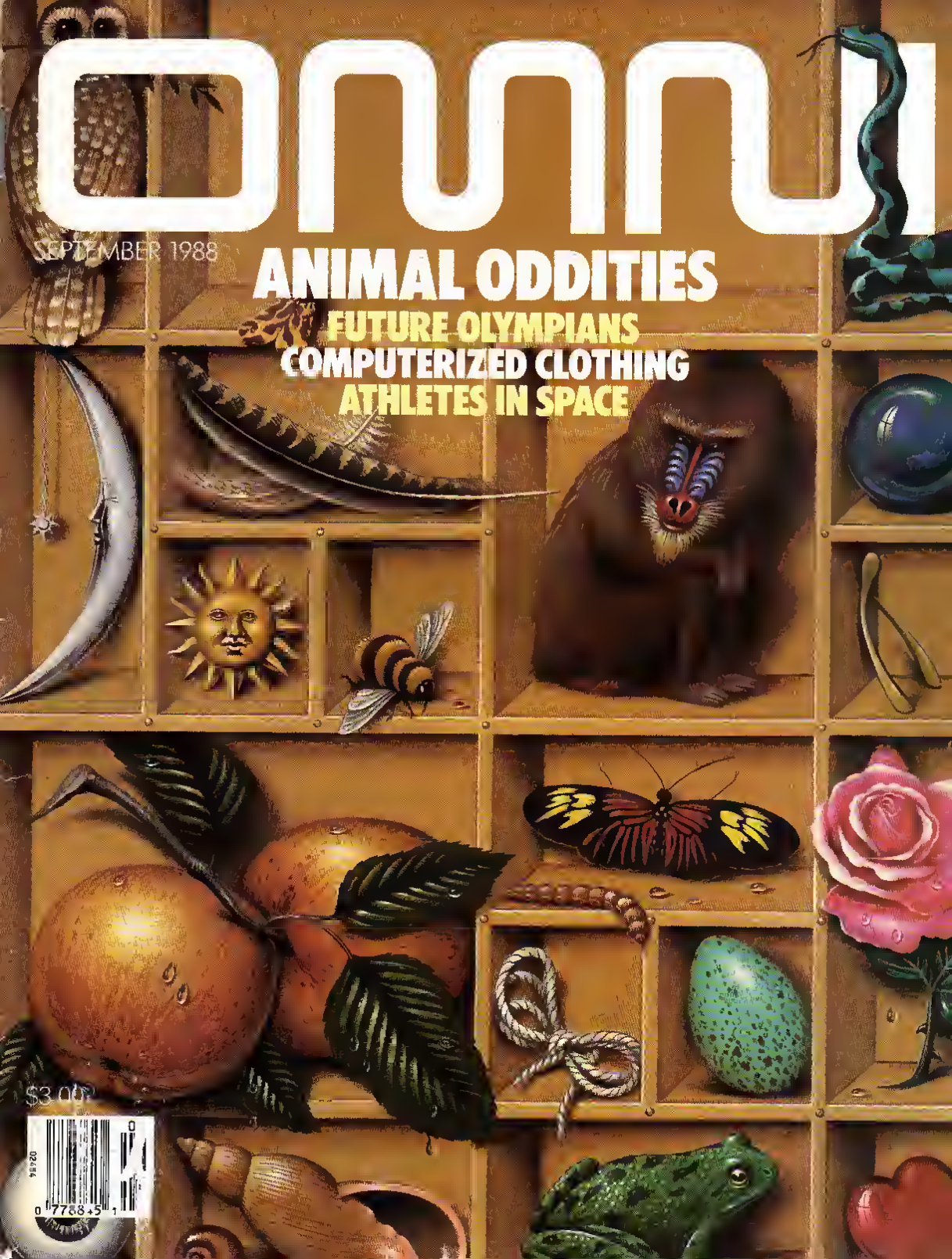
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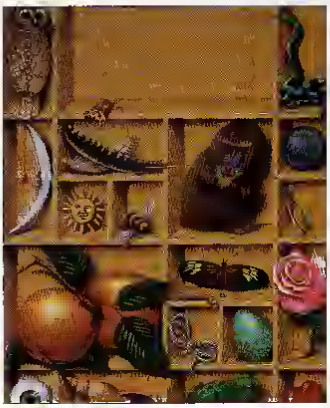
VOL 10 NO 12 SEPTEMBER 1988

CONTENTS



On this month's cover London-based illustrator James Marsh fills a printer's box with 'symbolic images' from dreams. First commissioned for a book, this creative cornucopia captures both the scientific and the natural worlds

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FIRST WORD

By Raymond Kurzweil

During the next century a music lover will be able to change a piece of music with voluntary and involuntary cues such as facial expressions, vocalizations, muscle tension—even brain waves

In the early Eighties a community of scientists and musicians began a revolution in music technology. The concrete expression of this collaboration—the computer-based digital synthesizer—is hurling our culture into a future of increased possibilities for communicating emotion and ideas through sound.

Before the advent of computer-based musical instruments, two worlds of music existed independently of each other—the world of acoustics and the world of electronics. Digital-sound technology combined these two worlds by re-creating the rich, time-varying acoustic sounds of the first world and then controlling those sounds through the computer-based technologies of the second.

In a twenty-first-century composition the listener will play a major role in determining the direction of a piece of music. This new participatory listening, however, will not require the knowledge of a musician. Instead, the composition—set within certain bounds determined by the composer—will respond to the listener's voluntary and involuntary cues such as facial expressions, muscle tension, vocalizations, and brain waves.

Music will move bit by bit away from passive entertainment toward an active learning experience in which listening to a composition will become a journey into creativity. The listener's active role and the composition's ability to respond to the listener's decisions and moods will serve to blur the distinction between listener and composer. Increasingly, regardless of musical talent and training, we will all be able to actively participate in the experience and express our feelings directly through music.

Musicians of all types, including classical concert pianists, will prefer the electronic piano over the acoustic piano because of its greater reliability. The computer technology incorporated into the electronic piano affords the musician the sound quality of a concert grand piano as well as a variety of additional capabilities. For instance, a computer can memorize every note and expressive parameter of a composition as it is being created. And, unlike the acoustic piano, the synthesized piano will never be out of tune.

Software-based musical accompaniment will be built into the computer, which will be inside the instruments and programmed by the musicians as they prepare for a performance. Software rich in knowledge of musical theory and styles will be used not only by professional musicians as they write musical compositions and prepare for performances but by amateur musicians who will "jam" with their computer-based instruments at home. The musical revolution created by digital technology will draw more and more people into the field of music and the industry will blossom with new musical styles and compositions.

Some professional acoustic musicians believe that digital technology cannot come close to duplicating the sound of acoustic instruments. Others fear that digital technology will replace many of the musicians who now play acoustic instruments. Digital music, however, will not turn a symphony into a one-man band but rather will provide the musicians with new choices. Live symphony performances by full orchestras (which will incorporate new computer-based instruments) will continue as a popular form of entertainment. Digital synthesizers will replace orchestras in most commercial applications, like the musical background of a motion picture, while creating a rich market for original musical scores.

Computer science will liberate sounds from the bonds of particular instruments and their playing techniques. For instance, before the advent of the microchip, if you wanted a saxophone sound, you had to play a saxophone. If you played the saxophone but wanted piano sounds, you were out of luck. Currently you can buy saxophonelike instruments that can be played with a saxophone technique and can also trigger a synthesizer to produce virtually any sound. Similarly, digital technology is perfecting equipment that emulates the playing technique of other popular acoustic instruments, including the piano, violin, guitar and drums. Musicians will play their instrument of choice but will not be limited to the sounds of that instrument.

Because we are no longer required to use certain set shapes of instruments (like an hourglass form for a violin) to create acoustic sounds, we can also develop a new generation of controllers. A controller is the part of the instrument the musician plays (like the keys of a piano) and many new ones will bear little resemblance to any found on conventional acoustic instruments. The design of these controllers will make optimal use of the human body's capabilities for manipulating instruments with fingers, arms, feet, mouth, and head. Musicians will no longer be restricted by the cumbersome features of acoustic instruments such as the long necks on violins.

Live music performance will have the appeal that it does today—as a form of human communication allowing an exchange of emotions and ideas from musician to listener using melody, rhythm, harmony, form, and timbre.

The challenge for the artist will remain the same—to select the precise elements of sound that can best express the musician's thoughts and feelings. Thanks to digital-sound technology, however, the musical expressions of the next century will incorporate new musical techniques, creating sounds never before heard by the human ear.

Raymond Kurzweil is the principal inventor of a digital synthesizer that duplicates the sounds of a grand piano.

CONTRIBUTORS

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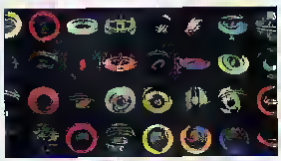
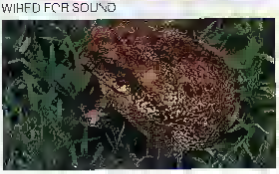
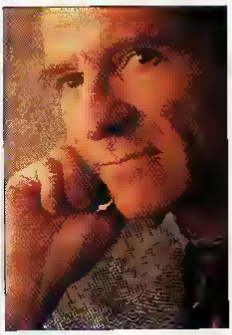
SCHRÖDINGER'S KITTEN



WIRED FOR SOUND



INTO THE WOODS



THORP

See Spot run. Run, Spot, run. This is good advice for Spot to follow if he lives in Dade County, Florida, or we'll be reading the sequel—see Spot stiff. In Dade County toxic toads awaken from their hibernation hungry. These toads love Alpo, but dogs aren't known for kindly sharing their food, so Spot bites toad; toad injects venom; Spot keels over. Until the poison wears off, the poor dogs have to endure this paralysis for hours, lying flat on their backs, with legs sticking straight up.

This tale is one of many unusual zoological oddities covered in *Jessica Maxwell*'s "Into the Woods" (page 42). Florida is also home to manatees—large, playful, vegetarian mammals whose family roots go back 60 million years. Manatees have no social hierarchy or natural enemies other than man. Maxwell was so moved by these creatures that she adopted one through the Adopt-a-Manatee program. "Howie," Maxwell says, "is a thirteen-hundred-fifty-pounder who has the delicious habit of turning over canoes filled with reporters."

Nature endows her creatures with ways to thrive in their natural habitats. But humans are a different story. What man was given, man improves on. So what does this mean for Dick and Jane? Well, if they happen to be athletes, it could be significant. See Dick jump, and up he goes, some 30 feet (see Jane run!).

"Body and Seoul" (page 34) by *Pamela Weintraub* and *Mark Teich* is a jump into the year 2088 and a look at the new breed of athletes who'll be competing at the Olympic games. Stronger and more powerful than their predecessors, future athletes will be trained from early childhood in a sport chosen for them—decided by their biological tendencies rather than their personal preferences.

The medical and technological advances devised to enhance the athletes' natural abilities will no longer be the sole property of the elite. These new and safe procedures will be available to the general populace so that they, too, can develop to their full potential. Special diets, chemical enhancers, and sensory implants are expected to become standard in future Olympics, which raises the question of whether the games will be a battle between countries' athletes or their scientists.

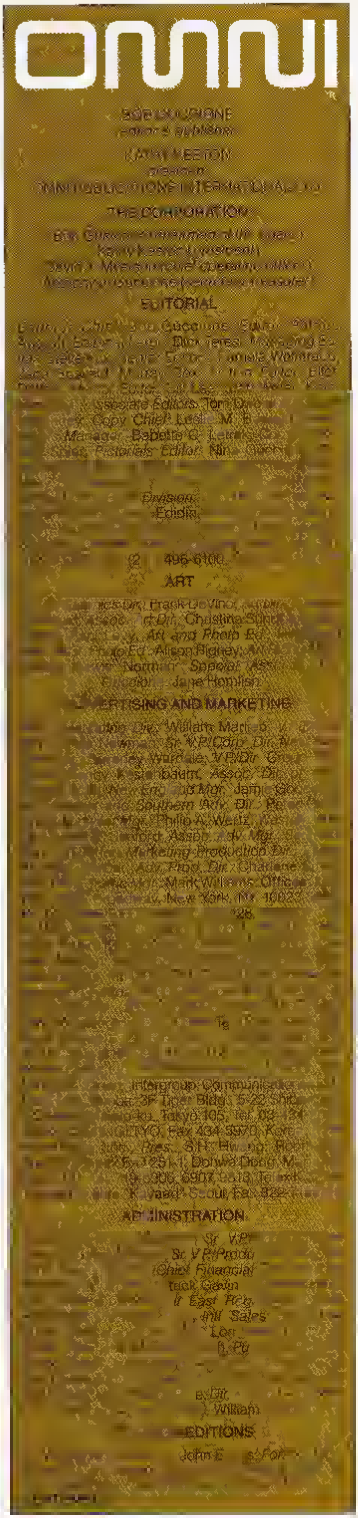
We can expect the games to be modified for these superbeings, and the environment will change drastically. Artificial sunlight and simulated ocean breezes will fill the ten-mile-long enclosure that sits on the outskirts of twenty-first century Seoul. Robots will sell souvenirs and maintain the sports dome.

"Body and Seoul" is illustrated by Attila Hejja, winner of the Society of Illustrators' Hamilton King Award. Hejja regularly does assigned works for NASA's Documentary Fine Arts program.

Some people never tire of games, as long as they can find a new challenge. This month's Interview (page 68) is with Edward Thorp, a mathematician who worked out a system to beat the Las Vegas gaming tables. Wanting a greater challenge, Thorp turned to the ultimate game of chance—the stock market. Thorp has taken his sophisticated, computerized mathematical formulas to Wall Street, coming out ahead even during last year's market crash. *Anthony Liversidge* spoke with Thorp and came away with some big tips. Remember thinking in high school that math would never help you in the real world?

In this month's fiction, *George Alec Effinger* has taken mathematical principles and woven them into the novelette *Schrödinger's Kitten* (page 58). An Arab girl has visions of what may lie in her future and offers an ingenious explanation of quantum physics.

The arts and sciences have never been strangers. Lewis Carroll used math in *Alice's Adventures in Wonderland*, and computers illustrate equations with beautiful designs. Wen-Ying Tsai, an engineer-turned-artist, uses his technical training to create interactive sculptures. The pictorial "Wired for Sound" (page 50) by *Joe Fodor* shows some of Tsai's earlier works. Fodor visited the artist's studio to "play" with the pieces. The sculptures utilize strobe lights and sound to create visually provocative effects. They respond to the viewers' noises—whether singing or screaming, hand clapping or foot stamping. Tsai's delightful work is scattered throughout the world.



LETTERS

COMMUNICATIONS

Stop the Press
Tom Wicker s article [First Word, June 1988] on the ethics of the press was interesting if for no other reason than to show just how much things have changed Imagine an exposé on JFK's love life while he was still in office, or on Eisenhower, FDR or Jefferson for that matter Just how would the public interest have been served if the personal lives of these presidents (and a dozen others) were exposed and they were hounded from office or prevented from running in the first place? While Wicker worries that a news council might become a threat to ' robust journalism' by inhibiting reporters, he shows no such compassion for the disgraced subjects of the inquiries

G L Gregory
Mesquite TX

AIDS and the O.R
I was struck by the example of 'John,' whose surgery was canceled when he was discovered to have a positive AIDS test [Body, June 1988]. We are supposed to sympathize with John, who chose to withhold this information from a number of people who were to be in intimate contact with his body fluids and would be handling sharp instruments People in the operating room *do* get cut with scalpels and stuck with needles At least one surgeon with no known risk factors other than the fact that he worked in an operating room with AIDS patients has died from the disease Anyone at increased risk for AIDS has an obligation to inform his physicians so they can take precautions to minimize risk

Although I've given anesthesia to AIDS patients without hesitation in this case my sympathies are with the surgeon

David Murphy, M D
Englewood CO

Dreamweavers
Thank you Your article "Fantasia" [June 1988] really hit home It helped explain the long-standing differences between me and my mother I fantasize all the time, and she does not These differences have led to several conflicts between us Hooray for Elijah Zupancic who has a mother able to understand him I've only fantasized about the day when my parents will be able to understand me

Susan Chambers
Duluth

Girls Just Want to Have Fun
It would seem the battle of the sexes is being vigorously played out by those who study human behavior Your June interview with Sarah Hrdy was an example of female sexism The answer to her question about why women have traditionally been politically powerless has nothing to do with man's alleged attempt to control women It is because we are childbearers Originally political power was based on hunting and warring skills Can you imagine a woman running alongside a gazelle during a hunt six months pregnant with three kids in tow?

Dinah McFarlane
Hopatcong, NJ

Beam Me Up, Scottie
The Scotland portrayed in your article on Pictish booze [Explorations, June 1988] is a remote, semimythical land occupied almost solely by archaeologists chemists and engineers operating out of universities with quaintly resonant names Honest there's more to Scotland than whisky archaeology and funny names For instance, there's the Association in Scotland to Research into Astronautics an organization that is keeping alive the wave-rider concept—that of a shock wave riding reentry gliding shuttle

Michael R A Cobley
Glasgow Scotland

The Times They Are A'Changing
You should check your clock! I love your magazine especially the Games section but your June column confused me In almost every instance the directions to turn counterclockwise or clockwise are reversed What happened?

Brad Russell
Temple Texas

Editors' Note You're right we erred ∞

LONG-DISTANCE LEARNING

FORUM

By Ron Schultz

Thousands of Midwestern students were suddenly propelled across the country to the briny deep of Washington's Puget Sound—or at least they felt as if they were. Actually, it was a live broadcast via satellite from the ocean floor. A marine biologist appeared on television screens in classrooms, taking the students on a tour of his octopus garden, familiarizing them with life in the salty depths, and providing them with an unforgettable teleteaching lesson.

These youngsters took part in the world's first electronic field trip. Linked to this watery grotto, they heard and responded to their underwater mentor from thousands of miles away.

The electronic field trip is the brainchild of Mike Jones, a seventh-grade science teacher at the Kellog Middle School in Seattle. "Obviously," says Jones, "teleteaching isn't a panacea for all our educational problems. But I think it's a way to motivate students in the sciences."

The realm of interactive teleteaching has dramatically changed from the passive classroom televisions of the past. Satellites, videos, and computers have knocked down the walls of the static classroom, making it possible for students to communicate with and learn from any point on Earth.

"We tried to make the experience the next best thing to being there," says Jones. The West Hills Middle School in Bloomfield, Michigan, took that notion to heart and turned its gymnasium into a beach. To enhance the experience, the gym was decorated with fishing nets and starfish and equipped with two 50-foot television screens. The day before the event, Jones shipped a half-dozen live sea cucumbers to the school. While students onboard a research vessel in Washington were dissecting a cucumber brought up from the ocean floor, the students in Michigan did likewise.

Michael Cole, professor of communications at the University of California, San Diego, was responsible for one of the first intercontinental teleteaching experiments. A SpaceBridge was built between high school students in San Diego and students in the USSR. Over this telecommunications link, the students from East and West discussed films they had both seen.

Andrew Molnar, program director for the application of advanced technology at the National Science Foundation, cites the importance of an Alaskan teleteaching project. "Because of the lack of direct terrestrial communication, Alaska is ideal for telecommunication projects," he says. "Out in the bush country, the satellite and television media are used very effectively." The University of Alaska at Anchorage has instituted a series of computer science telecourses between the school and Stanford University in California. "This is a case," Molnar says, "where difficult terrain has moved education into advanced technology at a very early stage."

One of the trailblazers in the teleteaching community is Classroom Earth. This organization is a clearinghouse for satellite-delivered learning. Teleteaching activities began in 1981 under the direction of Walt Westrum, superintendent of Hall Township High School in Spring Valley, Illinois. Hall high-school students built their own satellite receiver and antenna and used these to monitor the *Voyager II* Saturn flybys. They have covered a number of NASA launches since that initial venture, including the 1986 space shuttle tragedy.

By 1983 Westrum had put together a network of 400 schools nationwide. All of them based classroom exercises on visual data transmitted directly from space missions. "It allowed these kids," Westrum says, "to peek in on the events taking place aboard the shuttle. The science and math students would do things like project launch trajectories, plot the course of the spacecraft on its earthly revolutions, and listen in on the experiments conducted by the crew."

In 1984 Westrum contacted NASA directly. Eight months later, Classroom Earth found itself under contract with NASA's Teachers in Space Program to develop a project called Mission Watch—satellite transmissions of the lessons that Christa McAuliffe was scheduled to teach. Alternate View Network, the largest Earth-to-satellite transmitter in the South, broadcasted video and data transmissions to nearly 2 million students. Immediately following the *Challenger* tragedy, it received more than a million responses from students who were tied in to the Classroom Earth network.

Classroom Earth continues to link schools to one another, but these activities are not inexpensive. They can cost up to $3,500 a program, depending on production costs, and satellite tie-in fees range between $250 and $450 an hour.

In conjunction with the San Diego school system, Classroom Earth developed seven new teleconferences for the 1987–1988 school year, including an international conference with England. Topics ran the gamut from the U.S. space station to desk-top publishing. Classroom Earth also produces a school satellite guide to promote conferences for small, rural high schools to receive language, history, and advanced math lessons via satellite. By August 1989 Classroom Earth hopes to set up a mini mission control so that children in England, Japan, and Australia can watch the *Voyager* flight pass by Neptune.

Any school can join the Classroom Earth network. For an annual fee of $50, it can participate in the interactive projects broadcast via the system. For further information on how to become part of the program, write Classroom Earth, Spring Valley, IL 61362.

Teleteaching is an effective way to supply students with information and ideas they might never otherwise receive. There is a serious caveat, though, to the use of all this technology, and that is the notion of equal access. In some areas, even a $50 fee may be too much, and the idea of buying school computers and training teachers is completely out of the question. Are these schools and students then to be excluded from the technological world? This issue must be addressed to ensure that the less fortunate have equal access to the future and to the wealth of information that teleteaching can provide. ∞

ROCKET ON A ROPE

SPACE

By Randall Black

On a bright morning sometime in the mid-Nineties the space shuttle thunders to life. At first this launch looks like any other. But soon a crucial difference becomes clear. The craft continues into orbit without releasing the external tank (ET). Stranger still, when the two objects do finally separate, a link remains. They are connected by a strong, thin 20-mile strand of plastic cable: a space tether.

The prospect of saving fuel and generating electricity has engineers taking a look at potential uses for tethers in space. No one knows yet exactly what they will cost, but it does appear they'll be worth their price. According to Joseph Carroll, the principal engineer at the San Diego-based Energy Science Laboratories, a $2 million tether system could yield $15 million in savings by giving the shuttle extra lift. The proper use of tethers might even double the payload weight that each shuttle flight could deliver.

The tether concept works because the ET pulls on the orbiter, transferring momentum and energy from itself to the craft. This speeds up the orbiter while reducing the ET's velocity. Being lower in altitude, the ET-on-a-rope begins to move ahead of the orbiter because it doesn't have as far to go to complete one orbit, just as the planet Mercury travels more quickly around the sun than does the earth. With the 20-mile tether fully extended, the orbiter has stolen all the momentum it can from the spent fuel tank. The pilot hits the control that releases the tether, and the external tank plunges downward to fiery disintegration in the earth's atmosphere. At the same time, taking extra energy from the ET, the orbiter is thrown approximately 70 miles higher. Without firing its motors, the craft has thus achieved a change in orbital velocity that is equivalent to burning 2,500 pounds of propellant.

But this is not the only use of tethers in space. Continuing on its mission, the vehicle rendezvouses with the end of another tether, this one hanging from the space station. As the crew of the station reels in this second tether, the orbiter takes energy from the station and gains altitude, which causes the latter's orbit to decay slightly. When the orbiter leaves the station several days later on its return trip, another tethering operation will restore the station to its initial altitude. It drops the spacecraft into a lower orbit—saving 1.5 tons of propellant, too.

The astronauts aboard the docking orbiter cannot see it, but attached to the top of the space station is another tether, one that conducts electricity. It leads ten miles upward to a small satellite. As the copper-lined cable speeds around Earth at five miles a second, it cuts through the planet's electromagnetic field lines and generates up to 5,000 watts of electricity, just like the dynamo of an electric power plant.

This "free" power costs the station a small amount of orbital altitude. At times of low energy demand, however, the same cable could dump surplus electric power from the station's onboard solar cells into the circuit, turning the dynamo into an electric motor that boosts the station back to its former orbit.

Space tethers: The tie that binds

The tether principle will soon be demonstrated for real. Under a contract from NASA, Carroll's company is developing an experiment to fly aboard a Delta rocket that will deploy a high-strength polyethylene tether material called Spectra. This remarkable substance weighs only about one pound per mile. "We are living in the dawn of the age of tethers," says Carroll. "Years from now we will probably look back at the space program and wonder why they weren't used sooner."

On mission 50 of the shuttle, now scheduled for 1991, the tether concept will get its big trial. An Italian–American collaborative experiment, called the Tethered Satellite System (TSS), will test a conducting cable's ability to generate electricity in space. A five-foot-diameter, 1,000-pound instrumented sphere will orbit upward from the craft's cargo bay on a one-tenth-inch-thick tether.

Power-generating tethers would also be useful aboard unmanned spacecraft to the outer planets. "In the outer solar system, spacecraft use radioactive thermal generators. Because they are very, very limited in their power, this is quite an attractive option," says James Arnold, director of the California Space Institute at the University of California, San Diego. Adds Carroll, "The amount of power you could get in Jupiter's magnetic field is fifty times higher than at Earth, and with a six-mile tether you could get one hundred thousand volts. That's a tremendous amount of power for a transmitter."

Generating electricity, however, is not necessarily tethering's most useful purpose in deep space. The majority of research to date has gone into using tethers to transfer momentum from one body to another. The greatest of such changes in velocity come from spinning tethers: attaching two spacecraft, firing a small thruster to start them rotating, pulling them together to accelerate rotation, and then severing the tether to allow them to fly apart. Using tethers, any source of mass—even garbage—can produce thrust. Says Carroll, "Using a tether, you can change direction by throwing away something you don't want."

VOLCANIC CACHE

ARTS

By Pam Hait

Arizona's Roden Crater, some 50 miles east of Flagstaff, rises 700 feet from the desert floor. A black-and-red striated cone two miles wide at its base, the 500,000-year-old extinct volcano is impressive. Yet experimental artist James Turrell is transforming it into a sculptured observatory that alters perceptions of light and space.

Turrell is literally scooping out the open top of the volcano to form a more perfect ellipse. Standing anywhere inside, you will look up and see the sky as if it were a vast but contained vault. A constructed series of underground tunnels and chambers, moreover, will allow light to penetrate the interior, and the heavens will seem to change shape and color.

In the late Sixties, Turrell was one of three Los Angeles artists experimenting with space and light as an art form. In 1968 he turned his California studio into a lab to study how light floats in space. By creating what he calls "an extremely low-tech, artificially ordered environment" with controlled surfaces, lighting, and angles, Turrell demonstrated that it's possible to feel the presence of various kinds of light. "My art exists between the physiological limits of what we can and cannot see and the prejudice of perception," says Turrell, who graduated from California's Pomona College with a degree in perceptual psychology.

An accomplished pilot, Turrell spent seven months flying over the country, seeking the perfect location to expand his ideas. When he sighted Roden Crater, he instinctively knew its dimensions were what he wanted. Isolated in the middle of the desert, the crater happened to be on private property. So Skystone Foundation, set up by Turrell to support this project, negotiated with the owner and bought 640 acres for about $60,000.

Turrell lived at the crater for three months, making complex mathematical computations and astronomical observations. Having mapped out the entire volcano, he then began his reconstruction.

Four bunkerlike entrances will be dug out in what appears to be Roden's base but is, in fact, a smaller volcano contiguous to it. The entrances will blend into the terrain without marring the natural geography. In fact, when the entire project is completed sometime in 1992, the volcano's exterior will look the same as it did before Turrell began his work. Even uprooted vegetation will be replaced.

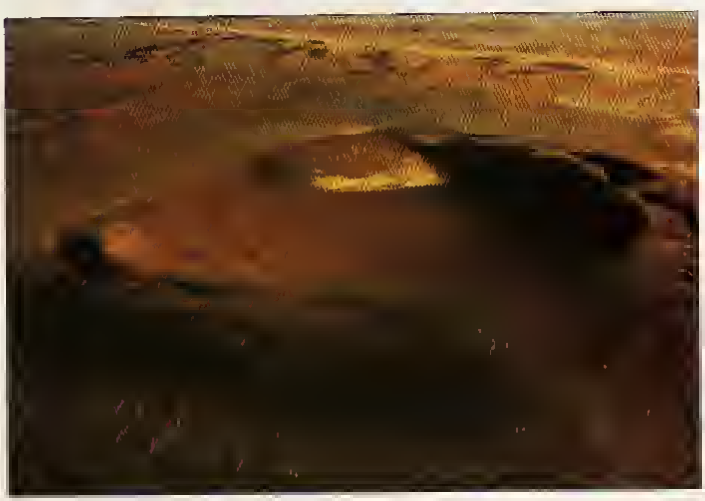
Visitors will travel through two major tunnels and 12 chambers up to the chambers in the fumarole, the bowllike top of the crater. Each tunnel and chamber will be positioned and designed apertures admitting increments of light at various times of the day and night during every season. To create shadows and reflections within the volcano, the spaces will be aligned with the movements of the sun, moon, stars, and planets. And Turrell has planned for a wide range of events, from moonrises and sunsets to the moon in its southernmost declination, an event that occurs every 18.60 years.

Turrell has infused the Roden project with a Guggenheim grant and a MacArthur fellowship, as well as Dia Foundation funds. He has invested revenue from the sale of his other artwork, and he has attracted individual patrons.

Young artists, curious about the Roden project, have also ventured out to the site. "To be an artist," Turrell tells them, "you first have to know how to survey land and how to drive in fence posts. And it helps if you can handle heavy equipment." In many cases, his eager followers have returned and volunteered to assist Turrell in his work.

The first phase of his $3 million art and science project will be open to the public from September 28 through November 9. When the completed volcano opens, it will take 24 hours to fully experience the effects of both day and night lights. Turrell has planned for that, too: spartan, exotic chambers fashioned for overnight guests. During the summer, visitors—knapsacks in tow—will stay in areas that are natural cold sinks within the volcano. In the cooler months, other spaces will be warmed naturally by the earth.

