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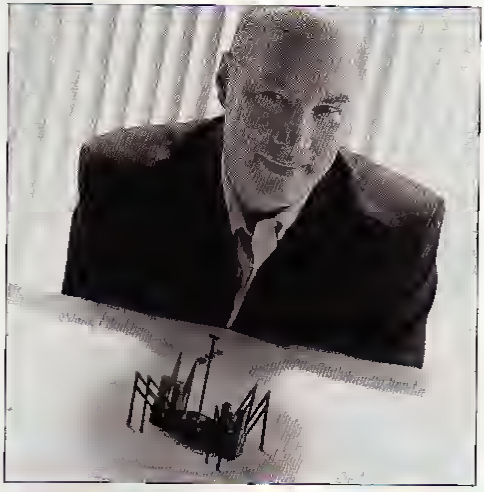
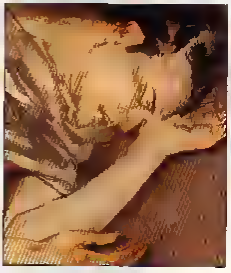
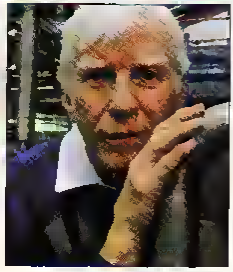
VOL. 16 NO. 4 JANUARY 1994

DEPARTMENTS







The quest for the top quark could shift us toward a new perceptual landscape. Will today's technology as Jean-Francois Podevin's illustration suggests, lend new sight to classic theory? (Art credits, page 101)

FEATURES

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FIRST WORD

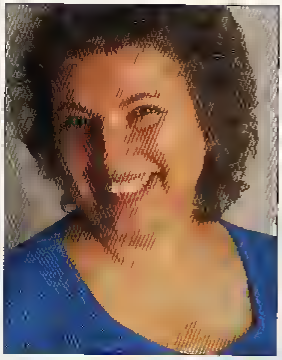
DRUG TOURISM IN THE AMAZON
Why Westerners are desperate to find the vanishing primitive

By Marlene Dobkin de Rios

A number of upscale, well-to-do prominent Americans and Europeans are touring Amazonian cities. Interested neither in parrots nor piranhas, they revel in special all-night religious ceremonies, presided over by a powerful shaman, drinking a foul-smelling brew—a woody vine called ayahuasca. Unlike the jungle denizens who for the last several thousand years have drunk the potion to see the vine's mother spirit—a boa constrictor—in order to protect themselves from enemies, to divine the future, or heal their emotional and physical disorders, the urban tourist is on a never-ending search for self-actualization and growth. In this postmodern period, where people no longer produce their own food, where the family has broken down, where there is a significant absence of community tradition and shared meanings, individuals are racked with feelings of low self-esteem and confusion about values. They are compelled to fill the emptiness with the experience of receiving something from the world. Why not a mystical experience with divinity? From travels, they bring home outrageous stories of their journeys, of the fabulous witch doctor encountered, of the vomiting and diarrhea, of the fast-moving kaleidoscopic visions of the sounds and the smells of the jungle—Wow! What a trip.

"These so-called shamans recognize the tourists' thirst for the exotic," says de Rios, professor of anthropology at California State University, Fullerton.

Unscrupulous practitioners who exploit the tourists abound, and they are conscious of the farce they perpetrate. In Amazonian cities, middle class men become instant traditional healers without undergoing an apprenticeship period, without any teachers, and without any control. They give tourists mixtures of 12 or more different psychedelic plants to help them mystically become embedded in the universe.



Many are witchcraft plants that affect neurotransmitters, decrease certain brain chemicals, and even make it impossible to read or write for an entire year. These so-called shamans fight among themselves, and all have their champions abroad who function as travel agents and tour guides. A few make money, seduce women, and obtain personal power and control over others. Agents abroad often earn as much as $8,000 to $10,000 from a three-week trip.

