race—overtakes them Butcher is an expert on what environmentalists call sustainability If the time frame you re looking at is long enough, you are not rewarded for destroying your most important resources You are not rewarded for wearing out your dogs or for exhausting the soil burning the rain forests polluting the rivers You win only when you care for these things consistently "

Is it really possible to expect people to eschew convenience—in this instance to reject the new wave of polluting plastics—in favor of a cleaner world 100 years hence? Bateson believes that our success in this depends on our ability to connect the future to ourselves—that is to envision how the choices we make today will affect the sort of world our children and grandchildren will have to live in "We must understand," she explains, "that each of us will be personally injured—through our progeny—if we don t expand and extend our vision of the world '—*ELLEN KUNES*

CONTINUUM

Another threat to the world's oceans. Research shows that the noise from offshore drilling, oil and gas exploration and ship activity may be wreaking havoc on marine life

NOISY OCEANS

There's no doubt that the chemicals sludge and other detritus regularly dumped into the world s waters are killing sea life But now another by-product of civilized society—man-made noise—is spilling into the seas, endangering the ocean populations "The din we create with offshore drilling oil, gas, and seismic explorations, as well as increased ship and boat activity is causing damage to the marine world,' says Arthur A Myrberg Jr a marine biologist at the University of Miami's Rosenstiel School of Marine and Atmospheric Science

A wide range of studies on fish and ocean mammals reveal that the noise we create drowns out acoustic signals vital to the survival of sea life, masking mating calls and sounds associated with feedings The growth and reproduction rates of various ocean species including the fish and shellfish we eat have slowed dramatically, reports Myrberg "Obviously this could have far-reaching effects It may eventually hamper our attempts at aquaculture [the growing of fish for food]."

Man-made ocean noise has also been shown to permanently destroy the hearing of fish and frighten whales and other cetaceans away from their normal migrating paths "They behave just as humans do when exposed to unbearable noise—they move away and take less direct migrating routes.' Myrberg says "The stress response that is elicited may drain their energy and, inevitably, reduce the population."

Myrberg, an authority on acoustic communication among reef fish, says the noise hazard—which can reach as high as 200 decibels—is greatest in coastal waters, particularly in the Gulf of Mexico and off the Pacific Northwest as well as in the Arctic, where much oil drilling is taking place Research reveals that only 110 decibels are needed to mask the sounds made by fish and exposure to 180 decibels and above destroys portions of the inner ears of many species of marine life

"I think noise pollution is no less a problem for sea life than water pollution is " says Myrberg. ' The difference is that the effects won t be seen immediately But I predict that if the issue isn't addressed the number of marine mammals fish, even turtles may be drastically reduced in areas of high noise exposure" Right now, Myrberg and fellow scientists are seeking funding for further research They are hopeful that large-scale studies may eventually result in legislation that will require noise reductions in ships and offshore machinery—Ellen Kunes

RECYCLED FORESKINS

Growing skin in a culture is nothing new but Dr Tania Phillips, a dermatology fellow at Boston University School of Medicine has found a plentiful new source of tissue—discarded foreskins from infant circumcisions.

New skin is made from these foreskins, explains Phillips by mixing epidermal cells with special enzymes and other factors and incubating them for several days What you get are small colonies of cells that expand and eventually join together to form a sheet" Phillips notes "From one foreskin you can get enough

skin sheets to treat several patients so you don't need a lot of tissue.'

The primary recipients of Phillips's skin sheets, called cultured allografts, have been elderly patients with nonhealing leg ulcers. Of the more than 100 patients Phillips has treated with the method in both the United States and England, almost two thirds were completely healed.

'We believe the [infant] skin cells promote healing through the release of growth factors,' Phillips says. It is known that young cells secrete far more of these growth factors than old cells do, so using young skin cells offers a great advantage.

In addition to healing leg ulcers, Phillips believes foreskin-cultured skin sheets may one day be useful in the treatment of burn patients and young paraplegics afflicted with pressure ulcers.

—Don Vaughan

PAINT PRINT

Joan G. Crihan, a New York nuclear physicist and engineer with an abiding interest in art restoration and preservation, has developed a radioactive 'fingerprint' that he believes can fool the wiliest art thieves and forgers.

His method involves mixing radioisotopes with a polymeric resin, applying a virtually invisible microdot to any piece of art (from an oil painting to a metal sculpture), then recording the location and the amount of radiation the dot emits. All these data go into computer storage along with a description of the client's artwork.

Since varying amounts of radioisotopes give different measurements, each painting's activity measurement is like a fingerprint. No two paintings will have the same amount of isotope, says Crihan, a trait he believes should cheer both collectors and dealers alike. Even if a thief or forger knows the location of the microdot—which is extremely unlikely—it cannot be removed or erased, the inventor claims.

Crihan plans to market his patented system to dealers, collectors, and insurance companies through his own company, Art Restoration & Irradiating Preservation, Inc., at about $100 per microdot.

—George Nobbe

'I'm an idealist. I don't know where I'm going, but I'm on my way.'

—Carl Sandburg

'A conclusion is the place where you got tired of thinking.'

—Arthur Block

PLAQUEBUSTERS

There may be a revolution in store for the toothpaste business. A group of chemists at the University of Louisville in Kentucky are experimenting with a substance that may stop plaque from forming on teeth.

The substance, called glucan, is a long, chainlike molecule with internal "links" made of glucose and water. Chemist K. Grant Taylor and his colleagues have shown that proteins on the surface of the bacteria that form dental plaque recognize certain segments of glucans, which the mouth produces. The plaque then binds with the glucans, thus gluing itself to the teeth. Taylor reasons that a 'glucan mimic" that will bind with the plaque-causing bacteria but not with the teeth could in effect wash plaque away—with water, say, or even saliva—before it gets a chance to develop.

By shortening certain segments in the glucan molecule, the Louisville chemists have created a synthetic glucan mimic. The next step will be studies to test the mimic's effectiveness as a plaquebuster. If glucan works well, it may help make a dent in the astronomical amount Americans spend on dental work each year. Currently, that's about $20 billion, 70 percent of which goes to fill cavities. Not surprisingly, Taylor says, 'There's a lot of interest.' Indeed, the group has received inquiries from such companies as Gillette, Colgate-Palmolive, and Du Pont.—Bill Lawren

Is this Van Gogh painting the original or a masterful forgery? Take its microdot fingerprint and find out

Hark, the plaqueless mouths will sing glory to the glucan thing

'... schools are out to teach patriotism, newspapers are out to stir up excitement, and politicians are out to get reelected. None of the three, therefore, can do anything whatever toward saving the human race from reciprocal suicide.'

—Bertrand Russell

CONTINUUM

HOMEGROWN RUBBER

Federal agriculture and defense officials concerned for economic and strategic reasons about our heavy reliance on imports of natural rubber used in high performance aircraft tires have begun growing their own at a 400-acre prototype facility in Santan, Arizona

They are raising guayule shrubs a drought-resistant latex producer that could replace the hevea trees of Southeast Asia, which now yield most of the world's natural rubber "We're not out to make a big dent in the import market, but we want a domestic capacity in the event we're ever cut off from our supply" says Richard Wheaton, director of the U.S Department of Agriculture's Critical Materials Office

Wheaton figures that if the United States were to meet even 25 percent of its natural rubber needs with home-grown guayule pronounced "why-oolie," the perennial shrubs would cover about 1 5 million acres

Guayule, which takes about two years to mature, can also be used to make epoxy resins termite inhibitors, fungicidal deterrents and carbon filtration products after it's chipped, ground up, chopped, crushed and treated with organic solvent to extract high-quality rubber at a cost competitive with that of the hevea tree

The hardy shrub is one of several wonder crops being studied Others include rapeseed and crambe which can be chemically rearranged into crude oil and plastics, and the kenaf plant whose fibers are used in paper production ' It's a fascinating area that's going to grow,' predicts Wheaton "We're just beginning to look at these multiuse plants "

—George Nobbe

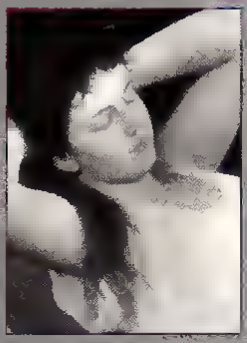
Rubber grown in America? The versatile and drought resistant guayule plant is making it possible in the Southwest

"Did you hear what the white rat said to the other white rat? I've got that psychologist so well trained that every time I ring the bell he brings me something to eat '

—David Mercer

CAN CHICK-PEAS HELP YOU SLEEP?

If you have problems sleeping check out what you ve been eating A recent study at the Human Nutrition Research Center in Grand Forks North Dakota found that an imbalance in minerals can interfere with sleep Shortages of minerals such as copper, for instance, can make it harder for someone to fall asleep and can cause problems with the length of time you sleep On the other hand, too much aluminum, much of which comes from



What you eat or don't eat, can indeed affect your sleep

antacids and/or iron made test subjects awaken more often during the night according to James G Penland, the psychologist in charge of the study

"Assessment of trace minerals is not easy' says Penland, who warns against the use of mineral supplements to correct deficiencies Overdoses of minerals, he says, can be toxic Instead he suggests more mineral rich foods in the diet For copper and zinc this would mean eating liver, seafood, chick-peas, and eggs

Penland's study looked only at the effect of trace minerals on the sleep of women He plans to conduct a similar study with men this year —George Nobbe

"The first and great commandment is, Don't let them scare you '

—Elmer Davis

"Moderation is a fatal thing Nothing succeeds like excess."

—Oscar Wilde

Scientists caucus to keep the solar system from being trashed

POLLUTING THE PLANETS

Ever since the first *Sputnik* went up in 1957, man has been cluttering the space around planet Earth with the debris of the exploratory urge—used-up satellites, old rocket parts, and the like. Our near-space backyard has begun to look like a Brooklyn alley. Now a group of astronomers warns that our capacity for contamination may not be limited to our own neighborhood. In fact, says Colin Keay of Newcastle University in Australia, we are in danger of junking up the entire solar system.

Keay, the incoming president of the International Astronomical Union (IAU), is primarily concerned about rockets and the propellants that power them. Both the ships and the fuels contain or produce trace elements that could contaminate otherwise "virgin" bodies like planets, moons, and asteroids, all of which may carry rare metals and other substances left over from the beginning of the solar system. Once these bodies are polluted, surveys of their composition would be hopelessly inaccurate.

At the moment, Keay concedes, the problem is extremely minor. "These places are so big," he says, "that they're going to take a lot of polluting." Even so, he says, one very bad event—an explosion, say—could "louse up an entire asteroid."

The IAU has now formed an international committee of scientists to persuade governments to use rocket fuels whose by-products are ammonia and water, substances that are often sprayed on moons and asteroids by passing comets and so don't count as pollutants. Over the next few years, the committee will draw up a list of strategies and recommendations for governments involved in space exploration. Not to do anything, Keay says, "would be the height of irresponsibility."—Bill Lawren

MUSICAL REFRIGERATION

When NASA found out it couldn't operate conventional refrigeration units in zero gravity, the agency thought it was stuck. But that was before a team of scientists at Los Alamos National Laboratory developed a refrigerator that runs on, of all things, sound. Now NASA may have a prototype refrigeration unit on a shuttle sometime this year. "We have a loudspeaker-driven refrigerator with an ordinary hi-fi mid-range for power that sends sound-wave oscillations through compressed helium in a tube with heat exchangers," says Los Alamos physicist Greg Swift, of the invention. The vibrations across a temperature gradient cause the helium to expand and contract as much as 1,000 times every second. "This breathing action pumps heat out of a refrigerated box much like your Frigidaire at home," notes Swift.

But why use such a bizarre system? "NASA," Swift explains, "found that you can't run conventional refrigeration units in space because they require gravity to work. The acoustical engine doesn't, plus there are no moving parts in an acoustical heat exchanger, so it'll never break down."

Swift and other researchers are also working on heat-driven engines that function in much the same way. The heart of the system is a metal tube, with heat exchangers and parallel metal plates at one end. When heat or sound waves pass through liquid sodium in the pipe, they create heat and magnetic energy, which can be transformed into electricity. The only moving part is the liquid sodium. Swift, who predicts that the practical application of these engines is about ten years away, admits that liquid sodium is not very easy to work with, but then again, it never needs oiling, won't wear out, and can't break. And someday these engines might power our large industrial plants. "I don't see why we couldn't make larger acoustic heat engines," Swift says. "The bigger we make them, the more efficient they'll be."—Bob Mangino

The sounds of science. Los Alamos scientists give NASA a hand by designing a refrigerator that's powered by sound

Conscience gets a lot of credit that belongs to cold feet.

—Anonymous

"We are absolutely certain only about things we do not understand."

—Eric Hoffer

CONTINUUM

Trick steps and a volunteer help scientists build safer stairs

SOFT STAIRS

People will do almost anything for money, including falling down stairs. Take, for example, a recent study conducted by John Templer, an architecture professor at the Georgia Institute of Technology. He enlisted volunteers to walk up and down a specially designed set of stairs. Suddenly, one of the steps would give way, causing the volunteer to stumble and fall. A modified parachute harness and protective clothing saved the volunteer from injury but didn't interfere with the mechanics of falling, which a high-speed camera captured on film. The outcome of this research, which is similar to the crash testing done to improve automobile safety, may be softer stairs.

Although the intent of building codes is to produce stairs that are uniform and safe, nearly 2 million stair-related injuries occur each year, most often at home. "Falls are the third leading cause of accidental deaths in the United States," says Templer. His research is aimed at finding material that can be traversed like ordinary stairs but will absorb high impacts "much like the padding on football goalposts," he says.

Templer adds that his volunteers thought falling down stairs was a lot of fun. "almost like going to Coney Island." He even took a few falls himself. "I knew how much thought had gone into the project," he says. "I literally threw myself over the edge to make sure the thing would work."

Although Templer doesn't yet know which materials make the safest stairs (the results of the falls are still being analyzed), he is already planning his next study: handrails and balustrades. Templer believes they are responsible for at least 10 percent of stairs-related injuries. —Jack Rosenberger

"There is a thin line between genius and insanity. I have erased this line."

—Oscar Levant

"The will to disbelieve is the strongest deterrent to wider horizons."

—Hans Holzer

FILET MIGNON, JAPANESE-STYLE

By growing crown mushrooms at special temperatures with special watering techniques, the Japanese company Kabushikikaisha Akita Inc. has come up with a mushroom that grows to the size of a hamburger. What's more, it is purported to taste like steak.

The mushroom spores, according to Masanao Kubo of Asahi Foods, Inc., which is handling domestic Japanese production, are cultured for 40 to 45 days to reach full growth. At that time, he explains, they peak in aroma, flavor, and crunch. Just pick them, throw them on the grill, and voila!—a low-fat, low-cholesterol meat lover's fantasy. The mushroom steaks also contain many of the same vitamins and minerals as beef but much less protein.

"We are going to start selling them at the end of September," says Kubo. The first customers will be Tokyo restaurantgoers, and although the company has yet to decide whether to ship the mushrooms to the United States, it is planning to export the technical know-how to produce the steaks abroad.

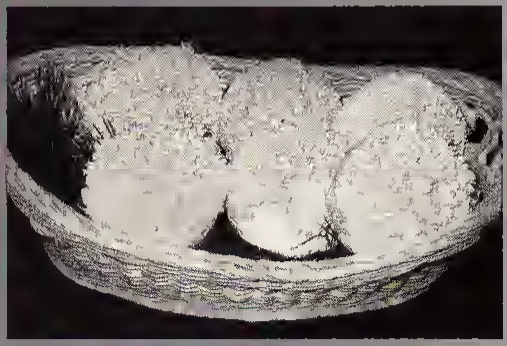
Is the American beef industry worried about this latest competition? "For those people who don't have beef available, it may be of interest," says Janet Williams of the Beef Industry Council, "but I would be surprised if it would be a significant product in the United States." —Paul McCarthy

"It is not enough to succeed, others must fail."

—Gore Vidal

"The attempt to define all mystical, transcendental, and ecstatic experiences which do not fit in with the categories of consensus reality as psychotic is conceptually limiting and comes from a timidity which is not seemly for the honest, open-minded explorer."

—John Lilly



Step aside, Big Mac: here comes a low-cal, low-cholesterol mushroom that's as big as a burger and tastes like steak

The great baking soda cleanup may soon be at hand Researchers have discovered that pouring sodium bicarbonate down smokestacks keeps some chemicals from polluting the air

SMOKESTACKS THAT BELCH

Remember when you were a kid and trashed the kitchen table by concocting a secret alchemical potion of baking soda and vinegar? If you'd poured the soda down a smokestack instead, you could have done away with a lot of pollution

Operators of fossil-fuel-burning plants have long been plagued by gaseous emissions, but recent experiments may change that Researchers have discovered that blowing sodium bicarbonate (baking soda) into smokestacks nullifies many of the discharges, removing between 70 and 90 percent of the sulfur emissions and 10 to 20 percent of the nitrous oxides

The problem with using baking soda in commercial plants is the cost Power plants may consume tens of thousands of tons of sodium bicarbonate a year At $70 to $150 a ton and with high shipping costs, it is an expensive practice Stuart Dalton of the Electric Power Research Institute in Palo Alto California, believes companies will be able to afford this sort of cleaning only if a cheaper alternative is found He points to recent developments in Czechoslovakia, where the National Academy of Sciences has devised a chemical process to create raw soda ash that's just as effective as sodium bicarbonate and far cheaper ($30 a ton) The Czechs are seeking help from U S companies to refine their product and it all goes well it should be available by 1991 —George Nobbe

"Money is always there but the pockets change it is not in the same pockets after a change, and that is all there is to say about money "
—Gertrude Stein

" In the Halls of Justice the only justice is in the halls "
—Lenny Bruce

WORLD'S WORST TASTE

If you think sour milk is the worst taste in the world, you haven t tried Vilex A nontoxic chemical compound made by Atomergic Chemetals Corporation of Farmingdale, New York, Vilex has according to the company the most bitter flavor known to humankind

"It's vile That s about all I can say It has a terrible lingering taste " reports Mel Blum who with Gary T Hollander, concocted Vilex when they combined the artificial sweetener saccharin with a chemical called denatonium benzoate They found that the mixture was so potent that even when diluted to one part per 2 million it was still bitter Blum even tested Vilex by applying some to the trunk of one of his sugar maples in Vermont It was so strong that it ruined the taste of his maple syrup

Vilex was originally designed for chemical warfare The researchers were looking for a substance that would render enemy crops inedible without damaging the soil But it s now being considered for many peaceful applications It might be useful says Blum as a shark repellent and as a coating for plastic garbage bags to discourage marauding animals Insurance companies are considering its use in household products in order to deter children from putting poisonous chemicals in their mouths It may also be effective in denaturing alcohol and as an adjunct to Mace —George Nobbe

CONTINUUM

OUT IN THE COLD

It s been known for years that exposure to extreme cold will keep metal blades sharper longer The Gillette Company, for instance, routinely cold-processes its razor blades at about -300°F Knowing this physicist Jeffrey Levine and engineer Bruce Norian of Applied Cryogenics in Newton Upper Falls Massachusetts began to wonder if what was good for razor blades might be good for other things as well

It started when Norian, an accomplished amateur violinist who plays in a local string quartet, stuck his violin strings in a -300° deep freeze for a few hours The result? "They stayed in tune longer," Norian says, "and they sounded brighter He next tried it with a friend's piano strings The piano stayed in tune four times longer than it had before treatment That did it. Levine and Norian started a new business that now, according to Norian, does an "astronomical business in cold-treating instrument strings

Encouraged, the two partners began throwing every thing that wasn t nailed down into the deep freeze They tried golf balls and local pros testified that after treatment the balls routinely went 20 to 30 yards farther They even tried panty hose and found that yes indeed, there was something about the cold that made the stockings last longer

No one really knows why exposure to extreme cold should have this effect, although Norian speculates that the process may relieve stresses and impurities in steel bringing about beneficial changes in the polymer molecules that make up nylon panty hose A student at MIT is currently working overtime in the lab, trying to unravel the mystery —Bill Lawren

Jeffrey Levine (left) and Bruce Norian can make violin strings better and panty hose last longer by putting them in deep freeze

"The brain is a wonderful organ It starts working the moment you get up in the morning, and does not stop until you get into the office."
—Robert Frost

DIRT EATERS OF THE WORLD, UNITE

The English are famous for their high teas; the Japanese for their formalized tea ceremonies In India, one culture has an even more novel approach to tea They make teacups out of clay and consume the vessels after drinking the tea. For many people worldwide, eating dirt or clay—a practice termed geophagia—is routine

According to a study by three Utah State University scholars, geophagia exists in more than 200 cultures, including many North American Indian tribes and certain rural communities in the South Geophagia appears for a number of reasons, says Carol Loveland, one of the study's coauthors and an assistant professor of anthropology at Utah State In cases of famine, for instance, clay is consumed as low-grade subsistence food Similarly in some cultures women and children practice geophagia for a feeling of fullness that they do not get from their regular diet Men in these cultures are not known to eat dirt or clay, either because they receive the better-quality food or because they are embarrassed to admit that they indulge in this predominantly female activity

The nutritional value of eating dirt or clay varies with the minerals found in it Study coauthor Thomas Furst, a doctoral candidate in soil science says that the "chances are pretty skinny that you could survive by eating clay every day

Clay is also sometimes an effective remedy for a variety of stomach ills, from diarrhea to constipation Indeed, in many of the cultures where geophagia is practiced clay is prescribed for such problems "A lot of folk beliefs turn out to be closely tied to what physically happens," explains Loveland Researchers remain uncertain, however, whether clay may not also spread parasites Some say it does others contend that people eat clay to rid themselves of harmful parasites

Loveland thinks that future dirt research should concentrate on linking geophagia to the type of dirt eaten and the effect it has on the digestive tract "It s such a widespread practice, and yet nobody has really gotten into this thoroughly enough to try to unravel what is going on," she says —Shari Rudavsky

"The most dreadful thing of all is that millions of people in the poor countries are going to starve to death before our very eyes upon our television sets."
—C P Snow

"Love for one's country which is not part of one's love for humanity is not love, but idolatrous worship."
—Erich Fromm

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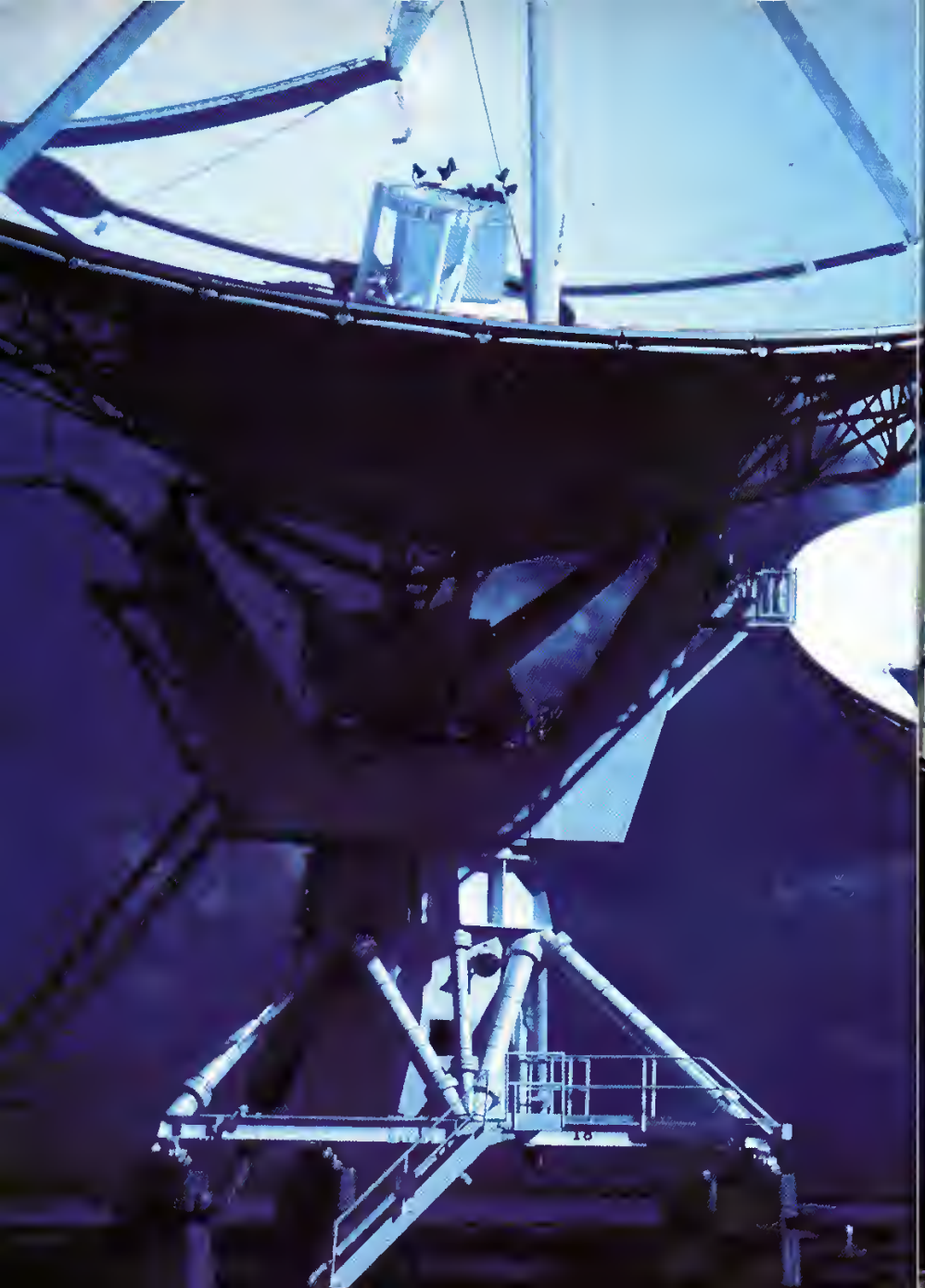


ARTICLE

OMNI'S FIVE STAR TRAVELOGUE

BY JEFF GOLDBERG

Imagine climbing aboard a spaceflight simulator in Toronto for a quick voyage around Jupiter. Or how about prospecting for pay dirt at prehistoric mine sites

in the Black Hills of South Dakota. Or spending starlit nights on a beach in the Virgin Islands, midwifing the nestlings of giant leatherback sea turtles. If these activities seem beyond your ken, think again. For *Omni* readers seeking the next frontier in travel, the travelogue below includes 24 of the most fanciful, meaningful, educational, unusual, and exciting trips imaginable. Hardy souls can explore the mystical voodoo underground of Haiti. More laid-back pilgrims can enjoy a leisurely drive through the relics of the recent past along America's fabled Route 66. And space buffs can glimpse the universe through America's most famous telescopes.

Whatever your ultimate destination, we've charted a route and planned an itinerary. All you have to do is go.

UNDERGROUND HAITI

Zombies . . . medicine men . . . bizarre tribal rituals and wild celebrations. The legendary netherworld of Haiti might terrify rather than tantalize. But for the right traveler, Haiti can be the perfect antidote to civilization, especially if you are ready to trek into the countryside to see what voodoo is really about.

As a base we recommend the Hotel Oloffson in Haiti's capital city, Port-au-Prince. Once splendid, this filigreed mansion, with its gingerbread turrets and towers draped in bougainvillea, now resembles the movie set for a seedy hotel in the tropics. The air-conditioning, even the water, works only fitfully. All that keeps it from crumbling into the sea below the veranda, it seems, is coat upon coat of white paint. But even at American hotel prices of $50 to $70 a night, the Oloffson is worth it if only for its colorful history.

Graham Greene wrote *The Comedians*, his novel about Papa Doc's Haiti, here. And the gossip columnist in the novel, Petit Pierre—thought to be connected to the Haitian secret police—still haunts the bar in his dark glasses.

More recently, New York Botanical Gardens research associate Wade Davis regularly returned to the Oloffson after spending nights at a time in the Haitian countryside researching his book *The Serpent and the Rainbow*. The book's subject? Davis's quest for the voodoo potions used to turn people into zombies. 'The Oloffson was my base,' Davis recalls. "Haiti is alive with spirit and belief, but the intensity can be overwhelming. So you need a reality check."

Davis provides essential advice for any traveler wishing to penetrate the voodoo underground of Haiti. "Voodoo is a religion with secrets, but it's not a secret religion," he explains. "The ceremonies are open to outsiders. In fact, visitors are welcome, providing you observe certain protocols. You won't accomplish anything by being cheap. If you go to a temple and are invited back for a ceremony, you should leave an offering of ten or twenty dollars. Everybody leaves an offering, and most likely the priest will not keep the money but will give it to someone in his congregation who needs it.