On the edge of nowhere in the Arizona desert, Roden Crater exemplifies what Turrell believes art should be—"work that the culture must contend with."



Burrowed in the bowels of this extinct volcano, visitors will view the heavens in a new light

UNDER THE WATERFRONT

EARTH

By Gregg Levoy

Scuba diving to the floor of a canyon off the coast of St. Croix in the U.S. Virgin Islands, a team of scientists encounters a school of porpoises. Suspended in the turquoise Caribbean waters, the humans investigate their new neighbors before floating up through a wet porch and into the 85-ton underwater habitat they will call home for the next two weeks.

Dubbed Aquarius, this advanced research habitat will allow revolving teams of researchers to make the most intimate and sophisticated foray yet into underwater exploration: marine biology, oceanic farming, coral studies, and the vagaries of living underwater for extended periods.

In this mission, the third to take place since the laboratory opened in February, a team from the University of Georgia is studying the survival skills of corals. James Porter, the group's principal investigator and one of the world's top coral ecologists, says he relishes the opportunity "to bring my laboratory into nature. Now I can see what the ocean sees."

And he can see it with most of the comforts of home. A fully carpeted main galley houses a kitchen and dining area equipped with refrigerator, microwave, and trash compactor. There is counter, shelf, and sink space for experiments; a toilet and a shower; radio and phone systems; a number of viewing windows; and a sleeping area with six bunks. A computer screen doubles as a VCR, a surface periscope, and a display for experiments that are monitored outside the lab. And for the first time a sophisticated bank of computers, not some bleary-eyed scientist, stands watch over all life-support functions day and night.

Operated for the National Oceanic and Atmospheric Administration (NOAA) by Fairleigh Dickinson University in Rutherford, New Jersey, the $5.5 million Aquarius reflects the first major design improvements in such a lab in 20 years—primarily in the areas of space and computerization. The lab, weighted by a 118-ton base to the ocean floor 50 feet down, is connected to an unmanned life-support boat by an umbilical cord regulating air, water, electricity, video, and computer systems. The size of a mobile home, Aquarius is movable. Its base is filled with air, and the lab can be floated to the surface and hauled up through the center of a specially built, 100-foot catamaran, allowing undersea research over a wide area. To explore other depths and reefs, NOAA plans to move it to a new location in the Caribbean in 1990.

Aquarius's biggest advantage over previous labs is its computerized data-acquisition capacity. Says project director Richard Rounds, "Scientists can now crunch their data right onboard and get instant feedback. Researchers can see trends and modify their experiments as they go." The computers also provide environmental monitoring of wave action, currents, water salinity, and light, further freeing up scientists to concentrate on their own experiments.

Aquarius is more than just a boon to scientists, however. It's also valuable for those involved in formulating a coherent agenda for ocean-resource management in places like the Caribbean, which will experience a 50 percent increase in population over the next decade and where regional fish and food production has already topped out.

Porter predicts that the data he collects during this mission will eventually wind up in court, to be used as evidence in cases pitting organizations mandated to protect many of the coral reefs of the Caribbean against developers and others threatening coral populations with harbor dredging, oil drilling, and fishing with sticks of dynamite.

Coral reefs, among the most complex and diverse ecosystems on Earth, may grow only three feet in 1,000 years and provide coastline protection, nurseries for young fish and crustaceans, and tourism revenue for vast areas of the Caribbean, the South Pacific, Indonesia, Australia, and the Galápagos.

"You can't make intelligent decisions without hard data," says Rounds. "Through missions like Porter's, we've found that reefs are a hell of a lot more delicate than we thought. It turns out we're seriously abusing them."

Aquarius. Seeing the ocean from the inside out. The marine lab has the comforts of home.

ARTIFICIAL INTELLIGENCE

By Steve Ditlea

It looks like something Neil Armstrong might have worn for the Bicentennial—a red, white, and blue space suit with a wide tube trailing from its torso. In reality, though, the suit is not meant for space or for any hostile environment. The DataSuit—as it's dubbed by VPL Research Inc., the company that manufactures it—may be the next major advance in human/computer interfaces, the first step toward simulated reality.

"Right now the DataSuit's primary use is to lend realistic motion to characters in computer-generated movie special effects," explains Jaron Z. Lanier, chief executive officer of VPL. "An actor wears the suit, and every body movement can be put into a computer."

The DataSuit's ability to record fluid movements makes it a special-effects dream come true for moviemakers who have been limited in what they can do with traditional stop-and-start animation techniques. The suit works like this: When it's in a normal upright standing position, light from fiberoptic cables, which run the length of the suit, is uninterrupted. But if the wearer bends an elbow, say, the cable bends with it, shutting out a portion of the light, which is then picked up by sensors set along the suit. The sensors translate the light signals into electrical ones and feed them into a computer. This process allows each incremental body movement to be measured and recorded.

"We supply the software to translate that input into stick-figure animation on a Macintosh II in real time [as it is occurring]," explains Lanier, "or to put it into storage for later processing."

Because the DataSuit, which was designed by VPL's Ann Lasko and Chuck Blanchard, can plot body movements so accurately, Lanier thinks it will also be important in medicine. "In physical therapy, for instance," he explains, "you can quickly input the range of movements in a patient wearing the suit and have a computer develop an individualized program of exercise and manipulation."

VPL's earlier product, the DataGlove, which, like the suit, relies on fiberoptic cables and light sensors, also has other applications that Lanier predicts will make it a standard interface. The glove, for example, allows you to handle an image on a computer screen as though it were the real three-dimensional object. This allows a car designer to grab hold of a computer drawing and, rather than run through a series of keyboard manipulations to turn the car 90°, simply twist it by moving his or her hand.

Once the glove was developed, the suit seemed a natural next step. And both, Lanier believes, bring researchers closer to "virtual reality," computer-generated simulation as detailed and convincing as the real world. "Virtual reality will be as popular as movies are today," says Lanier.

NASA has already developed a helmet for the suit, a set of high-resolution goggles that will eventually enable users to watch one another's movements. "With these goggle displays, two people wearing DataSuits will see each other as animals or dragons or whatever creatures they decide to program into the computer simulation," Lanier explains.

Reach out and touch someone

For these "metatelevision" experiences the suit will be programmed to change temperatures and to stimulate the skin in a way that makes the brain think the body is feeling something. This might be done through electrically stimulated crystals in each suit. When you touch your long-distance partner's hand, which you see via special goggles, he or she will feel the pressure of your hand.

"The secret to virtual reality," says Lanier, "is that the brain wants to fill in illusions. Computer-generated environments don't have to be perfect for people to believe in them." In other words, the same faculty that allows the human brain to fill in the gaps between the frames of a moving picture may enable researchers to create the illusion of touch.

Eventually the DataSuit will be used with a visual programming language that will enable users to create or improvise their own worlds. "In the physical world," Lanier explains, "there are a lot of tools you can use to change the world—like a light switch or the steering wheel on a car, which allows you to change the direction of the automobile. Our artificial reality language will provide millions of tools that can change anything at all. You will be able to turn day to night or turn yourself inside out."

Lanier admits that his current DataSuit is a "crude virtual reality suit" with the potential to become much more. "I think someday there will be a virtual reality network that uses the telephone system's fiberoptic cables to link one user to another," says Lanier. "And I hope that people will use it like they use the telephone—to communicate long distance, not to escape into their own canned, preset metatelevision realities."

In the meantime filmmakers are keeping his company busy. Too busy, in fact, to take on the challenge of creating a DataSuit for a horse, a project one Middle Eastern animated-film company is considering in order to simulate the prophet Muhammad's trusty steed. "We're just too busy to do it," Lanier says.

CONTINUUM

ZERO-G OLYMPICS

There's got to be something wrong with the idea. Dave Criswell, a physicist associated with the California Space Institute in La Jolla, wants to make a permanent home for the Olympic games — in orbit. Launch a succession of huge spherical rockets, he explains, connect them like pearls on a necklace, and presto—your basic orbital Olympic stadium. This could be done, he says, by 2008.

Think of it: a rotating space station two miles across, big enough to house 10,000 people at any one time. (Why two miles? "So that once around the ring will be a ten-kilometer run," Criswell says.) But Olympic City, as he calls it, will be more than a Space Age sports palace and the permanent home for the twenty-first century's Olympic games; it has the potential to become a world-wide symbol of international cooperation and goodwill, as well as a stepping-stone to the rest of the solar system. "It will be the brightest star in the sky," Criswell says, "an Olympic torch beckoning to the entire world."

When Criswell presented his idea a few months ago at the International Panel on Space Exploration of the American Institute of Aeronautics and Astronautics, there were a lot of stunned, openmouthed people in the audience. But at the end of his talk, nobody had any objections to his proposal. Perhaps they were silenced by the sheer audacity of the idea and the fact that Criswell had foreseen all conceivable objections in advance and answered them in his presentation.

• Objection one, of course, is money. Isn't the project just too pricey to take seriously? "Look at it this way," Criswell argues. "Since the dawn of the Space Age, the world has spent roughly five hundred billion dollars on space and ballistic missile programs. If the world spent that amount every year for only three years running, you'd be able to put Olympic City in orbit."

• Objection two: The unfamiliar space environment will mess up the athletes' performances. "Possibly, but this might be an advantage," says Criswell. At the winter games in Calgary, some events were decided by a few hundredths of a second, and it was a little boring watching them. The space environment would put some variability and excitement back into the competition.

It will also create new sports. In Criswell's plan, the ring of Olympic City will simulate Earth conditions, but the center will remain weightless, the perfect experimental setting for gravity-free sports. "You'd have to be an all-round athlete to compete, not just a specialized sports machine," says Criswell.

• Objection three: None of the athletes would stand for this. It would, after all, be virtually impossible to prepare for Olympic games that took place in such a celestial setting. Nevertheless, at least one athlete likes the idea. "I'd really love to be the first skater in space," says this year's Calgary Olympic bronze medalist Debi Thomas. "Can you imagine what that would be like? Once you started spinning, you'd never stop."

• Objection four: You can't get 10,000 people into orbit by 2008. This will be tough to do, but not impossible," Criswell answers. "Remember that on any given day there are several thousand people in nuclear subs. Nuclear aircraft carriers are like mobile cities on the high seas. Each of them carries more than five thousand people, and we think nothing of it. Our technology is extremely powerful. We can do this if we want to."

• Objection five: A trip to Olympic City would be too expensive for the average sports fan. "Don't be too sure of that," says Criswell. "Transpacific airliners use about as much energy per flight as it would take to get the same planeload of passengers to orbit. Ticket costs could come down to the price of an ocean crossing [$1,000 to $2,000]."

As for getting the people up there, Criswell has patented a design for an oval-shaped flying wing—a type of airplane with no fuselage. Pilots and passengers sit inside the wings. The craft will take off and land just like a regular aircraft. At high altitudes, though, the whole plane rotates and flies up to space like a rocket.

• Objection six: The Olympic committee would never go for it. Guess again. "It's a fantastic idea, very creative," says Robert Helmick, president of the U.S. Olympic Committee. "The Olympic games have a universal appeal throughout the world, and I think it would be great to hold them in space and for there to be some visible insignia up there that everyone could see."

Here, then, is the schedule of events. By the end of 1988, establish a formal Olympic City Organization. By 1990, hold a worldwide competition for an Olympic City design and announce the winners at the 1992 summer Olympics in Barcelona, Spain. Start full-scale construction in orbit by 2004, and in 2008 light the spaceborne torch to open the games. Then wait to see who brings home the first gold medal from space.—*ED REGIS*

CONTINUUM

It's a novel method of catching prey. Stun them into submission with sound. It is said scientists think the weapon of choice for the toothed whales, including the bottle-nosed dolphin (above).

DEATH SOUNDS

Biologists have long wondered how huge whales, like the sperm whale, catch fish as small as four centimeters in length and creatures as elusive and fast-moving as squid. But size is not the only reason the predatory habits of some of these creatures known as odontocetes (toothed whales, including dolphins) are unusual. The fossil record shows that odontocetes' teeth and beaks have become less, not more, functional over time. So how do they do it?

Kenneth Norris and Ken Marten of the Long Marine Laboratory in Santa Cruz, California, think that the sea mammals' secret weapon may be sound. Five years ago Norris was the first to suggest that odontocetes immobilized prey with loud vocalizations. Since then several researchers, including Marten, have tape-recorded the animals' loud hunting bursts, called bangs, and found that they are of a different frequency than those used in echolocation (the normal form of auditory communication among whales and dolphins).

Marten has performed several experiments to test this "big bang" theory. So far he has found that at least one odontocete prey species—anchovies—are stunned, with hemorrhaging in their bellies, by artificial sounds that are similar to bangs recorded in the wild. His next study will attempt to measure the effect of low-frequency bangs on locomotion and flight capabilities of a variety of fish. There is one glitch in his plan, however. He hasn't been able to find underwater speakers capable of reproducing the intense sounds found in the wild.

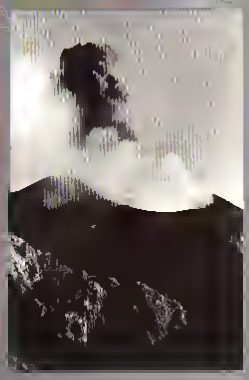
—Rob Applebaum

MAGIC MOUNTAIN

The Book of Exodus relates strange events that occurred when Pharaoh refused to release the Jews from Egyptian captivity. A darkness so thick "they saw not one another" blanketed the land for three days, hail mixed with flames rained from the heavens, a pillar of fire lit the night sky, and the Red Sea parted.

Proof of supernatural intervention or a fanciful allegory? Smithsonian Institution senior oceanographer Daniel Stanley thinks it's neither. "At least some of these phenomena were the result of a natural catastrophe," he explains.

According to Stanley, a well-documented volcanic explosion around 1500 B.C. on the Aegean island of Santorin was the likely source of the biblical account. He and colleague Harrison Sheng collected material from several sediment cores near Lake Manzala in Egypt.



Documenting Exodus: Did a volcano part the Red Sea?

and found 3,500-year-old volcanic ash. Then the researchers compared their analyses of the volcanic ash grains they had found in the Nile delta with ash discovered on Santorin. The result? A perfect match.

Stanley points out that the ancient volcano exploded with great force. The blast may have been heard in Egypt and even seen, which would account for the description of a 'pillar of fire.' Certainly climatic effects were felt, including hail," says Stanley. "Biblical references to darkness probably describe thick volcanic ash."

As for the parting of the Red Sea, Stanley has no proof. "But," he says, "we do know now that other statements given in Exodus that sound very strange most likely did happen."

—Sherry Baker

Moral indignation is jealousy with a halo.

—H. G. Wells

SPHINX JINX

What is older than the *Venus de Milo*, 240 feet in length, and being eaten away by salt? Although hardly a riddle befitting its reputation, the answer is the Sphinx. Close to a decade ago, K. Lal Gauri, a University of Louisville geologist, determined that salt was severely damaging the Sphinx, especially its body, which contains the heaviest concentration of salt. But only recently have Gauri and his research team figured out the process by which the mineral is undermining the 4,500-year-old limestone sculpture.

By mapping the pore system of the limestone, Gauri found that moisture, which condenses on the Sphinx's surface during the cool desert nights, is sucked into the porous limestone through a chemical process called capillary action. The water dissolves the salt inside the pores, and then when the sun heats the stone in the morning and evaporation begins, the salts recrystallize, "transmitting enormous pressure on the pore walls and breaking down the limestone," he says.

"In the desert," Gauri explains, "there is just enough water to do the maximum amount of damage." Nevertheless, Gauri sees hope for the ancient winged guardian of Giza. By spraying water on the monolith and then vacuuming out the dissolved salts, he believes that the destructive weathering can be stopped.

—Rob Applebaum

The case of the disappearing Sphinx. Scientists think they finally know why salt is destroying the ancient Egyptian monument.

AMERICA DEFLOWERED

Gardeners, beware. Those wildflowers you're planting could be some of the last ones on Earth. More than 150 flowers and plants are already on the U.S. government's endangered species list, and 2,000 more should be added, says Faith Campbell, director of the Plant Conservation Project of the Natural Resources Defense Council in Washington, DC.

Several species of cacti and orchids head the list of plants likely to become extinct, in part because of widespread harvesting in the wild and subsequent marketing to nurseries. "This is very distressing," says Campbell, who believes consumers should stop buying endangered wildflowers from nurseries. "I'd be suspicious of a nursery claiming to be propagating [growing its own from seed] lady's slipper orchids or large-flowered trilliums, some species of which should be on the endangered list."

Where have all the wildflowers gone? Check your nursery.

Like animals on the verge of disappearing from their natural habitats, endangered plants cannot be easily sustained solely in captivity. Many plants are enormously difficult to breed outside their natural habitats and are more vulnerable to disease and human mistakes when grown in gardens or other confined spaces.

To help protect endangered plants, Campbell plans to publish an educational pamphlet next March that will tell gardeners which species of wildflowers to avoid buying and how to obtain propagated plants. You can get a copy by writing to the Natural Resources Defense Council, 1350 New York Avenue, N.W., Washington, DC 20005. —Sylvia Rubin

"It is better to be quotable than to be honest."

—Tom Stoppard

CONTINUUM

BEACH HEADS

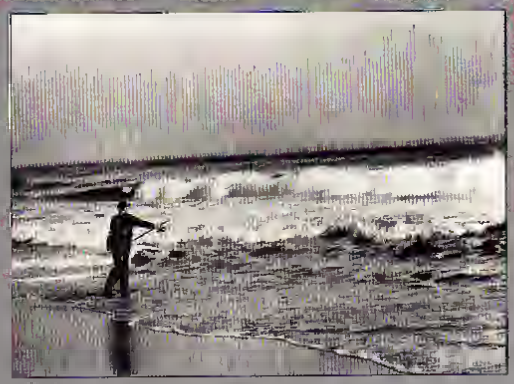
Everyone knows that the sights and sounds of the beach—rolling waves fresh breezes swooping gulls—can be a balm to a troubled mind Now a pair of psychologists from England s Warwick University report that the mere *smell* of the beach can soothe people who suffer from relatively severe forms of chronic anxiety

John King and Steve van Toller put a group of eight anxious patients in a "mock beach,' a laboratory room lit and orchestrated to re-create the feeling of the seaside Using a polygraph, they measured the degree of relaxation in the frontal muscles in the patients foreheads muscles that are among the hardest to relax In each case the patients showed measurable relaxation of these muscles while in the lab Then the researchers introduced a chemical "beach perfume' composed of ozone and essences of such familiar beach smells as seaweed and decaying clams With the introduction of the seaside odors the degree of relaxation in the patients increased by as much as 17 percent

The scientists speculate that the increased relaxation may have something to do with the fact that the part of the brain that processes olfactory stimuli is located in the limbic system the primitive area that regulates emotion and moods They are now using their seaside brand of "aromatherapy' to treat chronically anxious patients 'Some of our patients," says Van Toller were so anxious that they hadn t left their houses for months or even years Now they're coming out and being much more socially active"

—Bill Lawren

The believer is happy, the doubter is wise '
—Hungarian proverb



Scientists have created a perfume of ozone seaweed decaying clams and other seaside smells to calm the anxious mind

Look Mom no cavities Like their Cro Magnon relatives (above), Neanderthals apparently knew how to pick and floss their teeth

PREHISTORIC DENTAL FLOSS

The common image of Neanderthal man is that of a grimy, disgusting half beast with dirt-matted hair and flies circling the armpits Now some recent work by a pair of Midwestern anthropologists indicates that Neanderthal man may have been at least dainty enough to pick his teeth after meals In fact say David Frayer of the University of Kansas and Mary Russell of Case Western Reserve University in Cleveland tooth picking may represent 'one of the oldest and most persistent forms of tool use in the human fossil record

Frayer and Russell base their conclusions on their examination of several Neanderthal teeth from a site near Krapina, Yugoslavia Those teeth, the researchers found were grooved with tiny but regular channels running from the front of the teeth to the back Because the channels were so symmetrical Frayer and Russell rule out the possibility that they were formed by such natural processes as cavity formation or deposition of plaque both of which follow nature's general tendency

to be lumpy and irregular

The case would be clinched of course, if someone could find an actual example of a fossilized Neanderthal toothpick So far no one has Frayer speculates that fastidious Neanderthals 'could have been using bone splinters, using them once, and then throwing them away" In fact, he says, some researchers even think these ancient Flintstones may have used animal sinews or tendons, rubbing them back and forth across their teeth like "prehistoric dental floss'—Bill Lawren

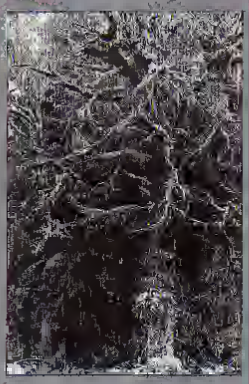
KILLER MOSS

Everyone knows that the forests of North America are dying at an alarming rate, and nearly everyone assumes that the killer is either too much ozone or acid rain But now a Colorado geographer and former logger tells us that the real killing is being done not so much by chemicals as by a hitherto unsuspected assassin the humble moss

Lee Klinger of the National Center for Atmospheric Research in Boulder Colorado, took an interest in the forest die off phenomenon while working as a logger in the wilds of Alaska Later, as a graduate student he came across two sentences in an obscure scientific paper suggesting that mosses might be the culprits That set him on a 30-state trail that ultimately covered as many as 100 dying forests In every case, Klinger found that mosses, particularly a variety called *Sphagnum*, were holding so much water (*Sphagnum* is derived from the Greek word for sponge) that they were turning the surface soil anaerobic, thus depriving the trees delicate feeder roots of vital oxygen In other words, the mosses were essentially choking the trees to death

Klinger's discovery does not fully exonerate acid rain since acid conditions are precisely what mosses like But it may point the way toward a simple and unexpected solution I'm optimistic,' Klinger says "There's enough research to indicate that the solution may lie in a light liming of forest soils" Klinger is now pursuing that in his own research In the meantime, he says "all mosses are lethal until proved otherwise"

—Bill Lawren



Too much moss can be hazardous to the health of forests

"Bureaucracy is a giant mechanism operated by pygmies."

—Honoré de Balzac

[illegible] fat[illegible] oked burger may help protect certain cells against cancer

PICKLES, LETTUCE, CHEESE, SPECIAL SAUCE, LINOLEIC ACID. . .

First came fiber then broccoli Now Michael W Pariza director of the University of Wisconsin's Food Research Institute reports a new and surprising entry on the growing menu of foods that may reduce the risk of cancer The latest medicinal munchie he says is fried hamburger

Pariza found that cooking causes a chemical change in one of hamburger's ingredients, a polyunsaturated fat called linoleic acid When he isolated that altered fat and fed it to lab mice in doses equivalent to what would be found in about eight hamburgers a day, it greatly reduced the incidence of certain kinds of stomach and skin cancer

Unfortunately the scientists still don't know why But Pariza promises that he and his team will make an "intensive effort to find out" When they do, he thinks that the altered form of linoleic acid in combination with other known inhibitors will have "serious potential as a prophylactic against cancer."

—Bill Lawren

CONTINUUM

Able to go where no man has gone before and survive Manny the robotic mannequin is helping scientists make new clothes

ROBOT THAT SWEATS

He's a quiet kind of guy, good at taking orders indefatigable Almost three years ago the Army commissioned Battelle Pacific Northwest Laboratories In Richland Washington, to design a five-foot-eleven-inch, 175-pound humanlike robotic mannequin that could be used to test clothing in simulated conditions that are hazardous to humans Called Manny by his co-workers the robot will get his first assignment later this year when he ll endure weather extremes like subzero Arctic temperatures and the blistering heat of a desert

Technically speaking, Manny takes his orders through a flexible cable linking him with a computer in a nearby room The robot s chest expands and contracts to simulate breathing, and "he even sweats" says David W Bennett of Battelle s Applied Physics Center Perspiration is made possible by computer-directed injection of distilled water through a series of capillary tubes beneath a 'skin surface A system of 40 articulated joints 'designed to provide motion and stress on tested clothing,' will allow Manny a wide range of movement

Manny may eventually be used to test space suits fire-fighting gear and many types of clothing The robot may be one key to defining this thing we call comfort ' say researchers by helping identify the amount of resist ance that clothing applies to the human body"

—Joni Miller

THE FLAT EARTH KIDS

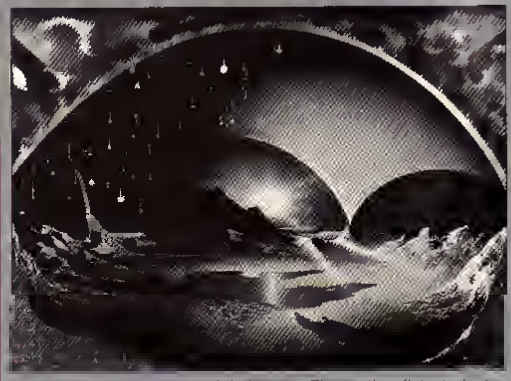
Kids know the earth is round right? Wrong According to a series of studies conducted over the last ten years in the United States and other countries, almost one half of children ten years and younger believe the earth is flat, and those who say it s round picture "round' as a giant pancake or a curved sky covering a flat ground Perhaps even more surprising one in four thir teen-year-olds also believes the earth is flat

In one of the studies teachers of kindergartners through eighth graders were asked to predict how many of their students knew the earth is round It was an assignment even the teachers failed They grossly overesti mated their students knowl edge of the subject

Philip Sadler of the Harvard Smithsonian Center for Astrophysics who conducted the study, was shocked "I think it shows that kids are not little adults. The sense they make out of the world is based on what they have personally observed ' Teaching would be more effective he believes if teachers concentrated on dispelling misconceptions If you try to prove to a kid that the earth isn't flat you'll make more progress than trying to prove it's round," he says —A J S Rayl

"Knowledge is ruin to my young men"

—Adolf Hitler



Looking at the world through kids eyes The earth is flat students say until their teachers prove that it s round

Chalk one up for the lowly mouse. A real estate developer in California has banned cats to protect endangered mice

CATRABAND

Real estate developers are nasty environmental know-nothings who would happily bulldoze an entire ecosystem just to throw up a bunch of clapboard condos. Right? Not necessarily. Southwest Diversified Incorporated is so intent on preserving one endangered mouse species that lives near its new subdivision in San Rafael, California, that it has slapped prospective home buyers with a ban on cats.

When Southwest proposed its new 224-home subdivision on San Rafael's Las Gallinas Creek, officials of the US Fish and Wildlife Service, the California State Fish and Game Department, and the Audubon Society warned the company of the potential adverse impact not only on the salt marsh harvest mouse but also on the equally endangered California clapper rail. Instead of trying to downplay the issue, the developer offered to ban cats in the subdivision and to require residents to trap any stray cats found around the neighborhood.

Cat lovers were outraged, but San Rafael city planning director Anne Moore, noting that her support of the ban has nothing to do with her attitude toward felines—"My cat Motley would attest to that"—holds to a strictly legalistic line. "Restrictions on pets are common in developments. No one's been able to establish that cats have a constitutional right to live anywhere."

—Bill Lawren

CHICKENS WITHOUT EGGS

Which came first, the chicken or the egg? Embryologist Margaret Perry of the Animal Physiology and Research Station in Edinburgh, Scotland, says unequivocally, the chicken. Perry recently raised chickens from ova to fully developed animals without the protection of their own eggshells.

After removing single-celled fertilized ova from hens' oviducts and putting them in glass containers—to re-create the environment inside the oviduct—"I added albumin collected from freshly laid eggs and a salt solution similar to uterine fluid," Perry explains.

Following a day in the incubated jars, the embryos were transferred to empty eggshells. Perry then sealed the shells to exclude air bubbles and rotated them every hour so the developing chicks would be submerged in their artificial culture medium. On the third day they were moved to larger shells. "At this stage, having an air space inside the shell is apparently crucial for their survival," Perry says.

Eighteen days later, live chickens emerged from the borrowed shells. About 7 percent lived, Perry relates, and one—a rooster now nine months old—has fathered normal offspring.

While it may seem a lot easier to let chickens manufacture and hatch their own eggs, Perry says growing chicks in artificial lab media could lead to superchickens. "This process," she says, "makes producing larger, more productive, disease-resistant chickens by genetic engineering easier."

Scientists may also turn chickens into living drug factories one day, Perry adds. "Genetically altered chickens could eventually produce eggs with proteins of therapeutic value in them."

—Sherry Baker

"The longer I live the more keenly I feel that whatever was good enough for our fathers is not good enough for us."