Drug tourism is like international mass tourism, where millions of temporary travelers from industrialized nations seek in the margins of the Third World a figment of their imagination, a fantasy of Western consciousness—the exotic, erotic primitive or happy savage. The drug dilettantism has a special rhetoric, and travel literature includes terms like "advanced shamanic training." Expensive brochures, in color-separated glory costing thousands of dollars, tout spiritual-transformation techniques of jungle shamans. The Amazon is the last remaining sanctuary on Earth, and by paying the cost of the trip, one becomes an impeccable warrior.

The phenomenon has become so flagrant since the mid 1980s that native peoples are in danger of extinction as New Age magazines invite readers to take guided tours to remote villages or sacred places of power. This is a deadly, contemporary weapon to hasten the demise of native cultures, as international drug enforcement treats this type of tourism as one more illegal activity and persecutes native peoples involved with tourists.

These tourists see exotic people of color, untouched by civilization, close to nature. They will not see the civilizing influences in these areas of Catholic and Protestant missionary activity. Little do they know that the Amazonian city dweller gets better TV reception than I do in Southern California because of the major telecommunications satellites on the outskirts of their cities.

There is little hope for dialogue between the drug tourists and the Amazonians whose traditions of ayahuasca use are linked in a matrix dealing with the moral order with good and evil, with animals and humans, and with health and illness. This has little to do with the experiences and needs of people in industrial societies.

There is an evil, exploitive aspect of this ecotouristic enterprise. These "native healers" are common drug dealers, dressed for deception. They provide the exotic setting and prep the tourist to have an "authentic personal experience." The drug tourism often leaves psychotic depression and confusion in its wake.

Modernization and cultural change over the last century have destroyed the material base of many Amazonian traditional cultures. Must we now allow this final spiritual denudation? Must the fifteenth-century Conquest still continue? Only the boa knows. ◻

COMMUNICATIONS

READERS' WRITES

Learning to see church windows, a sudden awakening, and turning back toward the stars

Synthetic Sainthood

Thanks for a rare unhysterical look at drugs and consciousness in your fifteenth anniversary issue [October 1993]. I was one of the divinity students involved in Dr. Pahnke's Good Friday Experiment mentioned in the "Short History of Consciousness" sidebar. Unfortunately, if the age of scientific study of hallucinogens and their role in religious ecstasy began there, it also ended there—in this country at least. A 25-year follow-up of that double-blind experiment was done a few years ago. Interestingly, almost all of us who got the psilocybin are still in the ministry. Most of those who got the placebo are not. Would I participate in a project like that again? Without a moment's hesitation.

Rev. Mike Young
Tampa, FL

Separate Corners

"Finding God" in the October 1993 issue attempted to define consciousness through the effects of hallucinogenic drugs on the brain. This approach begs the basic question about the nature of the entity—consciousness—that resides in the brain but is quite obviously on a different order of reality than the brain itself, or even of the neurochemical events that mark its physical operation. Science must take note of the anecdotal evidence which has long been produced by investigators of psychic activities but which has been virtually buried under an indifference based on refusal to admit the validity of nonmaterialistic phenomena.

John E. Harry
Cambridge, MN

Discontinuum

Anthony Liversidge's article, "Bacterial Consciousness" [Mind, October 1993], is limited in the notion that consciousness can be plotted on a kind of spectrum that ranges from microbial on one end to human on the other. Perhaps consciousness is not like that, perhaps it is an all-or-nothing event. Sensation, memory, recall/creation is an ongoing process in humans—often without awareness. Consciousness, then, must be different from mere neuroprocess.

Anthony Giannini, President
Cognitive Sciences International
Chelsea, MI

Space for Rent

Your comment about the condition of NASA is timely [Space, October 1993]. I think I understand why it's happening. The people who achieved wonders at NASA during the 1960s went to work there to put man in space. Whatever nutty politics occurred inside the organization, that was the focus of attention. Unfortunately, when NASA became a big budget agency with lots of good-paying jobs, it became a place where people went to have careers. They had talent and intense ambition, but few brought any enthusiasm for space exploration. Those people are in charge now. Describing the problem is easy. I don't know what to do about it.