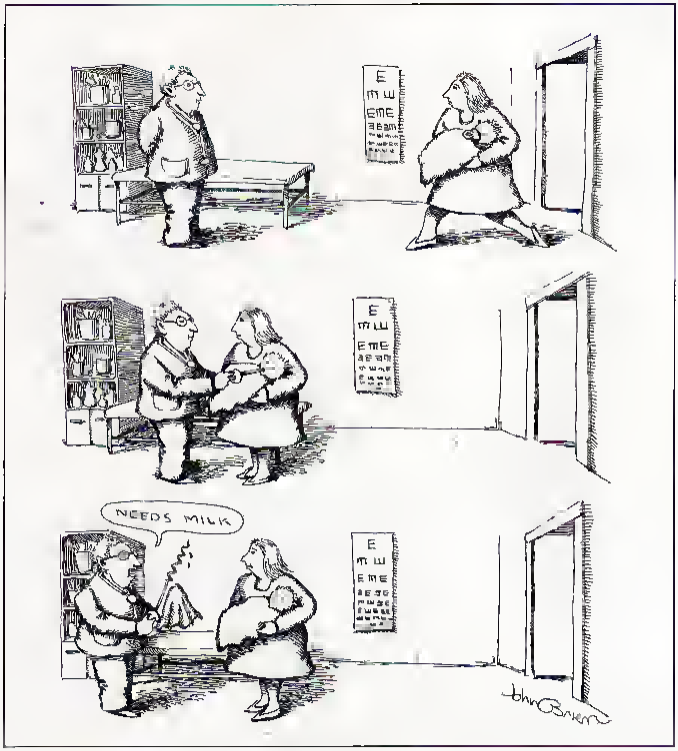
"Since the priests are respected members of a social elite, much like members of an exclusive country club, you must meet them through appropriate channels," Davis explains. To get started, you can visit Max Beauvoir at his *hounfour* (or temple) in Mariani, a few miles south of Port-au-Prince, where he conducts public voodoo ceremonies every night. Surprisingly cosmopolitan and fluent in several languages, Beauvoir is a ready source of information about voodoo. If you are lucky—if you impress him favorably—he may even take you around. If not, you can find an English-speaking guide (a Creole version of French is spoken in Haiti) by asking at the hotel.

Voodoo temples dot the countryside, particularly in central Haiti's Artibonite Valley. Don't expect the trip to be cushy, however. Whether you decide to travel by rental car or by tap-tap (one of the colorful buses traversing the island), the journey is liable to be rough going. Though the country has a main highway, many of its roads are very poor.

Rough or not, these roads should prove particularly fascinating this summer, when thousands of Haitian pilgrims—many of them in states of spirit possession—will journey on foot to the country's major religious festivals. We suggest you attend as well. The first of these events—the Festival of the Virgin at the Saut d'Eau waterfall—takes place in mid-June in the Ville Bonheur mountains of central Haiti, north of Port-au-Prince. A fusion of Catholicism and voodoo, the three-day celebration honors the miraculous appearances of the Virgin Mary at the site, as well as Erzulie Freda, the popular voodoo goddess of love, to whom the waterfall was originally consecrated.

In July two other large festivals take place on Haiti's lush northern coastal plain. At the sacred spring and mud baths of St. Jacques, congregants cleanse their spirits and heal their souls by rolling in mud during a ritual of purification. And at Limonade—the Haitian equivalent of Lourdes—a mass for invalids is conducted annually during the Festival of Saint Anne, on July 26.

Haiti is never dull, no matter what time of year you visit. 'But in the summer," Wade Davis says, "the countryside is electric. The spirits walk, and the people of Haiti walk with them.'



Previous pages, clockwise from left: The Very Large Array radio telescopes in St. Augustine, New Mexico, signs and attractions along Route 66, traditional healers working with herbs in West Africa, a member of a voodoo society in Haiti, prefabricated Sears, Roebuck house, mail-ordered for miners during the heyday of the Quincy Mine in Michigan.

TEN BEST RIDES IN AMERICA

Yearn for some high-tech thrills and chills? Today you can fly through space, plunge over white water rapids, or even experience the gut-wrenching loops and drops of an old-fashioned high-speed roller coaster—all without leaving your seat. Skilled experts at companies like Industrial Light and Magic, Showscan Iwerks, and Walt Disney are increasingly relying on motion simulators, robotics, sophisticated computer systems, and advanced filmmaking and projection technologies to create fantasy entertainment that looks and feels real. For a week of great rides on these next-generation attractions, just follow the itinerary below.

• Tour of the Universe, CN Tower, Toronto. The first of our great rides begins in a futuristic airport circa 2019. After passing through security and being inoculated against Martian dropsy and Canymede rash, you blast off aboard one of two Hermes Class IV shuttles. Destination: Gateway, the world's first free-fall city in space, where the shuttle is reloaded into the Hefix Catapult and fired for an exhilarating light-speed journey around Jupiter and its moons.

Created by Canadian television entrepreneur Moses Znaimer, Tour of the Universe relies on two state-of-the-art 727 flight simulators to mimic the pitch, roll, yaw, heave, sway, and surge of space travel. An advanced computer system coordinates physical cues with a film by Douglas Trumbull (he also created special effects for *2001* and *Close Encounters of the Third Kind*) projected on the shuttle's windscreen. From the experience of blastoff to near collision with meteors to the Hermes' safe return to Earth, Tour of the Universe is a surprisingly authentic venture into space.

• Body Wars, Epcot Center at Walt Disney World, Lake Buena Vista, Florida. The newest Disney Futureworld attraction (produced in collaboration with George Lucas) is also a simulator-based ride, only on this one you'll be traveling like the miniaturized scientists in the film *Fantastic Voyage*, through the inner spaces of the human body. Your mission: to rescue a crew member who has been swept away by a white corpuscle when she left the vehicle to remove a splinter deep beneath the skin. Along the way you'll encounter a beating human heart, ride the pulsing rapids of the bloodstream, and thrill to the spectacular light show of the brain's neuroelectrical impulses. It's a race against time and an unforgettable anatomy lesson. Currently getting its finishing touches, Body Wars will open to the public at The Wonders of Life Pavilion in October.

• The Great Movie Ride, Disney-MGM Studios, Lake Buena Vista. Since you'll be in the area, you won't want to miss this tour de force of advanced "audioanimatronics." Disney created the ultimate attraction: an homage to film classics from *The Wizard of Oz* to *Raiders of the Lost Ark* in which the stars are lifelike robots. Gene Kelly, John Wayne, Julie Andrews, and Harrison Ford, among many others, have been carefully reconstructed out of plastic, flesh, and transistors to do take after take of their most famous scenes, while sophisticated computers electronically synchronize voices, music, sound effects, and movement. More fun than any real studio tour, The Great Movie Ride (which opens in May) gives a new level of meaning to the words of an awestruck Thirties Hollywood screenwriter who said, "I've been to Paris, France, and I've been to Paris, Paramount, and I like Paris, Paramount, better."

• Earthquake, Universal Studios, Hollywood. Billed as the 'Big One'—the most technologically advanced thrill ride that's ever been constructed—Universal's studio tour simulates, with heart-pounding realism, the effects of an earthquake that registers 8.3 on the Richter scale. Of greater magnitude than any California tremor apart from the one in Universal's hit disaster movie, the simulated quake is nearly as catastrophic. As your tour tram enters a modern underground subway station, there's a tremor, the lights flicker, and the quake hits. A 30-foot beam crashes between the cars, the ground pitches, rolls, and drops several feet, a five-and-a-half-ton concrete slab falls from the ceiling, and a runaway propane truck hits it and explodes. Then everything goes black. There is a roaring noise, and a 15-foot-high wall of water rushes toward the disabled tram. All this takes place before you and other passengers escape by the skin of your teeth.

• Captain EO, Disneyland, Anaheim, California, and Disney World, Lake Buena Vista, Florida. The last stop on our itinerary of next-generation attractions takes us back to where it all started. Walt Disney's credo of 'suspending disbelief" is nowhere better illustrated than in this cinematic and musical collaboration among Michael Jackson, George Lucas, Francis Ford Coppola, and the Disney Imagineering team. Captain EO is a 3-D musical space fantasy in which Jackson and a merry crew of Disney characters discover a colorless planet where they are confronted by the Supreme Leader (Anjelica Huston) and her forces of darkness. Using music, dance, and light, the EO mission is to transform the black-and-white land into a magical world of color and happiness. The real magic, however, comes from the filmmaking and projection techniques that brought EO to the screen. The crew filmed sequences with two polarized cameras that are perfectly synchronized but focused from slightly different perspectives. They show the finished movie through a highly advanced two-lens projection system, enabling the audience to see 3-D images with 3-D glasses. Spaceships hover above them, lasers shoot past their heads, and Jackson dances off the screen and practically into their laps.

For diehards who like to get thrills the old-fashioned way, Robert Cartmell, official historian of the American Coaster Enthusiasts (ACE), helped us put together a list of the scariest roller coasters in America. As you're crossing the States on your way to the next high-tech attraction, you might want to test your courage and your stomach on one of these.

• Cyclone, Coney Island, Brooklyn. The Cyclone is the oldest (built in 1927) and, according to many enthusiasts, still the best all-around roller coaster in America.

• Thunderbolt, Kennywood Park, Pittsburgh. Thunderbolt features the two highest and steepest finishing hills of any U.S. coaster.

• Magnum X-L 200, Cedar Point Amusement Park, Sandusky, Ohio. This coaster features a world-record 201-foot first hill and speeds of up to 70 mph.

• Texas Cyclone, Astroworld, Houston. This is Cartmell's personal favorite. "It's got a great first hill, an even better second hill, and a vicious last drop,' he says. "It never lets up."

• Ninja, Magic Mountain, Valencia, California. The latest in coaster design, this "suspended coaster" does its drops, falls, and loops entirely upside down.

For the latest in roller coaster information, readers can write to ACE, Box 8226, Chicago, IL 60680.

EARTH ANGELS

Over the past several summers, the ultimate vacation spot for some 500 hard-working, ecology-minded Americans has been the Sandy Point National Wildlife Refuge in St. Croix. These travelers haven't just enjoyed the scenery. While there, they've been assisting the husband-and-wife zoology team of Robert Brandner and Susan Basford in their efforts to save the giant leatherback sea turtle from extinction. Working side by side with Brandner and Basford, the volunteers tag, measure, and weigh the 650- to 1,000-pound creatures, keep away poachers who value the sea turtle eggs as aphrodisiacs, and move endangered turtle eggs to safe locales.

These volunteers belong to Earthwatch, an organization that provides wide-ranging opportunities for nonscientists to participate in important scientific projects. And saving the leatherback tur-

CONTINUED ON PAGE 88

UPWARDLY MOBILE

Amateur car designers steer a course for the automotive future

PHOTOGRAPHS BY ALAN LEVENSON

Clockwise from top left: An *Omni* favorite, Phil Frank's forward-reclining sports vehicle, with swept-wing doors; honorable-mention-recipient Ward Moore designed this two-seat sports car, which stresses a concentric theme; J. B. Glover garnered an honorable mention for his five-passenger turbo sports sedan; the Plazma 3P, a six-wheel, three-passenger luxury sedan from Peter Petersen, earned first-place honors in the senior division.

Automobile shows conjure up images of huge convention centers, Mr and Mrs. Midwest milling about, futuristic cars on rotating, carpeted platforms. The Greater Los Angeles Auto Show was similar to any other exhibition, with one exception: When the show was over, several of the cars (see pages 48 to 51) were not garaged or sold but rather put in a closet or carned home.

The first annual National Automobile Model Design Contest, held this past December in Los Angeles, was a new addition to the auto show. "The only way to describe the models they've created is to keep in mind that this is a generation to whom *Star Wars* is already ancient history," says contest director Peter Frey.

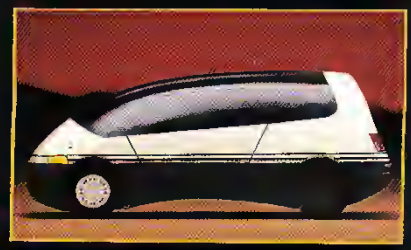
Among the 92 entrants (ages ranging from eight to sixty-eight), three top awards and ten honorable mentions were given in two divisions—senior (nineteen and older) and junior (under nineteen). The cars shown on these pages are from the senior category only. Some of these models didn't win prizes, but they certainly warrant recognition.

The models, which were built to one-fifth and one-tenth scale, varied both in function and construction. "The fewer the restrictions on the creativity of the entrants, the better off it'll be," explained contest consultant Edward S. Taylor, former styling chief for Chevrolet.

Designs ranged from a futuristic highway-patrol vehicle to a three-wheeled commuter car. Frey adds that he hopes to see futuristic 18-wheelers, fire engines, and motorcycles among the entries in next year's contest.

Construction materials were as diverse as the designs. Some entrants worked with aluminum or fiberglass; others molded clay or carved wood. One entry, not shown here, was constructed out of folded paper, notebook covers, pen tubes, and an empty potato chip bag.

Peter Petersen, first-place winner in the senior category, majors in transportation at the Art Center College of Design. His



creation, the Plazma 3P, is a three-passenger, six-wheeled sedan. Plazma represents the exterior's flowing, liquid form. Petersen's idea for the body is a self-healing skin—a plastic that repairs itself in the event of cuts or dents. "We use cutting mats in class made of a material that 'heals' back together," he explains.

Second-place winners Nick Pugh and Dean Robinson are also design students. Their collaboration, two three-wheeled commuter vehicles. The front wheels pivot like a shopping cart, and instead of sitting inside the traditional front hood, the engine slides out on a drawer. Pugh worked for GM this past summer (commuting back and forth in his Honda) and feels that the future of auto design lies east of Detroit—Far East. "I'd like to start my own design firm," says Pugh, adding, "and I'm looking to learn Japanese as soon as I can."

Korey Chun, who garnered an honorable mention, also sees his future leading him outside the United States. A senior design student at San Jose State University, Chun hopes to find work at a European concept studio—a designer's think tank. He says his auto design "is an attempt to capture the feeling of motion and acceleration."

Honorable mention J. B. Glover became fascinated with cars very early on. "According to my mother, the first word I uttered—about forty years ago—was *car*," he says.

Unlike their full-scale counterparts, the car models don't have to pass rigorous safety and engineering tests. For now the cars are meeting only visual standards. But Frey believes that both the designers and their creations will impact the automotive industry: "The design elements these kids are proposing will creep into production thinking."

Winners not shown: Minh Nhut D. Troung (senior division, third place); Brad Palmer (junior division, first place); William Eric Louk (second place), Brion Sohn (third place).

—Dooley Adcroft

Clockwise from upper left: Mid-engined coupe by Michael Day; Robert Johnson's six-passenger van; the Snark, Wojtek Stachowicz's three-wheeled vehicle for future commuters; John D. Marshall's five-seat minivan; the Apex, Manuel Laguatan's two-seat sports car; Nate Carvante's coupe, with four-wheel drive; Korey Chun's two-seater won honorable mention; Nick Pugh and Dean Robinson's commuter vehicles earned second place.

FICTION

FILMING THE MAKING OF THE FILM OF THE MAKING OF 'FITZCARRALDO'

BY GARRY KILWORTH

He told me his name was Cartier and we arranged a meeting at once, in a café on the Boulevard St -Augustin. He was a small, thickset man with dark features and an Eskimo's eyes. He claimed to be Canadian and spoke a form of French that I had to translate mentally into the purity of my own tongue. His story essentially involved three people—himself, a man called

PAINTING BY ROBERT GIUSTI

McArthur, and McArthur's niece, a twenty-year-old called Denise. Somehow—this was never fully explained—Cartier got wind of the filmmaker Werner Herzog's decision to make the movie *Fitzcarraldo*, and the three of them followed Herzog and his crew to the South American jungles, determined, clandestinely, to film the German at work.

I ordered cognacs before Cartier had gotten too involved with his story, and we waited for a few moments, watching the Parisian passersby, until the drinks were on the table. I then signaled for Cartier to continue.

"We pooled our money—all we had—and set off in pursuit of Herzog's crew. It might seem now that taking Denise with us was a bad decision, but she absolutely worshiped McArthur and unfortunately most of the money came from her. Anyway, McArthur had always been strong on family, you know. He wasn't married and his parents were dead. His sister, with whom he had always been close, was working somewhere in Asia. So he felt it was his duty to include his niece, her daughter, in the expedition, if that's what she wanted."

It was with intense annoyance (a mild word, I should have thought) that Cartier and McArthur realized an official movie of the making of the film was already in progress. In fact it was this second crew that he and McArthur had to shoot, since the party remained a barrier between Herzog's main crew and Cartier's secret camera.

"Denise stayed well behind at this stage, in a second canoe, but McArthur and I disguised ourselves as Indians and followed at a distance as they went upriver. McArthur had the camera in the nose of our canoe, camouflaged with reeds. In any case, we were quite a way behind and we had our Indians, who waved to those in front. We hoped they would just think us curious natives."

The Cartier–McArthur camp was established a little downriver from the other two crews, and on the opposite bank, their movements hidden by the thick foliage of the rain forest.

"The Indians helped us to make some huts out of the broad-leafed plants. They weren't much, but they provided shelter from the tropical rain. McArthur was like a schoolboy at first. Everything excited him—the jungle life, especially. He had a new single-reflex still camera—with a closeup lens—and he photographed anything that buzzed, croaked, or hissed. The place was teeming with life. It got into all the equipment and our clothes. The only things McArthur wasn't too fond of were the snakes and spiders. His phobias were very suburban.

"Denise, on the other hand, was contemptuous of everything she saw in the rain forest. She showed neither interest in any creature, nor fear. I personally believe that she was utterly incapable of being fascinated. That is, she saw no magic in this quite extraordinary world, only squalor. To her there were only two kinds of creatures, in myriad shapes—'slimes' and 'crawlers.' Oh, she knew the names for them all right, but she just wasn't going to waste her time finding the right word. That would have meant giving them a specific identity, acknowledging that they were even of minor importance to her, personally.

"All Denise was interested in was getting the job done. She didn't like me very much either. I think I was a *crawler*. And she was forever pestering me. One morning I had the camera in pieces—the spare wasn't working either.

"'Can I help?' she asked, but wearing one of those wooden expressions which I hated. She had several facial masks which were designed to keep me at a distance and in my place.

"'Yeah—you can scratch my insect bites,' I told her. 'They're killing me.' I lifted my shirt to show her three or four large red lumps on my stomach.

"'She didn't even say, "You're disgusting," or anything like that. She merely looked at me blankly and remarked, "I mean with the camera."

"'No. I'll have it fixed soon.'

"'What about the spare?'

"'I'll work on that next. You're in my light.'

"McArthur was busy cooking something and he said, 'Get out of his way, Denise. Let him see the light.'

"She laughed at that. I didn't think it was very funny, but they did. She went over to one of the Indians then, who was painting his body. He had a cut, which was infected, over the part of his face on which he was applying the ocher. She started remonstrating with him, quietly, though he couldn't understand a word she was saying.

"'Don't mother him,' I told her, 'he knows what he's doing.'

"Sure enough, when she tried to interfere he slapped her hand away. She went very red, glanced at me as if it were my fault, and looked as though she were going to cry. McArthur had seen the incident—a small one, you might think, but when all expectations are met with frustrations, and the rain forest is sending its squadrons of insects to harass you day and night, *no* incident is minor or too trivial—everything that happens is of a magnitude which threatens sanity.

"He put his arm around her, and she nestled in his shoulder for a moment. I watched them out of the corner of my eye. 'All right?' he asked her, and she nodded, still flushed, before getting up and going into her hut.

"The trouble with Denise was, she wanted to be doing things, all the time, to help—and there really wasn't that much to do. I didn't see it then, though I do in retrospect. God, she was so eager to help, it was stretching her nerves to tightwires. I think if a maniac had run into the camp, waving a gun, she would have looked around eagerly for someone to throw herself in front of, in order to take the bullet. She wanted to make her mark on the project—sacrifice herself—to give it every chance of success, so that afterward she couldn't be accused of being just a passenger. If I had given her the onions to peel and said, 'You know, Denise, we couldn't have made it without you,' she'd have been my friend for life.

"The funny thing was, it was her presence that kept us going, only she didn't realize it. She thought she had to give something physically or intellectually, or it wasn't worth anything. Her strength of will—the spiritual pressure that she continually applied—was powerful enough to keep us there, working away with almost no material.

"Nothing was stated, you understand. McArthur and I didn't say to each other, 'Let's go home,' and then, 'No, we can't, because Denise will be disappointed in us.' The fact that she was there prevented even this much admittance of failure. I just know, in myself, that had she not been with us, we would have gone home after just a few days.

"However, because it was one of those buried truths, *she* didn't know it, and she still sought some way, any way at all, of proving that her presence was necessary to the project.

"If only I had given her some acknowledgment of the very real part she was playing... but I didn't. All I could do was grumble that she was in my way. So we carried on as we were, stumbling around in the dark, and with Denise fluttering around us like some giant moth, ready to throw herself into the candle flame if it would provide us with more light."

Cartier paused here. There was a tenseness to him which the brandy seemed to exacerbate rather than relieve. He was gripping the glass as if to crush it.

"It was McArthur who thought of the idea," he said, placing the glass carefully on the table, "because nothing, absolutely nothing of interest was happen-

"She was so eager to help. I think if a maniac had run into the camp, waving a gun, she'd have looked around eagerly for someone to throw herself in front of, in order to take the bullet."

ing—not for us. All we could do was shoot that damn boat from a distance and watch the crews working and eating—not the stuff of exciting cinema.

"McArthur had noticed a certain antagonism evident between our own Indians and those in Herzog's camp. Something to do with territorial areas, I expect. He said it wouldn't be a bad thing—for us—if something developed.

"'Like what?' I asked him.

"'Well, if one of our Indians should meet, face-to-face with one of theirs, we wouldn't be responsible, would we?'

"Denise understood him instantly—they had a strange kind of mental rapport which needed few spoken words. It was only when he said, 'I suppose it should be me,' did I get the idea. I'm not saying I didn't approve the scheme, because I did. I was as anxious as the other two to go home with something of worth on film. But I was scared. Not only was it unethical, even criminal, it carried a very dangerous undercurrent. We might start something we wouldn't be able to stop.

'So I did endorse the plan, and we made certain preparations. McArthur had volunteered himself because he believed himself to be an archer. He was the obvious choice. I was as dark as he, and my disguise just as convincing, but the man behind the bow had to be good. We didn't want a death on our hands, just a little action for the film, you understand.

I could blame the heat, the insects, the rain forest—you know we had to wipe everything, each day, to get rid of the mold that grew on our possessions overnight—the humidity was unbelievable. We had begun to bicker continually amongst ourselves, fighting over silly things that meant nothing—nothing at all—even McArthur, whose initial wonder in the place had since dissipated. There was an indefinable sickness amongst us that we battled with medication and had a hard time holding down.

"It was another world—a kind of heavy drug-dream place. A place in which we felt we had a right to make our own rules. We had come a long way from civilization—used all our resources to get there—and we had to go back with *something*. Oh, I could blame a thousand things—the excuses proliferate, even as I talk to you now.

'So—we did it. The next time we saw a fisherman leave Herzog's camp in his canoe, we followed on foot, keeping pace with him along the bank. McArthur had borrowed bow and arrows from one of our Indians, and when the man stepped ashore, he shot him, aiming for his leg.

'Now, I'm not saying that McArthur's expertise with the weapon he normally used was wanting—he was probably very good with a precision-made longbow—but the Indians use much longer arrows and smaller bows. McArthur fired two arrows, I think, or maybe it was three—I can't remember exactly. The idea was to wound the fisherman, have him running back to his people, and provoke some sort of reaction from them. We had a naive vision of flights of arrows whizzing across the river and nobody actually getting hurt—badly, that is—so that some attention would be focused on our side of the water. We wanted a skirmish to film.

'Anyway, it was a disaster. The last of McArthur's arrows caught the fisherman in the throat. There was a kind of gagging sound, and the man went down, disappearing into the foliage. I've got it all here on the film. You'll be able to see exactly what happened when I show it to you. Even now I have difficulty in remembering the details. You know, when you're working, you're too involved with the business of filming to register a conscious blow-by-blow description of the scene in your own mind—the director's supposed to do that, and my director was one of the actors in this particular scene.

"I know I cried, 'My God, you've killed him!' when the next thing I realized was that McArthur was on the ground himself. He was staring stupidly at an arrow protruding from his thigh, as if it had just grown there—you know, like a bamboo branch had sprung from his flesh. I'm still not sure where that shaft came from, but I guess the fisherman must have fired back from a prone position. The angle seemed to indicate something of that nature." Cartier must have seen a look of inquiry on my face, because he added, "They fish with bow and arrows, there.

"Anyway, I dragged McArthur away with me and we headed back to camp, he using me as a prop while he limped along. He was as white as a fish belly, I can tell you, and he was vomiting the whole way.'

I interrupted the story here.

"I remember seeing a wounded Indian in the film of the making of *Fitzcarraldo*—was that the same man?"

'I think so. He lived, thank God. Or thanks to the doctor that their crews had taken with them.

'I got McArthur back to our camp and we put him in one of the huts. Denise was absolutely distraught—McArthur was babbling by this time, delirious, and Denise kept shouting about poison on the tip of the arrow. How she got that idea I don't know. I thought it was just shock—there was no obvious discoloration around the wound. No dark red lines going up into his groin.

"She wanted to get the doctor from the other camp, but after what we'd done I thought we'd be in for a nasty reception from the wounded fisherman's tribe. I was absolutely against it. I convinced her that the arrow, which we had left behind, was a fishing arrow and would not be poisoned. Finally she agreed and decided to nurse him herself. She went into that hut and... well, I have my own ideas about the events which followed, bizarre

as they might seem to you now, in the light of a Parisian day. Things were different there. It was all a little surreal. Our light, filtered by the roof of the rain forest, was of a sickly greenish hue and shadows moved back and forth through it like phantoms. There was the constant murmur of insects and sudden confrontations with amphibians and reptiles which seemed to appear on trees, in the grass, as if by magic. The whole place had a sense of the fantastic about it.

"Perhaps the arrowhead *had* been tipped with some kind of substance? Anyway, McArthur went into a state of fever. I heard him yelling occasionally, between bouts of absolute silence. Most of his complaints were concerned with being too hot, or too cold, but I also heard him shouting about the 'snake' and the 'river'—and following these cries, the low, soft voice of Denise, telling him it was all right, she would protect him. I didn't go into the hut. They had no need of me.

"Of course, fever can bring on hallucinations during bouts of delirium, but I believe it was more than that—something quite extraordinary was happening to McArthur. The mind is a delicate mechanism—if that's the right analogy—and once you tamper with its intricacy, its balance, it can respond in strange ways, playing havoc with reality. As I said before, I have my own ideas—ideas about memories and self-protection.

"The mind is like a camera, recording memories, which are never projected. Short films, locked away and only replayed internally, so there is never any doubt of their unreality. I say *never*, but I think in McArthur's case, there was.

"When McArthur was yelling about the snake, I think he was talking about the anaconda we had seen basking on the riverbank a few days earlier. From the canoe we had watched it uncoil its enormous length, as thick as a man's thigh in places, and slip into the river. McArthur had been petrified. He thought the creature might come toward the canoe, and he was shaking so much there was a danger of the canoe overturning.

"It didn't. It swam away upriver—slow, sinuous movements through the brown water, its blunt head showing just above the surface.

"I think that McArthur's mind was replaying this encounter, projecting it and superimposing it on the actual scene—the interior of the hut. A sort of double-exposure effect, which had him believing that the snake was in there with him and as real as everything else around him."

Cartier paused as a waiter passed our table, as if he did not want any eavesdroppers to hear what he had to say next. Once the man was out of earshot, he continued.

"He was projecting not just memories of the snake, though, but longer, deeper memories, which he had buried to keep from the light. These, too, began to emerge, to superimpose themselves on the dim scene within the hut. Memories evoke not only recognition of their familiarity, but emotions. Just as the snake stirred some primal fear within him, these older memories aroused a forbidden desire, a passion indulged during earlier years. McArthur's past was with him in that hut, and he could not separate real from unreal. Combined with this was his need to be protected from that terrible serpent, and Denise was there to provide that protection. She wanted to *help* him, you understand. She saw it as essential to herself, to do what she could for him, at the same time making her contribution to the expedition."

Cartier took a swallow of his cognac. I sensed that the revelation was about to emerge and tried not to make any movement which might distract him. He seemed on the verge of abandoning the tale altogether. So I sat quietly, waiting for him to continue.

"They were in that hut three days," he said. "I sent in food and drink, of course, but I didn't enter the place myself, not until I heard McArthur talking in more rational tones. I couldn't hear exactly what was being said, there was an intense quality to the speech, but the long periods of silence, punctuated by irregular sessions of screaming, had ceased.

"I went in then. I'm afraid I interrupted them. I was expecting to see—well, I don't know what I was expecting, but it wasn't two naked bodies locked together. I left immediately, but though Denise hadn't seen me, McArthur had...."

I groaned inwardly, expecting now that I would get a sob story about how much he Cartier had been in love with Denise and that he had never once suspected that her uncle would take advantage of her hero worship.

"So—it was incest," I said, hoping to ward off his outpourings. "A fairly mild form, though," I continued. "Both adults—and the relationship not as close as it could have been."

He stared at me, his dark eyes holding mine, something troubling their depths.

"Yes. That's what I thought—and no doubt Denise did, as well. She didn't know either, you see."

"Know what?"