—Oscar Wilde

The first step toward superchickens. Getting rid of the egg

CONTINUUM

More rare than the Asian land crab (pictured above), a myopic crust researchers design lenses for people whose vision is severely impaire

FISH-EYE LENS

A rare myopic crustacean called a copilla that lives 350 meters down in the murky depths of the Mediterranean is the model for a unique double-lens system that a Carnegie-Mellon University biologist hopes may one day help people with severely impaired vision

Jerome J Wolken says that the female copilla s ability to see through marine gloom is due to the unique structure of her optical system The male copilla however, gave up trying to see eons ago and has only vestigial eyes

Wolken s experimental model is a double-lens arrangement of plastic or glass, the front surface of which is a normal magnification lens the one behind it, a rounder fish eye lens designed to catch and concentrate all available light

'More clinical testing is needed on what is still essentially a lab device ' says the biologist, who has long been interested in light and imaging systems as well as the evolution of the human eye But preliminary work with the visually impaired has been encouraging Wolken says the synchronous lenses could be used in everything from optical scanners and microsurgery to high-resolution cameras and solar collectors —George Nobbe

"I have a perfect cure for a sore throat. Cut it "
—Alfred Hitchcock

FLYING NEWSROOM

In Chuck de Caro's TV newsroom, the reporters, editors, anchors crew, and cameramen will all have to be licensed pilots His newsroom a four engine turboprop airplane called *AEROBUREAU*, will be able to fly 400 miles per hour and land on runways as forbidding as a frozen gravel strip north of the Arctic Circle

'It has unique abilities for scoop journalism, ' says thirty-eight year-old De Caro "Imagine live reports from over the [Italian cruise ship] *Achille Lauro* live from inside the eye of a hurricane, or live over the Persian Gulf If there were a major earthquake in Guatemala tomorrow, we could be airborne in less than twenty minutes The whole bureau moves We land, gather the story video tape it, and broadcast it to the networks from inside the plane even while it s in the air '

AEROBUREAU can operate autonomously at full capacity anywhere for a week by providing its own power as well as living and dining facilities Also onboard will be a small jet-powered helicopter, dune buggies for fast on-land maneuvers, and high-powered computers The plane will carry remote sensors, such as radar and infrared enabling *AERO BUREAU* to ' see in the dark and through the clouds ' De Caro says

De Caro believes his flying newsroom will help change the nature of broadcast journalism, not only because of its technological advances but also ' because it will help to create an overall homogeneous fraternity of multipurpose journalists, instead of the factionalism one tends to find in broadcast journalism today "

The plane, based in Tucson Arizona, should be fully operational and ready for its first assignment by late fall —Sylvia Rubin

'Intelligence in diapers is invisible And when it matures, out the window it flies We have to pounce on it earlier '
—Stanislaw Lem

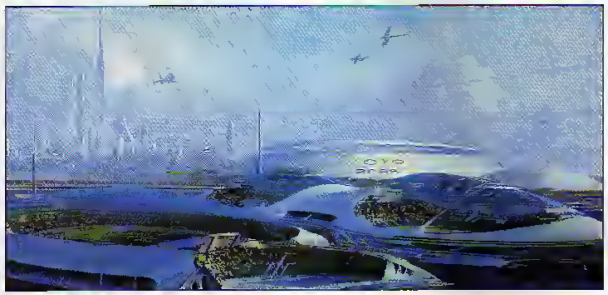
"A cynic is not merely one who reads bitter lessons from the past, he is one who is prematurely disappointed in the future "
—Sidney Harris

ARTICLE

In 2088 Olympians and weekend athletes alike will excel with the help of electronic sensors, brain wave supplements, and bionic joints and limbs

BODY AND SEOUL

BY PAMELA WEINTRAUB AND MARK TEICH

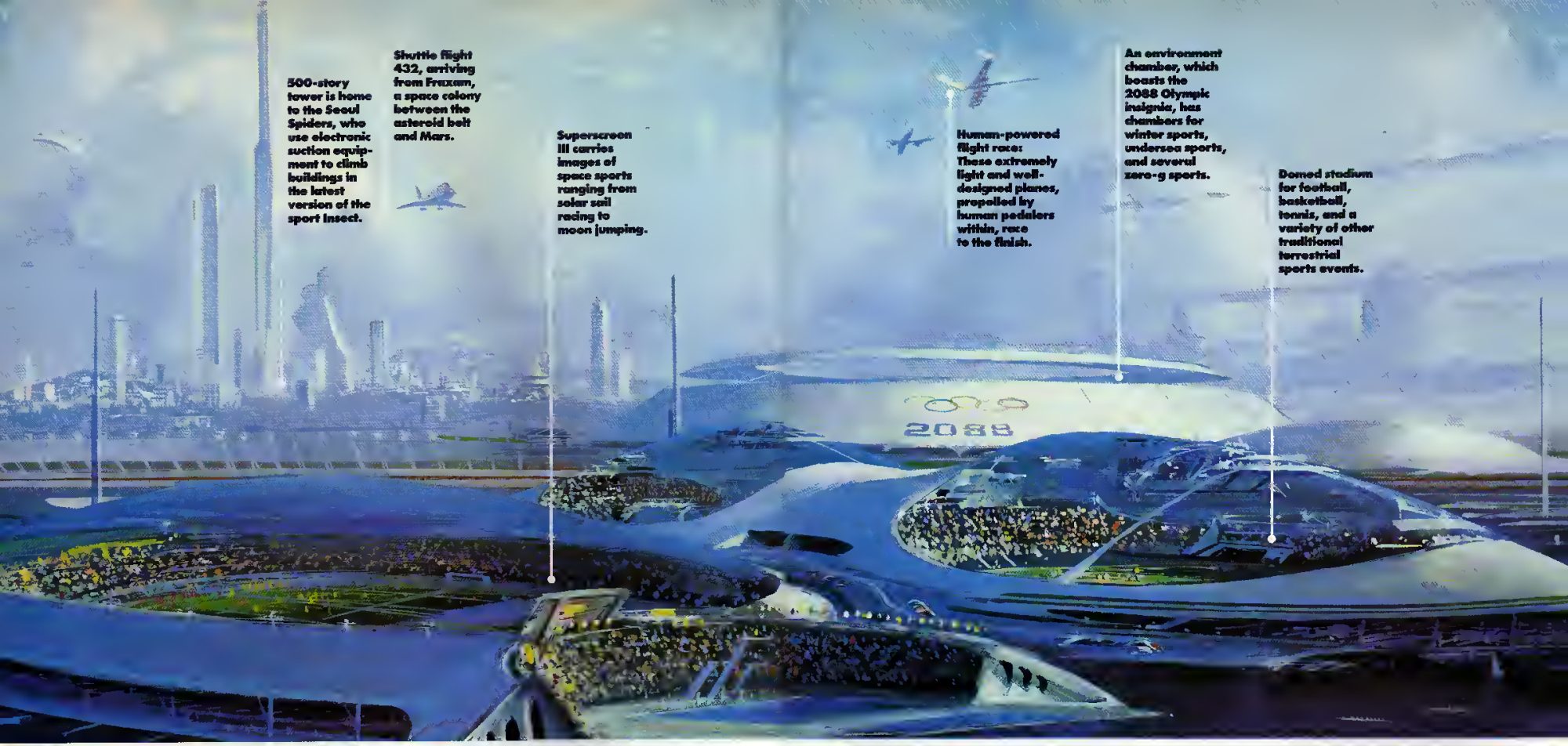


The dome sits on the outskirts of twenty-first-century Seoul, a raucous, international city of 500-story skyscrapers, robot drone workers, and some of the busiest spaceports on Earth. Millions of people from around the world and even from the sea and space colonies have arrived for this event, the Olympics of 2088. It is the first time in 40 years that international and interplanetary tensions have eased enough for humanity's best athletes to compete.

Spectators entering the ten-mile-long dome are instantly isolated from the city's incessant noise and pollution. Artificial sunlight bathes their skin; simulated ocean breezes, spiked with the scent of apple, keep them alert yet calm. Computers dispense information on schedules and hotels. Four-armed robots on wheels scurry back and forth, selling souvenirs and cleaning the stands. Within the depths of the dome, different habitats contain arenas for winter sports, summer sports, deep-sea sports, and sports in zero gravity. Stadiums for football, baseball, tennis, and a host of other sports that were once exclusively professional complete the scene. Aglow overhead, wide-screen displays circle the dome, projecting all the action simultaneously for everyone to see.

It is the athletes themselves, however, who capture our attention. Bred on genetically engineered food

PAINTINGS BY ATTILA HEJJA



and high-energy supplements, kept free of every kind of illness with a universal vaccine, these Olympians are strikingly taller, stronger, and broader than their counterparts 100 years before. As they compete, their natural advantages are enhanced by a multitude of sensors studding their skin. Measuring everything from heartbeats to muscle contractions to brain waves, the sensors radio information to a nearby computer station manned by each athlete's coaching staff. The coaching team radios physiological as well as cognitive-pattern updates and strategy suggestions back to the athlete via a tiny speaker in his or her ear.

When there's a break in the action, the athletes rush to the sidelines, where their teams test their muscles, organs, and neural circuits to make sure they're properly fortified; if not, the appropriate biochemicals are swallowed or injected into the appropriate body areas.

In 1988 some of these practices would clearly have violated all Olympic codes. But in 2088 people consider their blanket of technology as essential as their artificial air. How could any of these enhancements be immoral when the net result is improvement of performance and safety? The Olympic history books show that back in 1984 in Los Angeles a thirty-nine-year-old marathoner named Gabriela Andersen-Schiess was permitted to stagger and stumble the last quarter mile of her race, her eyes rolled back in her head, as spectators wildly applauded her "courage." We know now that Andersen-Schiess was unaware of their applause or anything else and that as she collapsed over the finish line, she was in danger of dying. Such a fiasco could never happen in 2088 because sensors would pinpoint the problem, if it couldn't be solved, the athlete would be removed from the race.

True, a few practices are controversial even in 2088. The shaping of some countries' athletes, for example, began before they were born, when their parents were selected from past champions and literally bred for qualities such as endurance, flexibility, coordination, and strength. Other parents had scientists genetically engineer their sperm and ova to produce a consummate athlete.

Whether parents in 2088 produce their offspring by these radical means or through more conventional courting and conception, they know within the first few years of their child's life if he or she has the potential to be an elite athlete. Indeed, in 2088 *all* young children are taken to aptitude centers, where experts measure their every mental and physical trait. The data are fed into a computer, which tells the children whether they are sports star material, if so, the computer also directs them to a particular sport.

Almost from the time they're toddlers, these natural athletes are exposed to the best sports technology. Each performs daily before video cameras while wired with sensors that measure energy output, muscle patterns, brain waves, oxygen metabolism, and more. The information is radioed to a computer programmed with the ideal patterns for every athletic movement under any condition (heat, rain, high altitude, low gravity) in every conceivable sport. After the computer analyzes the developing athlete's performance, it issues suggestions for improvement.

Athletically speaking, in fact, the computer is the young athlete's mother, father confessor, and coach. It precisely monitors every aspect of training so that he or she safely builds strength, coordination, and agility over the years without interrupting natural growth patterns. The computer suggests what to eat each day, how intense each workout should be, and what exercises to do to recover from an injury.

But computers aren't just an *external* support system anymore, they've become *internalized* as well. In the distant 1980's scientists at a few small laboratories invented an extraordinary

fechnology known as the biochip—an organic computer chip thaf provided the perfect interface between the body on one end and real silicon chips holding intricate data on the other

Today the biochip connects athletes' nerves and muscles to innumerable bionic parts some boasting greater strength and flexibility than natural counterparts Golfers with high-grade bionic shoulders, for instance, can hit drives of 500 yards or more Gymnasts with bionic knees and ankles can perform entire one-legged routines on the balance beam

Chemical aids to performance have also finally been embraced because they simply aren't harmful anymore. Shortly after the furn of fhe century for example scienfists altered the steroid molecule increasing its growth-producing benefits and totally eliminating its side effects By the year 2020 steroids were being routinely prescribed by doctors and trainers in a safe, controlled, systematic program Ironically because steroids have built up their overall strength, athletes nurtured on them are now far less prone to injury and disease than their drug-free predecessors

Athletes also now take daily doses of DNA repair pills These extraordinary enzyme supplements not only fix cells destroyed by injury, they also repair genes worn down by age Thus the rate of healing has sped up while the rate of aging has significantly slowed In 2088 a pitcher with a broken arm needs to wait only days to heal And he can count on the lengfh of his career virtually doubling

With this dazzling array of tools and abilities today's athletes have made a mockery of the records of fhe past Back in fhe Eighties Marvin Clein a sports scientist at the University of Denver wrote a computer program showing that as nutrition improved, diseases and injuries waned and as size increased athletic performance would increase exponentially Exactly as Clein suggested today's average seven-foot-seven-inch, 383-pound football punter can kick fhe ball 85 yards or more on the fly the average seven foot baseball pitcher can throw a 117 mile-per-hour fastball Some punters, in fact, can now kick the ball from end zone to end zone and the fastest flamethrowers in baseball have actually broken the 150-mile-per-hour barrier

As twentieth-century-style sports have gotten easier for the athlete governing bodies have been forced to raise their level of difficulty to keep fans interested In baseball, for example, biomechanical analysis and extremely flexible wrist and elbow implants have allowed pitchers to put inordinate rotation on the ball, by the mid-2000's, consequently, they had developed so many complex breaking pitches thaf they were virfually unhittable The leagues then reluctantly retired the tradifional wooden bats replacing them first with broad aluminum bats and then with ones made of boron and other powerful composites As a result 600-foot home runs became common the subfle balancing act between offense and defense had shifted to the hitters advantage To compensate teams have now extended their fences by as much as 200 feet, beyond the 650-foot mark Fielders all wear long lightweight, synthetic gloves with deeper webbing so they can grab more balls The catcher s mitt once piled with wads of padding is now made of a protective layer of impact-absorbing composites This has eliminated most of the padding, making the mitt as pliable as any fielder s glove

Ofher equipment changes have even more drastically changed the nafure of certain sports In tennis, racket strings have been replaced by magnetic force fields which repel balls with their negative charge The field provides equal power at all points on fhe head and eliminates the old dead spots near the edges of the frame.

Totally new sports have come to the fore as well The 26-mile marathon has been passed in popularity by the 2,000-mile run

"Tennis racket strings have been replaced by magnetic force fields that provide equal power at all points on the head, eliminating traditional dead spots along the edges of the racket frame."

and the bicycling Tour de France has given way to a Tour d Europe

The unique inhabitants of domed underwater cities have created new competitions Partly because they are surrounded by water and partly because they have easy access to artificial gills, these aquatic athletes regularly hold underwater marathons Residents of the aquaworld have also created elegant underwater versions of gymnastics and synchronized swimming because their bodies are buoyed by the surrounding water they can be far more elaborate in their routines than an athlete moving totally or partly through air The judging of these events is done by video

Even the boundaries of the earth and sea have not been able to contain man's lust for new sports frontiers When colonists settled the moon, which has one sixth the gravity of Earth, they became adept at the one-sixth-gravity run and jump At the start of their sprint athletes lean forward with their chests just off the ground Then just before they jump they splay their feet and spread their knees frog fashion to keep their balance Their leaps carry them six times farther than they would on Earth

Watching one giant screen in the Seoul dome, we can even glimpse the spectacle of the space cup, in which competitors use solar sails to race around the moon On the sun side of the moon, fhey are propelled by solar winds When they pass the dark side of the moon, they use energy already stored up by solar collecfors in the sails

As we witness the space cup and three dozen other Olympic events the primary attribute of the twenty-first-century athlete quickly becomes plain fo see In a word, it is *intelligence* Prodded by computers and stoked by chemicals, the competifor has leaped into a world of dizzying complexity, where only the clearest thinkers can prevail In an instant or two during competition, athletes must adjust strategy to electronic and physiological input from several teammates Then, through self-hypnosis and biofeedback, they must alter brain wave and muscle patterns as well

If our ancestors 100 years back could see us now they might well complain that the joy and simplicity of sports has been sacrificed to science But like all living creatures throughouf history the athlete has had to evolve As long as our athletes are human, fhey will evolve along human lines—and in 2088 that means breaking records not just with drive and perseverance buf also wifh tools and ideas

EVERYMAN'S GUIDE TO SPORTS TOOLS AND TECHNIQUES FOR 2088

"Man is a tool-using animal Without tools he is nothing With tools he is all"

—Thomas Carlyle

In 2088 the fruits of sports science are ripe for the picking Today elite athletes no longer have a corner on the market they have fo share the wealth with the resf of us With this in mind, we bring you our "Everyman's Guide to Sports Tools and Techniques for 2088" a directory of resources tapped by the twenty-first century's best athletes—and now available fo you as well Presented within are the mosf sophisticated producfs and services in sports nufrition, sports medicine sports psychology, biomechanical analysis and more The resources in this listing for years available only to the elite, can now help *you* reach your personal performance peak

SOFTWARE

Program perfect. Athletes have always sought perfection A century ago achieving truly perfect performance was all but impossible, a hit-or-miss process that eluded even the elite But now every dedicated athlete can attempt fo reach the peak with *Ideal Disk*

To create *Ideal Disk*, scientists first modeled in infinitesimal detail the techniques of the world s best athletes across the spectrum of sports The models were then analyzed by a computer, which generated composite figures representing optimum performance in each sport

To use *Ideal Disk*, load the program into the hard drive of your personal computer

Then record your performance on high-speed videotape. Run the tape through your PC, and in seconds the computer will break down your image into dozens of discrete segments, calculating force and motion for each of 600 muscles and 200 bones. *Ideal Disk* will then adjust the original composite of the athletic ideal so that it retains its biomechanical efficiency while taking on your exact body size and shape. Then it will tell you how your performance departs from your *personal* ideal. To make the comparison clear, the program will generate an animated stick figure of the desired technique and superimpose it over the video image of your current, imperfect game. By studying the twin figures, you will be able to correct your technique.

A more elaborate version of *Ideal Disk*—model 2088—works as you perform your sport. Model 2088 superimposes the stick-figure image of the ideal performance over the video image of your current performance on a large overhead screen. You simply watch as you play, adapting movement from one second to the next.

Holographic partners. To gain true greatness in sports, you must play against the truly great. In the past, only world-class athletes had access to others of their ilk. But now, with the creation of *Body Double*, you can practice against holographic images of the best athletes in the world.

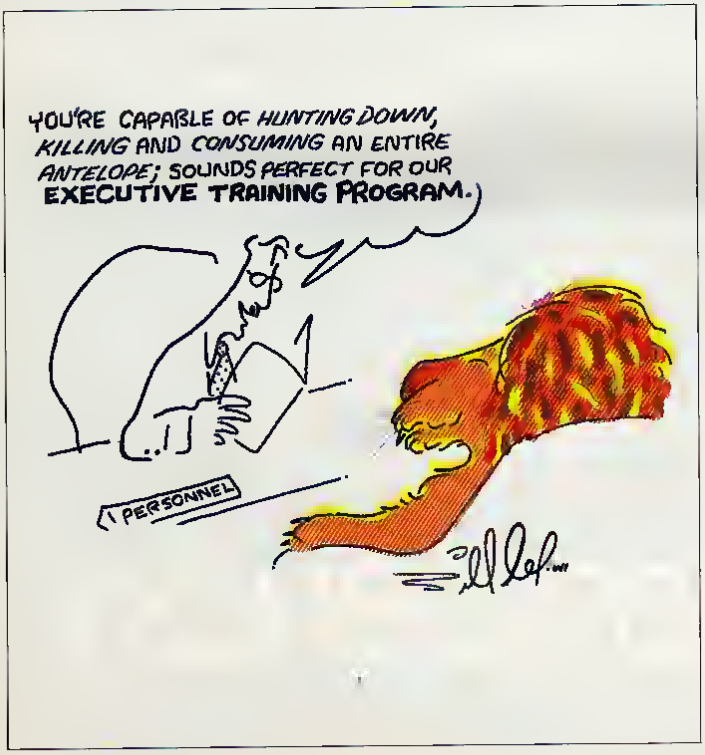
To increase your competitive edge, Body Double, Inc., has traveled around the world filming the performances of elite athletes. These images have been fed into a vast computer library and converted into holograms—lifelike, three-dimensional pictures of athletes projected into the center of a room. These holographic ghosts can spar with fencers and pitch to hitters, providing superbly skilled partners that will give you the best workout of your life.

The *Body Double Tennis Pro*, for instance, includes the best tennis players of the last two decades and projects dozens of types of serves. On each cycle of practice the *Body Double* system projects the life-size, three-dimensional ghost of a particular tennis great, including the specific arc of the racket and the path of the ball. You practice by returning the hologram ball with a special racket. If there is a hit, the strings, which are coated with a light-sensitive chemical, buzz and flash. Because the racket is also electronically wired, it radios the features of the hit to a computer. The computer then analyzes the accuracy of the return. Did you swing too early or too late? Did you swing too high or too low? Not only will the computer answer these questions, it will also tell you what type of mechanical adjustment you need to make—in millimeters and milliseconds. *Body Double Baseball King* serves a similar function, projecting images of pitchers and hitters. To practice, you wield a special bat coated with a light-sensitive chemical. When you swing, the characteristics of your stroke are radioed to a computer and analyzed. Suggestions for modifying your technique then ensue. *Body Double* programs also come ready-made for hockey, basketball, soccer, golf, running and cycling. Those interested in other sports must custom-order a program that will respond to their personal needs.

Athlete clones. There's something special about superstar athletes—their styles of motion and thought are part of a unique combination that makes them great. But elite athletes are perhaps most distinguished by the pattern of electrical signals that make their muscles move. After a decade of work, physiologists at the Tribuco Research Center have recorded the muscle patterns of top athletes in three dozen sports. They have stored these patterns in their computer system and, using electrodes, have transferred these patterns to the arms and legs of talented up-and-comers. With an eye on profit, the company has now decided to make the patterns available via mail order to the public. Donna Moses, public relations coordinator at Tribuco, says, "We have every major athlete of the decade on file. We have Carl Lewis and Dwight Gooden, too."

To use the Tribuco system, you need a strength machine that can be hooked up to your personal computer at home. A kit comes with a computer disk containing the pattern of the athlete or athletes of your choice and an easy-to-use electrode set. Put the disk in your computer, attach the electrodes to your arms and legs as directed, and then do an ordinary workout on your strength machine. Whenever the machine detects the slightest irregularity or weakness as your muscles contract, the electrodes will supplement your performance with feedback from the superstar.

Customers interested in the advanced Tribuco system can find the muscle patterns of selected athletes in a model dubbed the Bodysuit XL. The XL is a skin-tight, custom-designed suit fitted with tens of thousands of electrodes. Each electrode in the suit lies directly over a motor point in your body. As you exercise, the suit will communicate your precise movements to your computer, which, in turn, will send the superstar's electrical signals back to virtually every muscle group in your body.



BRAINWARE

Mind waves. During the last half century, scientists have gathered highly sophisticated data on what goes on in the brain during every phase of an athletic event. They have done this by using electrodes to measure brain wave patterns (known as electroencephalograms, or EEGs) as athletes perform. They have discovered the ideal brain wave patterns for each type of motor activity, for example, by placing electrodes on the temples, above the motor cortex. To measure emotional response, they put electrodes on the forehead, next to the frontal region of the brain. And to measure information processing

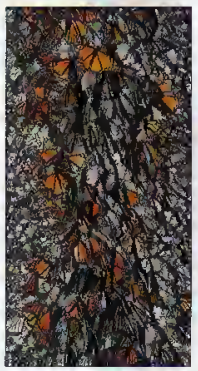
CONTINUED ON PAGE 86

ARTICLE

Superconductors, silicon chips, rockets, and robots all pale beside the antics of ants, toads, and worms

INTO THE WOODS

BY JESSICA MAXWELL



Call me a retro-nerd. Call me a gonzo naturalist. But when it comes to being impressed by genius, the Wild Kingdom wins over Silicon Valley every time. Would computer wizard Steve Wozniak keep his teeth in his stomach, and his stomach in his head? or replace a lost eye with a nose? The Maine lobster does. If a larga gator attacked microchip genie Bill Gates, could Gates cast off his leg, then grow back another? The starfish can. This alone is reason enough for technobrats to remember to take a field trip every once in a while. And it's a good excuse to launch a great American bio-quest, searching for bizarre bugs and animals whose daily habits make MTV look like a Mormon Tabernacle Choir Christmas special.

But as you stroll the countryside, peering into the greenery, don't forget that interesting animals and insects are hard to find. Using basic guerrilla warfare tactics, they tend to blend into the landscape. The dunce-cap head of the treehopper nymph, for instance, isn't as dumb as it looks—to a predator, it's simply another thorn. And ice worms appear as little flecks of grass against the broad, blue glaciers of Alaska. Even the overlooked inhabitants of our own backyards—ants and worms and butterflies and beetles—are able to do the oddest things. And, yes, toads.

"I was in third grade when I first remember hearing the frogs, hundreds and hundreds of frogs. When the sun went down they started croaking, sounding like a creaky swing set going back and forth, back and forth. I'd listen to this strange sound all night, get up in the morning, and find my dog Ralph stiff as a board." Susan St. Clair, a tailor who now lives in Seattle, grew up in Dade County, Florida, during the early Sixties, a time when the manicured lawns of suburbia began to encroach on the great squirmy swamplands of North Miami, when for Sunday dinner, Mom still served pot roast and mashed potatoes while ga-

tors slid under the house to eat the family cat. Kids took bubble baths in the same water manatees swam in at Snake Creek. Dad emptied can after can of Raid in a losing war against the flying cockroach: roughly the size of a Tootsie Roll. And every year, when summer finally yawned and rolled around, the yards filled with toxic toads of the genus *Bufo marinus*. (*Bufo* means "toad" in Latin.) "They were your basic big frog, muddy brown and lumpy," St. Clair recalls. "They had been hibernating, so they were hungry. They loved Alpo."

The toads sport a matching set of venomous glands on either side of the neck. When bitten by canines protecting their food bowls, the glands explode in a milky geyser that paralyzes Rover, or Ralph, for hours. "The morning I found Ralph he was twitching and breathing, so I knew he was alive," St. Clair says. "But his legs were sticking out stiff. On the way to school, I saw three or four other stiff dogs. At school kids would just say, 'My dog is stiff.' People tried to stand them up, but they'd fall over. We'd have to take them by their tails and throw them in the bushes until the poison wore off so they wouldn't get heatstroke."

The Museum of Natural Science in Miami houses one of the largest *Bufo*s in the world. Brian Mealy is in the aviary. A tightly built man with intense blue eyes, he is the curator at the museum. He leads me into the collection room, waves his hand toward the floor, and says, "Well, there's Jabba the Hut." Wide, fat, and bumpy, Jabba looks like a regular toad except that he's the size of a large cantaloupe. He's nine and a half inches long and weighs about four pounds, twelve ounces, depending on whether he has peed. And those are the venomous glands," Mealy says, pointing to the two teardrop-shaped dark areas behind Jabba's eyes. He reaches down and presses on the glands with his thumbs. Nothing. "Now if a dog really sinks his teeth in there, the venom squirts out automatically." Used as a defense mechanism, the venom paralyzes the toad's predator, giving the *Bufo* an opportunity to escape.

Every spring, toxic toads invade south Florida, monarch butterflies show up at the very same trees in California, and brine shrimp, living relics of an ancient inland sea, hatch senselessly in the hollows of Utah's boulders. All over the country gold beetles hide beneath morning glory leaves, keeping their remarkable secret to themselves—that at a moment's notice they can turn into ladybugs. There are even ants in Texas that plant rice, harvest it, crack it into meal, then make cakes out of it and set them in the sun to bake. Or are there?

"That's rubbish," sniffs Roy Snelling. "Where did you hear that one?" Snelling is the collections manager for the entomology section of the Natural History Museum of Los Angeles County. He's also an ant specialist—or, more precisely, a myrmecologist—which is why I call him to verify the story about the Texas baker ants. (Once Snelling was asked to decide whether the ants found on a corpse—the person had been killed by the Hillside Strangler—had left enough "evidence" of their own to "mess up the chemical analyses." According to him, they hadn't.)

After ridiculing the idea that ants "bake rice bread," he tells me about Southwest honey ants. "Just pop them into your mouth, holding on to the head and thorax, and eat them like grapes. They're delicious." The abdomens of honey ants, Snelling says, are filled almost to bursting with nectar. Several thousand live in each nest, and the Indians used to dig them out for a snack.

As convincing as Snelling was, I wasn't convinced. Not about the gastronomic joys of honey ants or the myth of Texas baker ants. Having read about baker ants in a book by a Texas naturalist who seemed to know his stuff, I decide to go to the source, Sanford Porter, a research associate in zoology at the University of Texas. "Good stories die hard," Porter says with a chuckle. "Those harvester ants were first reported back about 1860." The story according to Porter got into an encyclopedia and spread around the world. It was disproved early this century and has been disproved several times since then.

> *"People stood the dogs up, but they'd fall over. We'd take them by their tails and throw them in the bushes until the poison wore off so they wouldn't get heatstroke."*

For every false story in the Wild Kingdom there's an even more bizarre true one. Porter describes fungus-growing ants, "gardener ants" that strip trees and plants of leaves. Their common name, he says, is the leaf-cutter ant of the genus *Atta*. Cutting circles out of leaves, they carry the remnants back to their colonies. They chop the leaves into smaller and smaller pieces and put them in a fungus garden. When the fungus digests the leaves, the ants eat the fungus. The colonies are huge, 30 feet deep and 20 feet across. More than a million ants live in one colony. "The queens are an inch long," Porter says, "making them the biggest ants in the United States."

After the baker ant ordeal, I want something easy, something that stands out like a woolly mammoth in an ant farm. "Ice worms," suggests Alaskan geologist Dennis Rogers. "They're neat. Related to earthworms, they live year-round in glaciers, probably eat algae, maybe pollen. Look," he says, "the Cordova Ice Worm Festival is next week. Come and see for yourself."

When I call to make reservations, the Alaska Airlines clerk informs me that the airline is offering a "special Ice Worm Festival fare." Not wanting to seem frivolous, I make the mistake of telling her that I am on a serious scientific expedition. She finally stops laughing long enough to tell me that the festival is "just another Alaskan excuse for a party." She assures me I will see at least one ice worm—a mascot, some guy dressed up in an ice worm suit. "Ice worms are a myth, anyway. Just go and have a good time." Even my seatmate on the flight, a young lab technician who skis and hikes a lot, does not believe ice worms are real. "I've never seen one," she says.

I meet Rogers in Juneau. "This blizzard's a good one, visibility's shot," he says. "The Cordova flight's been canceled." No ice worms. No Ice Worm Festival. We do what any red-blooded Alaskan would do and head for the nearest bar. "So are they real or not?" I ask miserably. "Of course they're real," Rogers replies. He reaches into his pocket and pulls out a small stoppered glass vial filled with little black things floating around in a clear liquid. "Ice worms," he says proudly. "A biologist friend got them for me."

They are skinny and about half an inch long, looking suspiciously like fish droppings at the bottom of an aquarium. The old geezer sitting next to us looks at me, then the vial, then me, then the vial, and finally says in a fine whiskey baritone, "You interested in ice worms, missy?" He wears a sea captain's cap, his beard looks like a square-rigger. The sleeves of his plaid flannel shirt are rolled up, revealing his cream-colored long johns. Faded red suspenders hold up his work jeans, and his belt buckle is a brass king salmon. He's missing a finger on his right hand and smells like new tobacco and old fish. I nod, responding to his question. He sets his beer down with great ceremony, takes a deep breath, and begins the following poem:

With shouts of stark amazement and with whoops of sheer delight
They surged around the stranger but the first was Deacon White
"We welcome you," he cried aloud, "to this the Great White Land
The Arctic Brotherhood is proud to grip you by the hand."
And now," continued Deacon White to blushing Major Brown
"A Sourdough is a guy who drinks an ice-worm cocktail down."
"'Tis easy done," said Deacon White "Ho! Barman, haste and bring
Us forth some pickled ice-worms of the vintage of last Spring."
But sadly still was Barman Bill, then sighed as one bereft
"There's been a run on cocktails, Boss; there ain't an ice-worm left."