Robert Jahn
Indianapolis, IN

Instant *Omni*

You are to be commended for your online efforts. delivery of information when desired is the wave of the future. No more waiting for that magazine in the mail slot!

Steven Farmer
Savannah, GA

Correction: We inadvertently printed the wrong Hebrew letter in our October 1993 Games column on the number 15. We showed the Hebrew letters yod and heth reading right to left; we should have printed he rather than heth.

Got something to say but no time to write? Call **(900) 285-5483.** Your comments will be recorded and may appear in an upcoming issue of *Omni*. The cost for the call is 95 cents per minute. You must be age 18 or older. Touch-tone phones only. Sponsored by Pure Entertainment, P.O. Box 166, Hollywood, California 90078

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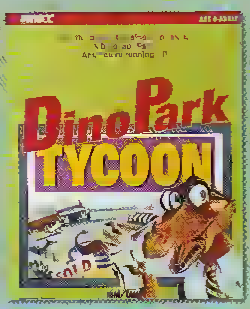

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ELECTRONIC UNIVERSE

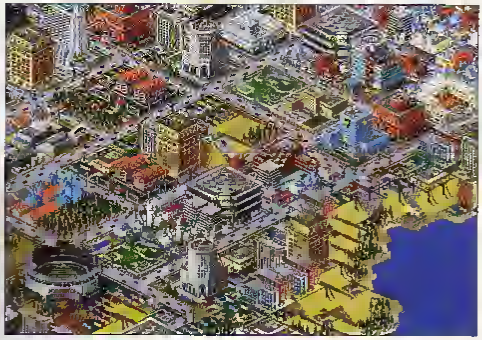
ALL THE NEWS THAT'S FIT TO DOWNLOAD
Newspapers from coast to coast take the online plunge

By Gregg Keizer

If the last thing you think of when you think of online entertainment is your newspaper, you're out of touch. Newspapers might not be as much fun as videogames, but they *are* planning on going electronic. Several major papers in fact already cruise what passes for today's digital highway, others are planning to join them, and all are trying to figure out what constitutes a newspaper when there's no *paper*.

One of the best electronic papers is the Mercury Center section of the *San Jose Mercury News*, a daily known for its top-notch technology reporting. You'll find the Mercury Center on America Online (AOL), a fast-growing electronic service that sports a graphical interface on either the Macintosh or IBM PC. To enter an area—Mercury Center, for instance—you simply click on an icon or you can pull down a menu before typing a keyword.

When you're tired of following the actions of the city planners in the online papers, you can turn to Maxis' *SimCity 2000* for a taste of power, calling the shots on zoning, taxes, schools, and more in your own concrete jungle.



AOL's electronic papers—Chicago Online, a digital version of the *Chicago Tribune*, also lurks there—share some traits with their inked forerunners. You can retrieve the international, national, and local news, check the latest scores on the sports "page," or take a walk through a limited number of classified ads. Movie reviews, concert and play schedules, and restaurant listings are also available, just as they are in the hardcopy editions.

Other elements of electronic papers go beyond the black-and-white-and-read-all-over versions. Both Mercury Center and Chicago Online offer two-way communication between readers and the papers' staffs, or simply between readers, via chat sessions and online bulletin boards where messages can be posted. And you can delve into the back issues of either paper by searching its electronic library, an excellent resource when you're following a complex and long-running story.

Because these papers ride the information wave with America Online, they're included as part of AOL's $9.95 basic monthly price. If you live in their vicinity, such papers are an excellent add-on to the newsprint you read in the morning. If you live elsewhere, they're still good sources for national and international news, sports, and entertainment.