It was the first time since we had met that I saw anything like real discomfort registering in Cartier's features.

He said, "She didn't know McArthur was her father."

My thoughts did a few acrobatics, and I said, instinctively, "But Denise was his sister's daughter." Then I stopped. I had the whole picture. He had fathered his sister's child and had now taken that daughter to bed. What a mess! The whole thing was revolting, incest in layers.

"He told you this?" I said.

"Shortly afterward. We pieced to-

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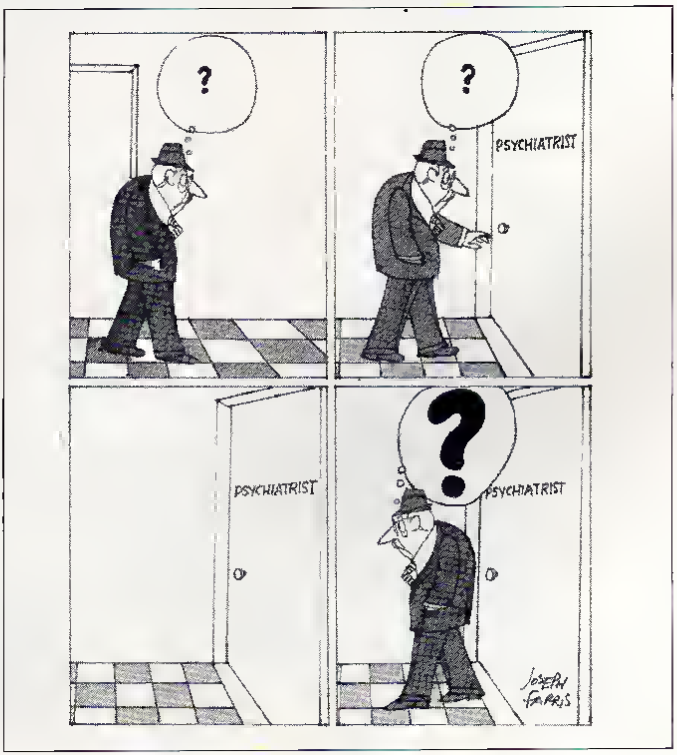

ARTICLE

Genius or divine instrument, he bequeathed a legacy to science

THE MASTER OF MATH

BY GURNEY WILLIAMS III

Srinivasa Ramanujan's interest in math waned after his death in 1920, according to some of his friends in India. They know because they chatted with the mathematician's spirit during a 1934 séance. Someone had asked if the spirit was continuing Ramanujan's earthly work. The planchette glided around the Ouija board. "No," it reported. "All interest in mathematics dropped out after crossing over."

Ramanujan's popularity, and interest in his mathematical equations, have increased in the years since

PAINTING BY ORI HOFMEKLER

his death at the age of only thirty-two. Some American mathematicians, like Pennsylvania State University's George E. Andrews, devote most if not all of their time to studying the Indian's notebooks and uncovering still-buried truths. They don't, of course, generally attend seances to communicate with Ramanujan's spirit. (The 1934 seance, for example, may well have been fraudulent. When asked mathematical questions, the spirit responded with equations that were valid but totally irrevelant.) But more than 125 of his devotees, including Freeman Dyson of Princeton's Institute for Advanced Study and mathematician William Gosper of Symbolics, Inc., a Mountain View, California, computer firm, did attend a centenary conference at the University of Illinois at Urbana-Champaign to commemorate Ramanujan's one-hundredth birthday.

Mathematicians' interest in his equations would not have surprised Ramanujan (rah-MAHN-a-jahn). He had predicted after all that his mathematics would be useful to mathematicians for more than a century,' according to his widow, Janaki, who recently responded to a series of written questions from *Omni*. Yet—lying on a cot, propping himself up on his elbows, and barely noticing the rice his wife put into the palm of his hand—Ramanujan could not have foreseen that he was building some of the foundations for the science of the Nineties. His work supports theories about 'superstrings,' the tiny theoretical entities that some physicists argue lurk in the multidimensional core of all matter. His equations also anticipated the work of advanced computer jocks. And he bequeathed this legacy without following the rubrics of academic rigor. Undereducated and poor, Ramanujan cared little for footnotes or complete explanations. He omitted whole chapters of his thoughts, forcing his successors to ask again and again: Where did that come from?

One typical Ramanujan discovery was an equation with a neat pattern of a dozen or so numbers and letters on one side of the equal sign, and a much simpler number—$2/\pi$—on the other. Again and again in his work, he seemed to produce the same message: Complexity reduces to simplicity.

Born in 1887 into a poor family of high caste in Erode, a town in southern India, Ramanujan was the son of a clerk in a cloth merchant's shop. By the time he was twelve years old, his teachers knew he was gifted. Without the benefit of any sophisticated instruction, he discovered a set of crucial theorems about sines and cosines shortly after he started studying trigonometry. He was crestfallen when he later learned that Swiss mathematician Leonhard Euler had made the same discoveries more than a century earlier.

There was no way for Ramanujan to have known about Euler's work, because he hadn't read much about math. He raced through a trig text when he was twelve and went for years without cracking another math book. Then, when he was about sixteen, a friend lent him a tome from the library at Kumbakonam, the city where Ramanujan grew up. The book was *A Synopsis of Elementary Results in Pure and Applied Mathematics*, by George Shoobridge Carr of Cambridge University.

Carr's work was simply a listing of some 5,000 theorems—mathematical statements with skimpy proofs—in algebra, trigonometry, calculus, and analytical geometry. But for the young number wizard, the book triggered something like a religious conversion. Ramanujan suddenly knew and loved numbers. "It was this book which awakened his genius," one of his biographers writes. "He set himself to establish the formulas given therein."

> *"Although he cut his hair and traded in his turban for a British hat, he continued to eschew shoes or socks, true to Madras style. The climate was torture for him. He returned home emaciated."*

By all reports, when the subject was math, no one surpassed Ramanujan. A professor of Government College in Kumbakonam, for example, would take two sliding blackboards to do an algebra or trig problem in 10 or 11 steps. Most of the students needed a series of explanations to understand each step. Then Ramanujan would ask permission to find shortcuts to the answer. Typically, he would pare the solution down to four steps, explaining each one to his teacher two or three times. The class was lost.

Ramanujan neglected English, history, and physiology, often working on math during lectures in these other courses. As a result, he lost a scholarship, dropped out of college, tried to get back in, got sick, and went home. He later tried again to take a key college exam and failed. By the age of twenty-five, having had trouble finding a job, the dropout had become a clerk in the office of the Port Trust of Madras, earning about £20 a year to support his young wife and his mother, who lived with them. His real work, however, was always his mathematics.

Ramanujan liked to work while lying on his stomach on a cot set up on a veranda shared with other residents of his multifamily dwelling. He would begin writing after the heat of the day had dissipated. Janaki and his mother would feed him dinner while he put down page after page of equations. Often he would continue to scribble until six A.M., then try to get a couple of hours of sleep before reporting to his desk job.

He might have remained on his cot by night and in his clerkship by day had not the chairman and the manager of the Port Trust office recognized his genius. They urged him to send some of his findings to British mathematicians and try to acquire a sponsor.

One of his letters, dated January 16, 1913, addressed to mathematician G. H. Hardy of Cambridge, included more than 100 theorems. Hardy initially dismissed Ramanujan's ideas but, after discussing them with a colleague, decided otherwise. 'I had never seen anything in the least like them before,' Hardy later wrote. 'They must be true because . . . no one would have had the imagination to invent them.' Ramanujan soon accepted Hardy's invitation to come to England and, leaving Janaki behind, arrived there in 1914.

Cambridge welcomed him, and almost immediately he began producing dazzling mathematics. But within a few months England was plunged into World War I, and the vegetarian Ramanujan suffered from the dearth of vegetables and fruits. Although he had cut his hair and traded in his turban for a British hat, which he despised, he continued to eschew shoes or socks, true to Madras style. The chilly, damp climate was torture for him, and in May 1917, Hardy wrote the University of Madras that Ramanujan appeared to have contracted an incurable illness. Some people later thought he might have suffered from tuberculosis, but the symptoms were inconsistent with that disease. It may have been severe vitamin deficiency, but no one is sure what the debilitation was.

He returned home emaciated, but for another year he wrote out formula after formula. "He did not reveal when he made an important discovery," Janaki writes. "He continued his work and did not celebrate in any specific way." At the end, "he was unconscious for nearly four days." After the funeral, his papers and notebooks were handed over to friends and buried in files.

Some of Ramanujan's most useful work arises out of what appears to be a child's game. Mathematicians call it partitioning, and the deceptively simple object is to figure out how many ways an integer can be expressed as the sum of other integers. The number 4, for example, can be partitioned five ways: 3

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+ 1, 2 + 2, 2 + 1 + 1, 1 + 1 + 1 + 1, and 4 itself (what mathematicians call a single-term sum). It's no longer child's play when the number is much larger. The integer 200, for example, can be partitioned nearly 4 *trillion* ways.

In one of his most famous discoveries, Ramanujan, along with Hardy, found a way to calculate the number of ways an integer can be partitioned. It's a long, complex formula that requires a continual generation of figures and also uses two shorter formulas. The number of times you have to repeat the calculations, moreover, depends on the square root of the number being partitioned. (Imagine watching a mad scientist in an old movie mixing and remixing test tubes of frothing chemicals to attain one magical solution.)

Ramanujan's partition finding has proved useful to theoretical physicists working with superstrings. According to superstring theory, the universe arises from the oscillation of infinitesimally small strings that wheel around in tight loops, each string 10^{-33} centimeters in length. (Such an incredibly minute length is difficult to understand—even for many theoretical physicists. It means that you'd have to have 10^{33} strings laid end to end to get a length of just one centimeter.) The movement of these strings, in theory, produces particles. The more intense the movement, the heavier the particle. And the particles range from the lighter ones we can perceive to heavier particles that exist only in theory.

A further complication of the dance of strings is that it happens in more than three dimensions. According to proponents of the heterotic string theory, there may be nine spatial dimensions and one time dimension. With our limited human vision, of course, and with insufficiently powerful particle accelerators, we can't see matter in six of the dimensions. Moreover, not only do the strings vibrate and rotate in the ten-dimensional world, each string possesses another 16 dimensions within it.

Thanks to mathematics, however, we can still explore this fantastic realm, with Ramanujan's discoveries being our most important guides. According to Princeton's Jeffrey Harvey, one of the four physicists of the "string quartet" who developed the heterotic string theory, the partition formula's mathematics is one of string theorists' everyday tools. Among numerous other benefits, the math aids the determination of the total number of particles—actual and theoretical—in the universe. And it is one way to study characteristics of strings like their oscillation.

Ramanujan's math resonates far beyond the subtle vibrations of superstrings. "There are many combinatorial problems—counting how many objects there are of a certain type—in physics," says Carlo Moreno, a mathematician at the City University of New York. When physicists were trying to crack the mystery of atomic structure, they looked to the partition theory for clues. The math gave them some idea of how many ways electrons could be distributed around the nucleus.

Physicists also use Ramanujan's math to study helium, an inert gas that lofts balloons more safely than flammable hydrogen does. Its simple structure makes helium easy to investigate. Helium's recombinations are the source of the sun's heat and may someday shed bountiful energy from fusion reactors on Earth. Within the past decade, physicists have found that Ramanujan's equations are vital for studying some of liquid helium's behavior.

Andrews himself was drawn into the study of helium in the late Seventies, after he gave a lecture on Ramanujan at the Australian National University in Canberra. At the time, a theoretical physicist named Rodney J. Baxter had been investigating how a film of cold helium, near absolute zero, behaves as it spreads over a carbon plate. It turns out that the carbon offers sites in its atomic structure for helium molecules to take up residence. But it's like playing musical chairs as the helium molecules rush around to grab space in the latticework of the carbon's surface.

The helium settles into the empty "chairs" according to a special rule. Once a molecule occupies a site, it prohibits any other helium molecule from settling anywhere near it within a hexagon-shaped territory. The area is "hardened" to further infiltration. Baxter's question was: How could billions of molecules wind up seated in the carbon if every one of them followed the "hard hexagon" rule?

Baxter wasn't familiar with Ramanujan's math and didn't bother going to Andrews's lecture. On his own, he discovered a few formulas for the kinds of helium-seating arrangements. But he wasn't able to verify all of his hunches. Seeking help from the National University math department, Baxter was told to write to Andrews.

The first letter sparked a collaboration that led to a full understanding of the "hard hexagon" model. The critical math came from the 1894 work of British mathematician L. J. Rogers. Ramanujan's rediscovery of Rogers's equations—they came to be known as the Rogers–Ramanujan identities—dealt with variations of number partitioning. (Baxter had, in fact, proved the Rogers–Ramanujan math on his own.) "It is remarkable how many of Ramanujan and Rogers's identities lurk within the hard hexagon model," Baxter wrote to commemorate Ramanujan's hundredth birthday.

Ramanujan's math lurks even in state-

"Yes, the Fifties were a golden era, son. People were afraid of us then."

of-the-art computer technology. One of his equations researchers recently found helps generate a fast way to calculate the value of π. The result is a number only a mathematician could love—it runs to millions of digits and would fill the *Encyclopedia Britannica*. But the calculation itself is a trial by fire, pitting one computer's speed against another. Some of today's most sophisticated software, in fact, now incorporates Ramanujan's equations, helping designers dream up the computers of the Nineties.

Despite the recognition of Ramanujan's work today, mathematicians who took a close interest in his work immediately after his death soon turned to other projects, leaving stacks of Ramanujan's formulas untouched. Cambridge mathematician George Watson, for example, first began editing Ramanujan's papers in the late Twenties but by 1940 had put them aside. Some of them remained stacked on the floor, next to old bills and tax returns, in Watson's house until his death in 1965.

Then in the spring of 1976, more than half a century after Ramanujan's death, Andrews was browsing through some papers in the Trinity College library at Cambridge. The collection had come from Watson's estate. To his surprise, Andrews found a box marked with a small sheet cataloging some of Ramanujan's papers. Inside was an unbound manuscript of about 90 sheets, some covered on both sides to make about 140 pages of mathematical symbols written in brownish ink.

"Some of it was completely chaotic, just scratched notes spreading out in all directions," Andrews says. "The other pages were listed with formula after formula, no hint of how he came up with it nor any attempts to prove it. There are formulas written upside down from others, or at forty-five-degree angles, and fragments that just trail off. It looked like somebody working as hard as he could, trying to get as much done as he could."

Andrews was almost immediately able to make sense of the jumble, however. He knew that after Ramanujan returned to India, his only letter to Hardy reported an advance in the mathematics that had enabled the two of them to develop the partition formula. To make that breakthrough, Ramanujan and Hardy used what mathematicians call theta functions, complex equations that acted somewhat like parents in siring the math behind superstring theory.

After he had returned to India, Ramanujan wrote that he had discovered a whole new family of equations, which he called "mock theta functions." According to Andrews, these functions are a bigger and more complicated class of equations than theta functions. "To this day, we don't know everything about them," he says. Having written his doctoral thesis on mock theta functions, Andrews knew immediately that he had found the key to a missing period when Ramanujan was at the height of his powers.

Since the discovery of the mock theta papers, which came to be called the "lost notebook," American scholars using computer programs to dig through all of Ramanujan's notebooks have continually encountered mystery. Where did his knowledge come from? Who was he? The questions have driven Ramanujan followers like mathematician Bruce Berndt at the University of Illinois at Urbana-Champaign into quests far removed from the realms of math.

Since 1974 Berndt's goal has been nothing less than proving some 3,000 of Ramanujan's mathematical findings. During the last 15 years he has worked through 2,700 of them. He expects it will take another five years to retrace Ramanujan's steps through the rest.

Typically Berndt opens a well-worn reprint of Ramanujan's notebooks to a page

> *"Some of his followers have found themselves driven into regions where religion mingles with math and where equations, hymns, and prayers are all on the same program."*

of symbols and begins manipulating them—often using a computer—to try to show that two sides of a monstrously complicated equation really are equal. Many of the calculations are so difficult to compute, Berndt comments, that it would take days or even years to do them manually. "Ramanujan obviously had better ways of looking at these problems than I do," he says.

Berndt's quest has led him to settings where religion mingles with math, where hymns and equations and prayers are all on the same program. In 1984, for example, during a pilgrimage to India to find out more about Ramanujan, he visited the Kumbakonam college where Ramanujan had studied. Professors there asked him to give a talk about his work on the college's former student.

Berndt, like all American mathematicians, is accustomed to sparse audiences. So when he approached the lecture hall, he was surprised to find dozens of students grouped outside the entrance. Inside, hundreds of faculty and students packed the room. Two women sang a Hindu prayer. One of his hosts gave Berndt a book of ancient proverbs. And after Berndt spoke for 45 minutes about Ramanujan and his math, the meeting ended with the singing of another Hindu prayer. "Ramanujan is regarded almost like a saint," Berndt says.

Many of Ramanujan's followers have had to deal, not always cheerfully, with the fact that the man has become something of a cult figure. Legend holds that the Hindu goddess Namagiri whispered in his ear as he slept. Even his widow remembers that her husband consulted horoscopes and believed in the influence of the stars and planets.

Hardy, of course, was certain that the man he'd discovered *wasn't* religious. "Ramanujan was no mystic," he argued. Ramanujan himself made it clear, Hardy reported, "that all religions seemed to him more or less equally true."

Berndt concurs, based on two conversations with Ramanujan's widow, one in 1984 and the other in 1987, that Ramanujan was not particularly religious. "He did not go to the temple because he never had time. He was always doing mathematics," Berndt notes. All the stories about Ramanujan's being religious were made up by his family, according to Janaki.

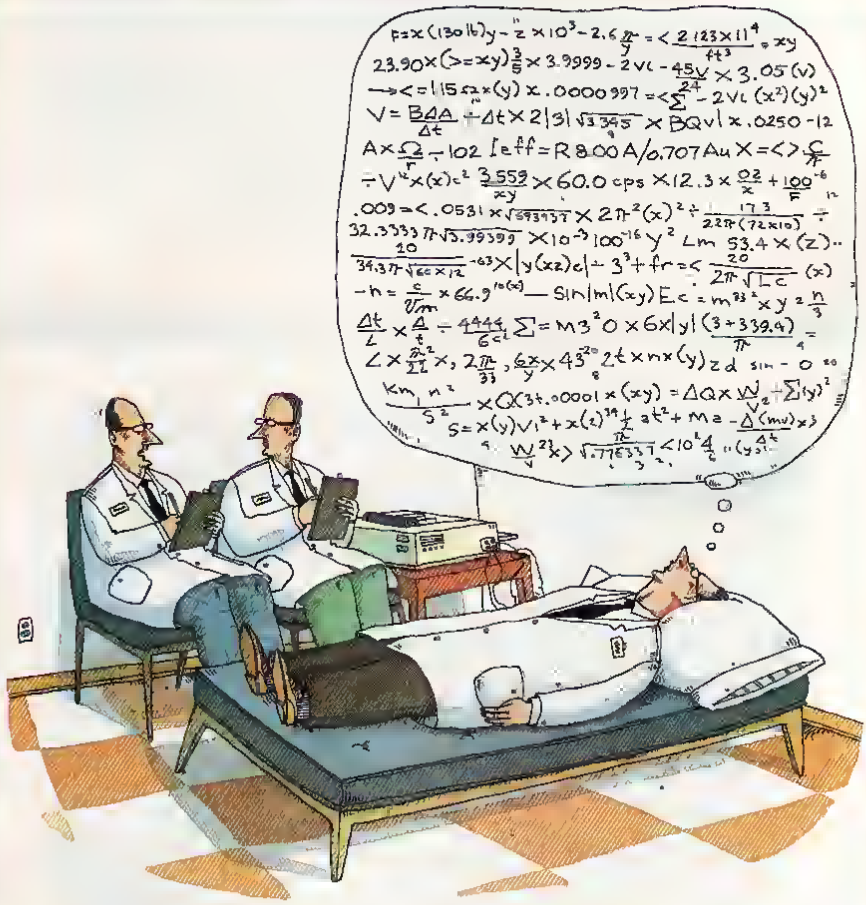
Why, then, would Ramanujan—if, in fact, he did—claim inspiration from Namagiri? "Contrary to popular belief, mathematics is not a deductive science," Andrews says by way of explanation. "When you make a discovery in math generally you sit at your desk and beat your head against a wall and nothing happens. So you set it aside and you're taking a shower or something, when all of a sudden the light dawns. And you say 'That's it!' However one explains this sort of experience, it doesn't seem to me unreasonable that a religious Hindu might explain it by the presence of the goddess Namagiri whispering things."

Whatever their source, Ramanujan's equations continually throw mathematicians off balance. "I rate my findings in terms of milliramanujans," says Symbolics' Gosper. Each of Ramanujan's major findings is given a top rating of 1,000 milliramanujans. "It's a measure of beauty," Gosper says. "It's pretty ego deflating. I don't think I've ever gotten above seven hundred fifty milliramanujans. And I'm working with a monstrously powerful computer. He was using *nothing* except his damn pencil and paper. How can we all love this man when he is forever reaching out from beyond the grave and snatching our neatest results?"

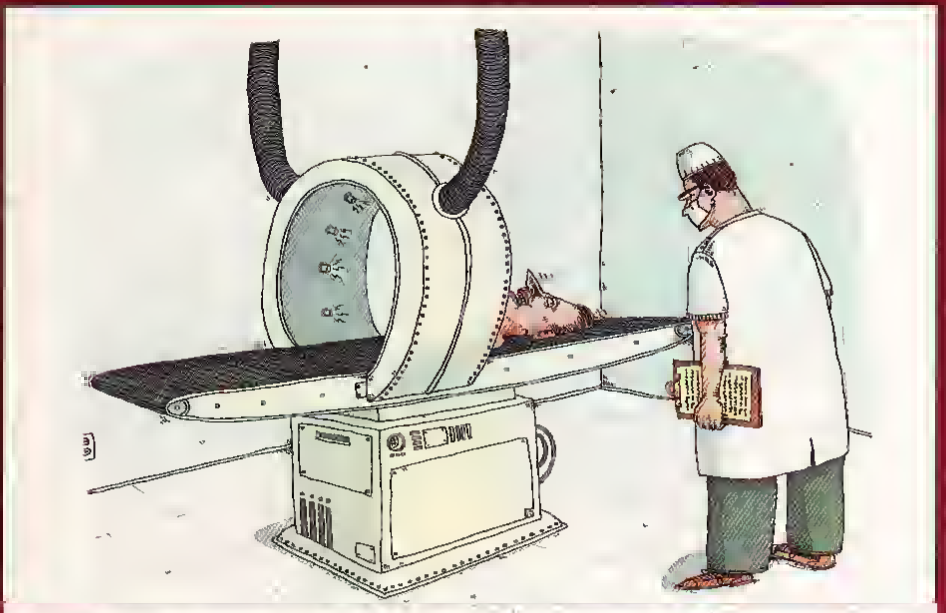
Freeman Dyson offers his own answer to Gosper's question. "Ramanujan had an extraordinary gift for picking beautiful identities [equations] out of thin air," says Dyson, who is still working on pure math problems Ramanujan left behind—research on number theory and the fundamental properties of numbers. "It's obvious, if you follow his tracks, that he saw things nobody else could."

CLOSE ENCOUNTERS OF THE THEORETICAL KIND

CARTOONS BY STEVE ATTOE

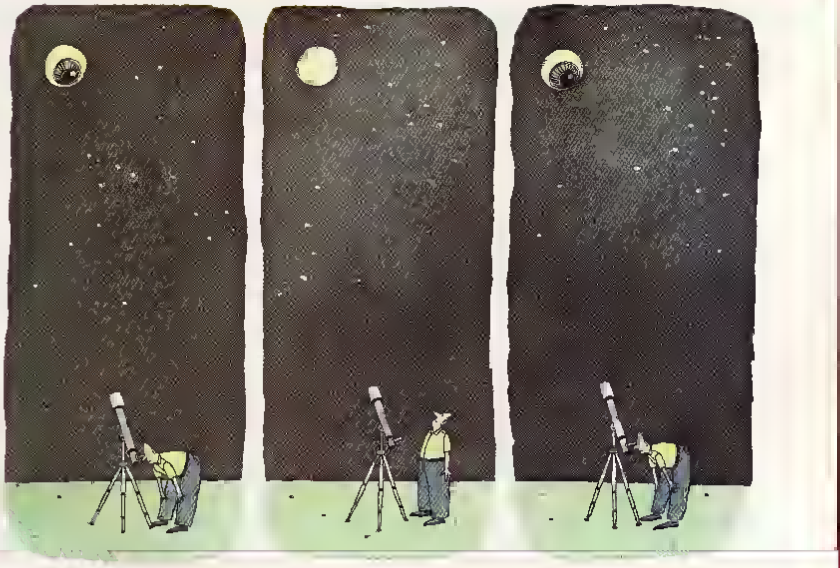


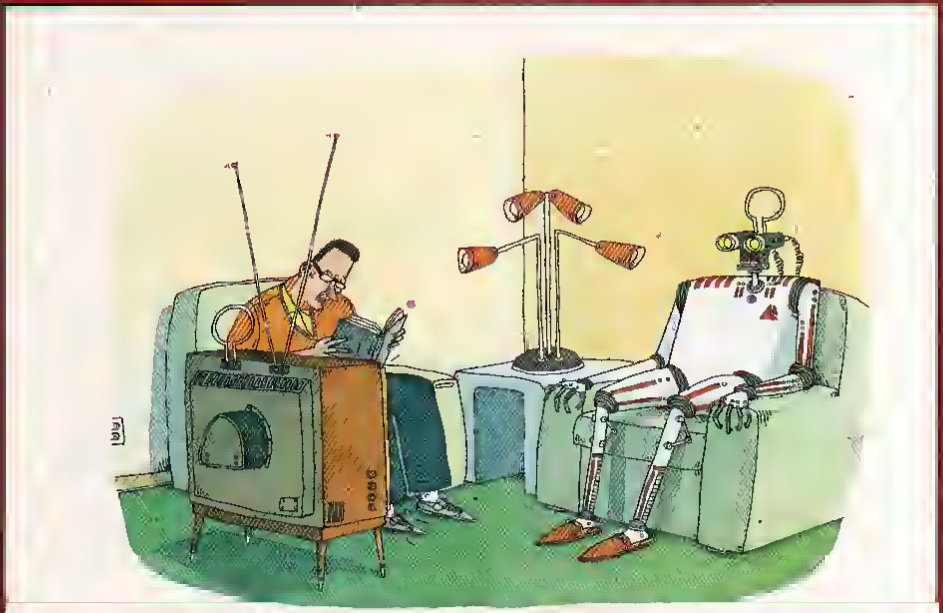
"He can never remember his dreams."



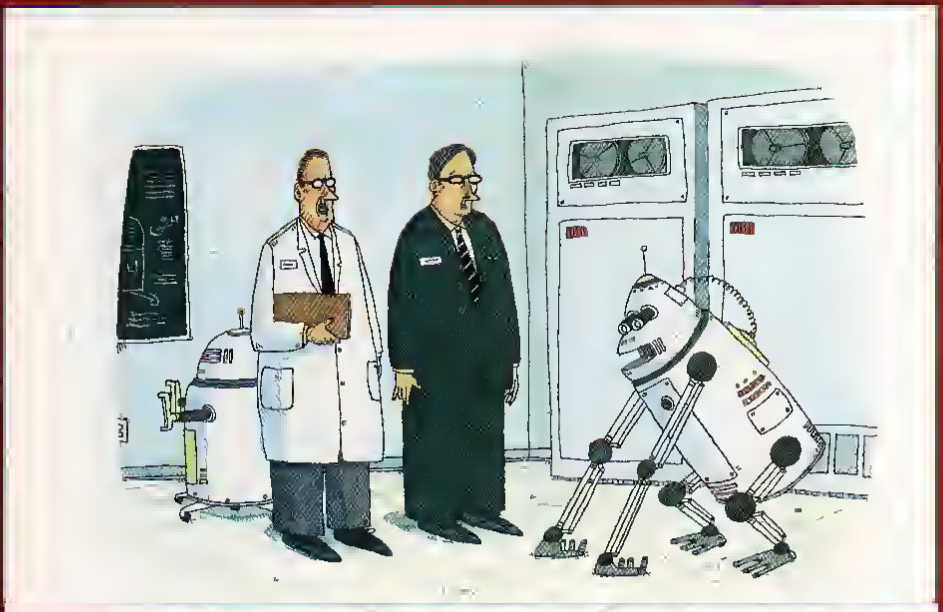
"You're right. I don't feel a thing."

"What else does it do?"