Toxic toad (page 42) and swarms of monarchs on a tree in Santa Barbara (page 43)

Yet wait . . . By gosh! it seems to me that some of extra size

Were picked and put away to show the scientific guys . . .

"Drink, Stranger, drink!" boomed Deacon White. "Proclaim you're of the best

A doughty Sourdough who has passed the Ice-worm Cocktail Test!"

The crowd in the bar roars its approval, and practically everyone in the place buys the captain a drink. the successful recitation of a poem by beloved Yukon poet Robert Service is a prized accomplishment in Alaska. But I'm still confused. Are ice worms real or aren't they? I need an authority, preferably not a sourdough.

"Oh, yes, they're quite real," says John Edwards, a zoology professor at the University of Washington. "I'm looking at a bottle of them from Mount Rainier right now." His bell-like British tones are wonderfully reassuring, as is the fact that he is an alpine ecologist. "I've counted as many as five hundred per square meter on Mount Rainier," he goes on. "They're about three quarters of an inch long, a dark red-brown but they look black to the eye, particularly against the snow."

Like many other organisms, ice worms have antifreeze in their bodies, Edwards explains, so they don't freeze. "People always forget that zero degrees Celsius is not the freezing point of water, it's the melting point of ice," he says. Temperate glaciers such as the ones on the western slopes of the Pacific Northwest always have water together with ice. The ice crystals are like marbles, like lots and lots of little ball bearings frozen together with water all through. Ice worms wriggle through those marbles—actually they can move very fast. The temperature is exactly 0 degrees centigrade, or 32 degrees Fahrenheit. There's generally a heavy snowfall before things get really cold, and snow is a superb insulator. Even though it's minus 40 or 50 degrees and blowing like hell on top of the glacier, underneath that pack of snow is a very warm (32° F) environment.

Because the air is full of insects and organic materials, including spores and bacteria, ice worms don't starve. In fact, they don't need to eat often to survive. "I've kept them in plastic bags in a cold room here for a year without any food," Edwards says, "so they can go a long time between dinners." But in order to adapt to a climate-controlled system, ice worms sacrifice flexibility. "If you warm them up too fast, everything inside speeds up so quickly they just dissolve. If the temperature drops severely, they freeze to death."

Fasting worms, buried alive. Giant toxic toads that paralyze dogs. Fungus-growing ants. Where is the lyricism of nature that John Muir always wrote about? I decide it's time for an aesthetically pleasing *objet d'aventure zoologique*. Something in a pluméd bird, perhaps, or better yet, a butterfly. It's early winter. The monarchs are clustering in Santa Barbara. O excellent creatures, fragile and fair. How worms and ants do pale beside your royal markings of mandarin and black. I'm on the next plane south to California.

Christopher Nagano works in the entomology section of the Natural History Museum of Los Angeles County. Officially he's a research associate, but he spends a lot of his time educating the public about the plight of the migrating monarch, a hundred million of which fly hundreds, even thousands of miles each fall to the coastline of California or the high mountains of central Mexico where they wait out the freezing temperatures farther north.

Monarchs east of the continental divide head for Mexico. Those west of it fly to California, weaving their way through the passes and valleys of the Rocky Mountains, then across the deserts of California. "They have to stop to fuel up with flower nectar and water on the way," Nagano says, "but the most they travel in a day is eighty miles." Like hawks, they like to ride the thermal currents because they can glide without having to flap their wings. They don't migrate in flocks, Nagano explains; they fly solo, though mountain passes often funnel them together. They start arriving in California in September; most of them show up in October, and they begin to leave in January. By mid-March they're gone. Every year these elegant black-and-orange lepidopterans return to the same trees. Like salmon and wild geese and whales, monarchs are living metaphors for what Native Americans call the Sacred Circle, representing a worldview that respects the ongoing cyclical nature of life and is opposed to interrupting or destroying those cycles. And as usual, we're wiping out the monarchs.

> *"The tree looks like it's strung with red Santa Fe chilies. No, I realize, it's covered with butterflies, and the butterflies are all moving. This is a bona fide butterfly tree."*

Approximately one dozen colonies in California have been destroyed or heavily damaged in the last few years because of urban or agricultural development," reports *DANAUS*, a newsletter about California monarchs named after the monarch's Latin name, *Danaus plexippus*, and edited by Nagano and colleagues Walter H. Sakai and Gary Wolfe. Recently the International Union for the Conservation of Nature and Natural Resources made the protection of wintering monarch colonies a "top priority." The monarch is the only insect listed in the Convention for the Conservation of Migratory Species of Wild Animals—or "Bonn Convention"—an international treaty protecting many animals. And last year California governor George Deukmejian signed into law a bill that officially recognizes wintering monarchs as a special California phenomenon. "It's the first time the state of California has admitted the environmental importance of an insect in a positive way," Nagano says.

He asks me to meet him at the Ellwood Colony at 10 A.M. It's a bright winter day, and following his map I park at the dead end of a modest residential street, then venture into an adjacent grove of eucalyptus trees. It's another universe. The air is cool, perfumed with the mint and medicine breath of the gum trees. Colors are transcendent—mottled lavender and peach and jade. The ground is a crinkly mop of leaves and shredded bark that makes you want to kick at it, regardless of your age. Nagano said he'd be "in the wash with the monarchs," but everything looks the same, and I don't have the faintest idea which way to turn. I'm lost. Then, with that same bewildering otherness that imbues the whole place, a monarch butterfly appears out of nowhere and flies right past my nose like a guide manifest. I follow.

We make a sudden left-hand turn, and there is Nagano, sitting cross-legged beneath a tree with a long-handled butterfly net on his lap, writing in a notebook. A monarch is walking slowly up his sleeve. I'm stunned. The tree looks like it's strung with red Santa Fe chilies. No, I realize, it's covered with butterflies, and the butterflies are moving. This is a bona fide butterfly tree. The constant fanning of all their wings sounds like a light rain.

"There are about three thousand monarch butterflies here today," Nagano says, clearly enjoying my awe. "They are also known by the name milkweed butterfly because that's all they eat." It turns out that a chemical in milkweed both nourishes the monarchs and makes them toxic to most birds. "A bird eats a monarch once and never tries again," says Nagano. With a chuckle he adds, "Lincoln Brower, distinguished professor of zoology at the University of Florida in Gainesville, won an *Esquire* Dubious Achievement Award for determining how many monarchs it takes to make a blue jay vomit."

"You want to tag a monarch?" he asks. We hold the kicking butterflies in one hand, while with the other we carefully rub a bald spot in the powdery microscopic scales on the upper edges of both sides of one wing. Then we gently pinch on a rather unremarkable-looking small white sticky label printed with the words MAIL TO NAT HIST MUSEUM LA, CA 90007 followed by a number like MP L 38465. Nagano records the tag number in his notebook, then we let the butterflies go. The tag doesn't affect their ability to fly. Nagano says they don't

even know the tag is there. Once they die, with luck someone mails them to the museum and says where the insect was found. By checking the tag number researchers know where it was tagged and how far it got. 'One that was tagged in Toronto showed up in Mexico,' Nagano says proudly.

During the time I spend in Santa Barbara I hear a story about a remarkable bug that changes colors, chameleonlike. I decide to look up Adrian Wenner, a natural history professor at the University of California at Santa Barbara. 'Insects are not known to change colors,' Wenner says with a wry grin. 'Some lizards do. Some octopuses do. But not insects. One of my colleagues refused to believe me when I told him that the gold beetle [golden tortoise beetle, or *Metriona bicolor*] changes color. I didn't believe it myself until I saw it about ten years ago. Fortunately, Wenner has an hour between lectures and agrees to take me on a beetle hunt.

"We're looking for morning glory plants with little holes in their leaves," he says. "That shows that the gold beetle has been there and, if we're lucky, still is." We find some morning glory leaves with holes. Wenner explains: "You can't disturb the beetles or they'll drop, and you'll never find them." Then, moving his long, graceful fingers like a magician, he tucks a plastic bag beneath the plant and shakes the leaves. To my astonishment, five tiny beetles roll out, bright as polished gold. Wenner sets one in my palm, and to my further astonishment it immediately begins to glow a fluorescent turquoise, then a brilliant green, then it turns bright vermilion and manifests two black spots—as I am watching.

"It's turning into a ladybug," I cry.

"Yes, a good defense, since ladybugs are toxic to many predators," Wenner adds. He explains that the gold beetle manipulates its own blood. It actually pulls blood away from the edge of its skeleton so that its shape becomes nearly identical to that of the ladybug, which is smaller and rounder. Sure enough, I can see a lacy hem of exoskeletal beetle wing skirting the new ladybug persona. Wenner drops some morning glory leaves into the plastic bag and sends the gold beetles home with me; they entertain family and friends for weeks.

Like the gold beetle, the octopus is a camouflage genius. If can change color and texture. But the biggest octopus on Earth, the giant Pacific octopus, which makes Washington State's Puget Sound its home, does something even stranger than blend into its underwater environment. Weighing up to 100 pounds, with an arm span of more than 15 feet, it routinely draws its voluminous skin up into longitudinal folds, forming numerous papillae. It looks like a giant mauve breast studded with nipples. The Houdini of the deep, the giant Pacific octopus slips its massive self through any hole, as long as it isn't smaller than its beak, which ranges from half an inch to two inches in diameter. That is an amazing feat given that a 118-pounder was caught in the Seventies in Hood Canal, south of Seattle. With a tip-to-tip arm stretch of 22 feet, the big beast made the *Guinness Book of World Records*.

Michael Kyte, a consulting marine biologist and one of the better-known giant Pacific octopus specialists in the country, maintains that octopuses are quite intelligent and can be trained. At the Seattle Aquarium an octopus named Oliver moves from tank to tank on command. "And we had one, a big seventy-five-pound male named Thor, who'd fire-hose you if you didn't stop and pay attention to him when you passed his tank. They can even open bottles," Kyte adds, "both stoppered and screw top." While octopuses usually keep to themselves, occasionally an incident reminiscent of Jules Verne occurs.

Washington State Department of Fisheries biologist Feney Matthews and a diving partner were tagging rockfish off an artificial reef in Puget Sound when suddenly a very large octopus with about a ten-foot arm span began slithering up Matthews's arm. "It took both of us to pry it off. When we did, it started displaying to me, moving its tentacles up and down," she says. "Then it came right up to me again and started wrapping me up. We got it off me, and it started making this threatening action—swimming very fast toward me. We immediately left the bottom."

> *"He sets a gold beetle in my hand. It immediately glows fluorescent turquoise, then a brilliant green, then bright vermilion and shows two black spots. "It's a ladybug," I cry."*

Kyte thinks an octopus becomes aggressive toward divers because from a distance, a diver looks like an octopus. "I've had males get aggressive because they were guarding a mate or territory. They'll lay their arms over your head. Usually as soon as they touch you, they realize you're not an octopus and back off. But they can take your mask and regulator off, and at eighty feet, that can be startling."

Another unusual thing about octopuses is their sex life. With all those arms in the way, how do octopuses do it? Well, the male has one arm equipped for the job, with a groove that guides and holds his sperm packages so they can be inserted into the female. "When the male ejects a sperm package, it's the size of a pencil," Kyte says. "But once it hits the salt water, it undergoes a spermatophoric reaction and rapidly expands in size to more than a meter in length. The male inserts his arm into the mantle cavity of the female, which assists the process with muscular contractions—sex at arm's length, if you will."

After one mating season, which lasts about five months, male and female octopuses mate and die. The male fertilizes three or four females, and a switch in his brain turns off his appetite. He goes senile, then he starves to death. The female octopus lays about 50,000 eggs in a den that she guards for six months. During this time, she doesn't eat. By the time the eggs hatch, the female is dead. Baby octopuses are orphaned from birth.

Ancestors of the giant Pacific octopus have been on the planet for millions of years. They were hard-shelled creatures called ammonites and nautiloids, similar to today's chambered nautilus. They left beautifully preserved fossil remains. But it's anyone's guess when the octopus shed its shell, since the pliable entity we know today leaves no fossils. The oldest fossil genus on the planet, however, can be found flitting around in puddles and ditches all over the United States.

Tadpole shrimp fossils, of the genus *Triops*, are identical to those found in Europe that date back two hundred million years. So as far as we can tell by morphology, it's the same species," says Denton Belk, adjunct professor in the biology department at Our Lady of the Lake University in San Antonio. "This means tadpole shrimp are the oldest genus living on the planet," he adds.

Tadpole shrimp and their cousins the clam shrimp and fairy shrimp are mysteries of modern biology, like the scientific quandary of how bumblebees fly—aerodynamically they're too heavy for liftoff. They are shrimp that might have evolved from some sort of oceanic origin, but you can find them in the oddest places, like stock tanks and snowmelt ponds—even in the hollows of boulders. They got there through the feces of birds and dust storms—even the muddy feet of birds. Even stranger, their eggs don't hatch on a regular schedule. In fact, they can remain in suspended animation for decades. They even breathe weirdly. Tadpole, fairy, and clam shrimp—all of the subclass Branchiopoda, meaning *gill foot*—breathe through their legs as they swim.

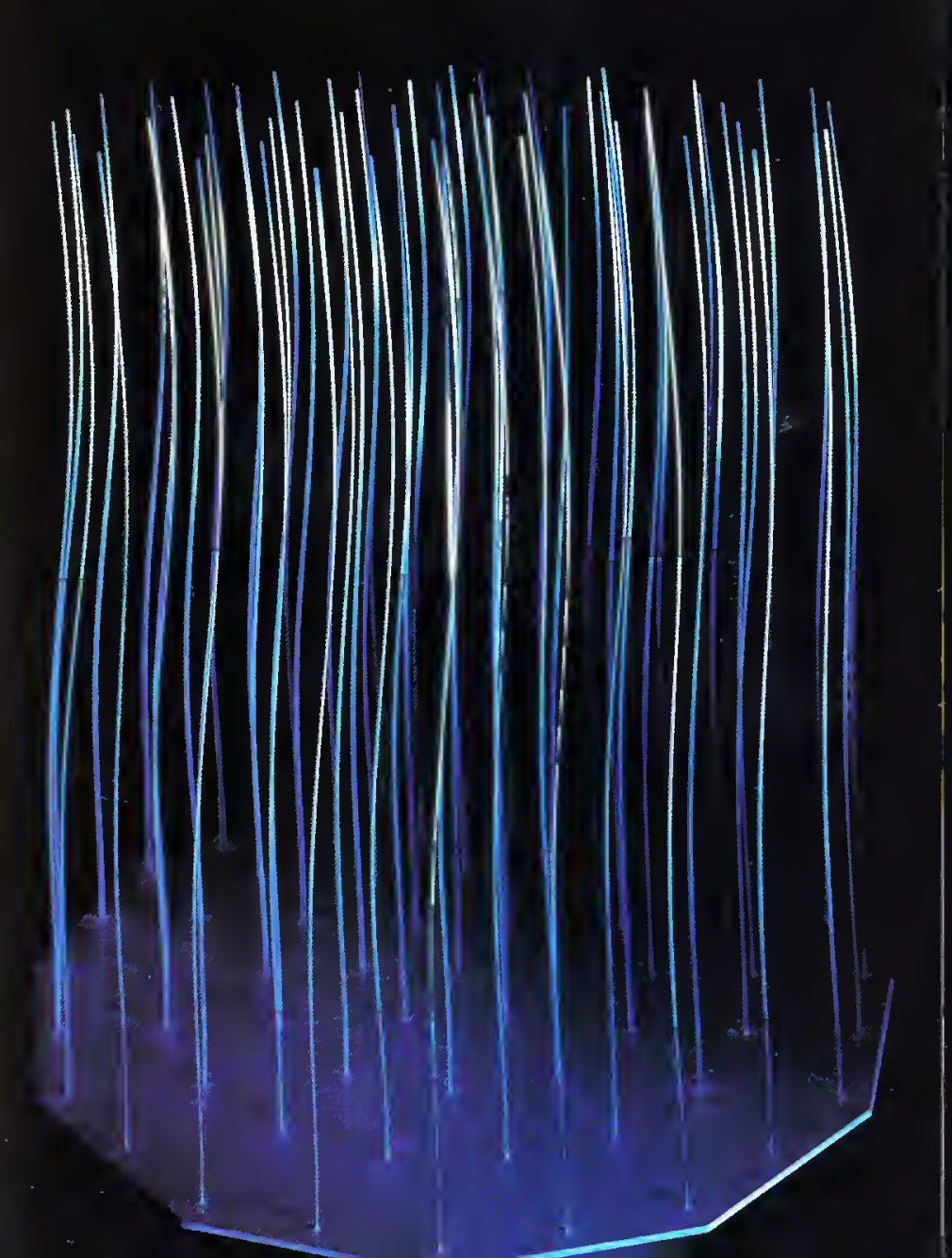
Tadpole shrimp should really be called horseshoe crab shrimp because that's what they look like—in two-inch miniature. Clam shrimp look like little teeny half-inch clams, with the addition of a couple dozen legs and two pairs of antennae—one for analyzing the chemical makeup of water and one for swimming. And fairy shrimp are almost all legs. Fragile and feathery, they appear out of nowhere, which probably accounts for their name.

A brand of fairy shrimp called brine shrimp are the only commercially viable one

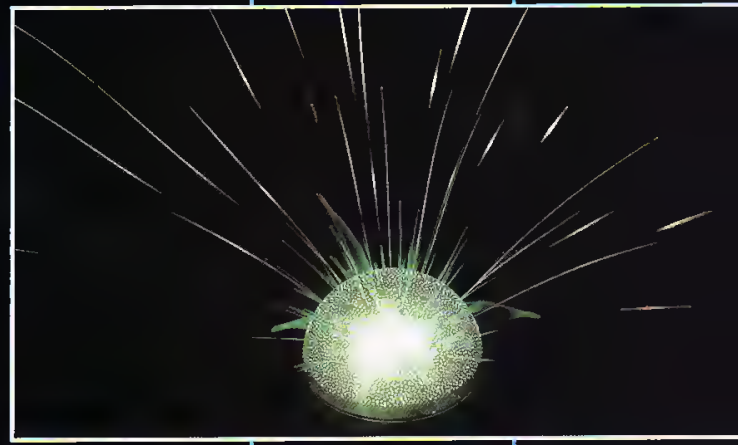
CONTINUED ON PAGE 90

WIRED FOR SOUND

ART BY WEN-YING TSAI



LEFT: *WIND FIELD*, HARMONIC SCULPTURE, STAINLESS-STEEL RODS. RIGHT, FROM TOP: *PERMUTATION NEON*, DESIGNED ORIGINALLY FOR NEW YORK CITY'S PORT AUTHORITY; *SEMISPHERE*, STAINLESS-STEEL RODS; *DDUBLE-DIFFRACTION*, VIBRATING RODS (ALL THREE PIECES OF ART COMBINE THE EFFECTS OF STROBOSCOPIC LIGHT WITH AUDIO FEEDBACK CONTROLS)

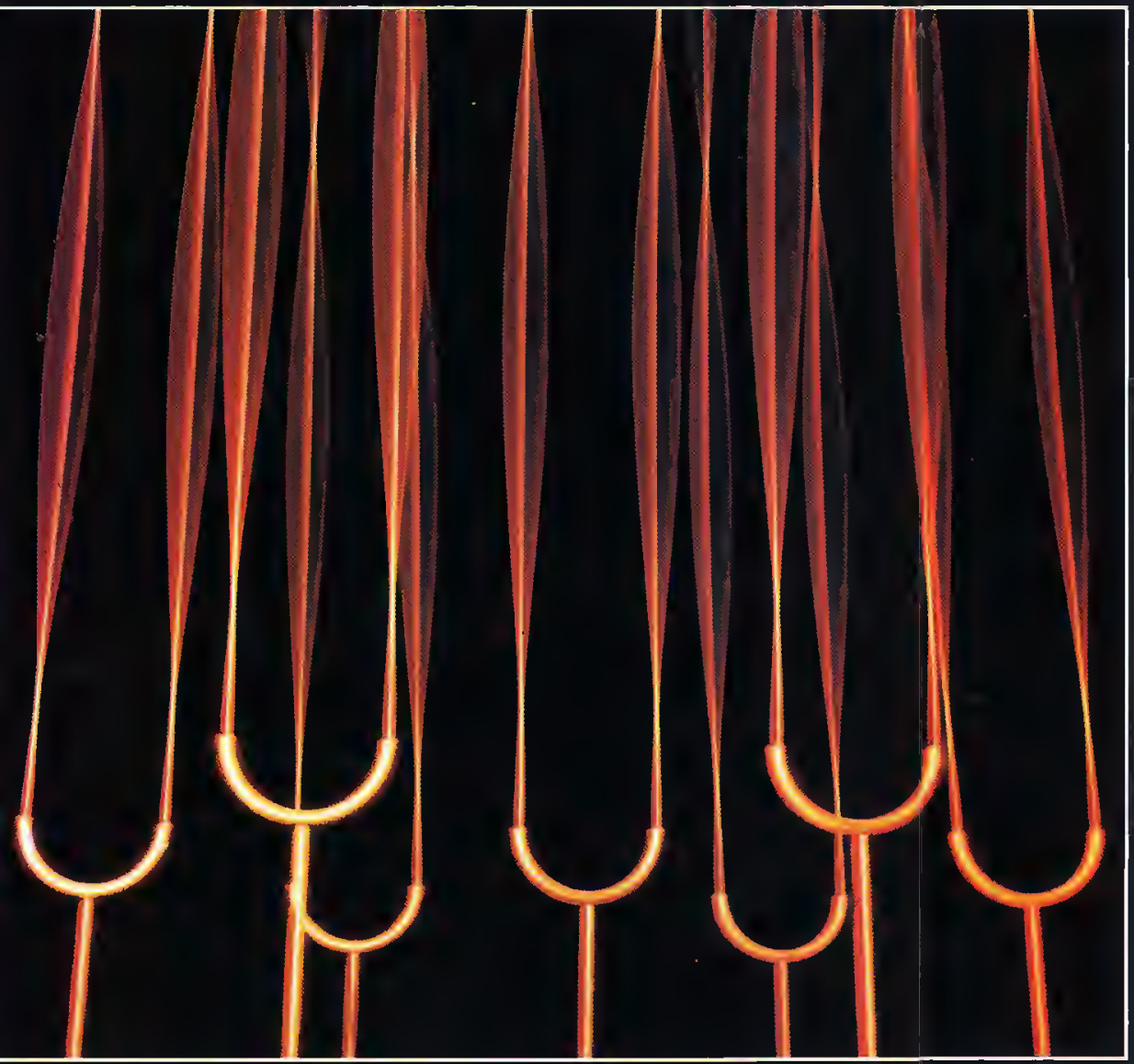


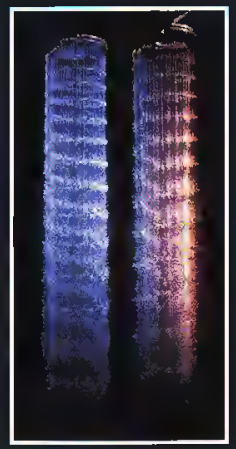
To many people, kinetic art is a pinball machine or perhaps even a painting thrown Frisbee style out a window. But the kinetic sculptures on these pages are a delicate balance between art and science. Created by engineer-turned-artist Wen-Ying Tsai (see Arts, June 1988), these works are lifelike and hauntingly beautiful.

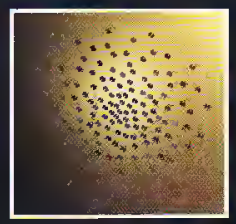
Tsai wasn't home the day I visited his New York studio, so Pei-De, his wife, gave me a tour. As if to welcome me, she clapped her hands, and a small fountain bubbled to life. I had a sense that this was something magical.

"Let's see if this one is plugged in," she said, pressing a button on a box next to a row of ten-foot-tall fiberglass poles. Soon the poles began moving in a blur, vibrating at a rate of 30 times a second. One of many strobe lamps blinked on, bringing to life a dozen sinewy creatures.

"Clap your hands if you'd like,"







she prompted, so I clapped, and the sculpture shuddered Delighted, I laughed, and it quivered, assuming an entirely new shape I tried whistling, humming, and coughing With each noise it reacted differently Mrs. Tsai smiled

"You don't mind?" I asked.

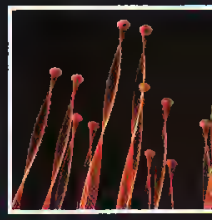
"No, go nght ahead," she prompted, so I sang in a high falsetto, stamped my feet, and grunted animal noises The waving rods dared me to further embarrass myself

An adjoining room contained a smaller sculpture designed with 20 slender steel rods tipped with diffraction discs that change color depending on the way light hits them A strobe light flickered on the rods, cuing them to start their synchronized dance They looked like waitresses holding trays of food above their heads while doing a slow bump and gnnd with their

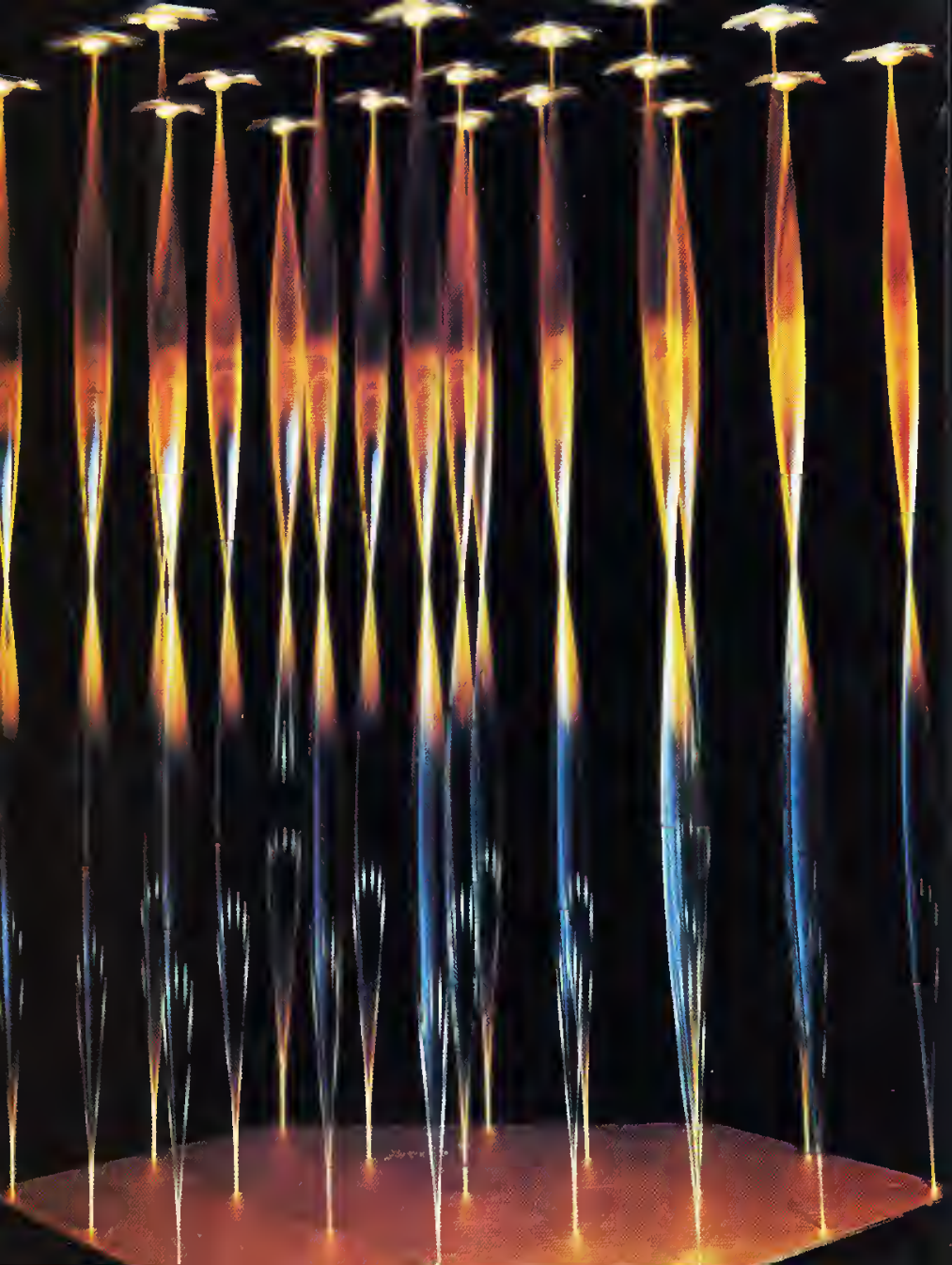
hips I laughed, and they froze, then they vibrated frantically for a few seconds before resuming their hypnotic motion I sang "Danny Boy" to the waitresses while entranced by their swaying.

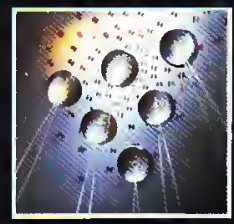
Nick Nicolaives, Tsai's assistant engineer, showed me a series of fiberglass rods mounted around a small copper hoop. It had been redone more than 20 times before it worked Each rod is cut to a precise length,

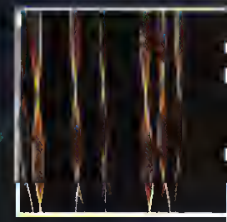
PAGE 52: *TUNING FORK,* VIBRATING RODS. THIS PAGE, CLOCKWISE FROM TOP LEFT: *UPWARD FALLING FOUNTAIN,* 12.6-FOOT-HIGH PROTOTYPE FOR A LARGER PIECE; *CYBERNETIC SCULPTURE #26;*



***TUNING FORK* (UPPER PORTION); *DANCING MENORAH,* IN ISRAEL, A STAINLESS-STEEL PREDECESSOR OF A THREE-STORY-HIGH SCULPTURE; *MULTI-CHROMIC DIFFRACTION,* ANODIZED PLATE WITH DISCS**







LEFT: *SQUARE TOPS*, CYBERNETIC SCULPTURE WITH MIRRORS. THIS PAGE, TOP LEFT: *OPTIC QUASAR*, TEN-FOOT-HIGH OPTICAL FIBERS; TOP RIGHT: *GLOBE*, WHICH EXPANDS AND CONTRACTS; FAR RIGHT: *CYBERNETIC SCULPTURE*; CENTER: *SQUARE TOP*; BOTTOM: *CYBERNETIC SCULPTURE* (120 FEET WIDE AND 16 FEET HIGH) HAS COMPUTERIZED FIBERGLASS RODS THAT VIBRATE

or the thing will wave around like a "crazy octopus," then crash under the stress. The materials are microscopically different (there is no way to tell beforehand what will work), so each one is shaved to an exact size.