But they don't have comics, and they don't have crosswords. Fortunately, you can plug in these gaps yourself until the papers wise up. Sierra's *Take-A-Break! Crosswords, Volume 1* and *Volume 2*, available for both Windows and the Macintosh, is one of the best puzzle programs. Using nearly 750 puzzles from Dell Magazines—publisher of those digest-sized crossword books you see in the supermarket—and featuring multiple levels of difficulty and an online dictionary, *Crosswords* is a worthy electronic competitor for anything but the *New York Times*' puzzles.

Calvin and Hobbes haven't turned up in digital form yet, but in the meantime, you can while away a few hours with something like PC Comix's *Lance Stone—Lifeforce, Lifeforce: Who's Got the Lifeforce?* Essentially a double-issue continuation of the first Lance Stone computer comic book for the IBM PC, *Lifeforce* may be more graphic novel than newspaper comic strip, but its sometimes-animated images, sound effects, and interactive links—which let you switch characters and points of view—make up for its all-at-once rather than daily-dose approach.

Still, there may come a time when you sicken of just *reading* the news of city council and desire to *make* some yourself. Maxis' *SimCity 2000*, an update to the classic metropolis maker and city simulator, lets you do just that. A new three-dimensional perspective is the most obvious change in *SimCity 2000*, although it adds some finer touches, such as schools, prisons, subways, and water pipe, to the venerable plot of founding and then maintaining a city of your choice. As mayor and city planner, you lay out residential and commercial zones, raise and lower taxes, and in the end fight for your phony-baloney job.

Someday, maybe electronic newspapers will include all that's now missing—comics, crosswords, photos, the connection to City Hall. Someday, maybe we won't have to search through the shrubbery to find the morning paper. Ain't the future grand? ☒

TRAVEL

GLADE TIDINGS
Exploring Florida's beautiful wetlands

By Kalia Doner

At first glance, the Everglades of South Florida appear to be an empty expanse of boggy, brown marshes carpeted with rough-edged sawgrass dotted by dreary clumps of gnarled trees

Look again.

The 13,000-square-mile watershed (six times the size of the state of Delaware) encloses a fecund metropolis of plant and animal habitats that are found nowhere else in the world. But few visitors ever see the elusive panthers, rare snail kites, or the bowers of vivid orchids that thrive in this unique clime.

"Most people enter the park at Homestead and drive south to Flamingo along a road that's been called thirty-seven miles of nothing," says naturalist and nature writer Ted Levin, who with nature photographer John Douglas runs Everglades Nature and Photo Tours. "No wonder they think the park is boring."

"But every year offers up a different mix of plants and animals, depending on how wet or dry it's been. You just have to know where to look. The challenge is finding the unexpected."

For 17 years, Levin has met that challenge, leading small groups of the urban brave into alligator-infested cypress domes and mysterious hardwood hammocks, revealing the secret lives of the park's animals and plants.

The Levin-Douglas tour first pitches camp in Collier-Seminole, a 4,760-acre Everglades preserve northwest of the national park. From there they explore the rarely visited Fakahatchee Strand, a 20,000-acre cypress swamp crisscrossed with old logging trails from the 1940s. Wading knee-deep through the crystal-clear streams that cross the trails, Levin and Douglas spy on the great blue herons and great egrets that gather at the water's edge and hope for a sighting of the rare Florida panther (there are only about 50 remaining).

"We go on alligator-stalking night trips, calling the beasts with a squeaking noise," says Douglas. "You haven't been thrilled until you've watched the glare of their red eyes caught in the beam of the flashlight as they emerge from the water."

At dawn, it's a short drive from base camp to the virgin cypress groves of Corkscrew Swamp Sanctuary. Owned and maintained by the National Audubon Society, it protects the 700-year-old trees and the endangered wood stork. "Two years ago, there was a flock of a thousand pairs of them," says Levin.

The tour enters Everglades National Park at Shark Valley. There, small islands called bay heads are home to sweet-bay magnolia, red maples, Carolina willows, and swarms of butterflies—next to plants, the most visible tropical life form in the park.