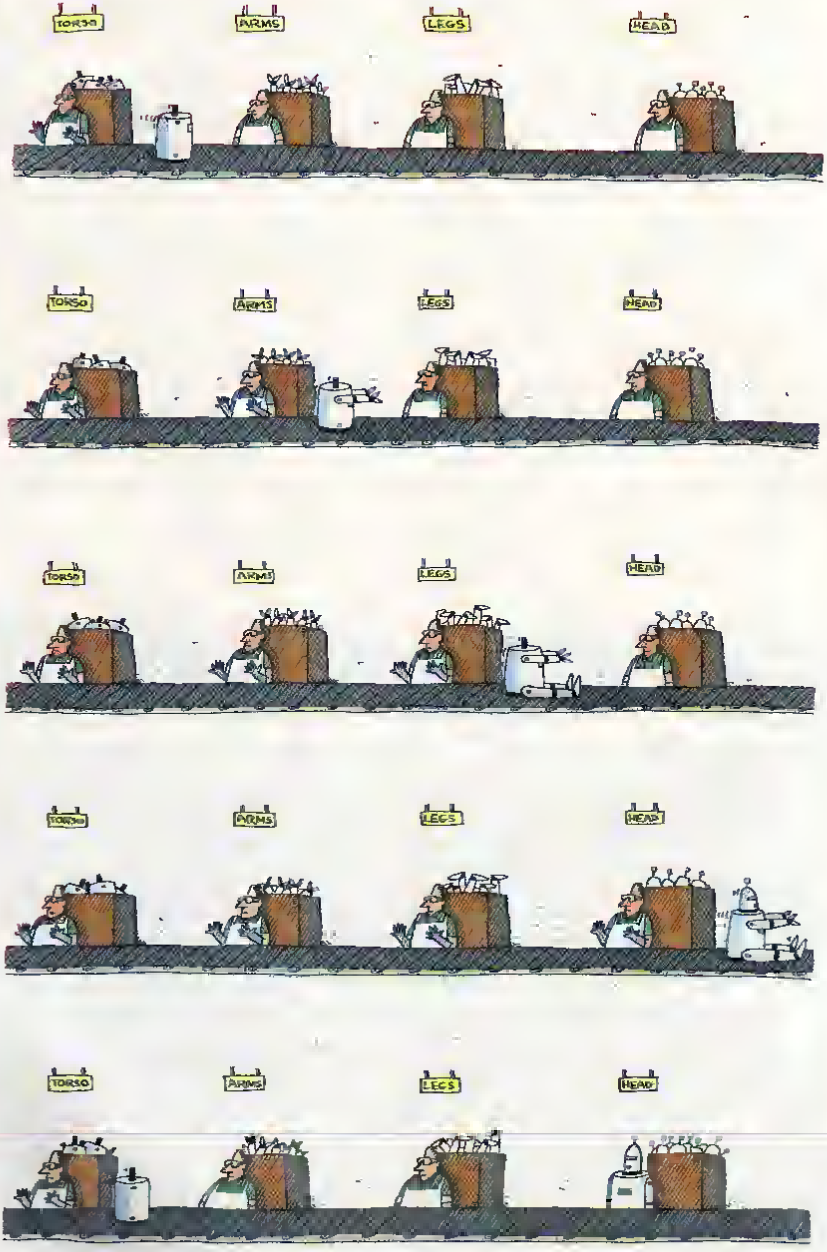




"Robots can tirelessly perform simple tasks that are much too tedious for human beings."



"This is one of our early models."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FITZCARRALDO

CONTINUED FROM PAGE 57

gether the theory of memory projection from it. You can see how it relates to the film . . ."

"And you want me to distribute this movie?" I stared out of the café window, waiting for his reply watching people hurrying along the boulevard. The distaste in this project almost made me jump to my feet and join them, but I decided to see the thing out.

"Yes—we all do. We thought you should have some background to the movie—it might help to create a little publicity, don't you think?"

Cartier's face was devoid of expression. I tried to imagine what was going on in his mind. It wasn't easy.

"Let me take the film away with me. I'll contact you tomorrow."

He agreed, and we went outside and transferred the movie from his car to mine. I did not shake hands. I just climbed into my car and said, "Tomorrow, then."

I had noticed, when we left the café, that he was limping.

As I drove home I thought about my own predicament. The bills were mounting up, and I still had not found the successful movie which would get me out of the rut. My recent decisions might have been sound ones based on my experience in the business, except that no one can predict success in the movie world with any certainty.

That evening I watched the film in my private studio. It was a boring collage of river and forest scenes. The Herzog boat was there, the area around busy with people, but it could have been an amateur movie taken by a camp follower; or more likely, it had been put together from stolen discarded cuttings of *Fitzcarraldo* itself, and the film of the film, to form a bastardized child of both. The whole effort folded in on itself, until nothing made sense because it was too internalized. It exposed too much of its inner self, which in the revelation showed nothing but a confusion of scenes and snatches of close-ups. It revealed everything, yet it revealed nothing, because at any core, whether it is human emotion or something more substantial, there is no truth which can be grasped and understood. Everything becomes a cluttered wash of incomprehensible color tones, weakened further by the continual rinsing of the thing in itself, until all you have is a faded copy of a copy, recurring.

When the film reached the scene where the arrows were exchanged, I paid particular attention, but even here I was disappointed. The light was all wrong, either too weak or too strong. There were figures in the gloom of the forest, and action certainly took place, but, bright and dark, what came out of it was a flurry of furtive movements, glimpsed through curtains of leaves and fences of tree trunks. There was a close-up of the wound in McArthur's leg, which looked genuine enough, as did the agony on his face, but it had been done better by Charlton Heston in *El Cid*.

McArthur, on film, was of course the spitting image of the man I had met in the restaurant, calling himself Cartier.

There was also a single scene of the niece, or daughter, both, half hidden behind smoke from a campfire. Either the shot was overexposed, or she was thin and pale, almost translucent, with red-rimmed eyelids. The sort of will-o-the-wisp female that gets cast as a fairy extra in *A Midsummer Night's Dream*.

What it amounted to was an unholy tangle. Of course, if the story were true, there were enough vultures in the world to make the film a success in terms of sales at the box office. Artistically, it stank, but some cinemagoers would be curious about this trio and their incestuous goings-on in the South American jungle. If it was released to the media, the gutter press would provide all the publicity needed. However, I doubted very much that the story *was* true, and I had my integrity to consider.

I met Cartier, or McArthur, at the same café the next day.

I gave him the standard rejection.

"It's not good cinema," I said.

He seemed very disappointed, leaving me his card and saying I was to call him if I changed my mind. I replied that there was little chance of that. Once I had made a decision, I told him, I usually stuck with it.

His eyes went to a corner of the café, where there was a door with a small window set in it. I thought I caught a flash of something behind the glass of that window and turned back to him. He had a dejected expression on his face.

"Who's behind the door?" I said.

He seemed about to argue, then must have changed his mind. I suppose that since I had rejected his offer, he saw nothing to gain by denial.

"A friend of mine—cameraman. He's filming us. I thought it would make a good postscript to the movie—you and I meeting, discussing the project . . ."

I looked him straight in the eyes.

"*You're* McArthur, aren't you? Who's that behind the door? Cartier?"

Before he could reply, I saw his eyes widen as he looked up over my left shoulder. Then a tremendous explosion filled my head. I felt the heat of a blast on my cheek and smelled the acrid odor of cordite. My head rang with the noise and for several seconds I was unable to see, let alone hear anything. If any sensible thought at all crossed my mind, it was that the café had been bombed by some terrorist organization.

When I was able to register a conscious understanding of what was happening, I realized that McArthur was sprawled on the floor where he had gone flying backward. There was blood in his hair, on his collar. What I had heard was the sound of a revolver being fired close to my ear.

As I turned around, still groggy and shocked, she was just putting the barrel of the gun beneath her chin. There was another explosion, not so loud as the first, since it was muffled by soft flesh. The body struck my shoulder as it fell, and I think I screamed.

The next thing I knew, I was being helped to my feet and led away toward the bar. My legs were shaking violently, and someone forced a brandy down my throat. I couldn't even hold the glass, my hands were trembling so much. There was a lot of shouting, which I could hear above the ringing in my ears. I remember glancing back at the woman's corpse, once. But it was impossible to tell whether the face—now covered in gore—belonged to the girl I had seen in the movie the previous evening. It crossed my mind that it might even be McArthur's sister—the mother of their daughter.

An unholy tangle. The police came and took me into another room at the back. I can't recall what I told them, but I must have just recounted what had passed over the last two days, between the man on the floor and myself. I found out later that they had secretly videoed my statement. Finally, I remembered about the cameraman, behind the window in the door, and started to tell them when one of them pointed toward the corner of the room. There was another man there, talking to more policemen. He glanced across at me, and I recognized him.

There was a movie camera on the table between him and his interviewers. He gave me a look, as he nodded at his recording device. It was difficult not to interpret that gesture into a language I knew well that said: "I've got it all here, on film, if you want to use it."

That was just before the TV crews arrived. I believe you saw what followed for yourselves on the six-o'clock news.

Alain d'Ivry, the talk show compere, offers me a glass of water, and with the cameras still working, I take a long drink.

"Are we still on?" I say.

He nods. "But don't worry—we'll edit this out later. Let's get back to the café scene. You say you didn't recognize the woman's face after she turned the gun on herself, but now, of course . . ." ∞

His astounding fossil finds—baby dinosaurs, nesting grounds, eggs, and the remnants of giant dino herds—provide a time machine back into the Cretaceous, 70 million years ago, and radically redefine the way we think about dinosaurs

INTERVIEW

JACK HORNER

Once again I'm in a bar in Bozeman, Montana, losing badly at eight ball. It's a familiar experience. This has been going on for years. I fly out to Bozeman to interview Jack Horner about the dinosaur fossils he's been finding. For a few hours I torture him with question after question—Jack is not very fond of interviews. Then when we are done, he tortures me by making me play pool and drink his favorite beer. Actually the beer is okay, it's the pocket billiards I'm getting a little tired of. I don't think it's revenge he's after, exactly. But it sets him back on an even keel to be in an environment that he likes, doing something that he's good at. Needless to say, I am not good at pool.

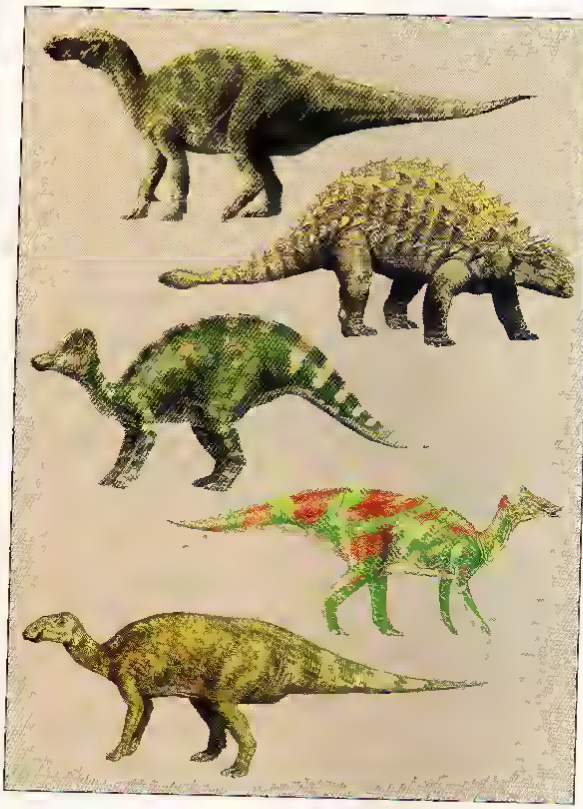
Most of these games of eight ball were undertaken for a book we wrote together, called *Digging Dinosaurs*. It might seem that after talking to somebody for five years about his work, there would be nothing left to find out

PHOTOGRAPH BY CHRISTOPHER SPRINGMANN

"Some of these bone beds are two and a half miles long, really huge. We're looking at thousands of individuals."

in an interview. Not true. Every time I talk to Jack I find out something new because he keeps discovering new fossils.

Ten years ago Jack was a preparator at Princeton University reconstructing fossils for museum display and study. Today he's famous for finding baby dinosaurs, dinosaur nesting grounds, and giant bone beds—the remnants of dinosaur herds—at a spot in Montana called the Willow Creek anticline. Single-handedly he turned baby dinosaurs from an extraordinary rarity into a growth industry. Now, following his lead and sometimes his direction, other researchers like Phil Currie from the Tyrrell Museum of Paleontology in Drumheller, Alberta, have been coming up with eggs, nests, and embryos in Canada and Mongolia. Jack himself has continued to find more eggs, more babies, and more herds of plant-eating dinosaurs, all in the Two Medicine formation in Montana, his geological stamping ground.



Jack was born in Shelby, Montana, in 1946. As a child he began collecting fossils of invertebrates from the fields around his home. At the age of eight he found his first dinosaur fossil, and after that there was never any real doubt what he would do when he grew up. He would keep collecting dinosaur fossils. And he did.

The dig at the Willow Creek anticline began in 1978 with a lucky discovery in a rock shop, a dusty little store in Bynum, Montana, that sold rock samples, gems, geodes, and fossils. In this shop was a coffee can full of baby duckbill fossils. Starting the next year, Jack and his crews, during six full summers of excavation, uncovered several nesting grounds of two new kinds of dinosaurs—named by Horner *Maiasaura peeblesorum*, a duckbill, and *Orodromeus makelai*, a small, speedy herbivore—as well as the remnants of a herd of 10 000 maiasaurs. The fossils showed that *Maiasaura*, or 'good mother lizard,' not only gathered in colonies to make nests but cared for the young in the nest the way birds do. The nest that produced that first coffee can of bones contained fossils of dinosaurs that had doubled in size since hatching. The dinosaurs showed wear on their teeth from eating and had trampled all the eggs from which they'd hatched. But they hadn't left the nest. *Orodromeus*, on the other hand, a smaller dinosaur—about eight feet from nose to tail instead of the maiasaur's 25 or more—left eggs with only the tops broken off. These smaller dinosaurs apparently left their nests as soon as they hatched.

From top: Iguanadon, *an ancestor of the hadrosaurs, armored, club-tailed* Ankylosaurus, Hypacrosaurus, *a crested skull duckbill,* Prosaurolophus, *a small crested hadrosaur.* Hadrosaurus, *a typical duckbill*

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"Jack is known as much for his contradictions as for his fossil finds. He has an honorary doctorate, a result of his paleontological success, but the highest degree he ever earned by actually going to school is a high-school diploma. And yet he received a MacArthur grant, the so-called genius award. As blunt as he is reticent, he always bridles at being asked why and how the dinosaurs became extinct. He is interested, he says, in how they lived and why they were successful, not how they died. In fact, his response has become such a trademark that he now has a rubber stamp given to him by a Bozeman writer that reads: WHO GIVES A SHIT WHAT KILLED THE DINOSAURS?

In my mind, the eccentricities and contradictions are not important. True, not many other paleontologists will recount the time they got swept up in a saloon melee during a small-town rodeo or how they left their rifle outside a Buddhist temple and spent an afternoon talking to two North Vietnamese Army regulars in the middle of the Vietnam War. But Jack's most striking characteristics—focused intelligence and gritty determination—are not at all out of place for a successful scientist.

In his conversation, everything relates to paleontology. He told me that when he studied paleohistology in Paris in 1985, he visited the catacombs and saw the piles of human skulls, femurs, and tibias. He thought it was 'one hell of a collection for some paleoanthropologist.' After describing that saloon brawl, he said that it is only when you get kicked in the head by somebody's heavy boot and still manage to escape to your pickup truck that you realize what a nice piece of engineering the human skull is.

These days what began with a pick and shovel at the Willow Creek anticline has taken Jack far afield. Airborne a week or two out of each month, he flies around the country lecturing. He practically commutes to Tokyo to consult on the

construction of an amusement park that will depict—with robotic re-creations of animals from lungfish to *Tyrannosaurus rex*—the history of the earth. He has five or six fossil sites in Montana that are either being worked or are ready to be worked. And he is overseeing the development of displays of *Maiasaura* and *Orodromeus* for the new wing at the Museum of the Rockies. Unlike any other natural history museum that I know of, the Museum of the Rockies will have lifelike sculptures of its dinosaurs in social situations with exhibits surrounding these displays.

"I want to be able to show exactly what things look like in the field when we find them and then go directly to fleshed-out models of the animals," he says. "And the whole museum is being built so that it can be changed. If we decide that the models of *Maiasaura* are wrong, we'll fix them. I refuse to have a museum that's out of-date."—James Gorman

Omni: If there were one thing that people should keep in mind to try to imagine what the duck-billed dinosaurs were like, what would it be?

Horner: They're more birdlike than reptilelike. You look at a snake and it doesn't look like it thinks or is curious. A bird is very curious and seems alert—I think that's the way a dinosaur would be. In these big nesting colonies they wouldn't be slugged-out. They would be very attentive to what was going on around them. In the new exhibit of Egg Mountain, being constructed for the Museum of the Rockies, some of the hypsilophodontids [small, graceful herbivores] are watching the bugs. We're talking about herbivores watching bugs. You don't know what the hell they're thinking, but you can have frugivorous birds that eat seeds and stuff, and if you put bugs in with them, they'll watch them.

Omni: When did you find your first dinosaur bone?

Horner: I took a trip with my father when I was eight years old. My father had at one time owned a ranch in Montana. He remembered riding his horse over the hills and seeing bones laying around. So when I was old enough to appreciate the fact that dinosaur bones were part of a dinosaur, he took me there. We walked around and looked at stuff on the ground, and I picked up a dinosaur bone. I still have it.

Omni: That bone came out of the Two Medicine formation, as did the fossils of dinosaur nesting grounds, almost twenty-five years later. You got wind of the find in a rock shop where you'd gone with your friend Bob Makela to identify some dinosaur bones. What happened?

Horner: That was 1978. The rock shop in Bynum, Montana, was in an old church. Inside, it was dusty, and stuff was lying all over. Marion Brandvold, the owner, was delighted to have all the bones identified, and then she wanted to know how much it cost. We said it was free, and she said, "Well, before you leave, could you look at one more thing?" And she handed me—it wasn't much—two pieces of bone, a piece of femur and a rib fragment, just an inch or so long each.

I knew right away. They were a lot smaller than I ever expected to see. I never expected to see tiny bones. To think of a hadrosaur [duckbill] that's going to grow to be almost twenty-five feet long and have bones that little—it just blew me away. I didn't explode with excitement. I was in a rock shop where they sell things. I didn't want to seem overly excited because I didn't want the owner to think she had something that was worth millions of dollars. I looked at it, and I turned to Bob and I said, "You're not going to believe this, but this is a baby hadrosaur." And Bob said, "Bullshit."

I told her it was very important scientifically that it was definitely a baby dinosaur, and asked if I could borrow it. She said, "Well, why don't you go over to the house—we have some more." And the stuff was just all over a card table, and we looked at it, and Bob picked up a jaw fragment and *his* jaw dropped. Marion Brandvold said she thought she could give the fossils to me, and she put them in a coffee can for me. Then we drove off.

> *"You see these old-time pictures of guys digging up dinosaurs and sending back boxcars full of bones. They weren't doing biological studies; they were stamp collectors."*

Omni: Those bones were from the first nest of *Maiasaura peeblesorum*. Over the next six summers you found nest after nest of these creatures, as well as other dinosaurs. What kind of animals were the maiasaurs?

Horner: To me the hadrosaurs are interesting because as reptiles, and I use that term very loosely, they're the most sophisticated of all. They have a complex dental magazine [sets of teeth] and are capable of chewing food, which is something hardly any other reptiles have ever been able to do. And hadrosaurs were the most common group of dinosaurs that ever lived, probably the most diverse, too.

If you looked in the mouth of a hadrosaur, you wouldn't see much other than teeth. It would just be sort of a pavement of teeth on each side, bottom and top. No animal today has anything like that. If you were going to compare them with some kind of animal, it would have to be a rodent. Put a duckbill beak on the front of a rodent and you'd sort of get the idea.

And that bill allowed them to eat a lot of different things. What's neat about a bill is that it allows you some variety in what you're going to grasp. With those dental magazines you're able to chew just about anything you can grasp. You're not stuck with one vegetable.

Omni: How big was *Maiasaura*?

Horner: Almost twenty-five feet long on average, a middle-size hadrosaur. It's difficult to say how big she finally got. Like all dinosaurs, she could keep on growing throughout her life. But there are bigger animals. There are hadrosaurs that have been found in Africa that are just huge, around forty feet long. *Maiasaura* had relatively massive hind legs, but not front legs. She had slender, long, not heavily muscled arms.

Omni: At the Willow Creek anticline you found colonial nesting grounds where dinosaurs gathered, nests of fossilized babies, eggs with embryos in them, a herd of dinosaurs. How did these finds change our view of dinosaurs?

Horner: The information from the Willow Creek anticline didn't change people's views because few had any ideas about what dinosaur behavior would be like, and there really wasn't any evidence until then. The Willow Creek anticline offered the first evidence of true social behavior in dinosaurs.

Paleontologists in the late 1800's and early 1900's had really done nothing more than go out, collect bones, bring them back, put them together in a museum, put a name on them, and write short little notes about them. Up until the mid-Sixties very little was going on in dinosaur paleontology. Then John Ostrom of Yale and a number of other people went back into a lot of the old sites and started getting some new material out and looking at the data a little differently. It was then that paleontologists started looking at biological problems of dinosaurs, looking at them as living animals. People started thinking about whether dinosaurs were warm- or cold-blooded. They began looking at their brain sizes and growth stages—trying to figure out their behavior. They began seeing that much of what seemed to be separate species were really just young dinosaurs of already named species.

Omni: Did you conduct the Willow Creek anticline dig any differently than it might have been done thirty years before?

Horner: It was a seat-of-the-pants operation. You have to remember that we were dealing with a site that was unlike anyone else's. Here we had nests on single time horizons—that is suggesting they were all together in one nesting season. So we worked it pretty much like an archaeological site, treating it as if it were a real community. We took it more slowly, looked

at the sediments looked at the bones in context with the sediments, made three dimensional maps, tried to figure out the ecology of the animal and the total environment. Maybe because I didn't have a college education or a college degree I wanted to make damn well sure that when all my stuff was back at the lab that people wouldn't come and say, "Well, you don't have enough information here to do this or that." I wanted to make sure I had too much information. I mean, we were looking at the living plant life on top of the fossils, we were looking at everything. There are lots of things you can do with the once-living, just like you can do with any living population.

Omni: Your approach certainly sounds time consuming.

Horner: We're using what people might call high-tech equipment to analyze these things. It's not like we're stuck with the old light microscope and a hammer and a chisel anymore. We're examining eggs and skeletons and skulls with CT [computerized axial tomography] scans to look inside the structures and see what's really going on. Andrew Leach at the University of Toronto has set up a big paleontology CT scan operation. So if you find a dinosaur skull and it's a real beauty and you don't want to chop it up in pieces or drop it on the floor, you can take it there, scan it, and get a detailed, accurate, three-dimensional image that you can put on a computer. You can rotate that image, look inside of it, and tell where everything is. It's wonderful.

Omni: There's criticism of trying to do scientific studies of dinosaur behavior on the basis of fossils and sediments.

Horner: Well, conjecture is certainly involved in dinosaur behavioral studies. But you can say the same thing about a murder, that if no one has seen the murder, then it's pie in the sky to think you could ever come up with a person that did it. And yet you know damn well that you can, given enough information. The more information you get, the closer you get to the murderer, and the same thing goes for dinosaur behavior.

The first maiasaur nest we dug up with the babies in it is a good case. The fact that a bunch of babies was there suggests that they were taken care of. They're bigger than they would have been if they had just hatched out of an egg and then died. And they're all together in this nest-like structure with eggshell in it. And so my first idea, my first presentation of this find, was it's a nest of babies that were taken care of by a parent.

The second piece of information I used had to do with the ends of the babies' bones, of their legs. We find that maiasaurs have these very incomplete bones. The growth areas are very incomplete, suggesting that these little dinosaurs would have had just a hell of a time walking around all by themselves. Other dinosaurs, like the hypsilophodontids, we found have more developed bones.

The third bit of evidence is neoteny. The baby dinosaurs in nests are neotenous, meaning they retain their hatchling look for an extended period of time. It's a kind of retarded development.

Omni: Just what do you mean by neotenous characteristics?

Horner: A flat face, big eyes, a big brain, a big, round head, just like a puppy or a little baby when it's born, plus a real tiny nose and big eyes. They're cute. When we look at something and we say, "It's not cute," it's because it doesn't have the right features. Some animals just are not cute at all, and yet if you give them those features—big eyes, big brain, squashed face—they are. If Konrad Lorenz and Stephen Jay Gould are correct, that's a releasing mechanism for parental nurturing behavior.

Omni: Are any reptiles neotenous?

Horner: No. The only ones that even come close are alligators. The babies have big eyes and the beak is tipped up a little bit. But they do not have a real pudgy face. There are no amphibians like that, so it's really neat to see neotenous characteristics in a baby dinosaur. Not all baby dinosaurs have them. The hypsilophodontids from the Willow Creek anticline are not really neotenous. The club-tailed ankylosaurs are not neotenous. Phil Currie's new ankylosaur babies that he found in Mongolia are not neotenous. And neither of these dinosaurs seem to have stayed in the nest after they hatched. So it appears to fit in with the other evidence.

Omni: These hypsilophodontids, *Orodromeus makelai*, what were they like?

Horner: They were about seven feet long. I have no idea what they ate. They have such primitive teeth I would think they may have been omnivorous, but they may have been insectivorous. I think the young were cared for to some extent, although they didn't stay in the nests. We find a high density of juveniles in these hypsilophodontid nesting grounds, and they're a lot bigger than they would have been at hatching. They might have left the nests but stayed in a creche, a little herd of young, as penguins do. All the young and eggs that we've found were on islands back in the Cretaceous, when the animals were alive. We find adults but never baby hypsilophodontids off these islands. So if they're staying on a small island, what the hell are they eating? Somebody must be bringing something home to them.

Omni: What were the anticline and the Two Medicine formation like during the late Cretaceous period?

Horner: All over the world during the late Cretaceous, sea levels were higher than they are now. There were a lot of inland seaways where there are now continents. North America was separated east to west by the Western Interior Cretaceous Seaway. The seaway connected the Arctic Ocean to the Gulf of Mexico. The Appalachian Mountains were the highlands of East America, the Rockies were the highlands of West America. In between the mountains and the sea in the west, as the Rockies pushed up, they created foredeeps or depressions out in front. That's where the Two Medicine formation was. It was deposited as the mountains kept coming up and the foredeep got pushed down. There was a slope from the mountains to the sea, but it was gradual, so it could catch sediment as it was shed from the mountains. So the Two Medicine formation, the upper part of the remains of that coastal plain from the Rockies to the sea, is a wedge that's thicker near the mountains.

Omni: What geological activity did the dinosaurs see?

Horner: If you try to visualize the whole area, think about mountains off in the distance, rugged looking because they are thrusting up, broken, not glaciated, but busted up. And there's stuff eroding from them—probably taster than any vegetation can hang onto them. Out in front of them you can probably see little volcanic cones, and to the south, another big volcanic pile. That's what the big topography would've looked like.

Omni: What are you finding along the Two Medicine River?

Horner: Well, there we've got a whole section, which is six hundred fifty meters square. In the last two years we've looked through the whole thing. This year I was concentrating on the upper part of it, the top one hundred meters. We're looking straight at seventy million or seventy-two million years ago, somewhere in there. At this site we're finding two kinds of duck bills, hypacrosaurs and prosaurolophids. We're finding hatchlings of both—nestlings, embryos, nests. And we're finding massive bone beds of hypacrosaurs and prosaurolophids.

At another, much bigger site we've found a nesting ground of hypacrosaurs and what appear to be nesting grounds of the horned ceratopsians, but they're not cleaned and reconstructed yet, so it's hard to tell. The hypacrosaur nesting

> *"We find that baby maiasaurs have very incomplete leg bones, suggesting that these little dinosaurs would have had a hell of a time walking around all by themselves."*

ground seems to be three miles long, up to a quarter of a mile wide, and on three different levels, suggesting that they repeatedly nested there. And at the same site we've also found some gigantic bone beds of ceratopsians [horned herbivores]. Some of these beds are two and a half miles long, really huge, huge ones. Everywhere we go we're finding giant nesting grounds and bone beds. We're looking at thousands of individuals.

Omni: What does this tell you about dinosaur social life?

Horner: It says that ceratopsians and hadrosaurs were in giant herds. We have no evidence that any other dinosaurs ever were, except iguanadonts [big, bipedal ancestors of duckbills]. Big accumulations of iguanadonts have been found in Belgium. But hadrosaurs and ceratopsians are the only ones that we really find in gigantic nesting grounds or in gigantic herds. The rest of the animals we find are isolated. So it appears that hadrosaurs and ceratopsians were very gregarious, but that other kinds, like hypsilophodontids, may have nested in smaller colonies and apparently were pretty much solitary animals after they left their nests.

Omni: Let's suppose we're standing on the upper coastal plain, seventy or more million years ago. What would we be looking at?

Horner: We're looking at probably a semiarid environment, very much like the Serengeti Plain in Tanzania. It's certainly not jungly or swampy or anything like that. And it's not covered with grass but with bushes. There's a lot of vegetation along the streams, around the lakes, but generally it's pretty sparse. If you looked out on the plain you might see herds of a particular kind of dinosaur and carnivorous dinosaurs creeping around the edges of the herd, looking for something to eat.