As a finale, Nicolaides turned on the *Upward Falling Fountain*, Tsai's most recent work and so far the only one of nearly 300 pieces to have received a U.S. patent—number 4,265,402. The light treatment causes the water droplets to appear as if they're running toward the ceiling.

It's an odd experience looking at a cybernetic work by Tsai, if you're left alone with one, it patiently waits for you to awaken it with the slightest noise or movement, and it replies with a graceful wave. And when you leave, it's with a creepy feeling and a look over your shoulder: Have you just looked at a piece of art, or has it just looked at you?—Joe Fodor

FICTION

SCHRÖDINGER'S KITTEN

By making the right decision one night, a poor girl of the Budayeen could change the destiny of the world around her

BY GEORGE ALEC EFFINGER

The clean crescent moon that began the new month hung in the western sky across from the alley. Jehan was barely twelve years old, too young to wear the veil, but she did so anyway. She had never before been out so late alone. She heard the sounds of celebration far away, the three-day festival marking the end of the holy month of Ramadan. Two voices sang drunkenly as they passed the alley; two others loudly and angrily disputed the price of some honey cakes. The laughter and the shouting came to Jehan as if from another world. In the past, she'd always loved the festival of Id-el-Fitr; she took no part in the festivities

PAINTING BY CHARLES PFAHL

now though, and it seemed somehow odd to her that anyone else still could. Soon she gave it all no more of her attention. This year she must keep a meeting more important than any holiday. She sighed, shrugging. The festival would come around again next year. Tonight, with only the silver moon for company, she shivered in her blue-black robe.

Jehan Fatima Ashûfi stepped back a few feet deeper into the alley, farther out of the light. All along the street people who would otherwise never be seen in this quarter were determinedly amusing themselves. Jehan shivered again and waited. The moment she longed for would come at dawn. Even now the sky was just dark enough to reveal the moon and the first impetuous stars. In the Islamic world, night began when one could no longer distinguish a white thread from a black one; it was not yet night. Jehan clutched her robe closely to her with her left hand. In her right hand, hidden by her long sleeve, was the keen-edged, gleaming, curved blade she had taken from her father's room.

She was hungry and wished she had money to buy something to eat, but she had none. In the Budayeen there were many girls her age who already had ways of getting money of their own, Jehan was not one of them. She glanced about and saw only the filth-strewn, damp, and muddy paving stones. The reek of the alley disgusted her. She was bored and lonely and afraid. Then, as if her whole sordid world suddenly dissolved into something else, something wholly foreign, she saw more.

Jehan Ashûfi was twenty-six years old. She was dressed in a conservative dark gray woolen suit, cut longer and more severely than fashion dictated but appropriate for a bright young physicist. She affected no jewelry and wore her black hair in a long braid down her back. She took a little effort each morning to look as plain as possible while she was accompanying her eminent teacher and adviser. That had been Heisenberg's idea. In these days who believed a beautiful woman could also be a highly talented scientist? Jehan soon learned that her wish of being inconspicuous was in vain. Her dark skin and her accent marked her as a foreigner. She was clearly not European. Possibly she had Levantine blood. Most who met her thought she was probably a Jew. This was Gottingen, Germany, and it was 1925.

The brilliant Max Born, who had first used the expression *quantum mechanics* in a paper written two years before, was leading a meeting of the university's physicists. They were discussing Max Planck's latest proposals concerning his own theories of radiation. Planck had developed some basic ideas in the emerging field of quantum physics, yet he had used classical Newtonian mechanics to describe the interactions of light and matter. It was clear that this approach was inadequate, but as yet there was no better system. At the Gottingen conference Pascual Jordan rose to introduce a compromise solution, but before Born, the department chairman, could reply, Werner Heisenberg fell into a violent fit of sneezing.

"Are you all right, Werner?" asked Born.

Heisenberg merely waved a hand. Jordan attempted to continue, but again Heisenberg began sneezing. His eyes were red, and tears crept down his face. He was in obvious distress. He turned to his graduate assistant. "Jehan," he said, "please make immediate arrangements. I must get away. It's my damned hay fever. I want to leave at once."

One of the others at the meeting objected. "But the colloquium—"

Heisenberg was already on his feet. "You can tell Planck to go straight to hell and to take De Broglie and his matter waves with him. The same goes for Bohr and his goddamn jumping electrons. I can't stand any more of this." Heisenberg took a few shaky steps and left the room. Jehan stayed behind to make a few notations in her journal. Then she followed Heisenberg back to their apartments.

"Jehan clutched her robe closely to her with her left hand. In her right hand, hidden by her long sleeve, was the keen-edged, gleaming, curved blade she had taken from her father's room."

There were no minarets in the Budayeen, but in the city all around the walled quarter there were many mosques. From the tall, ancient towers strong voices called the faithful to morning devotions. "Come to prayer, come to prayer! Prayer is better than sleep!"

Leaning against a grimy wall, Jehan heard the chanted cries of the muezzins, but she paid them no mind. She stared at the dead body at her feet: the body of a boy a few years older than she, someone she had seen about the Budayeen but whom she did not know by name. She still held the bloody knife that had killed him.

In a short while three men pushed their way through a crowd that had formed at the mouth of the alley. The three men looked down solemnly at Jehan. One was a police officer, one was a qadi, who interpreted the ancient Islamic commandments as they applied to modern life, and the third was an imam, a prayer leader who had hurried from a small mosque not far from the east gate of the Budayeen. Within the walls the pickpockets, whores, thieves, and cutthroats could do as they liked to each other. A death in the Budayeen didn't attract much attention in the rest of the city.

The police officer was tall and heavily built, with a thick black mustache and sleepy eyes. He was curious only because he had watched over the Budayeen for fifteen years, and he had never investigated a murder by a girl so young.

The qadi was young, clean-shaven, and quite plainly deferring to the imam. It was not yet clear to those in attendance if this matter should be the responsibility of the civil or the religious authorities.

The imam was tall, taller even than the police officer, but thin and narrow shouldered, yet it was not asceticism that made him so slight. He was well-known for two things: his common sense concerning the conflicts of everyday affairs and the high degree of earthly pleasures he permitted himself. He, too, was puzzled and curious. He wore a short, grizzled gray beard, and his soft brown eyes were all but hidden within the reticulation of wrinkles that had slowly etched his face. Like the police officer, the imam had once worn a brave black mustache, but the days of fierceness had long since passed for him. Now he appeared decent and kindly. In truth, he was neither, but he found it useful to cultivate that reputation.

"O my daughter," he said in his hoarse voice. He was very upset. He much preferred explicating obscure passages of the glorious Qur'an to viewing such tawdry matters as blatant dead bodies in the nearby streets.

Jehan looked up at him, but she said nothing. She looked back down at the unknown boy she had killed.

"O my daughter," said the imam, "tell me, was it thou who hath slain this child?"

Jehan looked back calmly at the old man. She was concealed beneath her kerchief, veil, and robe; all that was visible of her were her dark eyes and the long thin fingers that held the knife. "Yes, O Wise One," she said. "I killed him."

The police officer glanced at the qadi. "Prayest thou to Allah?" asked the imam. If this hadn't been the Budayeen, he wouldn't have needed to ask.

"Yes," said Jehan. And it was true. She had prayed on several occasions in her lifetime, and she might yet pray again sometime.

"And knowest thou there is a prohibition against taking of human life that Allah hath made sacred?"

"Yes, O Wise One."

"And knowest thou further that Allah hath set a penalty upon those who breaketh this law?"

"Yes, I know."

"Then, O my daughter, tell us why thou hath brought low this poor boy."

Jehan tossed the bloody knife to the stone-paved alley. It rang noisily and then came to rest against one leg of the corpse.

"I killed him because he would do me harm in the future," she said.

"He threatened you?" asked the qadi.

"No, O Respected One."

"Then—"

"Then how art thou certain that he would do thee harm?" the imam finished.

Jehan shrugged. "I have seen it many times. He would throw me to the ground and defile me. I have seen the visions."

A murmur grew from the crowd still cluttering the mouth of the alley behind Jehan and the three men. The imam's shoulders slumped. The police officer waited patiently. The qadi looked discouraged. Then he didst not offer thee harm this morning?" said the imam.

"No."

"Indeed, as thou sayest, he hath *never* offered thee harm?"

"No. I do not know him. I have never spoken with him."

"Yet," said the qadi, clearly unhappy, "you murdered him because of what you have seen? As in a dream?"

"As in a dream, O Respected One, but more truly as in a vision."

"A dream," muttered the imam. The Prophet, mayest blessings be on his name and peace, didst offer no absolution for murder provoked only by dreams."

A woman in the crowd cried out, "But she is only twelve years old!"

The imam turned and pushed his way through the rabble.

"Sergeant," said the qadi, "this young girl is now in your custody. The Straight Path makes our duty clear."

The police officer nodded and stepped forward. He bound the young girl's wrists and pushed her forward through the alley. The crowd of fellahin parted to make way for them. The sergeant led Jehan to a small, dank cell until she might have a hearing. A panel of religious elders would judge her according to Shari'a, the contemporary code of laws derived from the ancient and noble Qur'an. Jehan did not suffer in her noxious cell. A lifetime in the Budayeen had made her familiar with deprivation. She waited patiently for whatever outcome Allah intended.

She did not wait long. She was given another brief hearing, during which the council asked her many of the same questions the imam had asked. She answered them all without hesitation. Her judges were saddened but compelled to render their verdict. They gave her an opportunity to change her statement, but she refused. At last the senior member of the panel stood to face her. "O young one," he said in the most reluctant of voices, "the Prophet, blessings be on his name and peace, said, 'Whoso slayeth a believer, his reward is hell forever.' And elsewhere, 'Who killeth a human being for other than manslaughter or corruption in the earth, it shall be as if he killed all mankind.' Therefore, if he whom you slew had purposed corruption upon you, your act would have been justified. Yet you deny this. You rely on your dreams, your visions. Such insubstantial defense cannot persuade this council otherwise than that you are guilty. You must pay the penalty as it is written. It shall be exacted tomorrow morning just before sunrise."

Jehan's expression did not change. She said nothing. Of her many visions, she had witnessed this particular scene before also. Sometimes, as now, she was condemned; sometimes she was freed. That evening she ate a good meal, a better meal than most she had taken before in her life of poverty. She slept the night, and she was ready when the civil and religious officials came for her in the morning. An imam of great repute spoke to her at length, but Jehan did not listen carefully. The remaining acts and motions of her life seemed mechanically ordered, and she did not pay great heed to them. She followed where she was led, she responded dully when pressed for a reply, and she climbed the platform set up in the courtyard of the great Shimaal Mosque.

"Dost thou feel regret?" asked the imam, laying a gentle hand on her shoulder.

Jehan was made to kneel with her head on the block. She shrugged. "No," she said.

"Dost thou feel anger, O my daughter?"

"No."

"Then mayest Allah in His mercy grant thee peace." The imam stepped away. Jehan had no view of the headsman, but she heard the collective sigh of the onlookers as the great ax lifted high in the first faint rays of dawn, and then the blade fell.

Jehan shuddered in the alley. Watching her death always made her exceptionally uneasy. The hour wasn't much later: the fifth and final call to prayer had sounded not long before, and now it was night. The celebration continued around her, more intensely than before. That her intended deed might end on the headsman's block did not deter her. She grasped the knife tightly, wishing that time would pass more swiftly, and she thought of other things.

By the end of May 1925 they were settled in a hotel on the tiny island of Helgoland, some fifty miles from the German coast. Jehan relaxed in a comfortably furnished room. The landlady made her husband put Heisenberg's and Jehan's luggage in the best and most expensive room. Heisenberg had every hope of ridding himself of his allergic afflictions. He also intended to make some sense of the opaque melding of theories and counter-theories put forward by his colleagues back in Göttingen. Meanwhile the landlady gave Jehan a grim and glowering look at their every meeting but said nothing. The Herr Doktor himself was too preoccupied to care for anything as trivial as propriety, morals, the reputation of this Helgoland retreat or Jehan's peace of mind. If anyone raised eyebrows over the arrangement, Heisenberg certainly was blithely unaware: he walked around as if he were insensible to everything but the pollen count and the occasional sheer cliffs over which he sometimes came close to tumbling.

Jehan was mindful of the old woman's disapproval. Jehan, however, had lived a full, harsh life in her twenty-six years, and a raised eyebrow rated very low on her list of things to be concerned about. She had seen too many people abandoned to starvation, too many people dispossessed and reduced to beggary, too many outsiders slain in the name of Allah, too many maimed or beheaded through the convoluted workings of Islamic justice. All these years Jehan had kept her father's bloodied dagger, packed now beneath her shetland wool sweaters and still as deadly as ever.

Heisenberg's health improved on the island, and there was a beautiful view of the sea from their room. His mood brightened quickly. One morning, while walking along the shoreline with him, Jehan read a passage from the glorious Qur'an. "This sura is called 'The Earthquake,'" she said. "'In the name of Allah, the Beneficent, the Merciful. When Earth is shaken with her final earthquake, and Earth yields up her burdens, and man saith: What aileth her? That day she will relate her chronicles, because thy Lord inspireth her. That day mankind will issue forth in separate groups, to be shown their deeds. And whoso doeth good an atom's weight will see it then. And whoso doeth ill an atom's weight will see it then."

And Jehan wept, knowing that however much good she might do, it could never outweigh the wrongs she had already performed. But Heisenberg only stared out

over the gray tumbling waves of the ocean. He did not listen closely to the sacred verses, yet a few of Jehan's words struck him. "And whoso doeth good an atom's weight will see it then," he said, emphasizing the single word. There was a small, hesitant smile quivering at the corners of his mouth. Jehan put her arm around him to comfort him because he seemed chilled, and she led him back to the hotel. The weather had turned colder, and the air was misty with sea spray. together they listened to the cries of the herring gulls as the birds dived for fish or hovered screeching over the strip of beach. Jehan thought of what she'd read, of the end of the world. Heisenberg thought only of its beginning, and its still closely guarded secrets.

They liked their daily peaceful walk about the island. Now, more than ever before, Jehan carried with her a copy of the Qur'an, and she often read short verses to him. So different from the biblical literature he'd heard all his life, Heisenberg let the Islamic scriptures pass without comment. Yet it seemed to him that certain specific images offered their meanings to him alone.

Jehan saw at last that he was feeling well. Heisenberg took up again full-time the tangled knot that was the current state of quantum physics. It was both his vocation and his means of relaxation. He told Jehan the best scientific minds in the world were frantically working to cobble together a slipshod mathematical model, one that might account for all the observed data. Whatever approach they tried, the data would not fit together. *He*, however, would find the key. he was that confident. He wasn't quite sure how he'd do it, but of course he hadn't yet really applied himself thoroughly to the question.

Jehan was not amused. She read to him: "'Hast thou not seen those who pretend that they believe in that which is revealed unto thee and that which was revealed before thee, how they would go for judgment in their disputes to false deities when they have been ordered to abjure them? Satan would lead them far astray.'"

Heisenberg laughed heartily. "Your Allah isn't just talking about Gottingen there,' he said. 'He's got Bohr in mind, too, and Einstein in Berlin.'"

Jehan frowned at his impiety. It was the irreverence and ignorant ridicule of the kafir, the unbeliever. She wondered if the old religion that had never truly had any claim on her was yet still part of her. She wondered how she'd feel after all these years, walking the narrow, crowded, clangorous ways of the Budayeen again. "You mustn't speak that way," she said at last.

"Hmm?" said Heisenberg. He had already forgotten what he'd said to her.

"Look out there," said Jehan. "What do you see?"

"The ocean," said Heisenberg. "Waves."

"Allah created those waves. What do *you* know about that?"

"I could determine their frequency. I could measure their amplitude."

"Measure!" cried Jehan. Her own long years of scientific study were suddenly overshadowed by an imagined insult to her heritage. 'Look here,' she demanded. "A handful of sand. Allah created this sand. What do *you* know about it?"

Heisenberg couldn't see what Jehan was trying to tell him. "With the proper instruments," he said, a little afraid of offending her. 'In the proper setting, I could take a single grain of sand and tell you—' His words broke off suddenly. He got to his feet slowly, like an old man. He looked first at the sea, then down at the shore, then back out at the water. "Waves,' he murmured, 'particles. it makes no difference. All that counts is what we can actually measure. We can't measure Bohr's orbits, because they don't really *exist*! So the spectral lines we see are caused by transitions between two states. Pairs of states, yes, but that will mean a new form of mathematical expression just to describe them. referencing tables listing every possible—"

"It came to her then. If you had no water to perform the necessary ablution before prayer in the direction of Mecca, you were permitted to wash with clean sand instead."

"Werner.' Jehan knew that he was now lost to her.

"Just the computations alone will take days, if not weeks."

"Werner, *listen* to me. This island is so small. you can throw a stone from one end to the other. I'm not going to sit on this freezing beach or up on your bleak and dreary cliff while you make your brilliant breakthrough, whatever it is. I'm saying good-bye."

"What? Jehan?" Heisenberg blinked and returned to the tangible world.

She couldn't face him any longer. She was pouring one handful of sand through the fingers of her other hand.

It came suddenly to her mind then. If you had no water to perform the necessary ablution before prayer in the direction of Mecca. you were permitted to wash with clean sand instead. She began to weep. She couldn't hear what Heisenberg was saying to her—if indeed he was.

It was a couple of hours later in the alley now, and it was getting even colder. Jehan wrapped herself in her robe and paced back and forth.

She'd had visions of this particular night for four years. glimpses of the possible ways that it might conclude. Sometimes the young man saw her in the alley shortly after dawn, sometimes he didn't. Sometimes she killed him. sometimes she didn't. And, of course, there was the open question of whether her actions would lead to her freedom or to her execution.

When she'd had the first vision, she hadn't known what was happening or what she was seeing. She knew only the fear and the pain and the terror. The boy threw her roughly to the ground, ripped her clothing, and raped her. Then the vision passed. Jehan told no one about it, her family would have thought her insane. About three months later, the vision returned; only this time it was different in subtle ways. She was in the alley as before, but this time she smiled and gestured to the boy, inviting him. He smiled in return and followed her deeper into the alley. When he put his hand on her shoulder, she drew her father's dagger and plunged it into the boy's belly. That was as much as the vision showed her then. It terrified her even more than the rape scene had.

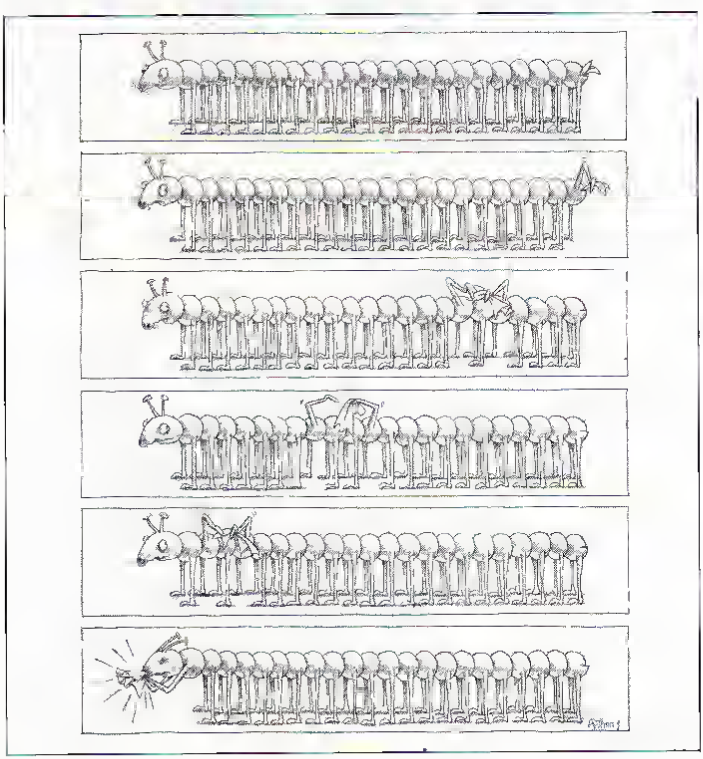
As time passed, the visions took on other forms. She was certain now that she was not always watching *her* future, *the* future, but rather a future, each as likely to come to pass as the others. Not all the visions could possibly be true. In some of them, she saw herself living into her old age in the city, right here in this filthy quarter of the Budayeen. In others she moved about strange places that didn't seem Islamic at all, and she spoke languages definitely not Arabic. She did not know if these conflicting visions were trying to tell her or warn her of something. Jehan prayed to know which of these versions she must actually live through. Soon after, as if to reward her for her faith, she began to have less violent visions. She could look into the future a short way and find lost objects or warn against unlucky travel plans or predict the rise and fall of crop prices. The neighbors, at first amused, began to be afraid of her. Jehan's mother counseled her never to speak of these "dreams" to anyone, or else Jehan might be locked away in some horrible institution. Jehan never told her father about her visions, because Jehan never told her father about anything. In that family, as in the others of the Budayeen—and the rest of the city, for that matter—the father did not concern himself very much with his daughters. His sons were his pride, and he had three strong sons whom he firmly believed would someday vastly increase the Ashûfi prestige and wealth. Jehan knew he was wrong, because she'd already seen what would become of the sons—two would be killed in wars against the Jews, the third would be a coward, a weakling, and a fugitive in the United States. But Jehan said nothing.

A vision. It was just past dawn. The young man—whose name Jehan never learned—

was walking down the stone-paved street toward her alley Jehan knew it without even peering out She took a deep breath She walked a few steps toward the street, looked left, and caught his eye She made a brief gesture, turned her back, and went deeper into the shadowy seclusion of the alley She was certain that he would follow her Her stomach ached and rumbled, and she was shaking with nervous exhaustion When the young man put his hand on her shoulder, murmuring indecent suggestions, her hand crept toward the concealed knife, but she did not grasp it He threw her down roughly, clawed off her clothing, and raped her Then he left her there She was almost paralyzed, crying and cursing on the wet, foul-smelling stones She was found sometime later by two women who took her to a doctor Their worst fears were confirmed Her honor had been ravaged irredeemably Her life was effectively over, in the sense of becoming a normal adult female in that Islamic community One of the women returned to Jehan's house with her, to tell the news to Jehan's mother, who must still tell Jehan's father Jehan hid in the room she shared with her sisters She heard the violent breaking of furniture and shrill obscenity of her father There was nothing more to be done Jehan did not know the name of her assailant She was ruined, less than worthless A young woman no longer a virgin could command no bride price All those years of supporting a worthless daughter in the hopes of recovering the investment in the marriage contract—all vanished now It was no surprise that Jehan's father felt betrayed and the father of a witless creature There was no sympathy for Jehan the actual story whatever it might be could not alter the facts She had only the weeping of her sisters and her mother From that morning on Jehan was permanently repudiated and cast out from her house Jehan's father and three brothers would not even look at her or offer her their farewells

The years passed ever more quickly Jehan became a woman of the streets For a time, because of her youth and beauty she earned a good living Then as the decades left their unalterable blemishes upon her she found it difficult even to earn enough for a meal and a room to sleep in She grew older, more bitter, and filled with self-loathing Did she hate her father and the rest of her family? No her fate had been fixed by the will of Allah, however impossible it was for her to comprehend it or else by her own timidity in the single moment of choice and destiny in the alley so many years before She could not say Whatever the answer, she could not benefit now from either insight or wisdom Her life was as it was, according to the inscrutable designs of Allah the Merciful Her understanding was not required

Eventually she was found dead haggard and starved, and her corpse was contorted and huddled for warmth coincidentally in the same alley where the young man had so carelessly despoiled any chance Jehan had for happiness in this world After she died, there was no one to mourn her Perhaps Allah the Beneficent took pity on her, showing mercy to her who had received little enough mercy from her neighbors while she lived among them It had always been a cold place for Jehan



For a while estranged from Heisenberg, Jehan worked with Erwin Schrodinger in Zurich At first Schrödinger's ideas confused her because they went against many of Heisenberg's basic assumptions For the time being, Heisenberg rejected any simple picture of what the atom was like any model at all Schrödinger older and more conservative than the Göttingen group wanted to explain quantum phenomena without new mathematics and elusive imagery He treated the electron as a wave function but a different sort of wave than De Broglie's The properties of waves in the physical world were well-known and without ambiguity Yet when Schrodinger calculated how a change in energy level affected his electron wave, his solutions didn't agree with observed data

"What am I overlooking?" he asked

Jehan shook her head "Where I was born they say 'Don't pour away the water in your canteen because of a mirage' "

Schrodinger rubbed his weary eyes He glanced down at the sheaf of papers he held "How can I tell if this water is worth keeping or something that belongs in a sewer?" Jehan had no reply to that, and Schrodinger set his work aside unsatisfied A few months later several papers showed that after taking into account the relativistic effects, Schrodinger's calculations agreed remarkably well with experimental results after all

Schrödinger was pleased "I knew in my heart that quantum physics would prove to be a sane world not a realm populated by phantoms and governed by ghost forces"

"It seems unreal to me now" said Jehan "If you say the electron is a wave you are saying it is a phantom In the ocean, it is the water that is the wave As for sound it is the air that carries the wave What exists to be a wave in your equations?"

"It is a wave of probability, Born says I do not wholly understand that yet myself" he said "but my equations explain too many things to be illusions"

"Sir," said Jehan, frowning "it may be that in this case the mirage is in your canteen and not before you in the desert"

Schrödinger laughed "That might be true I may yet have to abandon my mental pictures, but I will not abandon my mathematics"

It was a breathless afternoon in the city The local Arabs didn't seem to be bothered by the heat, but the small party of Europeans was beginning to suffer Their cruise ship had put ashore at the small port

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This mathematician spent his early years wrestling odds to the ground in blackjack, roulette, and other games of chance. But when he turned to Wall Street, the biggest gambling arena around, he really beat the dealer

INTERVIEW

EDWARD THORP

It was the Friday after last October s stock avalanche The Dow Jones had plunged a gut-wrenching 508 points—22 6 percent—on Black Monday Although the index had bounced back approximately 200 points, panic was still thick in the air Donald Trump and a few other financial celebrities were boasting that they'd escaped the debacle by getting out early but for the most part Wall Street was littered with broken dreams

If anyone had passed through the eye of the storm unscathed, however I felt sure it was fifty-five-year-old multimillionaire Edward Thorp A month earlier, by some fluke I had asked him what would happen to his investment funds if the Dow Jones dropped 500 points in a day 'There's a good chance we'd come out ahead," he'd said confidently

Dialing Thorp in California, I posed the big question The answer was reassuring While the entire market went through the floor, the value

PHOTOGRAPH BY WILLIAM COUPON

of Thorp's funds held at almost exactly the same level—as if nothing had happened. In fact, only the chaos prevented him from making a pile of money. "If all our orders had gone through," he said, "we would have made a huge fortune."

Thorp is a mathematician with pages of academic credentials. Described by one friend as "the most precise man I have ever met," he has a compulsion for measuring and computing. Thorp is the son of an army officer who began teaching his child math at the age of three. He won free ice cream cones by mentally racing the local grocer, who used an adding machine in totaling customers' bills. Thirty years ago, Thorp, then a math professor at UCLA, won fame as a game theorist. It started when he took his wife to Las Vegas for a weekend. "It was Christmas," he recalls. "I was quite poor, though very happy. I had no interest in gambling, but it was a low-cost holiday." Being the kind of man he was, he took along a method for improving blackjack odds. The idea worked so well that Thorp vowed to crack the game.

Back in the library at UCLA, he worked out his now-classic way of winning reliably at blackjack using a simple card-counting strategy. His short paper detailing his method, published in the *Proceedings of the National Academy of Sciences*, was heralded by a senior colleague as "the greatest achievement in game theory since [Girolamo] Cardano." (This sixteenth-century gambler-mathematician mapped the branch of math that studies the laws of probability and chance.)

In 1962 Thorp wrote his best-selling book *Beat the Dealer*. In effect, he demonstrated that a full-time player could beat the bank to the tune of $300,000 a year. Ever since, there has been a running war between his disciples—card counters—and casino managements, whose fear of losses has driven them to cheating and strong-arm tactics. Thorp himself was once nearly killed when a Las Vegas casino manager slipped drugs into his drink.

Thorp never lost his nerve, but he gave up blackjack after winning about $25,000. "I realized that if I pushed it sooner or later some unpleasant physical things would happen in Nevada," he says. His next coup was to work out a seemingly impossible trick: how to predict roulette by showing that whether or not the wheel was perfectly balanced, the house could be beaten by timing the ball's throw. He joined forces with MIT's Claude Shannon, the founder of information theory. Shannon and Thorp descended on Las Vegas to make a killing at roulette. They were foiled only by technical difficulties in their delicate improvised timing gadgetry. Thorp's strategies for winning at baccarat, the wheel of fortune, the game go, and backgammon are in his book *Mathematics of Gambling*.

In 1965 Thorp discovered the ultimate game: Wall Street. It has fascinated him ever since. For 20 years now, he has managed a $270 million fund based in Newport Beach, California. The fund has coined money at an impressive rate—20 percent nearly double the Dow Jones—while keeping risk so low that many investors use his fund as a Treasury bill substitute.

Thorp's money game is called hedging: applying computerized formulas to exploit the little inefficiencies of the market for options, futures, and other securities. Their prices typically relate to some benchmark, such as the value of ordinary stocks. But sometimes these standards get out of whack, offering the expert a fleeting chance to make a bundle with no risk involved. With the stock ticker feeding directly into his VAX computers, Thorp can trade every seven seconds. His firm Princeton/Newport Partners sometimes accounts for more than 1 percent of the New York Stock Exchange volume.

Apart from hedging, the role of computers is still largely that of helpmate on Wall Street. The exception is Battery March Financial Fund in Boston, where computers deploy $8 billion day and night. Thorp's latest venture, MIDAS, exploits the same computer-driven method. But MIDAS, at $40 million, is considerably smaller, fleeter of foot, and twice as profitable as Battery March. If Thorp's dreams are realized, it will mature into a billion-dollar sure thing, a lazy investor's dream. The computerized "black box" will be left to make money by itself with little need for human intervention—other than a call from your yacht now and then.