"Sadly, almost every part of the park has been damaged by urban pollution and the shortsightedness of man," says Levin, who first fell in love with the area as a youth when his family vacationed in Miami. "The Everglades start in the suburbs of Orlando. The water comes from there all the way down to Florida Bay through a system of lakes, marshes, and rivers, but much of it has been rechanneled or blocked off by increasing development."

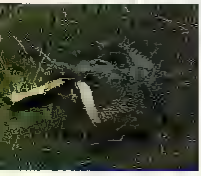
The repercussions are dramatic. Plummeting water levels kill off plants and fish. In 1900, there were estimated to be 2.5 million wading birds in the Everglades; by 1941, 1.5 million remained; today only 250,000 pass through the park, and primary nesting habitats that were crowded just 40 years ago no longer harbor rookeries at all.

But for all the ecostupidity that has plagued South Florida, there is still an abundance of natural wonders to be seen. On the last evening of the 1993 tour, as Levin and his group watched a flock of white ibises fly from Eco Pond to the open waters, 50 moon flowers opened up around them to greet the night.

"Our goal is to transform people's conception of the Everglades," says Levin. "By the time they leave, they care about what happens to the plants and animals that live there."

For more information on Everglades Nature and Photo Tours, write Ted Levin, Bloodbrook Road, RR 1, Box 313A, Fairlee, Vermont 05045. OO

Participants on Ted Levin and John Douglas's Everglades Nature and Photo Tours discover the richness and wonder of the wetlands ecology, from exotic birds like the spoonbill to the more



familiar alligators and the knotty tangle of cypress groves, gaining a new appreciation for this soggy, swampy world.

EARTH

CLEAN UP THE WORLD: Exporting a successful Australian environmental effort

By Anthony Liversidge

Ian Kiernan of Sydney, Australia, is an activist in board chairman's clothing. His elegant blazer, neat moustache, and affable manner are badges of his success in business, but now he is leading what has become the biggest grass-roots movement ever to clean up the planet.

First celebrated in Australia as a yachtsman, Kiernan represented his country in the BOC Challenge, a solo around-the-world yacht race, in 1987, placing sixth. The special pleasure of surfing mountainous seas in a small yacht is a feeling of being at one with the ocean, he says. The sense of harmony is so sweet that when he sleeps at sea, he dreams in Technicolor. So the sorry sight of the Sargasso Sea littered with plastic seemed a personal violation, not least since the BOC Challenge competitors had agreed before the start to keep their plastic garbage on board instead of tossing it overboard as is traditionally done.

Vivid scenes of pollution such as this inspired Ian Kiernan to mount a Clean Up Sydney Harbor Day, which eventually grew into last September's Clean Up the World weekend extravaganza.

That experience alone might not have changed Kiernan's life, but when he started finding broken glass on the Sydney beaches where he swam, he knew something had to be done. So he teamed up with a long-time friend, public-relations consultant Kim McKay, and mounted a Clean Up Sydney Harbor Day. The event was a startling success. Forty thousand Sydney citizens picked up a small mountain of trash. 'We expected to collect a hundred tonnes," Kiernan recalls, "and we got five thousand!'

Elated, the pair expanded to Clean Up Australia Days, the first one of which took place on January 18, 1990. Last March, 400,000 Australians gathered 25,500 tonnes at more than 5,000 waterways, parklands, and roadsides across the continent. "We got a hundred and fifty-eight cars and two buses out of Illawarra Lake alone.'

Raising the stakes to a global level, Kiernan and McKay next aimed to make September 17–19, 1993, a weekend the world would remember, and they succeeded in grand style. More than 7,000 communities in 79 countries around the globe took part in the three-day cleanup extravaganza, scouring parks, beaches, roadsides, and city streets, picking them clean of everything from candy wrappers to auto hulks. In Cotabata City in the Philippines, 23,000 school children hauled in piles of recyclable plastic trash, while volunteers in Mexico City collected 20 tonnes of old tires, mattresses, appliances, and other junked items. In Taiwan, 1,000 derelict cars were recovered, and the weekend effort was so popular that it's been extended for a whole month. McKay and Kiernan estimate that as many as 30 million people participated in this first Clean Up the World effort.