In most books what you see are artists trying to get all their dinosaurs in one picture. You wouldn't actually see that anywhere. Even if you were looking at the Serengeti Plain today, you might see wildebeests and zebras and lions all in the same picture, but it's hard to see many more species than that together at one time. Looking out on the dinosaur plain you might get three different genera of dinosaur also in one picture. But you're not going to get fifteen different animal types all in one picture.

Omni: When they gathered in nesting colonies, would they have been raucous and messy?

Horner: Absolutely. Around any bird colony it just stinks terribly. And it would have been similar for the dinosaurs. I was going to visit a pelican rookery near the Two Medicine River in Montana. When I started to get close, I stopped. Besides the noise of it all, the smell was just terrible. The whole damn thing was just covered with pelican guano. I'm sure that's the way a nesting colony of maiasaurs would have been. I'm sure they made

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The new Blue Book will be a private enterprise, free of official constraints, claims an Arkansas industrialist

ANTI-MATTER

UFO UPDATE

Twenty years ago the U S Air Force closed the doors on America s most prominent UFO investigation Project Blue Book After examining Blue Book's files many scientists declared that UFOs did not threaten national security Yet at the end of a 22-year operation, more than 700 sightings listed in Project Blue Book logs remained unexplained

Now these old cases and others are being thrust back into the active files of a reborn Project Blue Book brainchild of Arkansas industrialist William Pitts And this time Pitts insists things will be done right For one thing, he says while the old Blue Book depended upon government funds and military approval, the new Blue Book will be a private enterprise free of official constraints What s more while the old Blue Book never had more than three or four people on staff the new and improved version will tap a large group of anonymous advisory consultants, mostly retired professionals drawn from the Pentagon and a spate of U S intelligence experts

Starting with a handful of his own government and military connections Pitts was gradually able to round up 148 official participants—all of whom have been promised absolute anonymity in return for their expertise "I set it up that way because many associates didn't want their friends and families—and especially people in their offices—knowing they are [illegible] this new Blue Book or even interested in [illegible] explains

Assuring confidentiality everyone Pitts is calling on both civilians and military personnel to come forward with any data 'on classic cases still considered unsolved " Secret members of his high-level research team Pitts promises, will be on hand to evaluate incoming material, correlating it with newer case information

Such dedication apparently isn't enough to satisfy some Blue Book watchers Almost from the moment news of the new Blue Book made the rounds Pitts has had to contend with the suspicion of researchers who question his ties to the military and intelligence communities "It just makes me wonder what this project is *really* all about ' grumbles one researcher with a background in naval intelligence "Is this a ploy by the government to find out just who's leaking information? It sounds mighty fishy to me

Jerry Clark, codirector of the Center for UFO Studies in Evanston Illinois expresses some words of caution as well ' What he s doing is certainly a worthwhile project some of the early Blue Book cases are extraordinarily important But Pitts has to assure us that he is not reporting his information to government authorities Unless he does so, it will be argued—justifiably or unjustifiably—that he's actually *participating* in the cover-up "

Despite these concerns, the new Project Blue Book has received details of more than 120 cases since its inception in September 1988 A number of these cases may be explainable For instance Pitts says his crew of insiders may help identify flights of the eerie-looking Stealth fighter and other experimental craft, that witnesses have mistakenly concluded were UFOs —*VICKI COOPER*

SEARCH FOR THE BERMUDA FIVE

It was 1945 when five Navy bombers disappeared off the coast of Florida fostering the notion that the region known as the Bermuda Triangle held a mysterious malevolent force But now a former Vietnam helicopter pilot, currently employed by the Federal Aviation Administration says he knows where the bombers are

Jon Myhre who earned 30 medals, including the Distinguished Flying Cross during the Vietnam War does not believe the standard Bermuda Triangle theories that say the planes were swallowed up by UFOs or other supernatural fare Instead after extensive research Myhre says he has concluded that the planes were downed by harsh atmospheric conditions and stormy seas

Based on his studies he plans to conduct physical searches for the planes. His calculations derived from the velocity and altitude of the planes have convinced him he knows where they are

Despite Myhre s determination however one Bermuda Triangle expert—author Charles Berlitz—doubts he will have much luck 'These bombers have been identified' many times Berlitz says but the numbers never match those that were on the actual planes As far as I'm concerned their disappearance remains mysterious I would be very interested in seeing f the numbers on the planes he hopes to find match those that were on the original bombers

Myhre feels his conclusions are correct, however "The hard research is completed, he says and we have a couple of companies interested in helping with the physical search Positively identifying one or more of the planes he adds 'will put the question to rest for good

Rick Boling

SOAP OPERA BABIES

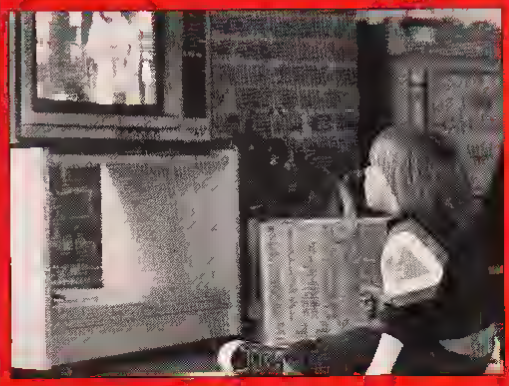
Some children may become soap opera fans while in the womb That s the conclusion of psychologist Peter Hepper of Queen s University at Belfast in Northern Ireland who says fetuses may link theme music from *Dallas* and *Dynasty* with the relaxed time their mothers-to be spend in front of the TV

'Mothers addicted to such shows report settling down with a cup of tea and their feet up to watch them, Hepper says In this way a fetus may become addicted to the theme tunes

What s more Hepper has recently supported his theory with controlled studies in the lab To do his experiment Hepper studied 14 pregnant women Half the women religiously watched *Neighbours* a daily Australian soap popular in the United Kingdom Another group did not watch the show at all When the children were born six babies in the first group became quiet and alert when they heard the theme tune compared with only two in the second group

Says Hepper We often overlook the fact that development begins at conception and not at birth

—Ivor Smullen



STRANGE YEAR

What does a fall of pink frogs on Gloucester England have in common with Ronald Reagan s alleged interest in astrology? Both events were honored on the latest top-ten list of last year s strangest occurrences Reagan took second place the trogs fifth But nosing out the ex-president for the top spot was the so-called Lizard Man of Lee County South Carolina (see *Omni* s October 1988 issue)

The sightings of this swamp thing probably took number one because the case peaked as we were preparing the list explains Mark Chorvinsky who compiled the Second Annual Ten Strangest list with the staff of his *Strange Magazine* "We re like the Oscars Things that come out near the end of the year have a better chance of getting selected Otherwise the only criterion for selection for the list, which covered events between October 1 1987 and October 1 1988 was their strangeness This is not an endorsement of their reality" he says

Appropriately strange is that the eighth-place winner is the one who walked away with all the money He is a New Jersey man who claims he had a dream in which his daughter who had died a month earlier appeared and told him to play lotto He did so the next day with numbers he found on tickets in his dead daughter s car and won $10 5 million

The exorcism of a ghost ship and reports of a Japanese Christ also made the list which appears in the third issue of *Strange Magazine* (Box 2246 Rockville MD 20852) But the list makers didn t think 1988 was an especially strange year In some years—like 1898 1932 and 1973—all hell breaks loose " says Chorvinsky 'This was not one of those years Patrick Huyghe

"To individuals, insanity is rare but in groups, parties nations and epochs it is the rule

—Friedrich Nietzsche

LIVE SOUTH SEA FISH

Deep in the Indian Ocean between Africa and the island of Madagascar lives the coelacanth The 350-million year old survivor is a close cousin to the first fish to come ashore and in effect father of us all

Long believed extinct a five-foot 90-pound coelacanth was discovered by a local fisherman in 1938 Scientists have since searched worldwide for more of the rare species but it seems to thrive only off the tiny Federal Islamic Republic of Comoros Here natives angling for oilfish have caught exhausted and quick-dying coelacanths at the rate of four or five per year

Enter the Explorers Club Hoping to capture the world s first *live* research specimen the group set up shop with top marine biologists The group finally acquired one live coelacanth from local fishermen

' The plan was to lower the fish immediately in a shark-proof cage and then mark the location with a buoy, explains project engineer Allan Tarvid Then we'd move it up slowly, about one hundred feet a day so that it could naturally adjust to changes in pressure '

The next morning brought disaster The buoy was gone and electronic scanning could not detect the caged coelacanth Project director Jerome F Hamlin doubts the fish was stolen for food 'Whoever stole the float," he says ' was probably just interested in six hundred feet of rope

The group remained several weeks longer, but with no further sightings Before heading home, however, Hamlin instructed local fishermen in the art of keeping their next catch alive I have confidence in the infrastructure I ve left behind ' he says Besides the reward for a live coelacanth has been posted at a princely (for Comoros) $400 —Mindy Leaf

That man is descended from some lowly organized form will, I regret to think, be highly distasteful to many

Charles Darwin

THE MIDAS MOUND

It was more than 30 years ago when University of Pennsylvania archaeologists excavated a burial mound near the ancient Turkish city of Gordium. There they found the remains of a small old man surrounded by caldrons, bronze drinking vessels and wooden furniture. Because some scientists believed the site to be the grave of the infamous Phrygian king who ruled Gordium from 738 B.C. to 696 B.C., they dubbed it the Midas Mound.

But has the mound been correctly named? Could this be the legendary Midas of yore? To find out, two British researchers—archaeologist John Prag of the Manchester Museum and face-reconstruction expert Richard Neave of Manchester University—reviewed the legend itself. The myth tells how the god Dionysus granted Midas his wish that everything he touched turn to gold. Midas subsequently angered the god Apollo and received the ears of an ass.

Keeping this information in mind, the researchers photographed and made a plaster cast of the 2,700-year-old skull. The face that emerged was that of an elderly man with a strong nose and a slightly protruding lower lip. "There appears to be nothing coarse or brutal about him," says Prag. "He appears a careworn but intelligent man."

To match the skull to myth, however, the researchers must account for the legendary ears. "Several medical conditions," Prag states, could have given rise to the story, but few, if any, would have left traces on the skull. At present, the most likely disorder seems to be one called hairy ears. Found only in men, it causes hair to sprout dramatically on the edges of the ear around the age of thirty.

To investigate this theory, geneticists will soon begin a study to see whether hairy ears are prevalent among modern residents of the region. If so, it would indicate that their notorious ancestor—King Midas—might have had the disorder as well.

—Ivor Smullen

EQUAL OPPORTUNITY ABDUCTORS

Are UFO abductions peculiarly American? In her new book *Abduction*, British UFO investigator Jenny Randles answers no. Although she emphasizes British cases, Randles provides a catalog of abductions from around the globe.

Randles wrote her book "to get the right people involved in the subject." By this she means psychologists, psychiatrists and sociologists. She says that the experiences should be treated like other psychological phenomena and thinks they would be if they didn't have "the little green men" connotation.

Randles worries because American investigators have jumped to the extraterrestrial conclusion, causing a confrontational situation between the investigators and the debunkers. This results, she says, "in the people who have had the experience and who want to find out the truth losing out."

So it is not surprising that Randles steers a middle course. Abductee memories may be jarred by hypnosis, she opines, but only by medical professionals. Interpretation of the memories should occur only when enough data are available to make that a fruitful activity.

Despite the publication of her book, Randles does not expect to generate the excitement abductee reports have created in the United States. "Abductions are viewed as a minor thing in Britain," she says, "almost a joke."—Paul McCarthy

"One gets to the heart of the matter by a series of experiences in the same pattern, but in different colors."

—Robert Graves

BODY

CONTINUED FROM PAGE 26

Most particle beam therapy relies on protons—positively charged subatomic particles—which have about the same biological effect on the body as X rays. By disrupting a cell's metabolism and breaking up its DNA, they prevent it from reproducing, and eventually the cell dies. Unlike X rays, particle beams can be strictly controlled to penetrate no farther than the tumor and to unleash their cell-killing energy directly on the target. The LBL Bevatron uses helium ion beams, which are heavier than protons and deliver even more precise results.

Until recently, however, even those doctors with access to particle accelerators weren't able to make optimum use of them because they couldn't accurately gauge the *volume* of their patients' tumors. The development of three-dimensional diagnostic tools like CAT scanners and MRI (magnetic resonance imaging) gave particle beam therapy a significant boost. Now that they can map tumors with great precision, doctors can tailor the *velocity* and direction of particle beams to destroy a malignancy while leaving the surrounding tissue intact.

The velocity of a particle beam determines how far into the body it will travel before depositing the bulk of its energy. To vary the beam's velocity, technicians pass it through a unit called a telescoping water absorber, structurally similar to the collapsible plastic cups campers use. When the absorber is adjusted to one of its longer settings, the beam must pass through more water and travels more slowly as a result. Once they pass through the absorber, particle beams converge on a tumor site from several different entry points, thereby minimizing the dose of energy carried on any given path.

Once a particle beam reaches the end of its range, it dumps the bulk of its energy within a very small area known as the Bragg peak (named after British physicist Sir William Henry Bragg, who first described the phenomenon), ideally right on top of the tumor. Heavier ions are considered superior to protons because they yield even sharper Bragg peaks, further minimizing the chance of damage to healthy tissue.

Physicians can also shape beams to fit a tumor by placing a customized metal shield between the patient and the beam at the point where the beam leaves the accelerator. In much the same way that photographers adjust or switch camera lenses when they focus on a new depth of field, radiologists using particle beams cut apertures in the metal shields to fit the dimensions of the tumor. Because they can tailor a beam to the precise configuration of a cancer site, they can confer on it a higher dose of energy than could safely be used with X rays.

Fermilab founder Robert Wilson was the first physicist to recognize, in 1946, that the Bragg effect could make proton beams a useful weapon for targeting cancer cells. Providentially, he was then designing the cyclotron that is still in use at Harvard, and in it he accounted for the therapeutic applications he foresaw. Wilson began experiments using his accelerator's proton beams to treat pituitary tumors in 1959, but proton therapy remained a limited option for the next two decades. For one thing, says Fabrikant, the early CAT scan images bore a greater resemblance to the work of painter Marc Chagall than to the sharply delineated maps of tumors generated today. Only with the advent in the early Eighties of sophisticated computer-assisted imaging tools like MRI and positron emission tomography (PET), along with a better understanding of tumor biology, did this new form of medicine really begin to hit its stride.

Today there are ten particle beam accelerators used for medical treatment worldwide—three in the United States, two in Japan, three in the Soviet Union, and one each in England, Sweden, and Switzerland. Altogether, roughly 6,000 patients have been treated for different types of cancer, as well as for a few noncancerous ailments like AVMs, acromegaly, and Cushing's disease. Originally designed for particle physics research, the accelerators were turned over to the medical community only when they became obsolete for physics experiments.

According to Kjellberg, the only negative aspect of particle beam therapy beyond the cost of actually building additional accelerators to treat more patients, is the delay between treatment and final results. It can take more than a year, he says, for tumors treated with particle beams to finish shrinking, during which time some patients continue to have gradually diminishing symptoms. Once the tumor finishes shrinking, however, it is far less likely ever to recur. After the two-hour surgery to remove a pituitary tumor, the patient is virtually cured but very often experiences a recurrence after several years,' he says. 'You don't have that likelihood with particle beams.'

Loma Linda's new accelerator, according to Kjellberg, "really proves the science." The first such facility to be based in a hospital, it reflects radical design changes from the accelerators originally built for physics. Capable of treating up to 100 patients a day, it should take some of the heat off the LBL and Harvard facilities, where patients currently have to wait as long as a year for treatment. Patients will probably reap an added benefit from particle beam therapy when they get their hospital bills. The treatment with an accelerator will be cheaper than a course of traditional radiation therapy, which can involve up to 20 X-ray treatments over a month or more. DO

EARTH

CONTINUED FROM PAGE 28

they noticed that in the early morning hours before dawn, green tips had begun to poke through the hard ground.

Evenari added more crops—a mixture of those named in ancient papyruses and those he thought would do well in arid conditions. He planted apricots, apples, cherries, almonds, olives, pistachios, and vines, as well as field crops like wheat, sesame, and sorghum. To his surprise, almost all of them thrived.

Within a few years, the farm had become a stopover point for anyone interested in desert agriculture. It attracted scores of volunteers from Israel, the United States, and Europe who stayed to do their own research. Flush with their success, Evenari and his wife, Lisle, established another farm near another wadi, or seasonal stream. This time they introduced modern technology in the form of wide plastic conduits to drain water from one terrace to another. Their disloyalty to history betrayed them. The plastic pipes didn't drain as well as the primitive stone sluiceways did, and a flood washed away large sections of the walls.

Meanwhile Evenari was churning out scores of scientific papers about the Nabataean method and how it could be used in destitute parts of the world. His research on how animals and plants survive hot, arid conditions made him one of the world's foremost desert biologists.

Evenari now works out of Jerusalem, where he moved several years ago after suffering a third heart attack. At eighty-five, he pursues botanical research, writes, and reaps degrees and awards throughout the world. He nurses a vision of a peaceful Middle East in which methods like his could be freely disseminated.

'This is one of the most important things that can help ease the hunger problems of developing countries,' Evenari says of his runoff agriculture method. 'This is the future.' DO

CREDITS

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TRAVELOGUE

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ties is only one of many available Earthwatch trips. Joan Thubel, a retired Bell Systems manager, has assisted University of Hawaii psychologist Louis Herman in his efforts to teach language to bottlenosed dolphins and has charted the movements of orangutans in the Tanjung Puting Preserve in East Borneo. Ernest Igou, owner of a Chattanooga lithography company, helped chart bird species on the British Isles. And Bill Davis, a Charlotte, North Carolina, bank vice-president, has participated in two dinosaur hunts.

Earthwatch-sponsored expeditions are neither cheap (two-week sessions range up to $1,500, most of which goes directly back to the project) nor easy. "It's menial labor; you work hard," says one volunteer. "But it's the sort of thing you could never do on an ordinary vacation."

Besides the ongoing projects listed above, this summer's Earthwatch expeditions include:

- An archaeological dig to investigate working-class life during the Roman Empire by examining mosaics, personal goods, and bones from an ancient Carthaginian graveyard in Tunisia.
- A project to photograph and preserve "The Lightning Brother," a series of spectacular aboriginal cliff paintings in northern Australia.
- A field effort to relocate the sanctuaries of meter-wide giant clams in the Pacific island kingdom of Tonga.
- A paleontological expedition to recover the remains of dozens of mammoths from the mammoth graveyards of Hot Springs, South Dakota.

In all, 115 projects in marine studies, animal behavior, climatology, art and archaeology, geosciences, and life sciences are planned by Earthwatch in 1989. For further information, contact Earthwatch, 680 Mount Auburn Street, Box 403, Watertown, MA 02272. Telephone (617) 926-8200.

WESTERN STATES TELESCOPE TOUR

The great domed observatories of the American West are the Stonehenges of the modern world. Massive shrines on isolated mountaintops, they enable scientists to pierce the limits of space and time. These modern temples of the stars, however, are not restricted to the astronomy elite. You can visit them, too. We suggest you start with a walking tour of the Very Large Array (VLA) on the plains of St. Augustine, New Mexico. A vast movable system of radio telescopes that resemble giant dish antennas on rails, the VLA picks up and amplifies radio waves the way optical telescopes pick up light waves. Aided by computers that process the radio wave data into images, scientists "see" what otherwise might be invisible, probing distant quasars and galaxies and even searching for messages from an erstwhile E.T.

At our next stop, Kitt Peak, just outside Tucson, Arizona, astronomers are currently studying black holes and cosmic strings. Kitt Peak, which looks like Merlin's castle, houses 22 research-grade telescopes, among them a huge 158-inch reflector and an 82-inch solar telescope that is the largest in the world. Movies are shown at this beautiful site every week-day at 10:30 A.M. and 1:30 P.M. On weekends the films are followed by tours. You might also make a stop at Flagstaff, Arizona, home of the Lowell Observatory, this nation's largest. It was at this site that astronomers discovered the rings of Uranus and the planet Pluto. For tour information, call (602) 774-2096.

You'll have a chance to look through a telescope yourself when you follow the North Star to California. On clear nights during the week, visitors to the San Diego area can glance through Mount Palomar's famous 60-inch telescope.

In Los Angeles the Griffith Observatory telescope is open and free to the public from 7:00 to 9:45 P.M. on every clear night except Mondays. (Griffith holds a particular fascination for movie buffs. It was the site of the planetarium scenes in *Rebel Without a Cause* and features a statue of James Dean.) You may also glimpse the heavens free of charge Friday nights from the Lick Observatory on Mount Hamilton near San Jose. Reservations are required. To make arrangements, call (408) 274-5062.

As with any unique culture, the realm of the observatory has an etiquette all its own. On this point we defer to Timothy Ferris, author of *Coming of Age in the Milky Way*. "If you visit one of the large observatories at night, you should shut down your headlights when you get in sight of the dome," he advises. "Headlights will paint lights across the sky and interfere with observations."

Visitors must refrain from disturbing the astronomers while they work, adds Ferris. "The large telescopes are greatly overbooked, which means that even a first-class astronomer will get about ten to twenty nights a year observing,' says Ferris. 'They're on the mountaintop in a high-stress situation, and it's definitely not the time to buttonhole them and ask how the rings of Saturn were formed."

Since such constraints make large observatories poor places to socialize with astronomers or study the stars, we suggest you stop at one of the large amateur astronomy conventions taking place each summer. You might, for instance, arrange to be on your way from Mount Palomar to the Griffith Observatory on May 26, when the largest and most famous of these gatherings—the Riverside Telescope Makers Conference (RTMC)—is ex-

pected to attract some 2,000 people for what organizer Clifford Holmes describes as a weekend of "fast and furious astronomy." Held on a YMCA campground near Big Bear City, California, the conference features speakers, demonstrations, telescopes and accessories, and nighttime observing. Two classical domes with 10- and 14-inch telescopes are also available on the conference site. For information, contact Holmes at 8642 Welles Avenue, Riverside, CA 92503. Telephone: (714) 689-6893.

After leaving the RTMC you could head out to the Prude Ranch near Fort Davis for this year's Texas Star Party. During the week of May 29 to June 4, more than 700 amateur astronomers will descend on the site. Ideally located for observation and astrophotography, it is far from city lights. It is also a short drive from the McDonald Observatory, where special tours and observing opportunities are being planned in conjunction with this event. For information, contact Bobby Braley at Box 386, Wylie, TX 75098.

PRECIOUS METAL FEVER

If you have a yen for adventure as well as wealth, you can go prospecting—and even get rich—on an underground treasure hunt through the abandoned mines of America.

Our tour begins in the copper country of Michigan, where the ruins of the Quincy Mine sit just north of Hancock on a hilltop above Route 41. Known as "Old Reliable," the Quincy was once the largest copper mine in the United States. In operation from Civil War times to 1945, it employed some 2,000 men to work a shaft that slants 9,200 feet into the earth. Just to haul miners and ore back and forth from these depths required a steam hoist with a 30-foot drum—the largest in the world—which may still be seen by travelers who visit the remains of this engineering marvel.

Besides the hoist, compressor and boiler house, the site includes neighborhoods of prefabricated Sears, Roebuck houses, mail-ordered for the miners in the early years of this century, as well as several elegant villas in which the mine's agents and general managers once lived. Tours of the historic Quincy Mine are offered by the Quincy Mine Hoist Association in Hancock. Telephone: (906) 482-3101. For a three-dollar admission, the association will also guide visitors into the nearby Arcadian Mine. Farther north on Route 41, the abandoned Delaware Mine is open to the public as well.

Ghostly reminders of American history during the early Industrial Revolution, these sites conceal an even more remote past. Like many historic mines in the Lake Superior copper region (and elsewhere in America), they were built on prehistoric pits used by Native Americans to dig copper for their weapons, tools, and ornaments as long ago as 3000 B.C. In fact, a nineteenth-century Smithsonian survey of these prehistoric sites guided Michigan prospectors in their search for the rich copper lodes that made operations like the Quincy Mine possible. Another ancient pit, one left untouched by nineteenth-century mining companies, has been excavated and is accessible to visitors in Isle Royale National Park to the north of the Quincy, 60 miles offshore in Lake Superior.

Travelers can explore other historic and prehistoric mines as they travel southwest from Michigan. At Lead, South Dakota, for example, the original Homestake gold mine—once the cornerstone of the Hearst family fortune—is open to the public, although you are unlikely to find any gold there. Another site can be found at perhaps the most impressive prehistoric mine site in America, near the towns of Guernsey and Lusk in Wyoming. Misnamed the Spanish Diggings by nineteenth-century ranchers loath to attribute such industrial-scale operations to Native Americans, this massive series of quarries is scattered over a 50-mile area. As long ago as 8000 B.C., Plains tribes used the site to mine quartzite, a hard, glassy stone. The Spanish Diggings are one of the best places for visitors to view ancient artifacts. Marion Odde, who heads the Platte County Wyoming Historical Society, will provide information about touring the Spanish Diggings. You can even stay at her Bunkhouse Motel, Highway 26, Guernsey, WY 82214. Since the Spanish Diggings range over rough and, in most cases, privately owned terrain, some friendly diplomacy and a four-wheel-drive vehicle are advisable.

"Many of the classic Route 66 motels, diners, and souvenir stands—the components of American culture in an age before shopping malls—have been restored along the roadside."

Farther south, at Virginia City, Nevada, the remnants of one of the richest of the Comstock Silver mines have been preserved. And visitors to Yosemite National Park might enjoy a side trip to Bodie, California, a gold-mining town that was frozen in time when its inhabitants abandoned it in the late 1800's, in some cases leaving behind all their possessions in a rush to move to the next mother lode.

There are many other historic and prehistoric mine sites unmapped and unpreserved, in the areas surrounding these sites. If you want to try to hit pay dirt, the equipment you'll need varies from site to site. In the Michigan copper country all that's required are a good pick and shovel, since the high-grade copper that characterizes the region is soft and easily extracted from its bedrock. The Indians did it by chipping stone. Precious metals like gold and silver are more difficult to extract, but the most commonly used method involves treating mounds of ore with cyanide to dissolve the gold or silver, then chemically precipitating them out of the liquid that runs off the bottom of the pile. Amateur miners might try the technique of panning, or washing samples through a fine sieve.

A word of caution for would-be prospectors out to strike it rich. Recent increases in the price of gold and other precious metals, combined with new high-efficiency mining techniques, have made both historic and prehistoric sites attractive to more than just curious travelers. After years of neglect, mining companies have returned to some of these once-abandoned sites. Some of these companies may discourage claim jumpers by enforcing no-trespassing signs with shotguns.

MUSIC MAKING FOR TONE-DEAF SINGERS, AND OTHER LIVELY ALTERNATIVE ARTS

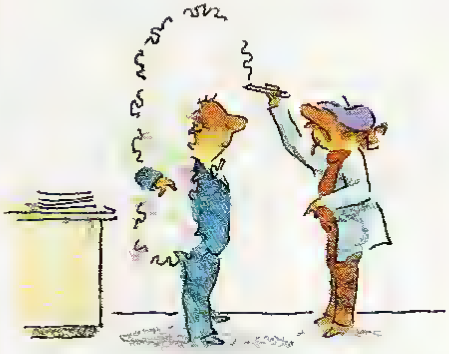
Express yourself! Our summer suggestions for programs in the arts are geared toward anyone with a creative urge—even if you'd like to dance but have two left feet or would like to lift your voice, no matter how off-key, in song.

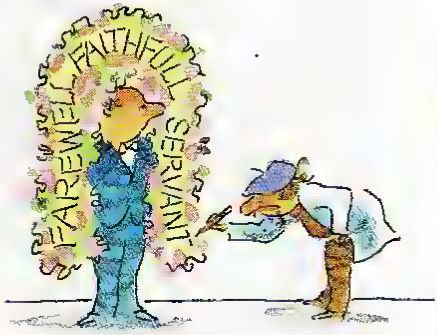
For those in the latter category, we recommend David Darling, a jazz cellist, composer, and arranger, who will be conducting several summer workshops for tone-deaf singers. Darling believes that anyone who can talk can sing. Most people who think they're tone-deaf are not, he explains. "Usually they've had a bad experience in school music programs. Teachers told them not to sing or to mouth the words, and from then on they thought they were unmusical."

Darling has worked with neurologist Frank R. Wilson, author of *Tone Deaf and All Thumbs?*, to develop a series of exercises that make it easy for virtually anyone to sing. "The first thing is getting people to slow down and relax," says Darling. "Once the tensions are gone, the joy of music takes over. Some workshop participants even discover that they are musically gifted. One of them currently sings with the Metropolitan Opera chorus." For a schedule of Darling's workshops, write to Carrie Coco, Box 881, Litchfield, CT 06759. The cost of the workshop ranges from $35 to $225, depending on the number of participants.