"My approach is to take some dream, like getting rich in a gambling game or cleaning up on the stock market, and formulate the dream so that it will happen according to my analysis."

Thorp won't say how much he has made running his money machines. But one symbol is his dream house on a hill overlooking Newport Beach, the largest house in this posh resort. The bomb shelter and guest room, with 16-inch poured concrete walls and steel blast doors, Thorp calculates could withstand a one-megaton blast a mile away. His obsession with minimizing life's threats extends to cryonics. His body will be frozen by a California firm for revival in some suitable future era. Meanwhile he runs marathons, training in the nearby hills where he has marked off trails so he can time himself at any point. Slim and wiry and speaking in machine-gun bursts, Thorp is as natural and enthusiastic as a school kid.—Anthony Liversidge

Omni: Without your expertise and equipment, does anyone have much of a chance in the stock market these days?

Thorp: Not if you want to gamble. You can always do as well as the average player by picking stocks at random and holding them a long time. Or you can buy a mutual fund that tries to copy an index like the *Standard & Poor's*. With no effort you can guarantee yourself an approximately average performance. If you go out there and slug it out, do a lot of trading, you are going to get eaten up by commissions and fooled by a lot of information you can't properly assimilate. Those are the guys who do badly—the active ignorant traders. But the passive ignorant trader can get an average result, which over the short term is not very predictable but over the long term is good and no worries. But that may not satisfy you.

Omni: If you match the stock market, that's eleven percent a year—hardly worth it.

Thorp: It's a lot if the clock runs for a long time. But maybe not a lot when you think how short life is. If they'd put their money aside at seven percent, the Indians who sold Manhattan for twenty-four dollars [worth of trinkets] in 1626 could buy it back now! I figured it out.

Omni: Some critics complain that the markets are essentially gambling arenas.

Thorp: There's a lot to that. Gambling is inevitable once you have free markets and can trade. People are going to use them for gambling simply because they can. Saying that's bad is like saying baseball is bad because people bet on it.

Omni: Are casinos an unsophisticated way to gamble compared to stock markets?

Thorp: Las Vegas and Atlantic City allow you small-stakes gambling, and things happen minute by minute. You keep turning your stake over. In the stock market things happen minute by minute, but typically you don't trade every minute.

Omni: Didn't you once say no mathematical system can beat roulette?

Thorp: Logically no mathematical system can. I gave the easiest proof I know of in my book *Elementary Probability*. If you have a roulette wheel that's well machined, and no pockets are favored over others so that it's perfectly random, then all numbers have equal probability. No matter what kinds of games you play by keeping track of numbers, there is no way in the long run that you'll get an advantage. In fact mathematical theorem says that in the long run the loss will be a certain percent of the total of all bets you make. On American roulette wheels, losses in the long run will be about 5.26 percent of the total of all bets—because of the 0 and 00 slots.

Omni: But you found roulette was predictable from an engineering standpoint.

Thorp: Yes. If you go to a higher level of information, like knowing the velocity of the ball and rotor, then you can create a system like Claude Shannon and I were work-

ing on. We timed the speed of the ball after the throw.

Omni: How come a well-behaved professor went to the casinos in the first place?

Thorp: Even though I didn't get any particular kick out of gambling, a professor in the UCLA math department suggested using a system just published in the American Statistical Association journal. The advantage to the casino was given as about six tenths of a percent. So I took ten dollars and sat down at blackjack. I had a good hand, and where an ordinary player would stand, I drew again. People around were quite disgusted, thinking it a foolish play. I got a six which I converted to fourteen and ended up with a string of six cards to sixteen. I drew again and got twenty-one.

A crowd gathered and the pit boss came over to watch. I saw these people knew nothing about the game, and the people who ran it knew almost as little as the players. I thought I had the cutting edge of analysis in the journal article and a game people don't seem to understand or analyze, so I'd think about it a bit more. Back at UCLA I went to the article, and within a minute and a half I saw the key idea. And I set to work.

My approach is to take some dream I have, like getting rich in a gambling game or cleaning up in the stock market, and formulate the dream in a way that according to my analysis makes it happen. One of the skills I have is to judge which dreams are possible and how to carry them out almost for sure over a period of time. So roulette is something I know exactly *how* to do. With advanced technology it would be far easier than when Claude and I were working on it. But it's something I've consciously elected *not* to do. It might take me a year of my life to really clean out roulette all over the world. After I won something in the low millions—I might get cut off before that—everybody would clue in to this and forbid betting after the ball spins. With that Achilles' heel and a limited upside of the low millions, it's nothing I want to do.

Omni: Why doesn't somebody else?

Thorp: A lot of people have made some rather magnificent efforts, but it requires more staying power than you'd think. They get worn out and quit. It takes time, money, and energy; you have to be a clear thinker and a first-class technician to build the [radio communication and timing] equipment. Then you have to be a good actor, too, to disguise yourself and misdirect the management. I learned how to do that, and it was entertaining for a while.

Omni: How did you get the inspiration that card counting had to work?

Thorp: It was an idea straight out of an advanced probability course. In one deck of cards a certain number of subsets of cards are possible under the rules of blackjack—about thirty-three million. All these subsets have different advantages or disadvantages associated with them. The subset consisting of the whole deck, for instance, was computed out with ten man-years of labor by four mathematicians. In principle, a person could figure the game out by doing for each subset what these mathematicians spent ten man-years doing for one subset. With a big dictionary of all the subsets you could count cards, look up the subset you were in, and know the advantage or disadvantage of your position and how to play. But that dictionary would fill Grand Central Station.

To solve that problem you need to simplify the idea. It took me a few seconds to realize this. My thought was that each subset has a probability of occurrence associated with it. Some are probable, some not very probable. I imagined all these subsets spread out on a table in a square, imitating the way people think in advanced probability. Any probability theorist would apprehend all of this in a second. The area that each subset takes up is proportional to its probability of occurrence. High probability occupies a large region of the square, low probability a small region.

> *"If they had put their money aside at seven percent, the Indians who sold Manhattan for twenty-four dollars' worth of trinkets could buy it back today."*

If we vary the composition of the deck—say, have relatively more aces and tens—you'd expect all the odds and strategies to vary, too. As you go from one subset to another, there's going to be a transition from one strategy table to another and from one advantage or disadvantage to another. This imaginary square is really a proxy for a ten-dimensional hypercube. That's where I'm thinking, because there are ten different types of cards. So you plot each type of card in each direction within this square and above the square. The height of the surface over each subset corresponds to the player advantage or disadvantage.

What I'm looking for are places on the surface that are above water, where the player has an advantage. As the composition of the deck changes from one subset to another there are going to be violent fluctuations in player advantage. It's as though you had a very rough mountainous landscape whose average height was minus six tenths of a percent. But excursions up and down from that value are rather great. With luck you'd expect to find whole regions or continents that stick up. There might be a single description that could identify in one sweep whole regions having some sort of average advantage.

This is roughly the first minute's thinking. The second is a strategy for finding those continents. This entails taking each card and separately varying it, holding the other cards fixed, and seeing how the advantage changes. You vary in one direction at a time, as physicists do with space, instead of varying in a whole lot of directions at once. So my first idea was, There must be lots of things in the player's advantage area in this square. My second idea was that I could probably find this area by varying one part at a time to see how it affects the advantage. That was the program. The problem was to carry it out.

Omni: And the casino managements tried to stop you?

Thorp: They were so two-faced. On one hand they were waving all the players in, on the other hand, when they got a player that could lick them, they didn't like it. They could have changed the rules without making the other players mad. If I'd owned the casinos, that's what I'd have done. But instead they fell back on cheating people to keep them from winning, or else throwing them out or beating them up. That's when I got irritated with them.

Omni: Weren't you taking real risks?

Thorp: One well-known blackjack card counter had a lot of his face caved in. A guy I know had his arms held, and every time he tried to catch his breath they'd punch him in the solar plexus again. I know of three beatings. I had my drinks drugged, and there were five witnesses to it. The first time it was a cup of coffee with cream and sugar, and I couldn't taste anything and didn't expect it. When I was drugged I couldn't count, couldn't think, and the pupils of my eyes dilated. I could barely walk and had sense enough to leave the table. It took six or eight hours before I straightened out. The next night I refused coffee and asked for water. I sipped it very slightly, two or three drops, and it tasted like they'd dumped a box of baking soda into it. Had I drunk more I would have been finished, because just the few drops on my tongue were enough to wipe me out for the night.

Omni: You might have died.

Thorp: I think so. But I carried on winning. I got drugged twice, came back again, and they banned me. This was at a casino on the Strip. They don't fool around there. Whenever they asked me to leave I left politely and slipped back in another week or into another place. Also if I were beaten up it would have been bad publicity for them, since I'd published *Beat the Dealer*. At first I didn't believe they were cheating. I had to have it shown to me irrefutably. I brought experts with me who identified that I was being cheated. They took me out, demonstrated it to me in a hotel room, then took me back to the same dealers. Then I watched them cheat me. That's how I learned to spot cheating.

Omni: Why did you opt out in the end?

Thorp: I thought I'd take the skills in math

money management, and so on that I'd developed in blackjack and see if they applied to other areas. I decided on the stock market as an endless source of fun and intriguing problems. A lot of ideas I had about gambling carried right over.

I also saw that to make money in the future I'd have to disguise myself all the time and spend my life in Nevada working the tables and probably ruin my family life and marriage. I figured the most I'd pump out would be three hundred thousand dollars a year, because it would take time to disguise myself, and I would be cheated part of the time. I was talking to Paul Newman once on a film set. He asked me how much I could make in blackjack if I worked at it. I told him three hundred thousand dollars a year, and he said, "Why aren't you out there doing it?" I said, "Would you do it?" He laughed because he was making six million that year. I thought I could make a lot more than three hundred thousand dollars a year with the same effort and intelligence doing something else. With much nicer conditions and a much higher class of people—at least until Ivan Boesky.

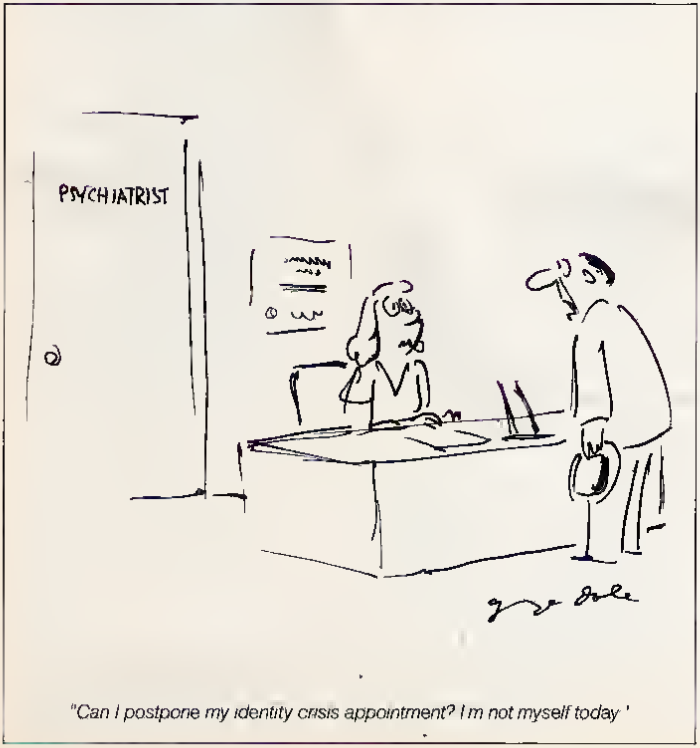
Omni: How far have you outrun the market index in the last twenty years?

Thorp: When we started business the Dow Jones [DJ] was around eight hundred fifty-five. So if you imagine you put eight hundred and fifty-five dollars into Princeton/Newport Partners and let it run, it would now be up to twenty-three thousand six hundred eighty-six dollars. Our twenty-percent rate of growth would double your wealth about twice as often over a long period of time as the eleven percent of the DJ. This is an enormous difference in payoff in the long term. Suppose you were to run for thirty-five years at twenty percent. Your money will multiply by a factor of five hundred and ninety. At ten percent, say, it will multiply only by a factor of twenty-eight. You will have twenty-one times as much money with only twice the growth rate. That's why one of the barons Rothschild called compound interest the eighth wonder of the world. It's quite amazing.

Omni: So how did things go during the week of the crash?

Thorp: On Black Monday our largest fund, Princeton/Newport Partners, made money. We had a lot of unusual opportunities we tried to exploit. It took nimble footwork. Because the markets were so chaotic it was difficult to place orders. We would have made a fortune had we been able to get orders confirmed.

MIDAS lost only three percent—when the market lost twenty-two. On fifty million dollars, MIDAS lost about 2.7 million during crash week. MIDAS does what it's supposed to do—basically to hedge itself against very drastic changes in price. It is the greatest test we could have had; the test of the century. Black Monday was tremendously exciting, and it showed that hedging is a very good way to do things.



"Can I postpone my identity crisis appointment? I'm not myself today."

Omni: Were you working on full automatic response to the ticker tape that week?

Thorp: A lot of automatic information was coming out, but the numbers were so out of the ordinary that we looked at everything in person. The automatic features did a lot of the preliminary work. Tuesday was the big day for me. I had to make decisions I had never had to make before.

Omni: Why can't MIDAS operate completely automatically?

Thorp: A takeover might be going on which makes the common stock volatile. You need a human with a list of these exceptional cases which change minute by minute, to override the program. The human screens them out and puts the other orders on the floor. We can act within a few seconds of a price change.

Omni: What's the future of using computers to automatically select stocks?

Thorp: Exciting. For MIDAS we spent seven or eight years using large databases in computers to develop a system to rank stocks from best to worst, along with a forecast of how much better or worse the stocks will do in the market. We've been running this system with real money for about two years. We can put a very large amount of money to work because we're trading in large, liquid securities. Now we have only a few hundred million in our hedging operation, but we may be able to put billions to work in this new way.

Omni: How computerized is your stock selection process?

Thorp: We push a button and it prints out a list of instructions. We call the traders. The only thing we screen is the takeover candidates. We also check to make sure that the stock is not trading too thinly, making our order too big for the market.

Omni: So can you go off on a yacht and let things run for themselves, making adjustments on your computer between drinks?

Thorp: You can't go off on a yacht without a reasonably intelligent person sitting here monitoring things. But he doesn't have to have the same background in understanding these things. My original aim was to get the system so you could fix it in an hour each day. We actually have a secret subroutine that I can't tell you a lot about, but you can think of it as a black box. We've had it for some years. It prints out orders in very large numbers and trades securities very rapidly on the exchange. It does it all electronically. And it makes money on a regular basis. I can't tell you the principles because we don't want competitors to come in on this one. The black box deals in a limited, valuable corner of the market. The big stock-selection system collects information—such as earnings, book value, size of dividends, yield, price momentum, earning momentum, sales-to-price ratio, and the level of insider trading. There are hordes of indicators, and the black box analyzes this information to decide which stocks are likely to perform better and which ones worse. Then it predicts just how good or bad performance will be.

Omni: Won't we have a lot of unemployed fund managers if your computerized system works out?

Thorp: That won't happen. Not everybody can beat the average. You always have a struggle to do better than the other players. There can be only some winners.

Omni: Are you sure you'll never go broke?

Thorp: The chances are very small. Things have been well hedged. It's pretty much a sure thing, yes, though I hate to characterize it as that. Blackjack isn't a sure thing either. If you play for a short time. But the longer you play, the greater probability that you'll have to be ahead. I calculate we have a one-in-thirty chance of losing something in a given year. We have no chance of losing everything, assuming we can trust all the banks and brokers we deal with not to go broke and the government not to suddenly freeze all assets by fiat. We try to take steps to ensure against a major broker going bankrupt, but that is difficult. And we do the thinking. The obvious way of combining the indicators is not necessarily correct. We tell the machine to produce a score, and we rank stocks by best scores.

Omni: Could your formulas be stolen?

Thorp: Yes, but we have several levels of defense. We hire people we trust and pay them a lot. We have security measures and signed agreements for trade secrets. Users get back only a blank when they call up our computer. Even if they [the programs] are stolen, a year later we'll have a higher-level system anyway. Once a trader stole one of our systems. The computer recorded a theft and told us which phone port and how long they were on the computer offloading which program—forty-five minutes. We guessed the culprit and got confirmation. It was a trader on the options exchange who wanted to steal the program and keep the profits. We forced him to return the program by threat of suit. Our new programs soon outmoded it anyway.

Omni: It takes five million dollars to get in on your fund at the moment. When will the public be allowed in?

Thorp: Probably never. There are too many regulations set up to protect them from misadventure. They cause lots of legal and accounting costs and make you subject to all kinds of litigation even if you don't do anything wrong. It's easy to litigate if you're a small person who's lost money. So one simply doesn't want to run money for so-called unqualified investors, those who aren't rich. The legal definition of qualified investor boils down to being rich. The point of all these regulations is that the rich can more easily afford to lose money. If a person with ten million dollars loses half his money, he is still rich. If a person with ten thousand dollars loses half, it pushes him right down near the borderline.

Omni: Why are you willing to talk so freely about your operations?

Thorp: I don't see any loss in telling people. There are thousands of people all screaming and yelling that they have good stock market systems. There are newsletters and people who get great bursts of dazzling performance and so on. The press is full of it—people crying out that they know how to make excess money. When they're all crying out at once, one more voice doesn't make much difference.

Omni: What's your view of chartists, those who predict the price of a stock from the shape of its movements in the past?

Thorp: Most have no validity. There is no evidence for their theories. Some might have a glimmer of something and have a little edge from it. But I tend to ignore them and reject information from that source. They tend to look at specific patterns.

Omni: You have computer-tested the predictions of Wall Street gurus like Joseph Granville. What do you think of him?

Thorp: With Granville we think there may be some art to what he does, something there, but that he doesn't know what it is. Just a kind of instinctual thing. He may have a long lucky streak, but he may just as well have an unlucky streak. That's in fact what happened to him. He got on the right side of the market for a while and then got on the wrong side. We studied him carefully and established that his prediction record—to the point where we wrote a paper—was remarkably good and very much extra chance. Then a year or so after we wrote the paper, it flipped the other way and was remarkably bad. He was the worst forecaster for a few years.

> *"Paul Newman asked how much I could make at blackjack. I said three hundred thousand. He asked why I wasn't doing it. I said, "Would you?" He made six million dollars that year."*

Omni: The factors your computers use to evaluate stocks are secret, but can you name just one?

Thorp: One factor we consider is called "earning surprise," which happens when the company announces earnings different from the consensus of analysts. This generally causes a rapid movement in the stock price. Because the effect of the move is not fully incorporated in the price for a few days or even a month or two, you can jump on it and get part of the ride.

Omni: Does fate have a role in people winning in lotteries?

Thorp: No. A person's control over which number comes up is no greater than an ant controlling whether a particular raindrop falls on it.

Omni: You are trying hard to maximize your chances of living a long time, aren't you?

Thorp: My cholesterol is very low. I followed a diet and got mine down to ninety-six, the lowest I've heard of. I can outrun almost everybody in the firm. I have a good chance unless I get cancer or some other disease to get close to the maximum one hundred, one hundred twenty or thirty. I have a cryonic suspension number. What have I got to lose if I don't wake up again? There is only one choice between nothing or a long shot at surviving. Yes, it is possible one might suffer truly horrible pains on waking, or other problems. I will specify other successes in reviving people before they wake me up.

Omni: You have all your jogging paths marked off so that you know exactly how you're doing at any particular point. Isn't that a little obsessive?

Thorp: I agree, no question about it. I have a compulsion to measure things. I check my pulse in the morning and see the relationship between my pulse and a cold that's coming on or stress I might be under. I went to the desert on vacation for two weeks and got really relaxed out there, and my resting pulse dropped in the morning to about fifty-four beats a minute. But back at work it rose to the low sixties as soon as I came back. I get a lot of information out of measuring my pulse. Same with the jogging paths. And I agree that it's excessive.

Omni: Have you had any ideas stolen?

Thorp: Twice, from papers stolen and published under another's name. It's traditional in science to send out preprints to a bunch of people to critique when something's going to be published. Once in a while someone will steal it. It's hard to be sure, but evidence I have in two cases persuaded me that it's a pretty high probability they were outright thefts. They dress them up in different clothes, but the key ideas are there and organized in much the same way.

To academics, publications are like money or possessions to other people. They represent the equivalent of power, wealth, and prestige. Ten years ago at UC Irvine we figured out how much one math paper was worth. From the salary differential as a function of people's publication, we figured that the present value of the lifetime income stream was ten thousand dollars per paper.

Omni: You seem to enjoy your millions without snobbery.

Thorp: I don't use money as a yardstick for choosing friends. What they are like inside and how they think are the important things. When Vivian and I got married, all I had was a suitcase with a broken clasp and some old raggedy clothes in it and some concrete blocks and some boards, which were my portable bookcase. I was twenty-three. Her parents were horrified; they thought their daughter would marry a doctor or a lawyer, and here was this impractical academic who was always going to be poor. They cheered up later!

In a canyon east of Aztec, New Mexico, scientists discovered a crashed spaceship and 16 small, humanlike occupants

ANTI MATTER

UFO UPDATE

For quite some time it has been considered the most notorious hoax in the history of UFOlogy But a recent book entitled *UFO Crash at Aztec* by William S Steinman and Wendelle C Stevens declares that the story of a flying saucer crash in Aztec New Mexico, in March 1948 was no fake

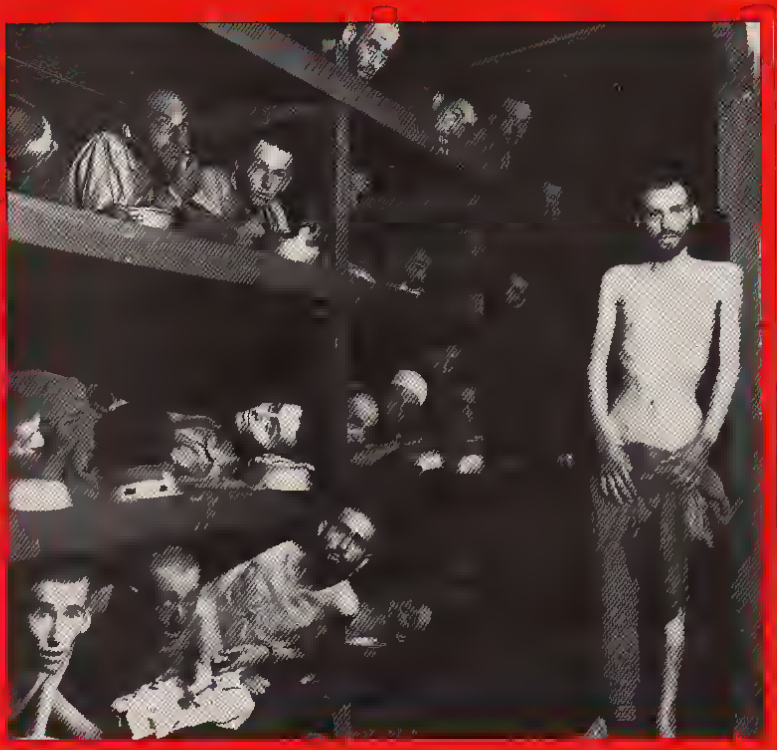
The story was first reported by *Variety* columnist Frank Scully who wrote a best-selling book called *Behind the Flying Saucers* Scully reported that in the spring of 1948, a "division of top scientists" descended on a canyon east of Aztec, where they recovered the remains of a crashed spaceship and its 16 dead occupants, small humanlike beings dressed in "the style of 1890 and believed to be from Venus Scully's sources for this remarkable story were one Silas Newton identified as a Texas oilman and the pseudonymous "Dr Gee who, according to Scully was the top magnetic research specialist of the United States" Investigative journalist J P Cahn who wrote about the episode in *True* magazine, had a different slant Newton was a lifelong con artist, Cahn said and "Dr Gee, one Leo A GeBauer, was his associate Cahn claimed that the crashed saucer story was concocted as part of a scam to sell a bogus oil-detection device allegedly based on extraterrestrial technology

Steinman and Stevens tell a different story still In their version, when the spaceship came down near Aztec the government dispatched a team of about 1 000 specialists and soldiers to the site Civilian witnesses were threatened into silence—a silence they maintain to this day When Newton and GeBauer honorable men who knew the truth, spoke out, they were framed and discredited

The book for all its 625 pages never makes clear how—or from whom the authors learned the truth about the Aztec crash In an interview Steinman, who lives in La Mirada, California, gives his source as a guy who was an analyst for the [U S government Research and Development Board Four other persons retired government scientists whom Steinman also will not identify told him the crash took place at Aztec And in a statement at the beginning of their book Steinman and Stevens acknowledge all of the encouragement and assistance by a great number of collaborators who of necessity must remain unknown

UFO researcher William L Moore who has investigated the Aztec story dismisses the new allegations as unsubstantiated conjecture And a reporter for the *Daily Times* published in nearby Farmington says nobody in Aztec even remembers a UFO crash Several years ago I got a call from a guy in California and that's the first time I ever heard the story, says the reporter "I decided to check it out No one knew anything about it except George Bawra who's now dead At the time he was editor of the *Aztec Independent Review* He told me he had written a tongue-in-cheek story about a UFO in the area Apparently some people outside the area picked up the story as gospel

When I told the guy from California about it, he said, 'So the CIA got to you too I told him that if that's what he wanted to believe, go ahead "—*JEROME CLARK*



HOLOCAUST REVISITED

Rabbi Yonassan Gershom of Minnesota wondered why the young, blond Norwegian woman was so interested in Judaism and the Jews. As they talked she related how the mere mention of the Holocaust filled her with terror. Suddenly the rabbi claims, he could "see" the face of a thin, emaciated Jew superimposed on the woman's youthful countenance. "I also heard voices singing the same Hasidic tune that thousands of Jews sang as they entered the gas chambers," he recalls.

As Gershom hummed the tune out loud, his visitor cried out that she had died in the Holocaust. Gershom concluded that the young woman, along with hundreds of other people he has talked to over the past five years, was a reincarnated victim of the Nazi Holocaust.

According to Gershom nightmares about Nazi Germany and a special affinity for Jewish traditions and symbols can be clues that a non-Jew is a reincarnated Holocaust victim.

"Two-thirds are non-Jewish, most with light hair and blue eyes," he notes. "I theorize that many died as children. Perhaps it was fixed in their minds that if they were blond and not Jewish, they could have escaped. So they have come back as non-Jews."

Gershom thinks another wave of reincarnated Holocaust victims is currently being born. "I've noticed in the Jewish community a lot of kids with an innate understanding of the mystical aspects of Judaism. Most of these children don't have nightmares and memories about concentration camps, but they may represent the return of martyred souls."

When the reincarnated talk about their deaths at the hands of the Nazis, Gershom says, an emotional healing takes place.

According to University of Oregon psychologist Ray Hyman, we often feel guilty about things we do. "Fair-haired, non-Jewish people may fantasize they are reincarnated Holocaust victims," he speculates, "to relieve the guilt they feel in being identified with the Nazi ideal—the Aryan race."

"There is no credible evidence for reincarnation," adds Brooklyn College philosophy professor Paul Edwards. "Unfortunately, people are hungry for mystery, so they tend to swallow any claim, including Gershom's wild ideas."

—Sherry Baker

ANCIENT SEEDS

Archaeologist Corey Malcom was inspecting the 365-year-old wreck of the ship *Nuestra Señora de Atocha* when he discovered several small seeds. "We stored what we found in fresh water to preserve it," Malcom says. "And it was after the seeds had been in the fresh water a little over a week that I noticed four of them had sprouted. I then planted the sprouts in soil, and two of them started to grow.

Intrigued by this botanical oddity David W Hall, a botanist at the Florida State Museum has studied the development of Malcom s plants Indeed it is very unusual for seeds to survive in salt water Hall says and literally unheard of for them to sprout after 365 years

'These seeds would have to have been in an environment where there was no salt water and probably no air he suggests, adding that they might have been compressed into the tightly

packed ballast taken on dur ing the ship s last trip

Hall has already identified the two plants as *Bidens alba* a weed common to Florida and the Caribbean Several other seeds that were found in the wreckage came from fruits and vegetables apparently carried aboard the ship Unlike the *Bidens alba* weed these apparently did not sprout

"*Bidens alba* is a weed ' Hall explains and weeds as we all know are tough as daylight —Rick Boling

NOVEL GRANT

Peter Froude an unemployed inferior decorator and part time psychic from Bournemouth, England has written a supernatural thriller called *The Demonic* with the aid of four spirits and a $65 weekly grant from the British government s Man power Services program

Froude says his helpers will get credit on the dust jacket right along with himself They are Zeta a spirit that guided his grandfather a noted nineteenth-century English historian Sybil, a Laplander Ging a Korean scribe and Jasmin a goat girl who died of starvation after the Persians drove her family into barren terrain

Doesn t this make for a clash of styles? Not at all ' he says 'Zeta sorts it all out for me It s a group effort

Froude commences to write after working himself into a trance with a pendulum pen in hand His hand then automatically moves sometimes from left to right and sometimes from right to left

In the latter case he simply holds the manuscript up to a mirror before reading it

Ernest Medlock an official of the program funded by Manpower Services says, "Froude told us he was inspired by the subconscious and we tend to think most writers are inspired in some shape or form He didn t mention spirits apart from the ones he was going to write about

"Because it's such an unusual case we l be keeping tabs on how he s getting on — Ivor Smullen

LIVER DIVINERS

It started as far back as the sixth century B C when King Nebuchadrezzar II of Babylon had his diviners examine the livers of animals to decide whether to invade Amman or Jerusalem The ancient Romans relied on this method too using it to select the right sites for military encampments

Now Elinor Lieber a physician and medical historian who has studied this seemingly useless mystical practice says it was clearly an invaluable method for military planning '

Lieber contends that because liver disease in animals is linked to outbreaks of liver disease in men the practice actually determined where soldiers would run the least risk of contracting diseases like malaria which claimed more lives than battle wounds

Lieber points out that many ancient peoples used the technique in a magical way There was something in it They just didn't realize what it was '—Rick Boling

GUIDE TO THE OCCULT

You might think anyone who spent six years compiling a directory of thousands of occult groups and books would be a New Ager himself But Laird Wilcox editor and publisher of *Guide to the American O cult*, says he s *opposed* to occult and mystical movements I m very skeptical of the claims of the paranormal but I m also against censorship, he explains I think the best way to deal with the beliefs and logic the occult represents is by honest discussion

Wilcox s *Guide to the American Occult* contains addresses for organizations as diverse as yoga retreats witches' covens and metaphysical bookstores The bibliography lists more than 1 000 titles on the supernatural along with Wilcox's personal critiques—which range from sympathetic survey of psychic research to 'hysterical pervert peddles humbug tarot chicanery

Wilcox who spends half his time as a carpenter and the other half researching the psychology behind occult and political groups on the far left and right notes there are some similarities among all these people Once they get to a point where they identify themselves as a New Age person a socialist or a member of the Aryan nation they become a lot alike They identify themselves in terms of their beliefs and nonbelievers become the enemies

There's one big difference between occultists and political extremists Wilcox points out The listings in my *Guide to the American Left* and *Guide to the American Right* are almost all organizations But the listings in my occult guide are basically businesses Most of these people are doing what they do to make money There s a lot of good old American entrepreneurship behind much of the New Age

Guide to the American Occult sells for $24 95 and can be ordered from Wilcox at Box 2047 Olathe KS 66061 Sherry Baker

'Do you not see that when a person becomes mayor commissary purveyor custom-house officer judge notary, bursar, he at once ceases to have human habits and takes on those of a wolf or a fox or some sort of vulture?"