Kiernan folded his Sydney construction company to devote himself to circling the globe seeking the funds needed to carry it off. The U.N. Environmental Programme (UNEP) has helped with one of its largest grants ever—$100,000—and American Express (Australia), Qantas Airways, the EGBAR Foundation, and IBM (Australia) contributed funds and other support. Lester Brown, president of the World Watch Institute, and John Denver were patrons.

Kiernan was particularly elated at the enthusiasm shown for the program in developing nations—Clean Up the World turned up ecologically minded citizens in the likes of Costa Rica, Malaysia, Nepal, and Burkina Faso. "Two-thirds of the world's people will be in the cities of those countries,' he explains, "and they all have the same waste-disposal problems we have."

Despite a lower sponsor turnout than they'd hoped for, Kiernan expects the success of the first Clean Up the World weekend to knock other corporations and foundations out of their "wait and see" stance and have them scrambling to board the bandwagon for 1994. Such pussyfooting around makes him impatient. In sailing, he says, the word is that 'when the flag drops, the bullshit stops,' and as far as he is concerned, the flag dropped long ago on the world litter crisis. One thing he has in hand already, however, is a good working slogan: The muck stops here. OO

For information on the 1994 event, contact Clean Up the World, 123 Harris Street, Pyrmont, Sydney, NSW 2009, Australia.

WHEELS

HI-TECH RIGS: Invading a loner's refuge?

By Paul C. Schuytema

High in the star-flecked ether satellites now receive and transmit data which is used to assure us that a truckload of ketchup makes it to our store on time. The next time you're out on the open road, take a look at the tractor-trailers as they scream by. Chances are, under that fiberglass air dam, you may see a flying-saucer-shaped gadget mounted on tripod legs. That saucer holds a small satellite transceiver, able to beam information up and out of the stratosphere while the driver keeps both eyes on the road as he tries to find a country-music station.

Based in Monmouth, Illinois, Munson Transportation was one of the first trucking fleets to enter into the next century of communication. Now every one of their 900-plus rigs is fitted with an advanced satellite communications system. Inside the cab, the driver is accompanied by a keyboard console (positioned on the passenger side so the driver can't type while driving) which is connected to a communications unit. Every hour on the hour, day or night, this mobile system sends out its silent clarion call. That transmission is picked up by a satellite transponder in high Earth orbit and then sent back to the primary station in San Diego, California. From there, the information is processed by a computer matrix and is sent, via a dedicated fiber-optic phone line, back to the Munson computers in Monmouth. All of that in around ten seconds.

While some fleets will soon use mobile printers and other onboard devices for instant service, Munson is considering adding pagers to the system so drivers will know when their trucks are receiving any messages.

Using the information sent by the two satellite transponders and a calculation known as triangulation, the computers at Munson can determine nearly the exact position of the truck (within a thousand feet), display it graphically on a high detail map, and know what interstate the truck is thundering down and when it will roll into south Cleveland.

The satellite-based communications system, manufactured by QUALCOMM, also has the capabilities to send information about the driver's and vehicle's performance such as speed and engine RPM, engine diagnostics, and critical operating parameters like the current temperature of the refrigeration trailer.

The most interactive of the computer's functions is to serve as a two-way communication system between the driver and the fleet manager. If there is a change in routing, the fleet manager can send a message to the driver. If the driver gets a flat or runs into icy road conditions, he can send for help and estimate his downtime. When a driver nears the drop-off point, he can access a database to receive directions to the warehouse.

The driver's primary device is equipped with a full-sized keyboard and a four-line liquid-crystal display. A driver can type in the text of a message or invoke a macro, which will bring up any one of a number of "stock" messages in which he or she merely fills in the blanks. When the driver receives a message (they get an average of three to four messages a day), a chime sounds and an LED flashes as the system stores the message for convenient retrieval.