For those hoping to explore other un-

The Artist





tapped artistic abilities, an excellent program is available at the Omega Institute in Rhinebeck, New York. Highlights of Omega's wide-ranging summer schedule include dance workshops for nondancers by Jonathan Wolken, a director of the renowned Pilobolus dance company, a Spalding Gray acting workshop for nonactors, Frederick Franck's Zen of Seeing class for nonartists and a class in South African choral singing for nonsingers, taught by Joseph Shabalala, leader of Ladysmith Black Mambazo (the group that backed up Paul Simon on his *Graceland* LP). Information and workshop listings may be obtained from the Omega Institute, RD 2, Lake Drive, Box 377, Rhinebeck, NY 12572, telephone (914) 338-6030. Costs range from $120 to $250. Tents, dorm rooms or cabins cost $30 to $50 per day.

Finally, those with secret literary aspirations can rub shoulders with Beat Generation greats like Allen Ginsberg, William S. Burroughs and Michael McClure during the summer session of the Jack Kerouac School of Disembodied Poetics at the Naropa Institute in Boulder, Colorado. The Naropa schedule also includes beginner workshops for the Japanese contemplative arts of kudo (Zen archery), bugaku (court dancing), ikebana (flower arranging), and tea ceremony, in addition to programs in dance, music and the visual arts. For details, contact the Naropa Institute, 2130 Arapahoe Avenue, Boulder, CO 80302, telephone (303) 444-0202. Workshops run from $250 to $500.

ROUTE 66: WHERE ARE YOU?

Route 66, America's most famous two-lane blacktop—the "mother road" of John Steinbeck's *Grapes of Wrath* and the legendary road of Jack Kerouac's *On the Road*—is enjoying a comeback, at least on stretches of its 2,200-mile course, thanks to people like Angel Delgadillo. For Delgadillo, who has been cutting hair in his barbershop in Seligman, Arizona (population 800) for the past 38 years, Route 66 is a way of life.

"I was born on Route 66 in 1927, when it was still a dirt road, and I've lived on Route 66 ever since," he will explain to anyone who drops in for a trim or just to pass the time of day. "When I was a little older, we'd see the dust bowlers in their beat-up cars headed toward the land of milk and honey in California, carrying everything they owned with them and always with a mattress or two on top. We used to say that a poor Okie had one mattress on top of his car and a rich Okie had two. Twenty years later, after the war, we'd see the children of them same dust bowlers headed back east, drivin' big cars, to visit their folks back in Oklahoma. During the summers when people was on vacation, there'd be a steady stream of cars, day and night.

"Route 66 is a piece of history, so a few years back, when the hard times hit Seligman, I said, 'Hell's bells, all we got to do is market it.'" Today Delgadillo heads the Arizona Historic Route 66 Association, which has mounted an effort to draw travelers back to the road.

His is not an isolated effort. Though new and, for the most part, boring interstates have replaced 66 as the principal route from the shores of Lake Michigan in Chicago to Santa Monica, California, where 66 dead-ends at the Pacific, any traveler with a good road map can retrace the fabled path, finding much aura and legend still intact.

"It's not a ghost road," says Michael Wallis, now writing a book entitled *Route 66: The Mother Road and Its People*. "There's been a lot of renovation. The neon is shining along Route 66 again."

Many Route 66 motels, diners and souvenir stands—the components of what Wallis describes as "American culture in an age before shopping malls"—have been restored along the roadside. You'll probably want to indulge in the syrup-sweet memories of Ted Drew's landmark ice cream stand on Route 66 in St. Louis and sample the classic American roadside cuisine at the newly refur-

bished metal-and-opaque glass Metro Diner in Tulsa. Af the famous truck stop of Tucumcari, New Mexico the blue neon lights of fhe Blue Swallow Motel beckon weary travelers at dusk. In Gallup, New Mexico, an important trading post for Hopi, Navaho, and Zuni Indians and the shooting location for many Hollywood Westerns visitors can stay in the same room of the newly remodeled El Rancho Hotel where Ronald Reagan slept during his days as an actor.

Heading west, ofher parts of the road are time warps, where past meets present and fufure. The northern fork of Route 66 at Santa Rosa, New Mexico, leads up fo Los Alamos, where the atomic bomb was developed and the most advanced star-wars research is currently under way. Farther south, in Albuquerque, the road passes a high-tech stretch of new computer, fiberoptic, and bioengineering companies, whose employees dine on chicken-fried sfeak and green-chili cheeseburgers to the beaf of Fifties records af the now-trendy 66 Diner.

Meanwhile farfher west in Seligman, Delgadillo is overseeing preparations to celebrate the second anniversary of the designation of Route 66 as a historic site by the state of Arizona. A three-day 'fun run," planned for April 28 to 30, will include a Miss Route 66 pageant and a road rally and special events all the way to the California border. For information, write to Delgadillo at Box 426, Seligman, AZ 86337, or drop by the barbershop. Delgadillo still gives fhe best haircut between Seligman and Kingman on Route 66, and he'll be glad to see you.

EPIPHANIES UNLIMITED

As the Dalai Lama says, "The world is increasingly interdependent. It is crucial that all of us, the strong and the weak, contribute in our own way."

If you agree a series of trips organized by the Institufe of Noetic Sciences may be for you. Indeed, you can make your contribution to humanify by meeting the Dalai Lama, visiting Mother Teresa's orphanage in Calcutta, or celebrating the spirit of *glasnost* with a Russian family.

The institute, a nonprofit educational and research foundation, was started by Edgar Mitchell soon after his 1971 return from the moon, when he had an epiphany of the earfh as a living organism. If funds research into such subjects as psychoneuroimmunology, biofeedback, creative altruism, and peak performance. As part of its ongoing program to apply such research to a "global mind change," it encourages travelers to see, feel, and fhink about the world nof only as it is but as it might be.

San Francisco psychotherapist Danny Slomoff, director of behavioral medicine at fhe San Francisco Center for Comprehensive Pain Management and an initiate into several West African tribes, is typical of fhose who lead Noetic Sciences groups. On October 28 he will be taking a group fo West Africa, where members will observe the preparation of herbal remedies and participafe in the rituals of traditional healers. Says Slomoff, "It's a terrific way for isolated Americans to see how our differenf culfures can interacf in significant ways."

Other Noetic Sciences tours include:

- A trip to southern India (October 28 to November 19) conducted in conjunction with the institute's Altruistic Spirit Program. In keeping with this effort to ease human suffering, participanfs will spend time at Mother Teresa's orphanage and home for the elderly in Calcutta, visit a slum called the City of Joy, and volunteer at the Aravind Eye Camps (for people with eye diseases) in Madurai.
- A citizen diplomacy tour of the USSR (April 23 to May 11). In visits to Leningrad, Moscow, and Kiev, tourists will talk with Soviet citizens in their workplaces, schools, and homes. The purpose, es tablishing common goals for the future.
- A women's pilgrimage to sacred sites in England, Scotland, and Ireland, slated for June 19 to July 6. Besides investigating fhe ancient Druids, tour members will deepen their own inner quests, using

journal-writing techniques developed by tour leader Sandra Lewis

• A journey to traditional Tibetan Buddhist strongholds in the Himalayas (July 25 to August 15) The tour tentatively includes an audience with the Dalai Lama at his exile home in Dharamsala A stopover is also scheduled at the Ladakh Project, aimed at easing the local transition to the twenty-first century by fusing modern agricultural techniques with traditional farming

For further information about Institute trips, contact Marguerite Craig, Institute of Noetic Sciences, 475 Gate Five Road, Suite 300, Box 909, Sausalito, CA 94966; telephone: (415) 331-5650. Institute trips cost between $3,200 and $3,900

DAY TRIPS

Pressed for time? Here are five terrific quick trips that can be slotted into even the busiest schedule or combined with some of the more ambitious journeys we've suggested

• Chicago's Haunted City Tour Norman Basile—ghost hunter and paranormal investigator—is your guide on this six-hour bus excursion through 13 ghostly graveyards and haunted sites in the Chicago area. You will see Bachelor's Grove Cemetery, where ghost lights and phantom cars have been spotted; visit Chicago's most famous haunted house—Hull House—where the original Rosemary's Baby was said to have once lived; and take a ride down haunted Archer Avenue, domain of Resurrection Mary, the hitchhiking apparition. Cost: $25 per person. Bring your camera! Basile is an expert on spirit photography, and you never know what might develop. For tour schedules, contact Norman Basile, 14028 Laramie, Crestwood, IL 60445, telephone: (312) 597-0249

• Poverty Point For as long as anyone can remember, tiny flint knives, stone tools, curious, little baked clay objects, and other unusual Native American artifacts have been turning up along a series of long, low earthen ridges at an old plantation known as Poverty Point just north of New Orleans

The ridges, it turns out, are part of a remarkable prehistoric earthwork consisting of six huge concentric octagons and a colossal bird-shaped figure. Like Stonehenge, the mounds align with the rising sun at the spring and fall equinoxes, suggesting that they might have functioned as an ancient observatory or ceremonial shrine. Spread out over an 11-mile area, the enormous size of the configuration makes it one of the most staggering primitive engineering feats in North America. Louisiana has recently designated the site a state park.

• DNA Learning Center Beginning this spring, weekend visitors to the Cold Spring Harbor Laboratory on the north shore of Long Island will have a chance to do their own gene-splicing and cloning experiments. Now, in the course of a fascinating afternoon, anyone can cut, separate, and identify DNA fragments, duplicating the ground-breaking techniques that won Herbert Boyer and Stanley Cohen a Nobel prize and gave birth to the field of biotechnology. In addition, Cold Spring Harbor Laboratory—where renowned scientists like James Watson and Barbara McClintock do their work—will offer visitors tours guided by laboratory staffers on March 18, April 29, June 17, August 12, September 23, and November 18. Self-guided walking tours of the laboratory grounds are available on weekends, and "The Search for Life," a museum exhibition on genetic research, will be on display through September. For information, call (516) 367-8455 or write to Cold Spring Harbor Laboratory, Bungtown Road at Route 25A, Cold Spring Harbor, NY 11724.

• *Tamara* For a great evening at the theater in Los Angeles or New York, you might put on your walking shoes and take in this "living movie," so termed because the audience literally follows actors—each pursuing an individual story—around a three-floor set.

The setting is the elegant villa of Gabriele d'Annunzio, an exotic turn-of-the-century Italian poet, patriot, and profligate. We find him under house arrest awaiting the arrival of the aristocratic Polish beauty Tamara de Lempicka. The villa is full of surprises; audience members quickly realize, as they trail after these or any of eight other characters. As D'Annunzio plans Tamara's seduction in the kitchen, plots of a more dangerous kind are being hatched in the guardhouse. From the bedrooms of the servant's quarters to the grand oratorio, you are caught up in a web of political and romantic intrigue in which nothing is as it appears. Is the composer Gian Francesco de Spiga really a spy? Will Tamara fulfill the secret commission that has brought her from Paris? The answer may lie behind the next closed door. Tickets to *Tamara* are expensive ($60 to $135), but then the evening also includes dinner, cocktails, and wine. For information in New York call (212) 239-2590, in Los Angeles call (213) 851-3692.

• Robot Factory If you care to see robots in the workplace, here's your chance. At the General Motors manufacturing plant in Flint, Michigan, 216 state-of-the-art robots labor side by side with their human co-workers on an assembly line that epitomizes the future of heavy industry. One of the most advanced robots places car seats on a conveyor belt, using its electronic eye to match each seat with the appropriate model of car. Other robots weld in the body shop and install and seal windshields. Morning and afternoon tours are available to the public every Tuesday and Thursday. To make reservations, call the Buick City General Motors tour at (313) 236-4494.

INTELLIGENCE

CONTINUED FROM PAGE 32

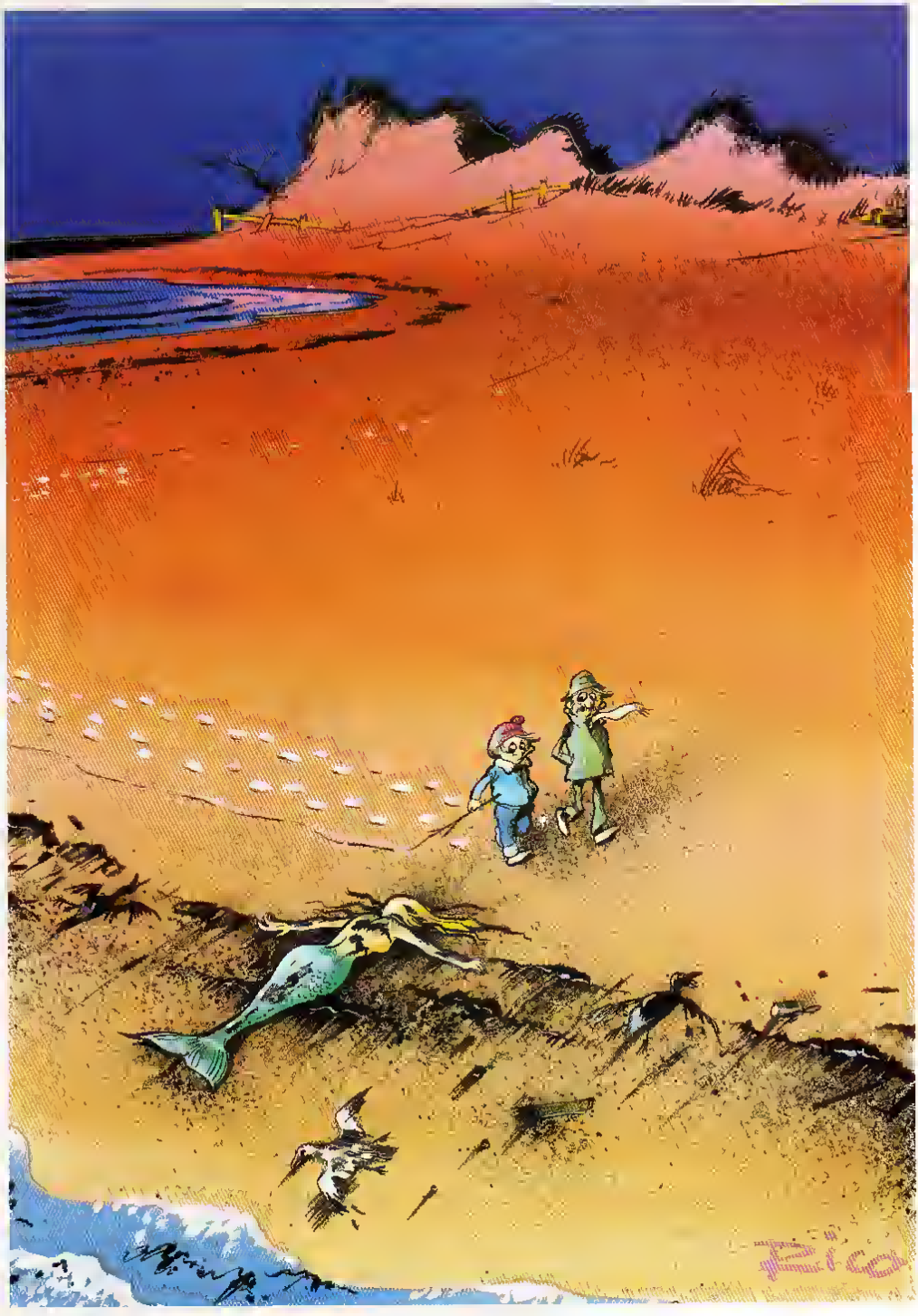
Assessment Center and developer of the RSAS software, has been debating Johnson for several months using a computerized Defense Department electronic bulletin board. "He's misrepresented or misunderstood everything we're doing," says Davis. "Most things he's simply wrong about. The RSAS is not part of any launch-on-warning system. There are fundamental differences between using war game models in peacetime to clarify issues and to think out alternatives and using such models for decisions in the midst of crisis or conflict."

From his origins as a lower-class Londoner, the thirty-nine year-old Johnson might seem an unlikely candidate to debate the U.S. Defense Department on its own turf. In fact, it wasn't until after settling in this country that he became concerned about nuclear war policy. "In 1983 the United States installed cruise missiles in Greenham Common, near my hometown in England," he recalls. "I started to think about the safety of my friends back there and then about my personal safety in this country. I did a lot of research into launch on warning. On February twenty-ninth of 1984—I thought the date quite appropriate—I filed my suit against Caspar Weinberger."

By this time Johnson was no stranger to litigation. He had been fired from the Bank of America after preparing a report—at his boss's request—on possible budget cuts in the computer department. Evidently, top management felt some cuts did indeed need to be made and fired both Johnson and his boss. Johnson sued the bank for $250,000 in damages and a satisfactory job recommendation. Acting as his own attorney, Johnson became enamored of the law—even though he ultimately lost this case and was ordered to pay $50,000 in trial costs to the bank.

In addition to that hefty fee, Johnson, who is now the manager of computer planning at Stanford University's Data Center, has spent more than $20,000 on his suits against the Pentagon, a figure that is certain to rise if he keeps to his game plan, namely to take his case all the way to the Supreme Court. Now aided by the Lawyers' Alliance for Nuclear Arms Control (LANAC), an association of 9,000 attorneys concerned with the legal aspects of nuclear disarmament, he may finally have enough backing to do so.

Till then, the impassioned Johnson and groups that support him, such as The Alliance to Stop First Strike, continue to sound a warning. "The idea of using artificial intelligence was to replace irrationality with rationality," Johnson says. "Instead, we're mechanizing the gambling component of war. The longer we continue to gamble, the greater the mathematical certainty of nuclear war."


Eric

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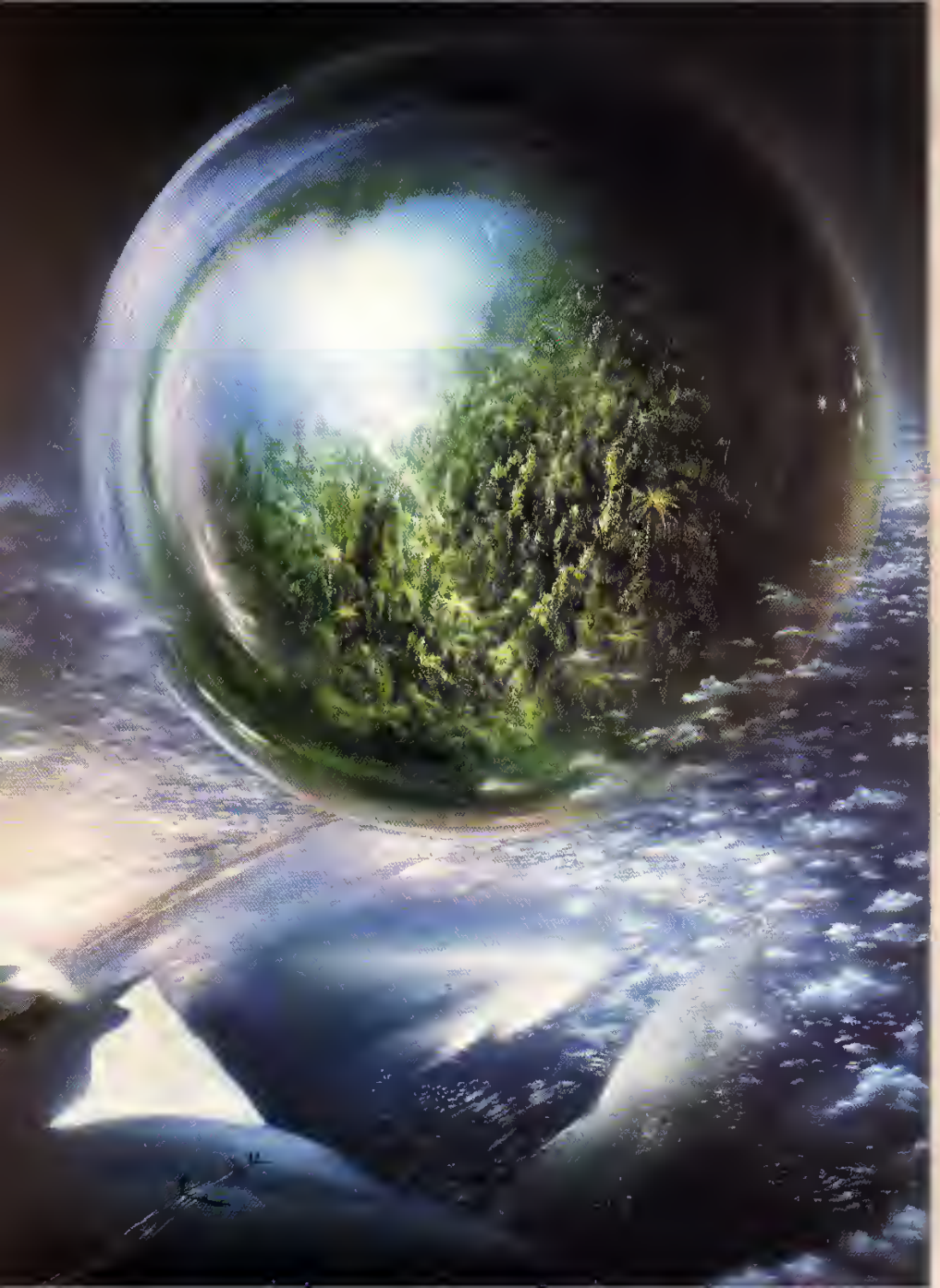
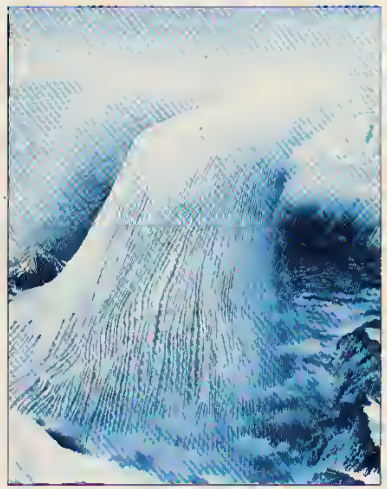


SKIING MIXED WITH MYSTICISM MAY NOT SEEM THE BEST WAY TO ACHIEVE ENLIGHTENMENT— BUT ONE NEVER KNOWS

SNOW ANGELS

BY MICHAEL SWANWICK



You couldn't see it but the sun was low over the mountains hidden by the same faceless cloud layer that kept the temperature hovering just above zero. Gray shadows were gathering in the depths of the wood, and gloom filled the hollows.

The man stopped and stared into the dark firs and skeletal oaks frowning with indecision. A stand of white birches loomed like ghosts. He'd been struggling up the old logging trail for hours now, hoping for a hunting lodge he could break into. But he wasn't going to find one—not before sunset. And it was no joke to be out after dark in this weather. He started forward again, pushing his stride. The snow was waist deep and it was slow going without snowshoes. He half floundered up the trail, arms held high.

Not long after, he broke through into a stretch of trail swept almost clear by the wind. To one side the snow drifted up against a granite outcrop, cresting higher than his head. He bit off a mitten and undid his waist cinch. Slowly, achingly, he shrugged off the pack. His legs hurt, and his body was sweaty and itchy under its layers of clothing. He unholstered his hatchet.

It took only a few minutes to chop out a snow cave. He tunneled down into the drift, kicking the loose fill out with his pacs, and dug a hollow big enough to squat in by the sheltering rock. It took somewhat longer to cut the armfuls of pine boughs he needed to insulate him from the cold floor. The last light was fading when he backed in for the final time, dragging his rucksack after him.

It was dark. He spread out his sleeping bag and knelt atop it, unpacking by feel. Then he blocked the tunnel with his rucksack and set up the stove. He'd made it himself from a coffee can, cutting off the top and punching air holes at top and bottom with a church key. Three dimples halfway down held a small grill. He put a handful of birch bark curlings in the bottom of the can. Then he unwrapped his precious supply of charcoal briquettes and placed five atop the grill. Seating the stove firmly where the pack would help reflect the heat back at him, he carefully struck a match and poked it through a bottom vent hole.

The bark went up with a roar. White light danced on walls and ceiling. While the charcoal was catching, the hiker leaned back and took off his pacs, thrusting them deep into his bag. Then he removed the three pairs of wool socks—one thick, two thin—that he wore beneath them. His feet were sweaty. He scratched them long and hard, holding them up to the stove.

He stripped quickly, carefully placing each item of clothing in his sleeping bag, where his body heat would keep it supple. Cold like this could freeze cloth stiff as a board. Naked, he waited a second before slipping into his bag, so the cold air could brace his skin. He lay on his stomach, shivering at first and then warmer.

The small space was already getting cozy. The briquettes gave off a dull, red light. He idly dropped a curl of birch bark atop the coals, just to see it flare. He wondered. *Could the light be seen through the snow, a faint starlike glimmer? Would a passerby see fairy lights at play in the drift or walk on unseeing?* The snow over the stove was slightly slick, partially melting from the heat and refreezing into ice. If he kept the fire going long enough, it would glaze over the entire cave. He thought he heard something—a helicopter thrumming through the sky?—and cocked an ear, listening, and afraid. But it was only imagination. Slowly, he relaxed.

The coals were ready now; he scooped a smaller can full of snow and placed it directly atop them. As the snow melted he was careful to stir it occasionally. If you didn't, you could burn out the can, raising a stink that would drive you out into the cold. Several times he added more snow, and when the water was boiling he stirred in a packet of dehydrated stew mix.

Sometime later, he pulled the sleeping bag over his face and fell asleep. He dreamed of giant cave bears swimming through the stars, and of baby mastodons frozen in the ice.

In the morning, the hiker emerged from his cave, pushing his pack before him, and discovered that the clouds had cleared during the night. A far sun was beginning its climb through a sky of purest pale blue. It was cold, too, a lot colder than it had been.

PAINTINGS BY FRIEDRICH HECHELMANN

the night before. The kind of cold that stings your face and scours it raw. A faint breeze stirred the air, passing effortlessly through his many layers of clothing. "Damn." He stamped his feet and spat onto the snow. The spittle froze the instant it hit, with a sharp crack. That meant it was at least thirty below.

The man ducked into the cave. Kneeling within the body-warm pocket of air, he undid his clothes and took a leak. The smell of urine mingled with pine. Pungent, but it was better than exposing himself outside. Carefully then, he wrapped his scarf about his face, leaving only the eyes exposed, laced up his parka hood, put his mittens back on, then reemerged into the day.

The air bit at his eyes, and he blinked in pain. He shouldered his pack and waded back to the trail. Yesterday's trace was almost undisturbed. If he chose, he could make it down the mountain to where he'd abandoned the Land Rover in half the time it had taken him to get this far. He headed upslope.

There was an inch-thick crust on the snow, not quite enough to support his weight. He had to break his way through. As he struggled, he thought of something he had been told once: that personality exists only in interactions between people. That when a man is alone, he has no traits, no characteristics. He is no different from anyone else. *Do I have no personality?* the man wondered. He laughed. *Here I go, up the mountain, a spirit of purest ethereality.* The sky was heartbreakingly clear. The day would be a bright one.

Around noon he stopped to rest, lying with his eyes closed and his feet up on the rucksack. He began cooling off immediately. The problem was that he had to keep moving to maintain his body heat. It was getting tougher to breathe, too, because the scarf before his nose and mouth had stiffened with frost, the moisture frozen out of his breath.

He forced himself to squint into the sky. It was bright and hurt his eyes. When he looked down, the snow was dazzling; he couldn't keep his eyes open. Iridescent red shapes swam in his vision. He was in trouble.

He wasn't prepared for real cold. He needed arctic gear, snowshoes, goggles to protect himself from snow blindness. There hadn't been the time to gather it together; he'd taken what he had, counting on temperatures staying above zero this late in the winter, going to maybe ten below at worst. He pulled a hand free of its mitten and crammed the last of his pemmican bar into his mouth so he could chew as he walked. Then he tugged at his scarf, readjusting it so that one eye was covered completely and the other nearly so. He moved his head up and down, and though pain lanced through his skull it gave him a rough picture of what was before him. He put his mitten back on and shoved the mittened hand under an armpit to warm it. Already his toes were getting cold.

As he walked uptrail, he worried what to do. He'd gone too far to turn back now. No way he was going to get down the mountain before dark. He had to find shelter somewhere ahead. Or die, he supposed. He wondered what the gang back at the Data Center in Burlington would think of that? It was hard to imagine people's lives going on after your own death. It didn't seem right. The world ought to come to an end. Out of respect. He laughed again.

He'd gone maybe half a mile up the road when he halted. He smelled smoke. Hastily he moved up his scarf for a better sniff. Cold, *cold* air. But there was the faintest tang of woodsmoke on it. The wind was not coming from up the trail, though. He'd have to strike out into the woods to find its source.

By the time he had his face rewrapped, his lips were numb and cracked. He felt a warm trickle of blood from one tiny cut.

The way was steep at first. He struggled downslope a step at a time, thrashing through a drift where only the tiniest fingers of brush poked free of the snow. At the bottom of the slope was a small, long-frozen stream. Trying to clamber up the far bank, he took a tumble and went sprawling. One legging pulled free, and he took in a little snow before he could get it tucked back in and the pac laced up again. The snow was cold at first, but then it melted and pooled in the toe, warm and sloshy.