Ludovico Ariosto

UFO PORT

Despite the persistence of UFO sightings there is no evidence that extraterrestrials have actually come to call The reason? They re waiting for a formal invitation

That, at least is the explanation offered by Tom Weber founder and president of the UFO Site Center Corporation in Chippewa Falls Wisconsin His proposed solution an invitation in the form of a landing facility adorned with pictures of humans and images of the alien occupants

Weber chose nearby Elmwood as the site of his UFO port because of the large number of UFO reports that have emerged from that area during the last 15 years "The community is well acclimated to the UFO phenomenon ' he explains 'It's part of the street language there. They talk about UFOs all the time "

To build his dream port Weber says, he must raise $50 million And if he succeeds in getting the funds he notes he will construct not only a landing pad but also a research and communications facility to be manned around the clock

Physicist Bruce Maccabee, Maryland director of the Mutual UFO Network says such a project is a waste of time and would divert funds that could be better used to study the implications of UFO contact An organization called Project Starlight International tried something like this about fifteen years ago outside of Austin, Texas ' Maccabee adds ' and they didn t attract anything '

But Weber thinks his project may give UFOlogy a boost It seems that extraterrestrials have no willingness to force a relationship upon us ' Weber says ' Therefore an invitation becomes vital If we want them to come we have to ask '

—Donald Vaughan

An alien's day on its native planet may be shorter or longer than ours For this reason an alien may sleep at odd times of the day or night

—Brad Steiger

"We will rediscover a [New York City] river so extravagantly polluted that new life forms will emerge from it spontaneously demanding welfare and voting rights '

Douglas Adams

SEOUL

CONTINUED FROM PAGE 40

they put electrodes up near the top of the head. By taking EEGs for each type of activity in each and every sport, researchers now know the myriad brain wave combinations that comprise the ideal cerebral patterns for success. For instance, they discovered that when world-class archers prepare to shoot, not only does right-brain activity increase, but the left brain produces alpha waves, indicative of relaxation. In essence, the analytic left brain relaxes until it shuts off. In its absence, the intuitive right brain takes over, controlling the subtleties of performance.

This knowledge has enabled the Mindwave Corporation to develop its latest biofeedback tool, the Mindwave Monitor. The entire technology has been enclosed in a single, ultralightweight cap, lined with electrodes that measure brain waves as the athlete performs. Whenever waves emanating from any portion of the brain depart from the ideal and impede performance, the helmet emits a tonal blip, different tones represent each sort of error. At the same time, the cap sends appropriate brain wave patterns back through delivery electrodes, improving performance on the spot and also training the brain so that it will be able to follow such patterns *without* help as the program goes on.

Couch potato. Brain wave bioleedback can obviously aid performance on the athletic field. But now such feedback can be a boon even when you're just *thinking* about your event. The most accessible product yet based on this notion is Armchair Athlete, an isolation chamber that includes a comfortable armchair, an electrode-lined head cap that monitors and alters brain wave patterns, and an audiotape that induces hypnosis in 30 seconds. After hypnosis has occurred, a recording played within the chamber verbally takes you through each step of your chosen sports event. Meanwhile the head cap measures the hills and crests of the electrical patterns created as you go through the event in your mind. If the patterns do not match the ideal established by scientists, the recording would suggest that you attempt a correction in your mind. At the same time, electrodes would prime you with the appropriate signals, thus fine-tuning your mental preparation for an upcoming event.

BIONICS

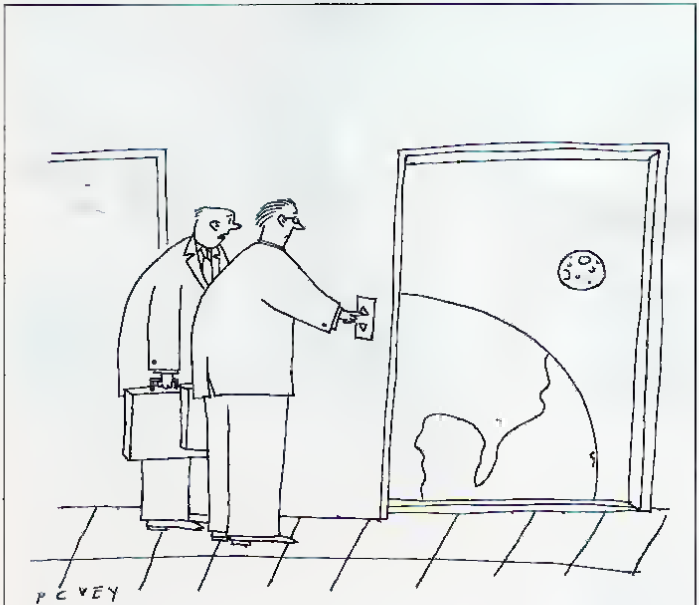
Superjoints. The process of evolution is supposed to render a species ever more perfect, ever more capable of dealing with its environment over the course of time. But humans have been left with a few weak links. The cartilage in the knee joint, for instance, tears or erodes with extreme use over time. The ligaments that connect the knee can snap like rubber bands. Shoulder joints, elbow joints, and hip joints can become damaged.

Now, however, anyone interested in truly world-class ability can order a custom-made joint from The Joint Factory in New York. The factory uses a technique known as computer-aided design and manufacturing (CAD–CAM) to custom-design entire joints on the computer screen. First the computer scans a three-D X ray of your body, designing the ideal joint (CAD); after the design is complete, the details are sent electronically to computerized machine tools (CAM) that produce a perfect version of the hip, wrist, thumb, or knee.

Made of superstrong elements such as titanium and boron, the joints are virtually unbreakable. They come with porous metal pads into which bone can grow, and other sections are designed so that muscles and tendons can attach. Each joint, moreover, is custom-designed on the computer for the specific needs of the particular athlete within the context of his or her sport. For instance, the gymnast's knee and elbow joints are made with extreme flexibility and a range of motion approaching 360°. For football, joints are not as flexible but are ultratough—one halfback with replacement joints survived a plane crash virtually uninjured. "We interact with the computer," states The Joint Factory founder Raju Khan. "The computer knows the characteristics of the body, the materials, and the prosthesis. It knows how the body works with artificial joints, and it knows the rules for designing the joint to meet the needs of each particular sport."

Track-and-field fantasy. The artificial leg (AL) workshop at the Southern California Running Club has the look and feel of a magician's lair. Located in the bowels of the club—the basement—the AL lab is filled with the white dust of cement casts as well as screwdrivers, files, and other assorted tools that hark back to the past. This yeoman's effort, says prosthetics and orthotics expert Kelsy Lee, is still less a science than an art. As if to support this contention, Lee points to her brainchild, dubbed AL—a lifelike leg (raised toenails, porous skin, veined foot) sitting on a table by the door.

The AL, Lee explains, is made of superlight composites such as carbon fibers and acrylic laminates. Because it has a human–silicon interface that attaches directly to nerves in the body, it reacts to brain signals at least as quickly as legs of flesh and bone. But it's better than legs au naturel, Lee contends, because it boasts an energy storing foot made with an ultraflexible plastic called Resilion. Resilion literally stores energy, bouncing back off the ground and enabling users to run significantly faster than they could with a normal foot. AL also contains a hydraulic knee joint with adjustable flexion and extension, to adjust performance for different types of events. The user need only operate an electronic control attached to the calf. One setting, for instance, allows the user to go



"Try pressing down."

superfast during a running event. Yet another adds inches to a pole-vaulter's jump.

Blood type bountiful. Back in 1984 a group of American cyclists got in trouble for something called blood doping—they withdrew some of their blood weeks prior to competition and then reinjected it shortly before the race. Their intent was clear. Because red blood cells carry oxygen to the muscles, they hoped that by shoring up their red blood cell supply they could prolong the muscles' ability to do work at a faster pace. At that time, of course, blood doping was illegal. Not only did it fly in the face of the Olympic idyll of the day, it also came with side effects: infection, blood clots, cardiac arrest, and in the most extreme instances, death.

Today, however, you can increase the amount of oxygen reaching your muscles without risking any side effects at all. The answer to your dreams: Bionic Blood. Starting this year, the product will be available via transfusion from sports clinics around the world. Bionic Blood contains densely packed clusters of synthetically created molecules known as hemocarts, which serve the same function as real red blood cells while transporting three times the oxygen. After your event, the body simply flushes Bionic Blood out naturally and your own blood supply is restored.

ELIXIRS

Fat cats. Most people still associate fat with such evils as cholesterol, cardiovascular disease, and cancer. They also believe that the best possible diet for endurance athletes consists of huge quantities of complex carbohydrates and hardly any fat at all. But now scientists have discovered that athletes who consume a special fatty derivative for weeks on end actually begin to metabolize it as efficiently as they metabolize carbos. That's good news because fat stores nine calories of energy per gram, while carbohydrates and proteins store less than five. Athletes on the high-fat diet, therefore, can keep going more than twice as long as those who load up merely on carbohydrates. Recent tests have shown that once these athletes start to metabolize fat, they are no more prey to high cholesterol, heart disease, and cancer than the rest of us. The result of all this research—a liquid supplement called Fat Pack—should be on the market soon.

Hyperdrive. If you have trouble achieving that primal state of intensified awareness that may guarantee success, Superjuice is for you. Enriched with the amino acid tyrosine, normally found in more moderate quantities in protein products, Superjuice stimulates the production of the brain chemical norepinephrine, pushing you to a life-or-death state of intensified alertness. An hour after drinking Superjuice, the drive to win takes on primal proportions, and you can roar your way to success. And if you happen to get injured, you can use the excess norepinephrine to balance blood pressure and avert shock.

Fetal feats It's common knowledge that muscle power increases during the first few months of pregnancy. But these days there's no reason to conceive a child just to win a race. Pro utero now manufactured in milk shake form, simulates much of the hormonal environment of early pregnancy for both women *and* men, increasing muscle power without any of the side effects associated with injections of steroids or growth hormones. Since Pro-utero creates the hormonal environment of early pregnancy only approximately users avoid such symptoms as nausea and exhaustion. This vanilla-flavored drink must be consumed on a daily basis for a week before effects take place.

SERVICES

Sports crystal ball. Throughout his playing career Mickey Mantle, one of the baseball greats of the last century, could run, throw, and hit with frightening power. But he had a single, tragic flaw—he was injured almost as often as he was healthy. In fact, the grand variety of strains, sprains, and broken bones that beleaguered him not only cost him weeks of play each year but eventually shortened his career. Mantle wound up in the Baseball Hall of Fame so he had to be doing something right. But the truth is that he might have done something else better. One of the greatest outfielders of all time, he may actually have missed his calling as a shortstop, quarterback, or champion tennis player.

If the Sport Profile had been around back then, Mantle might have found a truer calling, and his grievous injuries might not have occurred. The reason is the protocol of the profile itself. The Sport Profile involves a complex, comprehensive battery of diagnostic tests that measure every aspect of your internal and external physical structure. By minutely examining the strength and flexibility of your joints, testers can tell you whether you will be able to withstand the jarring pivots of tennis or the leaps and crash landings of basketball. By gauging the capacity of your heart and lungs and the overall cellular composition of your muscles, they can determine your endurance for such sports as swimming or running. By calculating equilibrium, they can predict your future as a platform diver or gymnast. And by determining your bone strength, they can encourage or discourage performance in contact sports like wrestling or football. You can go through the procedure at most sports clinics, where results of the evaluation are fed into a computer programmed with the physical and physiological capabilities required for every major sport. The final printout will tell you what activity is best suited to your body and your life needs.

Olympic network. Even with all the computer help—not to mention elaborate biofeedback systems for strength, flexibility, and aerobics—you can't do it all. In fact, it's almost impossible to plan the optimum sports training program without the help of experts who have access to all the latest research findings and techniques. The answer is a subscription to the Olympic Network system, which will become your ultimate coach.

Network subscribers receive ultrasensitive microsensors that record heart rate, muscle patterns, brain waves, nutritional status, and more. Every bit of pertinent data goes via computer modem to a central clearinghouse. There, a vast mainframe computer programmed with the most up-to-date training information and the subscriber's data makes changes in the training regimen as required.

TOOLS

Magnetic racket. Powerful control of the ball can be yours with the first stringless tennis racket, called the Magnum Force. The racket frame is made of Kevlar, a composite substance that is completely maneuverable yet has the strength of a sledgehammer. The frame is unbreakable and highly efficient at absorbing shock and trauma. But the most spectacular feature of Magnum Force concerns the strings—or rather, the lack of them. Instead of strings, Magnum Force has a magnetic force field that repels the ball. A battery in the racket handle generates electromagnetic pulses in the frame of the racket head; when you swing, the ball is repelled by the negative charge of the force field. The field provides equal power at all points on the head, eliminating the old dead spots near the edges of the frame. It also absorbs much of the shock that would otherwise travel up the arm, so tennis elbow and rotator cuff problems have all but disappeared. What's more, the field can be adjusted depending on the type of shot you want to make. Conventional rackets come at a fixed tension of say 60 or 70 pounds, but Magnum Force comes with a computerized adjustable-tension system. With a dial on the handle, you can change the force field to choose one tension for serving, then quickly switch to another tension when you charge the net. Some players may put the racket in auto mode, where an electronic sensor determines what the tension should be, depending upon the location of the ball, and changes it from one moment to the next.

Tripping the light fantastic. Solar sailing, once the province of a few space nuts, is now accessible to everyone with The SpaceSport Company's newest product, Sun Wings. The Sun Wings kit comes with space mask, bodysuit, jet pack, and oxygen tank. But the truly innovative part includes a sail and scaffold that resemble a hang glider's apparatus. The sail itself—a rigid, flat, lightweight sheet of tiny photovoltaic cells—can store enough solar power to propel you to the moon and back. Should you run out of power within the shadow of a space colony or around the dark side of the moon, the sail comes with a portable laser light. Just activate the laser and it will energize your sail, propelling you until you get out of your fix. ∞

WOODS

CONTINUED FROM PAGE 48

of the group. They are, in fact, a multimillion-dollar business, the backbone of the aquaculture industry." Belk says, used as food for tropical fish aquariums. "Maybe you've seen the ads for Sea Monkeys. Those are brine shrimp. They're sold as novelty items, as little pets." One-quarter cup of live shrimp goes for $1.50; eggs are about $4 for 9 grams, or 31 ounces.

Brine shrimp are the only oddballs of the gang that have two modes of reproduction. They produce both live young and eggs. The first or second batches are born live. "You can see them in Utah's Great Salt Lake,' Belk says. "From the air they look like red paint."

After the mother has birthed live young, she produces eggs, which can be 'vacuum-packed like coffee,' Belk says. 'Just add water.' This occurs because the mother secretes a sclerotized (leatherlike) protein that hardens around the embryo. 'It looks like solidified foam,' says Belk. 'We're talking about something two tenths to three tenths of a millimeter in diameter.' Mothers produce 50 to 100 of these at a time. Once the shell is set, the embryo is protected for years, even decades. Then the rains come or the snow melts, and if the temperature is suitable, the eggs hatch. Naturally enough, that's just what happens in rock holes and roadside ditches. Mothers of tadpole and clam shrimp perform the same feat.

But in many of the places where these shrimpettes live, rain isn't an annual occurrence. "The record for keeping any of these eggs and hatching them is about thirty years," Belk says. From an evolutionary point of view, no one really understands how these shrimp ended up in such places as Utah's Great Salt Lake. "Presumably their ancestors were from a marine environment,' Belk says. 'There just is no information. There aren't even any theories."

Not so with Florida's manatees. Scientists know just about everything there is to know about the manatees—from their evolutionary development, sexual behavior and physiology to their communication skills and feeding habits. These ancient, big, sweet, slow, vegetarian mammals, sometimes called sea cows, belong to the order Sirenia. Forty-five-million-year-old sirenian fossils have been found in Florida. Biologists believe that sirenians evolved from four-footed land mammals more than 60 million years ago, citing their undeveloped pelvic bones as evidence of terrestrial ancestors. Manatee bones also have been found in pre-Columbian Indian refuse mounds in southeastern Florida.

There's no creature in the United States even remotely as strange looking as the manatee, which reminds one of a cross between the Blob and a vacuum cleaner. The manatee is almost hairless, except for stiff, cactuslike whiskers around the face and sparse, fine hairs on the body. Thrown in to complete the absurd look, a beaver tail and flippers with three or four nails at the tip. Just under the finely wrinkled skin is a layer of fat deposits. A bulbous face and small, wide-set eyes give the manatee a sort of lost walrus look.

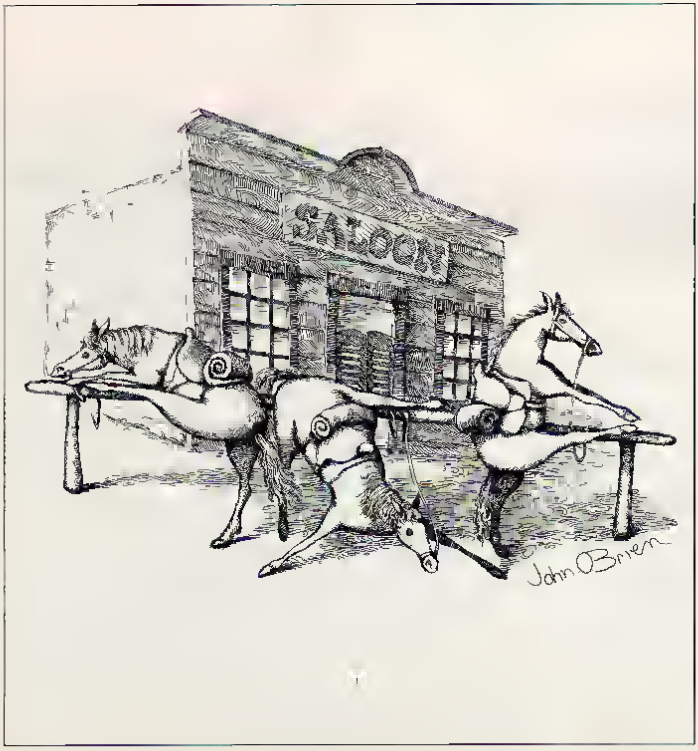
Found in freshwater, brackish, and marine habitats, they're usually about ten feet long and weigh from 800 to 2,000 pounds, though some grow to a whopping 12.7 feet and weigh in at 3,500 pounds. This makes sense, since the manatee's nearest living relative is the elephant. Though nobody knows for sure, it's thought that if left alone, manatees can live up to 60 years. The oldest one in captivity is 29.

Manatees have a prehensile mouth that folds in and out much the way an elephant's trunk works. In the wild, manatees put away up to 100 pounds of abrasive water plants a day, which explains their bizarre ability to wear away and grow back one set of teeth after another. This factor, biologists say, allowed the manatees to survive in the New World and replace the dugongs, their relatives in the Pacific. At any given time, new teeth are sprouting in the back jaw of a manatee's mouth. The new teeth move toward the front as the old teeth fall out. It's like an ongoing dental parade that lasts a lifetime. Even a dying manatee often has a new set of molars.

The social behavior of manatees fascinates biologists. They have no natural enemies besides man, no social hierarchy, no daily set routines. Many of them will swim right up to divers to be petted. When manatees are together in groups, one manatee does not dominate the herd, although a manatee often initiates playtime. Manatees love to play. Between somersaults, headstands, tail stands, and barrel rolls, they bodysurf, kiss, nuzzle, bump, and chase one another. And eat. Manatees spend about five to eight hours a day feeding. The Flying Karamazov Brothers of the animal kingdom, what we're doing to them with our speedboats is monstrous.

Of the 1,200 manatees left in the United States today, 900 are officially identified by their boat prop scars. 'There's one huge cow whose tail is just spaghetti,' says Cheryl Buckingham, a graduate student working with the U.S. Fish and Wildlife Service. During the summer months, Buckingham comes to the Gulf Coast town of Homosassa Springs, some 80 miles north of Tampa, to study the effects of boaters and divers on the 160 or so manatees that make the nearby Crystal River National Wildlife Refuge their winter home. The U.S. Fish and Wildlife Service staff—project leader Patrick Hagan, law enforcement officer Frank Brauszewski, and biologist Larry Hartis—manage five refuges, covering 80 miles of Florida's central west coast.

"You probably won't see a manatee today," Hagan cautions. "It's late in the season, and they're pretty much dispersed."



In summer manatees roam all over Florida's coastal waters estuaries, bays, and rivers. During the winter, cold temperatures drive the manatees to warm water discharges at power plants and natural warm water areas like the Crystal River refuge. But we take the boat out anyway and tour the nine islands and 33.12 acres of the refuge. Yellow-finned mullet leap out of the water all around us. We pass magnolia trees, red cedars, and pickerelweed with their purple floral spears. There are pines, oaks, banana trees, sweet gums, cabbage palms, and palmettos. And everywhere just under the surface of the water, lies the spongy green countenance of hydrilla. Buckingham reaches in and grabs a handful. "This is the manatees' favorite food," she says. "And this is where they like to stay when it gets cold. There are six hundred million gallons of water in the whole system and more than one hundred springs. This one stays seventy-two degrees year-round—it's the biggest one."

We pull into a little half-moon bay marked by signs that read MANATEE SANCTUARY and IDLE SPEED. Ospreys, eagles, cormorants, pelicans, major league gators, and countless jump-for-joy mullet—but no manatees. "You can always see them over at Nature World," Hagan offers kindly.

Nature World is just a short drive from the manatee refuge center in Homosassa Springs. It's a tourist attraction with the usual snack bar and tackola gift shop setup. But the main part is built over a natural spring, and it's really quite pretty. I meet Betsy Dearth. She works full time at Nature World, "doing just about everything." We're standing in the underwater observation room while the dozen or so resident manatees float eerily above our heads. "Rosie circles a lot—she has an equilibrium problem," says Dearth. With a sad smile, she adds, "They really ask for nothing. They don't kill anything. They just want to float along—and eat." Nature World manatees consume 50 pounds of carrots, five cases of lettuce, and three cases of cabbage every day.

I ask if I can feed them by hand. Despite the fact that state law forbids the public to feed protected species, Dearth agrees to bend the rules and leads me to a little clearing on the shoreline. Several large manatees come over—Hugh, Magoo, Amanda. I hold out a carrot, and Rosie surfaces, working her lips like gates in a pinball machine. Her breath smells powerfully of cabbage. "Their mouths are like a hand," Dearth says. Rosie takes the carrot, nudging my hand sweetly in the process.

Her touch disorients me. Forty-five million years, I think, compared to our meager 45,000. They were here with the first whales and the saber-toothed cats. When the mountains came barreling out of the seas they were here. When glaciers took the land like a cold cancer, they were here. What are the pyramids held against the cellular memories of manatees? What is a Corinthian column? Even I wonder what is the

Pythagorean theorem? And, certainly what is a 5000 Scarab Meteor powerboat with a Triple 420-horsepower Merc V8 cutting 20-foot rooster tails across what's left of the natural habitats of these ancient beasts?

The natural properties—the sun, the trees, the bays and rivers—that have supported life so luxuriantly for millions and millions of years on this long green peninsula are the very same ones that make Florida so attractive to *Homo sapiens*. Every day 1,000 people move to the state. Every month they launch 1,500 new pleasure boats. Only 1,200 manatees are left in Florida—the odds aren't good. At least for now the animals are still there, and there's a strong movement in the state to keep it that way.

If you ever find yourself discontented about our age, thinking that technology's homogenization has bankrupted the planet of its original eccentricities, that the presence of McDonald's in Beijing and of Whitney Houston T-shirts in Borneo has rendered the earth, once again, quite flat, then it is helpful to recall the day of the stiff dogs, to remember that each spring ice worms begin their tentative ascent through the thinning Alaskan snowpack, and brine shrimp bloom in the Great Salt Lake like a colossal aquatic Matisse. The new greenery sends inaudible shrieks of joy through the colonies of Texas leaf-cutter ants, and gold beetles huddle in wonder at the sudden profusion of morning glories. From Mexico to California, monarch butterflies plot their return trips north. The giant Pacific octopus slides along the bottom of Puget Sound, and gentle manatees float in Florida's waterways. For just beyond the roar of Mercs and Evinrudes, just beneath the dispassionate skins of Congoleum and Astro Turf, all strange symbols of modern life, that old natural magic is still going strong—and you don't have to float down the Amazon to find it. It's right here, snorting, flapping, wallowing, and burrowing in America's own backyard. ◻◻

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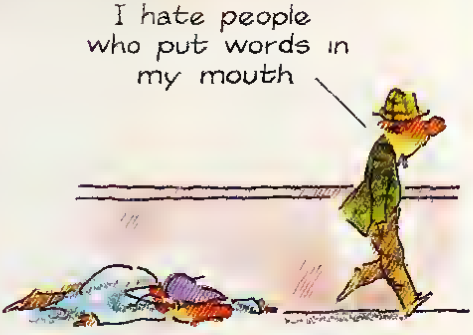
The Artist



SCHRÖDINGER'S

CONTINUED FROM PAGE 66

and a tour had been arranged to the city some fifty miles to the south. Two hours later the travelers concluded that the expedition had been a mistake.

Among them was David Hilbert, the German mathematician, a lecturer at Gottingen since 1895. He was accompanied by his wife, Kathe, and their maid, Clärchen. At first they were quite taken by the strangeness of the city, by the foreign sights and sounds and smells, but after a short time, their senses were glutted with newness, and what had at first been exotic was now only deplorable. As they moved slowly through the bazaars, shaded ineffectually by awnings or meager arcades of sticks, they longed for the whisper of a single cool breeze. Arab men dressed in long white *gallebeyas* cried out shrilly, all the while glaring at the Europeans. It was impossible to tell what the Arabs were saying. Some dragged little carts loaded with filthy cups and pots—water? Tea? Lemonade? It made no difference. Cholera lingered at every stall, every beggar offered typhus as he clutched at sleeves.

Hilbert's wife fanned herself weakly. She was almost overcome and near collapse. Hilbert looked about desperately. 'David,' murmured the maid Clarchen, the only one of Hilbert's amours Frau Hilbert could tolerate, "we have come far enough."

"I know," he said, 'but I see nothing—nowhere—"

"There are some ladies and gentlemen in that place. I think it's an eating place. Leave Käthe with me there and find a taxi. Then we shall go back to the boat."

Hilbert hesitated. He couldn't bear to leave the two unprotected women in the midst of this frantic heathen marketplace. Then he saw how pale his wife had become, how her eyelids drooped, how she swayed against Clärchen's shoulder. He nodded. "Let me help," he said. Together they got Frau Hilbert to the restaurant, where it was no cooler but at least the ceiling fans created a fiction of fresh air. Hilbert introduced himself to a well-dressed man who was seated at a table with his family, a wife and four children. The mathematician tried three languages before he was understood. He explained the situation, and the gentleman and his wife both assured Hilbert that he need not worry. Hilbert ran out to find a taxi.

He was soon lost. There were no streets here, not in the European sense of the word. Narrow spaces between buildings became alleys, opened into small squares, closed again, other narrow passages led off in twisting, bewildering directions. Hilbert found himself back at a souk, he thought at first it was where he'd begun and looked for the restaurant, but he was wrong. This was another souk entirely, there were probably hundreds in the city. He was beginning to panic. Even if he managed to

find a taxi, how could he direct it back to where his wife and Clarchen waited?

A man's hand plucked at him. Hilbert tried to shrug the long fingers away. He looked into the face of a lean, hollow-cheeked man in a striped robe and a blue knitted cap. The Arab kept repeating a few words, but Hilbert could make no sense of them. The Arab took him by the arm and half-led, half-shoved Hilbert through the crowd. Hilbert let himself be guided. They crossed through two bazaars, one of tinsmiths and one of poultry dressers. They entered a stone-paved street and emerged into an immense square. On the far side of the square was a huge, many-towered mosque, built of pink stone. Hilbert's first impression was awe; it was as lovely an edifice as the Taj. Then his guide was pushing him again through the throng or hurrying in front to hew a path for Hilbert. The square was jammed and choked with people. Soon Hilbert could see why—a platform had been erected in the center, and on it stood a man with what could only be an executioner's ax. Hilbert felt his stomach sicken. His Arab guide had thrust aside everyone in their way until Hilbert stood at the foot of the platform. He saw uniformed police and a bearded old man leading out a young girl. The crowd parted to allow them by. The girl was stunningly lovely. Hilbert looked into her huge, dark eyes—"like the eyes of a gazelle," he remembered from reading Omar Khayyám—and glimpsed her slender form undisguised by her modest garments. As she mounted the steps, she looked down directly at him again. Hilbert felt his heart lurch; he felt a tremendous shudder. Then she looked away.