Truck driving is a solitary operation, hours alone on the road to think and gaze at the dotted yellow lines converging at the horizon. So how do the drivers feel about the system? Around Munson, it's been nicknamed "Big Brother," for obvious reasons. After talking with several drivers, though, the reaction is not that negative. The system took some time to get used to, but on the whole, the drivers really appreciate the invasion of technology.

One driver explained that before the system was adopted, he had to call in every morning to the office, which meant waiting for a phone at the truck stop. And since Munson is a sizable operation, with every driver calling in every morning, it meant spending a lot of time on hold, often nearly an hour, just to check in. Some drivers don't like the system because they have to drive on course and on speed and must stop for eight hours after every ten hours of driving. Whether drivers consider the system a benefit or an invasion apparently doesn't matter. The satellite management of trucking fleets is here to stay.

STYLE

TWO SCENTS' WORTH:
A new fragrance company takes advantage of pheromones

By Michael Krantz

A woman I used to know liked to claim that all human relationships were based on smell. She may have been right. Recent years have seen the rise of *aromachology*, the study of how odors influence our behavior, with applications in fields as diverse as medicine, psychology, corporate-office design,

Dabbed with one of Erox's gender-specific fragrances, you might find that socializing becomes easier and more comfortable, but don't count on instant sex appeal. This is applied science, not magic.

and cosmetics. In September 1993, the Erox Corporation, founded in 1989 by Dr. David Berliner, began offering REALM Men and REALM Women, the first perfumes containing synthesized human pheromones.

In the 1950s, Berliner, an M.D., was an anatomy professor at the University of Utah. His work involved isolating human-skin compounds, some of which, when left in the open, seemed to make lab workers more relaxed and sociable. He ran a few experiments and found correlations with the behavior he'd first observed.

At the time, there was no scientific context for Berliner's discovery. But in the decades that followed, biologists identified naturally produced airborne substances dubbed *pheromones* in all manner of species, from insects and bacteria on up through amphibians and almost all mammals, save humans. And in 1971, researchers determined that the vomeronasal organ (VNO), a tiny cone-shaped tube found in the tissue of the nasal passages of most mammals, functioned as a pheromone receptor in humans.

So, after several decades spent in the business world, Berliner returned in 1989 to his old skin substances, which he'd left frozen for 30 years. Were these pheromones? And was there a receptor specific to them?

University of Utah neurophysiologist Luis Monti-Bloch did a series of tests showing VNO responded to Berliner's skin substances but not to common odorants. The system works somewhat like the sense of smell, except the nerve impulses triggered on the VNO by pheromones travel specifically to the hypothalamus, the part of the brain that controls such autonomic bodily functions as the fight-or-flight response, hunger, and the sex drive.

Thus was a new consumer product born. Erox president Pierre de Champfleury, formerly president of Yves Saint Laurent Parfums in Paris, developed the REALM fragrances around the pheromone core.

The behavioral effects of pheromones become hazier with each step up the Darwinian ladder. Dab female moth pheromones on a piece of cardboard and your average male moth will do his darnedest to mate with the cardboard. Pheromonal effects in humans, however, are much more complex and even today are only dimly understood.

Still, pheromones clearly do *something*, and this is the selling point of Erox fragrances. "A symphony without any violins," says Erox biologist and patent attorney Dr. David Dolberg, "would sound different even if it played the same piece." The Erox fragrances may smell pretty much like their cousins, but apparently they deliver more bang, as it were, for the buck. Men wearing REALM Men, says Dolberg, report their experience as "one of sociability and comfort." Women

dabbing on REALM Women enjoy increased confidence, friendliness, and well-being.