Upslope was tough going. In places he had to pull himself up by grabbing onto scrub trees. At the top of the ridge, he looked over his shoulder at his straggling trail and moved to the side to compensate for drift. Then he picked out a landmark ahead to aim for—a black, wasted tree. If you didn't watch out traveling in the woods, you'd go in a large, slow circle. Something about favoring one leg over the other. He started downhill again.

The hours passed with bleak monotony as he traveled up one slope and down another. The warm water in the one pac cooled. He lost feeling in his toes and then his feet. His parka was too bulky for him to keep both hands pressed under his arms, so he took turns warming them, waiting until one was screaming with pain before releasing the other. Neither ever really got warm.

The wind shifted, and it was a long time since he had smelled smoke. The shadows lengthened. The sun was not high above the mountains.

He was beyond weary. His entire body felt dead. *Just a little farther*, he kept telling himself. *night comes fast in the mountains.* When it was night, he would give up.

There came a time when he was struggling up and sliding down, and he realized that he did not have the strength to make it all the way up. Not with that rucksack. So he left it behind. It made him a little sad, because losing it cut his chances of survival in half at least.

The shadows were dark now, and he could not see the sun. His eyes felt a little better, though his head still ached crushingly resoundingly. *Is it night yet*, he asked himself. *can I quit now? Just a little farther.* He topped the rise. There was a cabin.

He stood looking at it, not sure what to do. Smoke lifted thin and blue into dark evening sky. Orange light spilled from a small window. You couldn't see inside because a lace curtain covered the window. It was a little room-and-a-half hunting cabin, better made than most, probably hammered together over the course of five or six alcoholic weekends. He stumbled forward, the end of his scarf swinging free where it had started to unwind from his face. He tried to run and couldn't. His feet hit the short wooden porch clumsily. He pawed up the latch and lurched within.

"Come in." A woman smiled up at him from an overstuffed chair in front of the fireplace. "I've been waiting for you."

He stood there. The woman rose, geisha-graceful in loose chinos and plaid flannel shirt. Hardwood logs blazed at her feet. There was a wood stove going, too, behind her, with a kettle steaming on the stove top. It seemed too much. He couldn't think what to say. Numbly he shut the door and tried to unwrap his scarf. His mittens kept getting in the way.

"Let me help." She had crew-cut red hair and green eyes as pure and merciless as laser light. Glint of silver at her neck. Her fingers danced over him, undoing the tie strings of his parka. "Poor baby, you went and got yourself all cold."

I'm okay, the man thought. *You don't have to.* Then his legs buckled, and he hit the floor hard. He was lying on his back. Bang. He imagined little white stars.

The woman laughed. Like glass bells afloat in midsummer evening air. She scooped him up in her arms, whirled him around, and set him gently on the bed. *That is one strong woman*, he thought. She unlaced his packs, taking a knife to one where the compacted snow had frozen the thongs, and tugged them off. Looking down the length of his body he saw that his feet were both corpse-white, turning to gray. He tried to move one, and the pain was like needles of ice lancing his flesh. The woman was singing softly to herself, something calm and sweet.

Somehow his eyes were closed. He listened to the woman bustle about the room. She took a metal bowl from a cupboard and poured water from the kettle into it. Then she added more water from something that gurgled just like a plastic gallon jug. Nice homey sounds. When the temperature was right, she put the bowl on the bed. "Easy breezy," she said, easing his feet in. "This'll help." She rolled up her sleeves and began chafing his feet, rubbing them hard between her hands. It hurt, but the pain was distant, almost lost in the universal warmth and ache of his every muscle. His head still throbbed darkly, and he felt queasy. It was too much trouble to tell her that current theory was that rubbing was bad for frostbite.

He opened his eyes and immediately closed them again. Seeing the snow lands he had crossed glowing a radioactive blue, rising and falling to the rhythm of the woman's hands. Every now and then she bent to kiss his feet, chafing all the while.

He fell asleep.

He awoke under a pile of quilts and comforters. It was morning, and he was alone. His head felt awful. He wanted simply to burrow deep into bed and darkness forever. "You'll never get to Heaven that way," he grumbled, and, throwing back the blankets, swung his feet off the bed. It was agony to stand. The floorboards were like ice. But there was a fire in the stove, and the kettle bubbling away atop it, so the air was almost warm.

Wrapping himself in a blanket, he hobbled about the cabin. It was cluttered in the way that a ship's cabin is cluttered, with crowded tidiness and logical economy. A console windup gramophone stood by the bed, its belly crammed with old 78's. A gun rack was bolted over the bathroom door. But the rack was empty; there was no ammunition in its drawer, and a portable cassette player rested atop the gramophone. A hurricane lamp had been rehung on its ceiling hook, the chain looped to give more headroom. The woman didn't belong here any more than he did.

The bathroom was crammed with kerosene cans, crates of toilet paper, and cardboard boxes of dusty paperbacks—nothing he could use. Old sports and hunting magazines lay atop the stacks, covers slightly greasy with age. Poking about, he found one that had been angrily folded in three and shoved behind a crate. He teased it out, stuck it under his arm, wrapped himself in the blanket again.

He prowled the room, laying hands on everything. He found the woman's clothes in an empty liquor cabinet. Atop the mantelpiece was a chunk of Lebanese hashish bigger than his fist, the maker's mark stamped in its side. A brass-and-ebony pipe leaned against an unmarked bottle with a hundred or so small white pills. *Jesus*, he thought, in a nightstand drawer he found a leather case that unzipped to reveal row upon row of fine tools—picks, scalpels, wire cutters, needle-nose pliers—that glittered like gems. There were three syringes and a small vial of clear liquid. A set of optically flat palm mirrors, a jeweler's loupe, pencil flashlight, loops of silver cable no thicker than string. *This is it*, he thought—the heart of last night's weirdness. But it told him nothing, and he put it back. He turned on the cassette player.

Alien music filled the room. He stopped, transfixed. Long, trilling ululations swelled and receded, came to sudden stops, chuckled, and began again. He'd heard these songs before, the songs the humpback whales sing. But not atop a mountain. It made him aware of what great masses of air there were about him, how far they extended, and how alone he was.

Then he heard the woman outside, stamping her feet on the porch, and hastily retreated to the bed. She came in with a gust of cold air, dangling his rucksack from one hand. She dumped it in the middle of the floor and snapped off the cassette. Silence, sudden and absolute. Then she went to the stove and pulled off her mittens so she could start warming her hands. She hadn't once looked his way.

"Uh, I suppose I owe you thanks," the man said awkwardly. He was suddenly aware how inadequate words were. "For saving my life, I guess. So, um, thank you." He waited and, when she didn't respond, said, "My name is—"

She whirled, her parka hood still up, and her pupils were cold black holes afloat in green fire. "Mister, I don't give a royal fuck what your name is. All I want to know is when you're leaving."

He flinched, startled, but said nothing. He just stared at her hands, at the fine silver cables that looped over pale skin, tiny flexible tendrils dipping into Teflon sockets implanted in the flesh above each joint. The cable was restrained at the wrist by a black rubber bracelet before sliding under her sleeve. He glanced up. A thicker cable emerged from her jersey, looped through a neck strap, and plugged into a false vertebra at the base of her skull.

"You've got biochip augments," the man said stupidly.

"Have I?" Her mouth was bitter. "I hadn't noticed." She shucked her parka, the motions as graceful as a marionette ballerina's. Each small movement was smooth and discrete from the next. The man watched, fascinated by how complex a set of gestures went into removing a coat. "Well?" she said.

He looked at her.

"When are you leaving?

Her contempt took his breath away. But he bit down on his anger before it could find expression and kept his voice casual, impersonal. "What's the weather like? Still cold?" No reply. "I guess I could make it down the foot of the mountain and hitch a ride out if I started early enough in the morning. I'll have to wait for it to warm up some, though. I doubt that I could weather over."

Hard, stony face. She glided to the mantelpiece, shook a pill from the unmarked bottle, and threw it down her throat without water. "You are real, aren't you?"

"Well, yeah, sure. I mean, I guess so."

"I'd hoped otherwise." With sudden decisiveness she threw on her parka, pulled a ski mask over her face. Bright, modernized African tribal pattern. No mouth. She turned to him, eyes burning from that archetypal terrorist face, and said, "I'm going skiing. When I get back, I expect to find you gone."

"My feet—"

She stamped outside, slamming the door after her. He could hear her putting on her skis, and then she was gone.

"Wow." Shaking his head, he got out of bed, began dressing. "Lady, you are the strangest—" His feet ached. No way he was going down the mountain today. He yanked the magazine from where he'd shoved it under the mattress.

It was a three-year-old copy of *Sports Illustrated*. A marginally younger version of the woman smiled from the cover above the headline "Great White Hope?" Inside was an article titled "Fire on the Slopes." Two-page trick shot: the photographer had taken in near dusk, a low sun setting her hair ablaze so that she etched a bright, time-exposed line of fire down the shadowy slope, twisting and shifting to create a long, cryptic rune to which she alone had the key. Magic.

> AS HE STRUGGLED, HE THOUGHT OF SOMETHING HE HAD BEEN TOLD ONCE, THAT PERSONALITY EXISTS ONLY IN INTERACTIONS BETWEEN PEOPLE. THAT WHEN A MAN'S ALONE, HE HAS NO TRAITS.

He remembered her now. Jessie James, the desperado of the slopes. A local girl in a place where that counted, born and raised in Montpelier, heart of the Green Mountains, at age nineteen the girl wonder everyone agreed was going to bring Olympic gold home to Vermont. But more than that, an exciting skier, so the article said: an athlete who redefined the possible: a creature of the edges.

'A creature of the edges,' he said aloud. He liked that. According to the magazine she practiced her art right on the cutting edge of disaster, courting the kind of perfection found only a reflex twitch from death or disfigurement. "At peak form,' the article read, 'she is harrowing even to watch."

The man didn't know the first thing about skiing. But these shots of Jessie James in action—they were beautiful. The human body at its best. One in particular: face keen with concentration, hunched low on her skis, making a difficult turn, rooster tail of snow rising in a complexly beautiful four-dimensional curve behind her. What could it possibly feel like to be able to do that?

He found a broom, began vigorously sweeping the floor. Trying to remember what had happened to the famous Jessie James anyway. It wasn't all that long ago that something had stopped her career dead in its tracks. An accident. Something about an ultralight. A downdraft had slammed her into high-tension lines, burned out her peripheral nervous system. She'd fallen, crisped and broken, to the ground. Hell of a way to end your dreams.

At noon he opened a pouch of soup. He ate, then donned his parka and stepped out on the porch. Air bit his face, forcing tears to his eyes. The snow before the cabin was crisscrossed by ski tracks. Down the trail a break in the trees afforded a narrow glimpse of distant mountains and far-below valleys. Directly under him a thin vein of road followed a small frozen river. Something trembled in the still air like a violin string about to snap. The weather was going to change soon. He could feel it.

He went inside to warm up some powdered milk. Thinking about a yogi he'd read of who'd agreed to stop his heart while wired to an ECG machine. They'd found that he didn't slow it down at all but actually sped it up until it was vibrating so fast and erratically it couldn't beat and began to fibrillate. His life had been accelerating like that, faster and faster, in increasingly violent jolts, moving toward a sudden stop. He felt himself being pushed to the edges. If he could, he'd leave now. But he didn't dare. People died in weather like this. After a minute he burned a peephole in the window rime with the heel of his hand and peered out. A puff of wind blew a few crystals of snow past, pickup from the drifts. The woods were still. As soon as he turned away, he had to stifle the urge to look again.

The fifth time he looked out the window he saw Jessie struggling up the trail. She was leaning on a bundle of skis and poles, as if they were a staff, using them to drag herself forward. One leg was loose and trembling. She fell, and he hurried out to help. He wrestled her into the cabin, let her fall across the bed. She lay there, her leg twitching spasmodically while he shut the door.

'Damn, damn, damn," she muttered softly. He peeled the mask from her face. She was sobbing with exhaustion and humiliation. 'Please.' Her eyes were soft and imploring, pupils enormous and black. "My repair kit. It's—it's in the drawer."

'Let me,' he said. He laid out the kit, caught her spasming leg between his knees. There were Velcroed slits up the sides of her leggings, and he ripped the one open. "I do electronics work all the time, it's my job.' The knee ring held the mother cable and three daughter cables. It looked to be the calf muscle that was malfunctioning. He slid a pick into the Teflon cuff and twisted, unlocking the sleeve. Then he yanked the cable, and her leg went dead. "We'll have this fixed in a jiffy." He fitted the jeweler's loupe to his eye, examined the cuff with the pencil flash. It was clean. "Took a spill, didn't you? Probably bruised the cable just above the lead. That's easy enough to take care of."

"I didn't take enough mellow. Should've doubled the dosage. Stupid of me."

"Well, nobody can think of everything." The cable network was fitted in short modular lengths to make just this sort of repair feasible. He got out a coil of new cabling, eyeballed length, and cut. 'You know I' remember when I was in high school, my guidance counselor said to me, 'Your problem is that you're bright, but you're a plodder. You can make a good living at anything you care to put your mind to, but you'll never be the best at anything.' At the time, it felt like being sentenced to death.' Jessie's attention was total now, her gaze as focused as a scorpion's. He grinned. 'But you know what? For something like this you're better off in my hands than with the best electronics tech who ever lived. And you know why?" She shook her head. "Because I'm not good enough to take any shortcuts. I have to do everything a step at a time, carefully. Story of my life. Jack-of-all-trades, master of none. There.' He plugged in the new cable, rocked back on his heels. 'How's that?"

Slowly she raised her foot, a traction, lowered it. The leg worked perfectly. She sat up, looked at him expressionlessly. "I envy you, Jack."

"Jack—? Oh, right. Jack-of-all-trades. I get it." He chuckled, shook his head. Lightly touched her knee. 'So tell me, Jessie, just what happened to you out there?"

She didn't ask how he knew her name. 'Like I said, not enough mellow.' She began removing her outside things. "There's a nice stretch of climax forest not far from here, no brush at all, just big trees and empty space. That's where I like to break away from the trail. You know how it is when it's really cold—nothing moving, no wind, perfect silence. And with no trail it takes all your concentration to keep going, so your ego dwindles down to almost nothing. You're just a pair of eyes floating along, moving, not thinking a thing. The hit I took in the cabin was just kicking in, and it was like the air was filled with liquid God and my body had dissolved into it. So I'd got up a little speed, and I found a short slope I liked, picked out a five-tree slalom, and went down it. But right around the last tree, there was a low limb I hadn't noticed. It just leapt up in front of me. I could have ducked, but it came to me that it was time and I could just pass *through*. Only before I could center myself, everything welled up, and I was lying on the ground, skis and poles scattered about, and this leg flopping over and over. That was awful. I hadn't broken anything, but I was a mile from the cabin with a bruised cable and an implant that kept cycling on and off. It was a nightmare getting back.'

He listened attentively, hands clasped below his chin, index fingers forming a steeple that peaked at his lips. When she stopped, he said, "But you weren't really expecting to go through that branch, were you? Not actually."

"Oh, yes.' Her smile was sunshine and confidence. "That's the whole idea."

'And the pills?' He nodded toward the bottle on the mantel.

"MDA. It's an amphetamine-related psychedelic. Very big with the suburban bohemian crowd—they call it mellow. It's sort of like LSD, only without the hallucinations. You know what they used to call LSD, don't you? Acid.' She giggled. 'That's a good one. A little acid to etch some new circuits in my brain.'

"You took drugs and went skiing?' He thought that one over for a minute. Then he turned away, slid the pot of milk from the stove's warming shelf, and began fixing her a mug of cocoa. 'Well, it's your business."

Jessie took the cocoa in her hands, set it down untasted. 'No,' she said. "I want you to understand. It's important to me." She

HE STUMBLED FORWARD, THE END OF HIS SCARF SWINGING FREE WHERE IT HAD STARTED TO UNWIND. HIS FEET HIT THE WOODEN PORCH CLUMSILY. HE PAWED THE LATCH AND LURCHED WITHIN.

looked over her shoulder. "Where's that hash pipe?"

After a small ceremony of whittling crumbs from the brick of hashish, toasting them in the pipe, and drawing in a lungful of smoke, Jessie raised an eyebrow and smiled with little-girl mischievousness. He shrugged, accepted, inhaled. Everything grew very still. He exhaled.

As they smoked, Jessie spoke of her accident. Of knowing she was going to die, and then knowing she was paralyzed for life, and then knowing that there was a new series of operations that could return her freedom of movement but that she'd never be able to afford them. And when a Swiss foundation for sports medicine—one she had never even heard of—paid for her implants, she knew than that anything was possible.

At first she was as helpless as a baby. "It's like learning to move all over again. You have to consciously think commands, like 'green triangle three' to make a single muscle twitch, and it's so hard to do, sometimes you cry with frustration. Your body is one big phantom pain, overlaid with the visual feedback alphanumerics, and it's months before the simplest little motion comes naturally." But she'd given herself to the therapy with the same concentration she'd put into her sport, and by the end of the first year she was walking again. By the end of the second year she was skiing. It wasn't until her third year that her coach—gently, regretfully—explained to her that not everything was possible after all. That no matter how hard or virtuously she practiced, she would never reach the Olympics.

He looked for the pipe, saw it lying on its side by his feet. But when he reached for it his arm wouldn't move, and he couldn't bend forward. *Just as well,* he thought. As well. Just. He felt as big as God and as distant.

"You have to understand that I was eleven years old when I started serious training for the Olympics. Even before that—I can't remember not knowing I was going to win the gold. It was my entire life, and when they took it away from me, I was devastated."

"What did you do?"

"I cried a lot. Broke furniture, hurt my friends." Her chuckle was warm and throaty. "At last I decided to do something a little more positive. I thought if I couldn't excel in the body, then I'd have to excel in the spirit. I was doing a lot of yoga then, for muscle control, and there's this discipline of meditation by which you transcend the body entirely, if you keep at it long enough. I mean, you're actually transported into a higher spiritual realm. So I thought, *Aim high. Nothing is impossible.*"

But decades of meditation were not for Jessie, not if there was a shortcut. She learned that researchers had found that large doses of psychedelics could actually reprogram the brain—change personality, rewire modes of thought—if the subject was imprinted by a strong stimulus when the drug's effects were greatest. These experiments were usually conducted in isolation tanks to eliminate outside impressions, but Jessie didn't like the helplessness of that technique. She figured a mountaintop in midwinter would be isolated enough.

"One of my doctors had an unlimited supply of mellow. He had these parties. They were a little weird to get used to at first. But if you were a regular, he was willing to share." She stopped. "I know what you're thinking, but it wasn't like that."

"I didn't—"

"Nothing is like that when you're on mellow. You're filled with love for everyone, genuine love. It was perfect for me because I was steeped in darkness. I needed to purge that. You've seen what I'm like straight—I used to be like that all the time. And I brought whale tapes to play while I was peaking. Because whales are a superior intelligence, aren't they? More spiritual than us."

The man shook his head. He really didn't know.

Once she'd found this cabin, it had taken five trips to backpack supplies in. That was two weeks ago. Since then she'd been on a rigorous schedule of vitamins, exercise, and meditation. Once a day she popped the MDA and went out. "It's like skiing through the inside of your own skull," she said. "The body is gone, and only the discipline of will provides motion. The world flows by, and you're that close to breaking through it entirely." As the drug peaked, she'd return to meditate to the tapes. Slowly reprogramming herself into a new consciousness. When Jessie had finally finished, the afternoon was gone, darkened into evening. The only light in the cabin came from the embered logs in the fireplace. The man shook his head admiringly. "That's brilliant," he said. "I'd never have thought of that myself." Jessie reached out to take his hands in hers. "Your skin is like ice!" he cried.

"Touch my face. The feedback capability in the augments is just numbers. I can't feel anything below my neck."

Hesitantly, he touched her cheek, the soft skin under one ear. She shivered and rubbed his hand with her face like a cat. "That's nice," she murmured. Then, "Both hands, please?" And when he did, she started to unbutton his shirt.

"Wait, no," the man said.

"I can make love as well as any woman," she said. "Better. I have perfect conscious control over every muscle in my body." She unbuckled his belt, tugged it from its loops.

"But you can't feel anything."

"Caress my face. I'd like that." She toppled him down on the bed and knelt over him. "Don't be shy, babe. I almost transcended the material world today. That makes me a holy woman, doesn't it? When was the last time that you got to fuck a saint?"

Her body was cool and pale, like marble, and the cables of her harness gleamed in the firelight. He entered her carefully. Slowly Jessie clamped tight about him, warm and moist. She rose up slightly like a flame rising high on its wick, settled back down like a wave subsiding. He slid a hand up one side of her neck, and his forefinger explored her lips, the tip of her tongue, the wet interior of her mouth. In a kind of wondering stillness, he realized that he believed in her. This very strange woman. It was either belief or a wild kind of love. She bent over him, a jungle cat to the feeding, and the cables dug into his flesh.

She was ferocious. Crouched atop him as if negotiating a difficult slope, her concentration was total, pure and holy. Long before they were done he could no longer tell which body was his and which hers, where he ended and she began. If only, he thought crazily, he could become her and flee with her, the both of them, out of this world. Into someplace better.

He melted into her.

Afterward, they lay in each other's arms, under that big mound of quilts, talking quietly about this and that. Things of no matter. "I thought you were a god when you first showed up," Jessie said. "Just for a minute there."

He laughed at the idea. "Why would you think that?"

"When you're meditating, you progress through higher and higher mental levels. And just as you're making real progress, you

break through into the realm of the gods, and they approach you with gifts and power and say 'Give up your quest. Stay here with us. We'll make you a god.' So I was kind of expecting them. I'd reached that state of perfect clarity where you're riding the top of the rush and everything's going faster and faster in a kind of controlled explosion, an endless expansion of reality, right? When there was this sudden *hush*, this sense of . . . immanence in the air. Like something important was about to happen. And just at that precise instant in you walked."

He hesitated, then said, 'Suppose it's not true? What if there aren't any other levels of reality? No gods. No . . . other world to move into.'

Then I haven't lost anything by trying, have I?'

"No, I suppose not." He felt her dig her face into the side of his neck, the tip of her nose small and cool. "It must be hard on you. Knowing that you used to be the best."

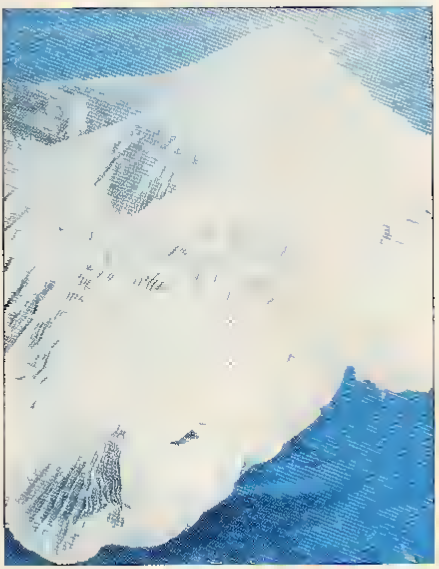
"I still am." she said. Even better than before the accident. Everybody says so. But the bastards won't let me compete."

Something within him grew very still. How's that?'

'There was a big scandal, year before last, a couple of members of the U.S. fencing team had the nerves to their wrists severed and augments implanted. See, a nerve fires slow compared to electrical current through silver wire, so they were upping their reflex time by a few hundred nanoseconds. That was right after the stink about the Bulgarian peptide treatments and the big Finnish operant conditioning scandal. So they came down hard, rewrote the rule book, redlined me out of the Olympics forever." Her voice was flat, with the monotone of a tale repeated so many times all residual trace of bitterness had been worn away. "But I'm putting all that behind me now."

"But you can ski as well as before?" he insisted.

"They told me I should get a gig in Austria or one of the new resorts in Kenya, teaching rich—'scuse me—rich tourists." She yawned again. Her voice was low, murmurous. "Bastards wanted me to coach."



In the morning the sky was a uniform gray, and the temperature had risen above zero again. He carried his rucksack on the porch, glanced toward the woods, and cocked his arm. He threw as hard as he could. The bottle made a silent hole in the snow by the trunk of an old pine. He hoisted the pack.

He'd meant to slip away before Jessie awoke. Just be off and gone without having to confront her. But now he looked down the mountain and saw a gray dragon creep into the valley below. It flowed across the frozen river, rippled over a fence, and came to a halt on the roadway. One of the army's new personnel carriers. He knew its operational specs by heart. Those carbon whisker reinforced 'legs' were capable of forty-five miles per hour on the straightaway and lesser but dependable speeds on slopes of up to sixty degrees. Any terrain a man could cross, it could follow.

"Come and get me," he said bitterly.

The dragon stirred, twisted, and sped down the highway. It would be back, though; he knew it. A few snowflakes blew past. The man looked up, over the rooftop, and was startled how dark it was getting to the north; how fast the clouds were coming on. It was going to be a real bitch in a few minutes.

By the time he stepped back inside the cabin the first slanting flumes were coming down.

He slammed the door. Jessie sat up in bed, eyes shadowy and cryptic. In the morning light her skin was ashen under its metal harness, with small, puckered black nipples. "I don't suppose you have a gun?" he said. "A hunting rifle, a pistol? One of those ladylike little electronic jobs you see on TV?"

"Cram it up your ass," Jessie said drowsily. She gathered her clothes and the palm mirrors from her kit, then disappeared into the bathroom. The wind boomed and shook the cabin. With a pounce and a crunch of airy fangs and claws, the storm was upon them.

He spent the morning packing and repacking his gear, while Jessie ran through an endless series of exercises in the middle of the floor. Always he kept one ear on the blizzard, its shrieks and moans and sudden silences. It had come on too fast, too eager—he guessed it would blow itself out by noon.

Jessie grunted and rose to a kneeling position. Their eyes met, and she snapped, 'What are *you* looking at?'

The unrelenting silence between them had eaten away at him through all those long hours, gnawed at his patience until there was none left. He blurted, "You know I believed in you!"

She blinked.

"I thought . . . I met you here, I heard your story, and I thought, *Here's someone special*." He stood, walked to the far side of the cabin and back again. There was no room. He peered out the window. Still snowing. He let the curtain drop. 'You know there was a nineteenth-century sculptor somewhere in Bennington. I think it was Maybe Brattleboro. One Christmas Eve, while everyone else was at services, he created his masterpiece—a life-size angel in snow, right out in front of the church. All the local people, they came out from midnight mass, and there it was. This . . . beautiful angel. Waiting for them in the moonlight.'

Green eyes, reptilian calm. 'So?'

'So, okay, I've never done anything remarkable in my life. I accept that. But I've never even seen something special. Those townspeople, they couldn't have made the snow angel themselves, but at least they saw it. They bore witness. And you, I thought you were special, a snow angel, someone like nobody's ever seen before. But you're just one more quitter. You say you're the best, but you're giving it up because you can't get a lousy gold medal. What does a medal have to do with anything?'

She lifted the pipe from the floor and, with a feathery touch, brushed a few unburned crumbs of hash from the end table into the bowl. 'Okay, I give up. I wasn't going to ask, but just who the fuck are you, Jack? What are you doing in my life?' She fired up the pipe and handed it to him.

He took a puff. Suddenly he was dizzy and had to sit down. The fabric on the easy chair's arms was frayed and white. When he tried to draw on the pipe again, there was nothing in the bowl but ashes. "I'm not doing anything," he said unhappily. "I'm just a guy. The government's after me." Jessie said nothing.

"We were doing contract work for the Canadians. Harmless enough stuff, really, but then the government stepped in and classified everything. They wanted us to falsify the results. To cover up that we'd come up with something valuable. I guess I did something stupid." He brushed a hand through his hair. "I couldn't cheat them like that. We accepted their money."

Without warning, Jessie roared with laughter. It was spooky, how her features twisted and reddened, her head bobbed and shook, and yet her body sat immobile, hands on knees, feet on

floor, like a dynastic Egyptian statue. At last she calmed. "Ah, God," she said. "Ah, God. What a sad creature you are, Jack."

"Well, maybe I am!" he said angrily. "Maybe I'm on the run. But at least I'm *running*, I'm not sitting in the middle of nowhere, burning my brains out, waiting for gods to walk in the door. Committing suicide—that's what you're doing."

"How you talk." She sounded genuinely amused. Then, cold again, "When are you leaving?"

A burst of wind howled like a celestial freight train chasing its tail across the mountaintop. The personnel carrier would be stalled down below, it couldn't travel in this. Still, it was brightening up outside. The wind was carrying less snow. "Soon."

Jessie nodded and stood with stately grace. The hashish flashed him an iceberg avalanching upward to rejoin its mother glacier. She snapped on the cassette player and went to the mantelpiece. Delicate cetacean music mingled with the wind in a swirl of dissonances and chance harmonies. "Jack," she said. "What happened to my pills?"

"I threw them away."

Her back was to him. "Why would you do a thing like that?"

For the same reason a man would take a can of poison from a child or a loaded gun from a drunk. For the same reason that same man might suddenly find himself homeless, without career or friends, alone and hunted. Because he'd been brought up that way. Because he had no choice.

"Those things are making you crazy," he said. "Trying to ski through a branch. Next time it'll be a tree. Or a cliff. You're not the Buddha, Jessie, and you're not any kind of saint. You're just plain deluding yourself."