The Arab guide screamed in Hilbert's ear. It meant nothing to the mathematician. He watched in horror as Jehan knelt, as the headsman raised his weapon of office. When the fierce, bellowing cry went up from the crowd, Hilbert noticed that his suit was now spattered with small flecks of red. The Arab screamed at him again and tightened his grip on Hilbert's arm until Hilbert complained. The Arab did not release him. With his other hand, Hilbert took out his wallet. The Arab smiled. Above him, Hilbert watched several men carry away the body of the decapitated girl.

The Arab guide did not let him go until he'd paid an enormous sum.

Perhaps another hour had passed in the alley. Jehan had withdrawn to the darkest part and sat in a damp corner with her legs drawn up, her head against the rough brick wall. If she could sleep, she told herself, the night would pass more quickly, but she would not sleep; she would fight it if drowsiness threatened. What if she should slip into slumber and waken in the late morning, her peril and her opportunity both long since lost? Her only companion, the crescent moon, had abandoned her; she looked up at fragments of constellations, stars familiar enough in their groups but indistinguishable now as individuals. How different from people, where the opposite was true. She sighed; she was not a profound person, and it did not suit her to have profound thoughts. These must not truly be profound thoughts, she decided, she was merely deluded by weariness. Slowly she let her head fall forward. She crossed her arms on her knees and cradled her head. The greater part of the night had already passed, and only silence came from the street. There were perhaps only three more hours until dawn.

Soon Schrodinger's wave mechanics was proved to be equivalent to Heisenberg's matrix mechanics. It was a validation of both men's work and of the whole field of quantum physics as well. Eventually Schrödinger's simplistic wave picture of the electron was abandoned, but his mathematical laws remained undisputed. Jehan remembered Schrödinger predicting that he might need to take just that step.

"It was a breathless afternoon in the city. The local Arabs didn't seem bothered by the heat, but the party of Europeans was suffering. They concluded that the expedition was a mistake."

Jehan had at last returned to Göttingen and Heisenberg. He had "forgiven her petulance." He welcomed her gladly because of his genuine feelings for her and because he had much work to do. He had just formally developed what came to be known as the Heisenberg uncertainty principle. This was the first indication that the impartial observer could not help but play an essential, active role in the universe of subatomic particles. Jehan grasped Heisenberg's concept readily. Other scientists thought Heisenberg was merely making a trivial criticism of the limitations of their experiments or the quality of their observations. It was more profound than that. Heisenberg was saying that one can never hope to know both the position and momentum of an electron at the same time under *any* circumstances. He had destroyed forever the assumption of the impartial observer.

"To observe is to disturb," said Heisenberg. "Newton wouldn't have liked any of this at all."

"Einstein still doesn't like it right this very minute," said Jehan.

"I wish I had a mark for every time he's made that sour 'God doesn't play dice with the universe' comment."

"That's just the way he sees a 'wave of probability.' The path of the electron can't be known unless you look, but once you look, you change the information."

"So maybe God doesn't play dice with the universe," said Heisenberg. "He plays vingt-et-un, and if He does not have an extra ace up His sleeve, He creates one—first the sleeve, then the ace. And He turns over more natural twenty-ones than is statistically likely. Hold on, Jehan! I'm not being sacrilegious. I'm not saying that God cheats. Rather He invented the rules of the game, and He *continues* to invent them, and this gives Him a rather large advantage over poor physicists and their lagging understanding. We are like peasants watching the card tricks of someone who may be either genius or charlatan."

Jehan pondered this metaphor. "At the Solvay conference, Bohr introduced his complementarity idea: that an electron was a wave function until it was detected, and then the wave function collapsed to a point, and you knew where the electron was. Then it was a particle. Einstein didn't like that, either."

"That's God's card trick," said Heisenberg, shrugging.

"'Well, the noble Qur'an says, 'They question thee about strong drink and games of chance. Say: In both is great sin, and some usefulness for men, but the sin of them is greater than their usefulness.'"

"'Forget dice and cards, then,'" said Heisenberg with a little smile. "What kind of game *would* it be appropriate for Allah to play against us?"

"Physics," said Jehan, and Heisenberg laughed.

"'And knowest thou there is a prohibition against taking of human life that Allah hath made sacred?'"

"'Yes, O Wise One.'"

"'And knowest thou further that Allah hath set a penalty upon those who breaketh this law?'"

"'Yes, I know.'"

"'Then, O my daughter, tell us why thou hath brought low this poor boy.'"

Jehan tossed the bloody knife to the stone-paved alley. It rang noisily and then came to rest against one leg of the corpse. "I was celebrating the Id-el-Fitr," she said. "This boy followed me, and I became afraid. He made filthy gestures and called out terrible things. I hurried away, but he ran after me. He grabbed me by the shoulders and pressed me against a wall. I tried to escape, but I could not. He laughed at my fear, then he struck me many times. He dragged me along through the narrowest of streets, where there were not many to witness, and then he pulled me into this vile place. He told me that he intended to defile me, and he described what he would do in foul detail. It was then that I drew my father's dagger and stabbed him. I have spent the night in horror of his intentions

"My God, they must be getting desperate up there!"

and of my deed and I have prayed to Allah for forgiveness."

The imam put a trembling hand on Jehan's cheek. "Allah is All-Wise and All-Forgiving, O my daughter. Alloweth me to return with thee to thy house, where I may put the hearts of thy parents at ease."

Jehan knelt at the imam's feet. "All thanks be to Allah," she murmured.

"Allah be praised," said the imam, the police officer, and the qadi together.

More than a decade later, when Jehan had daughters of her own, she told them this story. But in those latter days children did not heed the warnings of their parents, and the sons and daughters of Jehan and her husband did many foolish things.

Dawn slipped even into the narrow alleyway where Jehan waited. She was very sleepy and hungry, but she stood up and took a few wobbling steps. Her muscles had become cramped, and she could hear her heart beating in her ears. Jehan steadied herself with one hand on the brick wall. She went slowly to the mouth of the alley and peered out. There was no one in sight. The boy was coming neither from the left nor the right. Jehan waited until several other people appeared, going about the business of the new day. Then she hid the dagger in her sleeve once more and departed from the alley. She hurried back to her father's house. Her mother would need her to help make breakfast.

Jehan was in her early forties now, her black hair cut short, her eyes framed by clumsy spectacles, her beauty stolen by care, poor diet, and sleeplessness. She wore a white lab coat and carried a clipboard, as much a part of her as her title, Fraulein Professor Doktor Ashuti. This was not Gottingen any longer, it was Berlin, and a war was being lost. She was still with Heisenberg. He had protected her until her own scientific credentials became protection of themselves. At that point the Nazi officials were compelled to make her an "honorary" Aryan, as they had the Jewish physicists and mathematicians whose cooperation they needed. It had been only Jehan's long standing loyalty to Heisenberg himself that kept her in Germany at all. The war was of little concern to her; these were not her people, but neither were the British, the French, the Russians, or the Americans. Her only interest was in her work, in the refinement of physics, in the unending anticipation of discovery.

She was glad therefore when the German atomic bomb project was removed from the control of the German army and given to the Reich Research Council. One of the first things to be done was the calling of a research conference at the Kaiser Wilhelm Institute of Physics in Berlin. The conference would be conducted under the tightest security; no preliminary list of topics would be released in advance, so that no foreign agents might see such terms as *fission cross sections* and *isotope enrichment*, leading to speculation on the long-term goals of these physicists.

At the same time, the Reich Research Council decided to hold a second conference for the benefit of the government's highest officials on the same day. The idea was that the scientists speaking at the Kaiser Wilhelm Institute's meeting could present short, elementary summaries of their work in plain language so that the political and military leaders could be briefed on the progress that was being made toward a nuclear weapon. Then, following the laymen's presentation, the physicists could gather and discuss the same matters in their more technical jargon.

Heisenberg thought it was a good idea. It was 1942, and material, political support, and funding were getting more difficult to find. The army wanted to put all available research resources into the rocketry program; they argued that the nuclear experiments were not showing sufficient success. Heisenberg was a theoretical physicist, not an engineer; he could not find a way to tell the council that the development of the uranium bomb must necessarily be slow and methodical. Each new step forward in theory had to be tested carefully, and each experiment was expensive in both time and money. The Reich however cared only for positive results.

One evening Jehan was alone in an administrative office of the Reich Research Council, typing her proposal for an important test of their isotope separation technique. She saw on the desk two stacks of papers. One stack listed the simple synopses the physicists had prepared for the Reich ministers who had little or no background in science. She took those papers and hid them in her briefcase. The second stack was the secret agenda for the physicists' own meeting. "Nuclear Physics as a Weapon" by Professor Dr. Schumann, "The Fission of the Uranium Atom" by Professor Dr. Hahn, "The Theoretical Basis for the Production of Energy from the Fission of Uranium," by Heisenberg and so on. Each person attending the technical seminar would be given a program after he entered the lecture hall, and he would be required to sign for it. Jehan thought for a long while in the quiet office. She remembered her wretched childhood. She recalled her arrival in Europe and the people she had come to know, the life she had come to lead here. She thought about how Germany had changed while she hid in her castle of scientific abstractions uninvolved with the outside world. At last she thought about what this new Germany might do with the uranium bomb. She knew exactly what she must do.

It took her only a few moments to take the highly technical agendas and drop them into the already-addressed envelopes to be sent to the Third Reich's leaders. She had guaranteed that the brief introductory discussion would be attended

by no one. Jehan could easily imagine the response the unintelligible scientific papers would get from the political and military leaders—curt, polite regrets that they would not be in Berlin on that day, or that their busy schedules prevented them from attending. It was all so easy. The Reich's rulers did not hear the talks, and they did not learn how close Germany was to developing an atomic bomb. Never again was there any hope that such a weapon could be built in time to save the Reich—all because the wrong invitations had been slipped into a few envelopes.

Jehan awoke from a dream and saw that the night had grown very old. It would not be long before the sun began to flood the sky with light. Soon she would have a resolution to her anxiety. She would learn if the boy would come to the alley or stay away. She would learn if he would rape her or if she would find the courage to defend herself. She would learn if she would be judged guilty or innocent of murder. She would be granted a glimpse of the outcome to all things that concerned her.

Nevertheless, she was so tired, hungry, and uncomfortable that she was tempted to give up her vigil. The urge to go home was strong. Yet she had always believed that her visions were gifts granted by Allah, and it might offend Him to ignore the clear warnings. For Allah's sake, as well as her own, she reluctantly chose to wait out the rest of the dying night. She had seen so many visions since last evening—more than on any other day of her life—some new, some familiar from years past. It was, in a small, human way, almost comparable to the Night of Power that was bestowed upon the Prophet. may Allah's blessings be on him and peace. Then Jehan felt guilty and blasphemous for comparing herself to the Messenger that way.

She got down on her knees and faced toward Mecca and addressed a prayer to Allah, reciting one of the later suras from the glorious Qur'an, the one called 'The Morning Hours," which seemed particularly relevant to her situation. "'In the name of Allah, the Beneficent, the Merciful. By the morning hours, and by the night when it is stillest, thy Lord hath not forsaken thee nor doth He hate thee, and verily the latter portion will be better for thee than the former, and verily thy Lord will give unto thee so that thou wilt be content. Did He not find thee an orphan and protect thee? Did He not find thee wandering and direct thee? Did He not find thee destitute and enrich thee? Therefore the orphan oppress not, therefore the beggar drive not away, therefore of the bounty of thy Lord be thy discourse.'" When she finished praying, she stood up and leaned against the wall. She wondered if that sura prophesied that soon she'd be an orphan. She hoped that Allah understood that she never intended anything awful to happen to her parents. Jehan was willing to suffer whatever consequences Allah willed, but it didn't seem fair

for her mother and father to have to share them with her. She shivered in the damp cold air and gazed up to see if there was yet any brightening of the sky. She pretended that already the stars were beginning to disappear.

The square was jammed and choked with people. Soon Hilbert could see why—a platform had been erected in the center and on it stood a man with what could only be an executioner's ax. Hilbert felt his stomach sicken. His Arab guide had thrust aside everyone in their way until Hilbert stood at the very foot of the platform. He saw uniformed police and a bearded old man leading out a young girl. The crowd parted to allow them by. The girl was stunningly lovely. Hilbert looked into her huge, dark eyes—"like the eyes of a gazelle," he remembered from reading Omar Khayyam—and glimpsed her slender form undisguised by her modest garments. As she mounted the steps she looked down directly at him again. Hilbert felt his heart lurch; he felt a tremendous shudder. Then she looked away.

The Arab guide screamed in Hilbert's ear. It meant nothing to the mathematician. He watched in horror as Jehan knelt as the headsman raised his weapon of office. Hilbert shouted. His guide tightened his grip on the outsider's arm, but Hilbert lashed out in fury and threw the man into a group of veiled women. In the confusion Hilbert ran up the steps of the scaffold. The imam and the police officers looked at him angrily. The crowd began to shout fiercely at this interruption, this desecration by a European kaffir, an unbeliever. Hilbert ran to the police. "You must stop this!" he cried in German. They did not understand him and tried to heave him off the platform. "Stop!" he screamed in English.

One of the police officers answered him. "It cannot be stopped," he said gruffly. "The girl committed murder. She was found guilty, and she cannot pay the blood price to the victim's family. She must die instead."

"Blood price!" cried Hilbert. "That's barbarous! You would kill a young girl just because she is poor? Blood price! *I'll* pay your goddamn blood price! How much is it?"

The policeman conferred with the others and then went to the imam for guidance. Finally the English-speaking officer returned. "Four hundred *kiam*."

Hilbert took out his wallet with shaking hands. He counted out the money and handed it with obvious disgust to the policeman. The imam cried a declaration in his weak voice. The words were passed quickly through the crowd, and the onlookers grew more enraged at this spoiling of their morning's entertainment. "Take her and go quickly," said the police officer. "We cannot protect you, and the crowd is becoming furious."

Hilbert nodded. He grasped Jehan's thin wrist and pulled her along after him. She questioned him in Arabic, but he could not reply. As he struggled through the menacing crowd, they were struck again and again by stones. Hilbert wondered what he had done: if he and the girl would get out of the mosque's courtyard alive. His fondness for young women—it was an open joke in Gottingen—had that been all that had motivated him? Had he unconsciously decided to rescue the girl and take her back to Germany? Or was it something more laudable? He would never know. He shocked himself. While he tried to shield himself and the girl from the vicious blows of the crowd, he thought only of how he might explain the girl to his wife, Käthe, and Clarchen, his mistress.

In 1957 Jehan Fatima Ashûfi was fifty-eight years old and living in Princeton, New Jersey. By coincidence, Albert Einstein had come here to live out the end of his life and before he died in 1955 they had many pleasant afternoons at his house. In the beginning, Jehan wanted to discuss quantum physics with Einstein; she even told

Jehan was in her early forties, her black hair cut short, her eyes framed by clumsy spectacles, her beauty stolen by care, poor diet, and lack of sleep. Her only interest was in her work.

him Heisenberg's answer to Einstein's objection to God playing dice with the universe. Einstein was not very amused, and from then on their conversation concerned only nostalgic memories of the better days in Germany, before the advent of the National Socialists.

This afternoon, however, Jehan was sitting in a Princeton lecture hall, listening to a young man read a remarkable paper, his Ph.D. thesis. His name was Hugh Everett, and what he was saying was that there was an explanation for all the paradoxes of the quantum world: a simple but bizarre way of looking at them. His new idea included the Copenhagen interpretation and explained away all the objections that might be raised by less open-minded physicists. He stated first of all that quantum mechanics provided predictions that were invariably correct when measured against experimental data. Quantum physics *had* to be consistent and valid, there was no longer any doubt. The trouble was that quantum theory was beginning to lead to unappetizing alternatives.

Schrödinger's cat paradox—in which the cat in the box was merely a quantum wave function, not alive and not dead, until an observer looked to see which state the cat was in—was eliminated. Everett showed that the cat was no mere ghostly wave function. Everett said that wave functions do not "collapse," choosing one alternative or the other. He said that the process of observation chose one reality, but the other reality existed in its own right, just as "real" as our world. Particles do not choose at random which path to take—they take every path, in a separate, newly branched world for each option. Of course, at the particle level, this meant a huge number of branchings occurring at every moment.

Jehan knew this almost-metaphysical idea would find a chilly reception from most physicists, but she had special reasons to accept it eagerly. It explained her visions. She glimpsed the particular branch that would be "real" for her and also those that would be "real" for other versions of her, her own duplicates living on the countless parallel worlds. Now, as she listened to Everett, she smiled. She saw another young man in the audience wearing a T-shirt that said: WIGNER DO YOU THINK YOUR FRIEND COULD FEED MY CAT? HEISENBERG WASN'T SURE. THANKS, SCHRÖDINGER. She found that very amusing.

When Everett finished reading, Jehan felt good. It wasn't peace she felt; it was more like the release one feels after an argument that had been brewing for a long while. Jehan thought back over the turns and sidetracks she had taken since that dawn in the alley in the Budayeen. She smiled again, sadly, took a deep breath, and let it out. How many things she had done, how many things had happened to her! They had been long, strange lives. The only question that still remained was: How many uncountable futures did she still have to devise, to fabricate from the immaterial resources of this moment? As she sat there—in some worlds—Jehan knew the futures went on without her willing them to, needing nothing of her permission. She was not cautious of when tomorrow came but *which* tomorrow came.

Jehan saw them all, but she still understood nothing. She thought: *The Chinese say that a journey of a thousand li begins with a single step. How shortsighted that is! A thousand journeys of a thousand li begin with each step. Or with each step not taken.* She sat in her chair until every one else had left the lecture hall. Then she got up slowly, her back and her knees giving her pain, and she took a step. She pictured myriad mirror Jehans taking that step along with her, and a myriad that didn't. And in all the worlds across time, it was another step into the future.

At last there was no doubt about it. It was dawn. Jehan fingered her father's dagger and felt a thrill of excitement. Strange words flickered in her mind. "The Heisenty uncertainberg principle," she murmured, already hurrying toward the mouth of the alley. She felt no fear.

STAR TECH

ACCESSING THE FUTURE

PERSONAL ELECTRONICS

After attending the annual Summer Consumer Electronics Show, held this past June in Chicago, *Omni* contributor Margo Costello reported that this year the giant electronics companies focused on personalizing their products. Here are her choices for best of show.

VIDEO WALKMAN

Personal electronics took a step forward with the debut of the Video Walkman (right), a battery-operated TV-and-VCR combo. The 8mm hand-held device can record off the air as well as play back tapes on the unit's built-in three-inch color LCD (liquid crystal display) TV. Cost: $1,300. Available later in the fall.

TALKING REMOTE

The mysteries of VCR programming can now be solved for you by The Voice Coach (left), a friendly remote from Sharp's new Optonica line that uses a synthesized human voice to guide the user through the ordeal. The talking remote is included with all Optonica VCRs, starting with the VC-6960U. Cost: $549.95. Available in October.

TOP DRAWER

This videodisc player eliminates the need to get up in the middle of a movie to flip or change discs. The Pioneer LD-W1 LaserDisc (above) features two (instead of the usual one) disc drawers, for four-sided continuous play. It also has new special-effects capabilities, including still-with-sound and strobe motion with sound. Cost: $1,700.

TUNEFUL

Dream of singing like Streisand but sound like Yoko Ono? The Vocalizer 1000 (right) from Breakaway Music Systems may help. This "personal voice synthesizer" can expand your musical repertoire. Hum into the Vocalizer's microphone, and it will transform the pitch of your voice into any one of 28 instrumental sounds, including piano, saxophone, flute, trumpet, or violin. It even heaps you on key and includes a multitrack digital recorder. Cost: $299.

TAPING BY PHONE

Now there's a VCR for dedicated home tapers who don't want to be tied to their machines and can't remember to plan ahead. The Panasonic PV-4826 (above) can be connected to a phone and "called" to record a show. Instructions are entered via the keypad of any touch-tone phone. Cost: $550.

TRAVELING SPEAKERS

Take your speakers along for the ride. The RoomMate II from Bose (left) can be powered by batteries as well as by house current and can be fitted with an acoustically transparent travel bag. Cost of the speakers: $279. Travel bag: $85.95. Rechargeable batteries: $89.95.

Hybrid sports: Competitors in these games need multiple talents

GAMES

By Scot Morris

At university centers, corporate headquarters, and private labs around the world, scientists hope to produce a custom-designed superathlete. Others, however, are combining established sports to create new ones that are more challenging. Some are even developing hybrid sporting gear. The fastest means of human-propelled transportation, the pedal-powered *Flying Fish II*, for example, is a combination bicycle and boat.

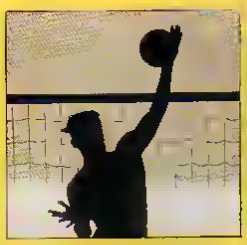
As we reported in January 1987, the *Fish*'s pedals control a propeller underneath. The back hydrofoil houses the propeller directly below the rider's center of gravity. When the cyclist gets the craft up to about seven miles per hour, the *Fish* seems to fly. The pontoons rise out of the water, and the machine can accelerate to 12 or 13 miles per hour. Only the main wing below the rider and a smaller one in front (to keep the craft's nose at a constant depth) remain below the water's surface. "Riding the *Flying Fish* is incredible," says 1984 Olympic cycling gold medalist Steve Hegg. "It just skims the water, almost like hang gliding."

Pedaling the *Fish* over a 2,000-meter course at California's Long Beach Marine Stadium, Hegg set a record of 5 minutes, 48 seconds. It was almost a full minute less than the best time of Allan Abbott, who codesigned the vehicle with Alec Brooks. "I think I could beat any eight-man crew in the country," says Hegg, who hopes to win another gold medal this month in Seoul. Not an idle boaster, Hegg, along with Abbott and Brooks, is actively challenging any team willing to race him. So far, however, no one has accepted the challenge. One team's coach nixed the idea because Hegg says, he didn't think it would be good for morale if the team lost. Brooks tried to arrange a race at an Olympic training meet, but, he says, the organizers told him they were too busy to accommodate a showdown.

Surely somewhere there must be someone willing to race against the *Flying Fish II*—for science. Contact Alec Brooks, AeroVironment, 825 Myrtle Avenue, Monrovia, CA 91016.

HYBRID SPORTS

Like the *Flying Fish II*, the Windsurfer is a hybrid—part surfboard and part sailboat. The skateboard is a surfboard and a roller skate.



And roller skating and ice skating have likewise been melded into Rollerblades, a skate with its wheels aligned rather than positioned at the four corners. In each case, someone developed the idea of making a new sporting apparatus by combining two older ones.

Some games have also been combined into totally new sports—like the triathlon, in which competitors must swim, bicycle, and run. In Hawaii's Ironman, for example, participants swim 2.4 miles, bike 112 miles, then run a 26.2-mile marathon.

There are other sport combinations, however, that are not as well-known. One is wallyball—traditional volleyball played on a racquetball court, requiring a whole new level of strategy and defense. With the net running wall to wall, players can now spike the ball by bouncing it off the wall into the opponent's court.

On Rio de Janeiro's Copacabana Beach, the locals play *futvolle*, a combination of volleyball and soccer. Many volleyball rules still apply, like using as many as three hits—by three different team members—to send the ball over the net. As in soccer, however, no hands are allowed. Players can touch the ball only with their feet, knees, or heads.

There's also Ride and Tie, in which team members

alternately run and ride (Games, August 1988). There are two different versions of this relay race. One combines running and horseback riding, the other replaces the horse with a bicycle.

Other combination sports that have small but enthusiastic followings include bicycle polo, Frisbee golf, and underwater hockey. Snowboarding is a hybrid of skateboarding, surfing, and (snow) skiing, and joggling is the sport of juggling while jogging (Games, May 1987).

LET THE GAMES BEGIN

What will be the next combo-sport to garner attention? Downhill hurdles? Cross-country ski golfing? Synchronized jet skiing combining synchronized swimming and jet skiing? It may be up to you.

As Seoul's summer Olympics take place, you have the chance to possibly influence the events of future Olympics. To qualify for Competition #47, develop your original idea for a combination of two or more sports or of more than one piece of sporting equipment. Send your written description in 100 words or less—and illustrations, if appropriate—to Competition #47, Future Sports, c/o *Omni*, 1965 Broadway, New York, NY 10023-5965.

Grand prize: a Windjammer Cruise for two. Five runners-up will receive tennis rackets, shoes, or apparel from Prince Manufacturing, Inc.

A distinguished panel of guest judges will assist in selecting the winners. Representatives of Prince and other sporting goods manufacturers as well as sports celebrities will review contestants' entries that fall within their specific areas.

All entries must be postmarked by October 15, 1988, and become the property of *Omni* magazine. None will be returned.

TREASURE HUNT WINNERS

In the *Omni* Treasure Hunt (February 1988), our clues led the adventurous to page numbers 3, 5, 25, 41, 45, 49, 56, 63, 70, 80, 83, and 99. Readers then added these numbers for a grand total of 619 and submitted more than 650,000 entries. The 21 winners: Elenora Lanning, Las Vegas (Jeep Wrangler); Scott Harman, Kingston, New Jersey (Euro tan Tanning Shower); Jack Lundquist, Ontario, California (Water Ventures Toobie); Michael Grimbilas, Santa Cruz, California (Kawasaki Jet Ski and generator); Laurie Pace, New Rochelle, New York (Divi Hotels' holiday); Milton Isaacs, Hiawatha, Kansas (Canon camera outfit); Joyce Smith, Muncie, Indiana (Omega watch); Terry Mackey, Belleville, Illinois (TriStar Sports skis); Ralph Payne, Knoxville, Tennessee (Prince tennis rackets); Melissa Biers, Rochelle, Illinois (Casio synthesizer); Gary Madison Walker, Louisiana (Pioneer CD player and changer); Lamberto Diaz, Los Angeles, and Harry House, St. Charles, Missouri (Canon personal copiers); Vicki Fountain, Corpus Christi, Texas, and Judith Segall, Del Valle, Texas (Smith Corona personal word processors); William Bradley Lutz, Florida, Mitchell Brooks, Fort Lauderdale, and Mary Ripley, Hollywood, Florida (Cantion liquor); Naomi Sharp, Greenville, Ohio, Charlotte Stoppelmann, St. Louis, and Collen Christenson, Appleton, Wisconsin (Koss stereophones).

LAST WORD

By Doug Bennett

"Almost any inconvenience seems a small price to pay for a firsthand look into the future or a glimpse of the days when people ate apples instead of programming them."

Time. The wise invest it. Einstein warped it. Timothy Leary smoked it (or was that thyme?), and the late Jim Croce tried to bottle it. I find Croce's concept the most intriguing. It suggests that time may be more than just dimension no. 4—something perhaps like Chanel No. 5. After all, it's common knowledge that "time is of the essence." So through some future feat of technology, time could actually become an essence, a tangible curiosity.

Initially, time would be scarce, expensive, and federally regulated. Tucked away in underground vaults, precious moments would be restricted to a handful of scientists for research purposes only. Nearly impossible to keep track of, time would slowly work its way into the life-styles of the rich and trendy. "Doing time" would fast become the buzzword at exclusive social gatherings, little spoons would remain at home with the rest of the silverware.

Unfortunately, once the word got out, the demand for quality time would soon exceed the supply. The resulting time lapse would give rise to a network of nefarious time dealers. These chronological con artists could put a month as short as February into the equivalent street value of a year. Consequently, the following scenario would be all too common. A timeless individual, who shall remain nameless, approaches a person who he suspects is keeping time. (Such people are easy to spot, as they usually have some time on their hands.)

"Excuse me, sir. Would you happen to have the time?"

Flashing a handful of tiny capsules, the time peddler replies, "I might be able to spare a few minutes. How many do you want?"

"I'm not really sure. Can you give me a few seconds?"

"Sorry, kid. No freebies. Time is money."

"Okay, I'll take ten minutes."

"Forward or backward?"

"Make it backward. I'm feeling a little nostalgic today."

Anxiously the time junkie finds a secluded spot and takes a little time out for himself. Instead of the expected three or four minutes, however, he regresses maybe 30 seconds, tops. Once more in the company of the time pusher, he chalks up his feelings of familiarity to déjà vu and again pops the question, "Excuse me, sir. Would you happen to have the time?" It's a vicious circle. (The time dealers laughingly refer to these neophytes as "two-time losers.")

Eventually time abuse would run rampant, forcing the government to subscribe to time as an issue. Time would be legalized with the intention of stripping away its alluring veneer. On the recommendation of time-management experts, the past would be first to flood the market. Through mass production, low-budget excursions into yesteryear could become as commonplace as commercials on prime-time television. To cut costs further, mail-order houses could repackage some of history's less-popular moments in mystery grab bags. Holding no guarantees for the consumer, some of these "dates" could turn out to be real dogs. Then again, a person might be lucky enough to be mailed his own birth date but would have to wait four to six weeks for delivery—something to which his mother might object. Once the past was saturated, time tourists could begin planning trips for the future. Certain restrictions would no doubt apply, especially on those who could stand to gain financially from a peek at progress. Topping the restricted list would be politicians, weathermen, future *Wheel of Fortune* contestants, and the amazing Kreskin.

To avoid the high interest rates of conventional time payments, several individuals could purchase a ten-year parcel and split it up—each person acquiring equal time, thus reintroducing the practical notion of time-sharing.

The advent of "generic time" will offer people everywhere the time of their lives. Housewives could attend sales they'd missed last Saturday, husbands could enjoy instant replays at live sporting events; while teenagers could dabble in "high time," "double-dating," or whatever else time would permit.

If man is going to subject himself to time exposures, he must expect a few side effects. The worst complaint would probably be "time lag"—a period of disorientation caused by weaving in and out of time frames. Another malady would be "chronic constipation," characterized by the inability to pass time with any degree of regularity. Also, during rapid time acceleration, one's body might experience the sensation of physique flattening, or "being pressed for time." Yet almost any inconvenience seems a small price to pay for a firsthand look at the future or a glimpse of the "good ol' days" when people ate apples instead of programming them.

In my efforts to adhere to the Croce concept of "time in a bottle," it could be said that I have wrongfully ignored the classic model of the time contraption. With all due respect to H. G. Wells, I have a hard time visualizing a man mounting a machine and riding off into the sunset. But imagine the advantages for a teenager. Consider a conversation between father and son on some future Friday night.

"Hey, Dad. Can I borrow the time machine tonight?"

"Sure, son. Just make sure you have it back before you leave."

When Doug Bennett isn't using his time drifting in and out of the Sixties, he's spending his time writing.