In one swift, frictionless motion, she turned and seized his hand between hers. Her face glittered with tightly restrained violence, and for the first time he was a little afraid of her. "How does my skin feel?"

"Cold."

"Wait." She fell silent. After a second her flesh felt less chill. He thought it an illusion at first, their shared hands reaching for isotherm. But then her hands were definitely warmer than his own. Much warmer. They were actually hot, as if she were flushed and running a fever. They grew hotter yet, until finally he yanked his hand away in pain.

"How did I do that?" Jessie demanded. "How could I do that if I'm deluded?"

"Biofeedback—" he began falteringly.

"Biofeedback, my ass!" She folded her hands open, as if making the sign for *book*. "Look at my palms!"

He could feel the heat radiating from her. As he watched, the angry red skin blossomed with clusters of white blisters. They swelled and ballooned, and the skin edging them darkened, blackened, and crisped. He could smell her flesh burning.

Small hairs rose on the back of his neck. Abruptly, the room seemed all color and shimmering surface, unreal, impermanent, the floor ready to give way underfoot, the walls about to melt into starless void. He staggered back a step. "You can't do that!"

"I'm a god, baby. I can do what I want." She thrust her hands almost into his face. "Look at them. Touch them. Is this a trick? Am I faking?" When he shook his head, she stuck her hands under her arms, as if to warm them. "The body is only illusion, Jack. It does what the mind tells it to do. But that's only the beginning. The body is easiest to control because you grow up thinking of it as yours. But everything is illusion. Existence is illusion, being is illusion, the world is illusion—it'll do whatever you tell it to. You only have to learn confidence."

She held out her hands again, and the charring was gone, the skin whole. He opened his mouth, could say nothing. The last blisters dwindled to nothing and were gone, like soap bubbles winking out of existence. "Bring me my pills, Jack."

He stumbled outside, zipping his parka. He'd forgotten his mittens. The snow was falling lightly, the storm over. The hole by the old pine had been swept away, but he remembered where it had been. Falling to his knees, he swept about under the snow with both hands. The bottle stung his fingers as he carried it in.

"Thank you, Jack." Jessie popped two pills in her mouth, hesitated, and then shook out two more. She raised an eyebrow, a look of almost malicious caprice on her face. "Tell you what, Jack. I'll take you along with me. That's what you'd like, isn't it?" She proffered the pills.

He was stunned. The pills stared up at him from her palm, and the effermage of her smile burned beneath them like neon. In that instant he wanted it so badly, this form of escape she offered, that he almost bent his lips to her hand. He was never going to make it over the border. Not without some kind of miracle. *Beam me up*, he thought. *Get me the hell out of this shitful world.*

She could do it, too. It would be easy for her. Just reach out a hand from the other side and drag him after her, leaving nothing behind but a cooling wood stove and a cabin surrounded by virgin snow. Jessie swam in his sight, all but sparkling with impermanence, anchored to existence by the most fragile ties of habit and nostalgia. But it wasn't his way. Everything he'd gotten in this life had been by his own efforts, even the trouble he was in. He wasn't about to start cheating now.

"You don't understand." He took a deep breath, shouldered his rucksack, turned away. "You don't understand a thing."

The way down a mountain is always easier than the way up. Still, night comes quickly in the winter, and it wouldn't do to reach the state highway at sunset. Best keep an eye out for a spot to dig a cave so he could sleep over. When the clouds rose, they'd be able to lift a copter over the mountain. He'd have to keep under the trees then.

Canada wasn't more than fifteen miles distant, twenty at the outside, but he doubted he'd ever reach it. Now he was glad he hadn't found a gun. Those things weren't protection. The most he could do with one was fake some poor grunt with him.

The trail turned, and he suddenly came face-to-face with a stretch of sheer cliff. The slow seepage of water from bedrock had covered the rock with organ pipes of ice, hundreds of them, cascading one over the other, some thicker than both his legs together, others as slim as his little finger. Pale colors lurked in the depths, yellows and blues and pinks in rippling curtains, as if the aurora borealis had been frozen and slammed down to Earth. He bared his head to the cold, shoving back his hood and snatching off his cap, struck by the presence of something holy.

For a long minute he stood there, not even thinking.

But there were still soldiers down the mountain. They'd likely found the Land Rover by now. If so, they'd be coming up after him. He couldn't stay.

Reluctantly he trudged on, repeatedly staring back over his shoulder, until the old logging road turned into a stand of dark firs, and the ice was gone.

A few light, fluffy flakes of snow were falling now. Slow, puffy things that nobody could possibly take seriously. He tried to catch one on his tongue. Then he stepped up his pace, swinging his arms. After a while he began to sing. "Oh, the bear went over the mountain..." For some reason he felt wonderful.

He thought of snow angels then. The kind you make as a child, lying down in the snow, kicking arms and legs to form the wings and skirts. He hadn't made a snow angel since he was a boy. The man laughed. He promised himself that before the day was over he would find an open space and make one.

Perhaps several. DO

HE REMEMBERED HER. JESSIE JAMES, DESPERADO OF THE SLOPES. A LOCAL GIRL IN A PLACE WHERE THAT COUNTED, AND AT NINETEEN THE GIRL WONDER WHO'D BRING HOME THE OLYMPIC GOLD.

CONTINUED FROM PAGE 79

noise because the little ones had to be able to communicate with the adults and the adults with each other in case of danger. The scene might have seemed chaotic to us. But it wouldn't be any more so than in a bird rookery. All the females would be hollering at each other whenever anybody got too near somebody else's nest. Just like people in a city.

I'm always asked if I wouldn't like to go back in time to the Cretaceous to walk around in, say, a maiasaur colony. I say no. You'd be knee-deep in dinosaur guano, for one thing.

Omni: When you were growing up, why were you fascinated by dinosaurs?

Horner: I don't know that anyone can answer that. If you ask a kid why, he'll say it's because they're so big and mysterious. We don't have them, so anything you find out about them is something new. And you'll probably never have everything about them, so it's always this mystery. It's something I can't put my finger on. I know when I find a fossil mammal or an invertebrate fossil, I get very little thrill from it. Maybe it's because I've found a lot. But every time I find a dinosaur, it's still a very exciting thing.

Omni: Although you're now an acknowledged leader in paleontology, you had a tough time in college and in school in general because of the reading disorder dyslexia. What was school like for you?

Horner: When I was a kid, I thought I was a real idiot, and I'm sure everybody else thought so, too. I read real slow. If there were difficult concepts in a conversation, it took me a long time to understand what was being said. So it takes a lot of concentration. And in most cases it just goes right over your head. And then you think, *Why should I listen to this, because I've lost it already?* I couldn't read half of a chapter overnight unless I sfayed up until four o'clock in the morning. So you never can get anything done on time.

Omni: How did you find out that it was dyslexia and not just...

Horner: Stupidity? When I was at Princeton working as a preparator in the mid-Seventies, there was a little note on the bulletin board. It had a list of questions like "Do you read slowly?" I looked at the questions and I thought, *Yes, yes, yes, yes!* I thought, *How do they know me so well?* So I went in, and they did a couple of tests. At the end they said I was dyslexic.

It was the worst in college. In high school you can doodle along and get bad grades. But in college it was really, really bad. Chemistry class was just terrible, because the guy would be talking about one thing and writing something else, and none of it was going in and staying in. I was still trying to sort out the first three sentences by the time they got to the end of the class. So I kept flunking everything. At the end of three and a half quarters I had a 0.06 average. I had taken bonehead math and bonehead English and flunked them both. It's just a horrible, horrible thing to go to school and watch your friends study for three hours and be done. And you know that you can't get near them unless you study fourteen, fifteen, or maybe twenty-four hours.

Omni: You first flunked out in 1967. You were drafted, served in Vietnam, came back, and went at it again. How did you manage to push on?

Horner: I took only courses I thought applied to paleontology. Every once in a while I tried to sneak in an English class, but I was just too far gone by then. I took the courses I wanted to. I didn't pay any attention to my grades at all. At the end of every quarter they'd kick me out, and I'd just reapply. I'd come back and take some more courses. One quarter they wouldn't let me back in, so I just went and sat in on the classes. As time went on, after I'd taken the classes, I started taking all graduate-level courses. For the first couple of quarters they allowed me to take them for credit, thinking I was going to get my degree. When it became obvious that I never would, they quit letting me take them. But all the professors still let me sit in on the classes.

> *"If you looked out on the plain, you might see herds of a particular dinosaur, and carnivorous dinosaurs creeping around the herd's edge, looking for something to eat."*

Omni: That must have taken an incredible amount of determination.

Horner: Just because I wasn't getting good grades didn't mean that it was bad. I enjoyed the hell out of learning about lizards, snakes, reptiles, and mammals and having access to a big library where I could read at my own pace.

Omni: Do you think that the dyslexia may have had anything to do with your interest in paleontology?

Horner: It had a lot to do with it. Fossils are something you can get your hands on—you can feel them, see them. They're three-dimensional objects. It's not like learning a language or doing mathematics. For a dyslexic person, math is probably the worst there is. You know, we've had children visit the site, and one season we had a group of high rollers, the bright kids, and then we had some special-ed kids. The bright kids, they were okay for a while, but they didn't do any where near as well as the special-ed kids.

Omni: When you started looking for a job, did it occur to you that the odds might be against you?

Horner: I figured they kind of were, but I always figured I had enough talent. I was a preparator. I knew quite a bit about carpentry. I knew welding and mechanical things. In 1973, I guess it was, my father retired and sold his ready-mix sand-and-gravel business to my brother and me. During that time I'd go out on weekends and look for dinosaurs. I wrote letters to all the museums in the English-speaking world, looking for a job—anything from janitor to curator.

I think that if kids are really dyslexic and they want to do something, they're going to do it. Some of us have a great deal of drive because people keep telling us we're idiots. We're out to prove them wrong. I figured if it came to the point where I was starving, I could always go drive a truck. There have been many things people might call a struggle. Trying to get a National Science Foundation grant when you don't have anything beyond a high-school diploma—that's a struggle. But it worked out. And it wasn't anything insurmountable. Fixing a concrete truck when you don't know what's wrong with it is what I consider insurmountable.

Omni: What new directions is your work taking now?

Horner: My current research deals with the evolution of dinosaurs through a particular time span. And that particular span of time is the Two Medicine formation. I'm trying to figure out what influences there were on the population of dinosaurs in response to certain environmental factors. The environmental factor I'm looking at is the coming and going of the interior seaway. During the Cretaceous this seaway would sometimes rise and fall. When it rose, it would compress the habitat of all the populations of dinosaurs that were living on the shore between the sea and the Rocky Mountains. I'm interested in whether we'll see a change in the rate of evolution or a change in the rate of extinction or anything during these times of habitat compression.

Rocks from the bottom of the Two Medicine formation show the sea on its way out. At the top of the formation we find the sea on its way in. I'm looking at both the bottom of the formation, when animals were coming out onto the coastal plain, and the top, when the sea comes back in. With this formation we can look at what's going on in the upper coastal plain for a twelve-million-year period.

What you see overall is that during times of transgression—when the water is coming in—you have extinction. You're compressing your habitat area, so a lot of animals have to die. Then when you

get release of that compression with the sea going out you get new species. So it looks like speciation events [appearance of new species] are occurring simultaneously with the coming and going of the sea. What we have to do now is go in and look at these apparent effects quantitatively, statistically.

Omni: What sort of fieldwork will you have to do in order to cover the whole twelve million years?

Horner: I have to collect a hell of a lot of dinosaurs! If I'm going to look at a speciation event, I need to be able to tell what a species is, how much variation there is. And these big bone beds allow us to do that. We can get thirty or forty individuals out and see how much variation we have. We can then go a little higher in the section, find another bone bed of the same kind of dinosaur, and see whether we have change that goes beyond the limits of our species variation in one population. Through enough time we ought to be able to pick up a speciation event. To tell you the truth, we're getting more material than I had ever expected. There's just a tremendous amount of stuff! We got about thirty thousand pounds of fossils and the dirt they're still embedded in just this summer. I expected this project to run four to five years.

Omni: What's so special about these dinosaur finds?

Horner: There are new species. And there's a real wide variety of babies, so we can get a real good growth series of some of them. It's beyond my wildest dreams. This year we found a bone bed that had everything in it. It's not a monospecific bone bed. It has hadrosaurs and lambeosaurs [duckbills with crested heads] and ceratopsians and ankylosaurs and carnosaurs [meat eaters] and ornithomimids [the herbivorous family that includes duckbills] and turtles and crocodiles. Everything's all mixed up together. Not only does it have all these different kinds of animals, but it has different size classes of them, too. We've got little carnosaurs, big carnosaurs, and little everything. Everything you'd ever want is all piled up together.

Omni: In 1975 you got your first job as a preparator at Princeton. Now you're curator of vertebrate paleontology at the Museum of the Rockies, an assistant professor at Montana State University, and a recipient of a hundred-eighty-thousand-dollar National Science Foundation grant. You have what's probably the biggest field operation of any paleontologist in the country. And you got a MacArthur grant. So it's really been one success after another—dyslexia or no dyslexia. The Willow Creek anticline certainly changed your life, didn't it?

Horner: Yes, it did. But if it all falls apart, I can still drive a truck.

Omni: And you'd still be looking for dinosaur bones?

Horner: On the weekends.

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ON SALE AT NEWSSTANDS EVERYWHERE

STARTECH

ACCESSING THE FUTURE

CINEMATIC SOUND

Home video sound now rivals that of the original film, thanks to the three-amplifier, six-speaker Shure HTS Home Reference system. A special decoder preserves the all-around sound you hear in a state-of-the-art movie theater. System does not include monitor, VCR, or disk player. Price: $9,600. Contact: Shure Brothers, Evanston, IL; (312) 866-2608.

MIRROR IMAGE

Laser disks bring the clarity of CD sound to video viewing. Now Pioneer produces a library of music laser disks to accompany its own player. Prices for the Pioneer players range from $900 to $2,000. Contact: Pioneer Electronics, Long Beach, CA; (800) 421-1404.

DISCO TECH

For those who like to mix media, one player, the Sony MDP-200, can handle all viewing and listening formats: eight- and twelve-inch laser disks, three- and five-inch CDs, and five-inch video CDs. Price: $950. Contact: Sony, New York, NY; (900) 222-SONY.

TOWER OF POWER

If one-stop shopping is your bag, the Mitsubishi Home Theater System might be a wrap. It combines all the stereo necessities (turntable, cassette deck, receiver, loudspeakers) with a rear-projection video monitor. A remote controls all the components. Price: $4,500 to $11,000. Contact: Mitsubishi, Cypress, CA; (800) 556-1234, (800) 441-2345 (in CA).

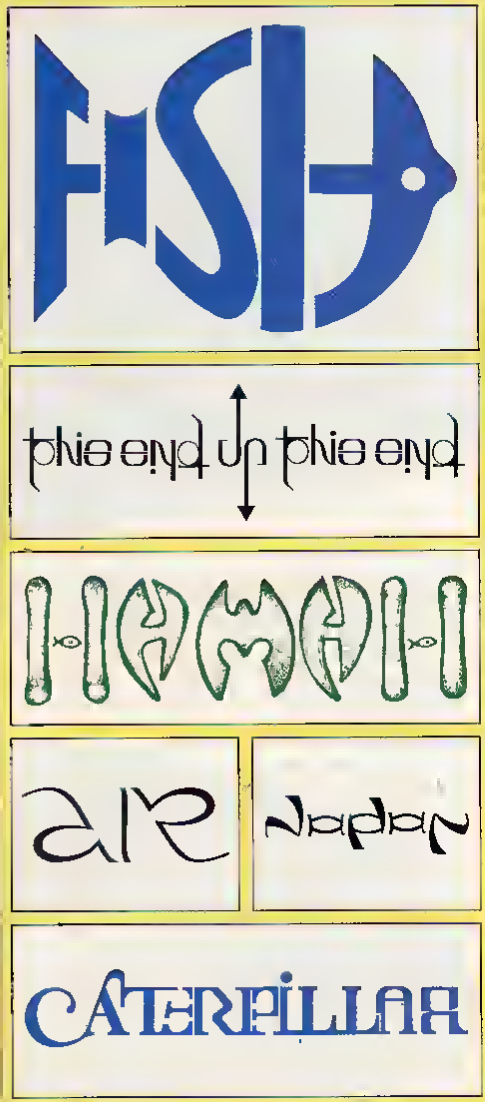
SCREEN GEM

Rear projection is the secret of big-screen beauty. Now Sony has added a new twist: The KPR-46CX10 uses state-of-the-art digital circuitry to display two images at the same time. Thanks to a built-in electronic memory, you can also replay the last two seconds of whatever you're watching—perfect for judging close plays—and freeze frames. Price: $3,999.98. Contact: Sony, New York, NY; (800) 222-SONY.

Cockeyed calligraphy.
Wordplay with a graphic twist

GAMES

By Scot Morris



Last June we devoted this column to ambigrams—ambiguous writing in which words can be read upside down, in a mirror, in two languages or in other unusual ways. For Competition #46, we asked for new ambigrams and offered $500 for the grand prize-winner and $25 for each of the ten runners-up.

From thousands of submissions I picked about 70 favorites. Before making my final choices, I sent copies to two experts for their opinions. They are Douglas R. Hofstadter, who coined the term *ambigram*, and Scott Kim, author of *Inversions*, a collection of similar wordplay. Hofstadter has a book, *Ambigrams*, which will be published soon by Basic Books; and W. H. Freeman will publish a new edition of Kim's book this spring, along with a Macintosh disk, *Letter forms and illusion*. This collection of games and fonts will let you try your own hand at this kind of visual wordplay. Thanks go to both for their suggestions and assistance.

In addition to the cash prizes, all 11 winners will receive a copy of our second Games column collection, *The Next Book of Omni Games*, recently published by New American Library.

GRAND PRIZE-WINNER

Cheryl Bischoff of Fort Wayne wins for her rendition of FISH. She distorted the letters into the cute fish shape you see at first, and for the unexpected FISH you see swimming the other way when you turn the design upside down.

RUNNERS-UP

(In no particular order)

THIS END UP, from Nicholas Dollak of Fair Haven, New Jersey. Upside down, THIS becomes END, and END becomes THIS, UP reads the same both ways, creating a maddening, ambiguous label.

HAWAII, by Eleanor T. Cate of Hilo, Hawaii, has several pleasing symmetries. Her design reads the same

in a mirror—the letters *A* and *W* have left–right symmetry. The only trick was getting the crossbar of the *H* to become a tropical fish between the two *I*s. HAWAII also reads both forward and backward when turned upside down—and that took some clever manipulation.

CATERPILLAR by Robert A. Tucker of Stockton, California, turns into a BUTTERFLY when inverted.

The invertible CHRISTMAS greeting is from Hal Taylor of Berlin, New Jersey.

GOD BLESS AMERICA was a friendly tribute from Canadian Joffre Saint-Aubin of Montreal. This ambigram has left–right symmetry for mirror viewing.

The lighted bomb in the middle of SOUTH AFRICA, by Lefty Frontenrose of Hacienda Heights, California, hints at the inverted reading WORLD CHAOS.

NEW YORK, by Robert Pertrick of that city, has a unique symmetry, as if the NEW were reflected on the surface of a lake.

Warren Lunt of Duncanville, Texas, boldly united all four seasons: it reads SPRING and WINTER from one direction, SUMMER and AUTUMN upside down.

The cynical view of GORBACHEV (when inverted PROPAGANDA) was penned by Suzanne Higgason of El Paso, Texas.

Of all the variations on the *Omni* name, my favorite is this figure–ground version by Brigid Clawson of San Diego.

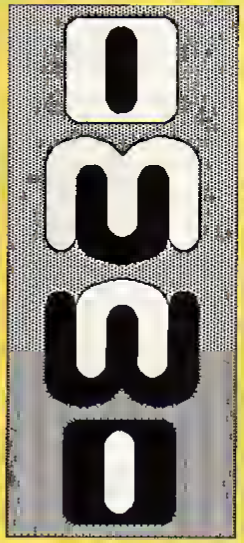
HONORABLE MENTION

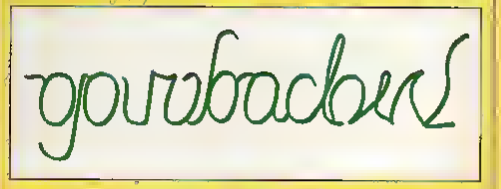
AIR, sent in by Mary Ernst of La Jolla, California, is the logo for her line of women's clothing.

JAPAN, an invertible design in Japanese-style lettering, comes from Steven C. Thorpe of Long Beach, California.

CREATIVITY was submitted by Kristy Visek of Morgan, New Jersey.

POLICE by Pat Clancy of North Massapequa, New York, is a design intended to also be read in your rearview mirror. OMNI





GAMES

Golf, the gracious diversion, has expansive lawns, lofty trees, fresh air, excessive fees, rain outs, and snide caddies. If you're not chipping low balls into the water trap, you're tipping highballs in the clubhouse watering hole. All this—and the illusion of exercise, too. What a terrific sport!

If you can forgo the great outdoors and the pseudo-exertion of the real thing, golf makes an excellent video game. It can teach a lot about choosing clubs, plotting strategies, and gauging putts.

Golf simulation first reached the video screen as a visually schematic affair, with on-screen blips and blocks crudely imitating overhead course views. As video graphics became more detailed, however, video golf became increasingly realistic. The graphic point of view changed from "overhead vague" to "eyewitness authentic." Pioneered by the lavishly computerized trees and greens of Access Software's *Leaderboard Golf*, golf is now one of the most satisfying sports simulations. From the cartridge-based courses of Bandai's *Golf* (Nintendo) to Electronic Arts' *World Tour Golf* (MS-DOS/Tandy, Apple IIgs, Commodore 64), there's a solid simulation available for the electronics hiding in any video golf bag.

One of the best strokes in video golf is Accolade's marathon-titled *Jack Nicklaus' Greatest 18 Holes of Major Championship Golf* (MS-DOS/Tandy, Commodore 64), personally supervised by Nicklaus himself. The challenge begins with Jack's Greatest 18, a custom-designed course composed of Nicklaus's favorite holes from such courses as Scotland's St. Andrews and Georgia's Augusta International. Then the action moves to simulations of Colorado's Castle Pines Golf Club and Golf Club at Desert Mountain (Cochise) in Arizona, two courses Nicklaus designed.

Play Nicklaus's golf courses alone or against human competitors, or challenge computer-simulated opponents, even a simulated Nicklaus. You aim your shots by using the computer's cursor keys. To determine the strength and accuracy of your stroke, press the keyboard to trigger a moving bar that offers your choices.

Tapping a computer keyboard, of course, is nothing like, say, the physical discipline of lining up and executing a long drive down the fairway. But this game offers something else to enhance the experience: Nicklaus's personal suggestions for sizing up a hole's problems and picking the perfect club.

"Before every shot," Nicklaus says, "look hard at what confronts you and then decide on a club and target. Identify the risks—water, wind, slope, and so on—then weigh them against your capabilities."

Throughout the game Nicklaus's digitized image appears, with visual comments that capsulize the distinctive problems of a hole. His advice adds an instructive element to the video simulation that you just can't get elsewhere.

The major fault of most video golf, though, is that the "ups and downs" are usually limited to your score. There's no vertical dimension to the landscape. The effect is like playing golf on a pool table. Only Activision's *Gamestar Championship Golf* (MS-DOS, Amiga) goes truly three-dimensional with a full representation of the course. You not only select your club, your aim, and the strength and timing of your swing, but you also get down to foot position and whether to swing with the wrists, arms, or a combination of both. And the finger manipulation required to execute a swing on the computer keyboard calls for dexterity not unlike the precision demanded in bringing off the real thing.

Gamestar offers only one course—a simulation of California's Pebble Beach. But you truly play Pebble Beach, with its windswept oceanside setting, steeply contoured course, and holes perched on hills. Overputt and you can find yourself halfway down the mountain, gazing wistfully up toward the green.

So turn on and tee up. I'll be waiting for you near the fireplace at the Nineteenth Hole.—Bob Lindstrom

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LAST WORD

By Kathy Thornock

"Miss Abeja's antennae were broken, her thorax swollen, and her whole body bruised black, blue, and yellow—a perfect sting operation for the Dragnet bee team."

5:35 PM, August fifteenth. I was working border patrol when I received a call from Miss Honey Abeja of 440 South Hive Drive in the quiet middle-class community of Las Colmenas. Miss Abeja, owner of the Bee Motel, reported a Section 38 violent assault by a motel guest. I responded immediately.

My name's Hornet. I'm a bee.

I work at the Insect Immigration Center. My assignment: to halt the illegal immigration of killer bees.

5:57 PM. Miss Abeja was waiting on the front steps of her motel. Her antennae were broken, thorax swollen, and her body bruised black, blue, and yellow.

"Evening, ma'am. Police officers. I'm Sergeant Jack Hornet, and this is my partner, Officer Buzz Alldrone. Can you describe the bugs that attacked you?"

"Oh, officer, I'm so glad you're here! They're maniacs, killers!"

"Just the facts, ma'am."

"I didn't do anything! They attacked me. It was horrible! They had the biggest stingers I've ever seen."

After looking through bug shots, Miss Abeja pointed to a photo. "That's the bee that buzzed me!" she cried.

She pulled out a photo of BeeBee Redondo, kingpin of the South American killer cartel. We had heard rumors that the Hive was swarming north.

"Any idea where they went, ma'am?"

"I'm not sure," she replied. "They talked about scoring some pollen, lighting on a rose hip or two, and trying a few flyby stingings."

"Anything else?"

"They mentioned Claws Barbee."

"Thank you, ma'am," I replied. "We at Dragnet are dedicated to protect law-abiding worker bees from those who would destroy our American way of life."

"Jack, Jack!" interrupted Buzz, shaking me. "Stop it! You're droning again!"

6:21 PM. We made a beeline for Barbee's Tavern, well-known for criminal activity. It was time to go undercover.

6:46 PM. We rented a room in the sleazy motel across from Barbee's Tavern. Buzz got into his Brigitte Nielsen costume. I dressed as Charo.

7:52 PM. We were ready. I had taken extra care with my makeup—used a touch more mascara, a little brighter foundation. I wanted to look my best.

"Perfect," announced Buzz as I adjusted my wig. "You look like a real queen tonight."

8:01 PM. We entered Barbee's Tavern just as Redondo came out with his bodyguard. BeeBee was shorter than I had imagined. And rounder. Actually, he looked remarkably like John Belushi.

Without hesitation, I addressed BeeBee in my deepest Charo voice. "Hhhhey, joo beeeg hhhhunk of a drrrrone. Whhhhat's your hhhhooree? Whhhy don't joo hhhave a siesta wit' me?"

At first, he appeared disinterested, even hostile. Then he eyed my maracas and leered, "What have we here?"

I fluttered my eyelashes. "Less see hhow well joo can pollinate."

BeeBee's bodyguard, Sting, was about to protest, when he spotted "Brigitte" motioning provocatively. Mere minutes later, BeeBee Redondo, unguarded, entered my cabana.

8:05 PM. I switched on the red light (which started the hidden camera), put a Julio Iglesias album on the turntable, and sprayed my wings with a dash of Eau de Tijuana.

BeeBee produced a container filled with a waxy amber substance that I recognized as royal jelly. He dipped his stinger in and offered me a hit.

Breathing seductively, I said, "Note jet. I hwan to remember ebry moment."

"What's the matter, are you yellow, Jackie?" sneered Redondo, jerking off my wig. "Really, Hornet, did you think I'd fall for that old trick?" BeeBee pointed his stinger at my head.

Frantically, I glanced toward the door. "I'm afraid Brigitte won't help you tonight," Redondo taunted. "Sting took her. It's just you and me. Alone."

Just when it looked like I was about to make the ultimate sacrifice for my profession, the whole SWAT team suddenly swarmed in through the windows and doors, shouting, "RAID!!!"

On February twenty-first, the trial concluded in Las Colmenas Superior Court. BeeBee Redondo was convicted of assault with a deadly weapon, possession of a controlled substance, and impersonating a celebrity. His lawyers requested a closed-door conference with the judge. Immediately after, Redondo was deported to the island of Abejera, to live in exile with an entourage of aging queens.

Sting was tried as an illegal alien. He was convicted and sentenced to five years hard labor at Cal State Penn, Berkeley. He is currently negotiating his autobiography with Steven Spielberg, who says it promises to be "the definitive bee movie."

Claws Barbee was declared incompetent to stand trial and committed to an insectarium. On August twenty-sixth, his beekeepers reported that Barbee had committed insecticide.

Buzz Alldrone and Honey Abeja were married one month after Redondo's capture. Following a short honeymoon, they moved into the Bee Motel, where they're sharing the same wardrobe.

Me? I took quite a ribbing after photos appeared in the newspapers announcing BEEBEE CAUGHT WITH HORNET. Now I'm back on the streets, doing my part to keep America safe for wasps.

Dum-de-dum-dum. Dum-de-dum-dum-DUMMMMM ∞

Kathy Thornock lives in Washington so she can flee across the Canadian border when the Hive arrives.