The most pressing question, of course, regards the sex drive. Will pheromone perfumes spark unreserved lust in the opposite sex? Probably not. "We have not identified a specifically aphrodisiac effect," Dolberg notes carefully. "Pheromones appeal to our sensuality, not our sexuality." The effect on the wearer—and those in his or her vicinity—will be, says Dolberg, "one of romance, of the imagination.

"But that," he adds, "is getting a little poetic."

For more information, or to order REALM Men or REALM Women, call (800) 692-9191.

ARTIFICIAL INTELLIGENCE

THE SOUND OF DATA

Data may fill your ears rather than your eyes

By Steve Nadis

In the late 1980s, while reading about chaos theory for the first time Gregory Kramer had an idea that would change his life. He was pondering a problem relating to cognition. How could humans possibly comprehend complex multidimensional systems with data pouring in from many separate tracks? The eyes can only assimilate so much information. Then the answer came to him: Why not convert data into a soundtrack that trained observers could listen to rather than watch?

Kramer possesses the right qualifications for turning data into sound. He taught at New York University's music department and is a National Endowment of the Arts Composition Fellow. He also designs equipment for playing and recording electronic music. In 1989, armed with this experience and his idea, he visited the Santa Fe Institute—a nonprofit think tank devoted to the study of complex systems—and met mathematicians and physicists working in the field of chaos. Intrigued by Kramer's proposals, the institute invited him to become a member and work with its researchers on tools to help people comprehend complex data.

Kramer subsequently learned that he wasn't the first person to hit upon the notion of making scientific data audible, or 'sonification.' First discussed in technical literature in 1952, the idea has popped up sporadically ever since. In the past few years, an active group has formed at the National Center for Supercomputing Applications (NCSA) at the University of Illinois. "If you work in the field of computer music, representing data with sound is a pretty obvious idea," explains Illinois composer Robin Bargar.

Since the 1950s, composers have occasionally used satellite data and scientific equations to provide raw material for their music, caring nothing about the numbers themselves. "Sonification is the other side of the coin," Bargar says, where sounds have to correlate with data in an intelligible manner. That requires composing skills and an awareness of how people listen to sound.

A group at NCSA has created sonification software that, when run on an IBM-compatible PC with a MIDI (musical-instrument digital interface) synthesizer, can turn just about any data into sound. In addition, NCSA's Alan Craig and Carla Scaletti of Symbolic Sound in Champaign, Illinois, have created a videotape that demonstrates the use of sound and graphics to represent data, including smog information in Los Angeles and forest-fire data in Yellowstone National Park.

Sonification offers obvious benefits for visually impaired people who are unable to see computer screens. David Lunney, a chemist at East Carolina University, is developing tools that will help blind chemists and chemistry students to analyze compounds by listening for specific sounds.

Clarity, the company Kramer founded in Garrison, New York, investigates more advanced applications in which sound represents several variables at once. Clarity may use the technology to create an audio system for operating rooms, which will broadcast a patient's blood oxygen levels, blood pressure, and other vital signs. Clarity has already 'sonified' an ecosystem model for Apple Computer and a mock nuclear-power-plant control room. The company has also spoken with financial-service firms interested in developing programs using audition to analyze stocks.

The rub is that it takes a skilled ear to be able to discern subtle sound patterns. "Sound blends together into a gestalt much more readily than images do," Bargar admits. "Another problem is that we tend to correlate what we see with what we hear."

Kramer sees training as a big challenge but not necessarily a show-stopper. "You know when your car is running well just by listening to it. A certain noise, like a rattle, might also tell you what's wrong. Sounds in a well-designed sonification system could be interpreted in much the same way." DQ

Chaos theory initially sparked musician and designer Gregory Kramer's interest in using sound to represent complex patterns of data.

KID STUFF

THE IMPORTANCE OF BEING COOL

Hip, fun software packages get kids learning

By Gregg Keizer

Kids want cool. They want cool clothes, cool shoes, cool friends, cool moms, cool dads. At the mall, all they care about is *looking* cool. At school, they're happy enough learning cool stuff about dinosaurs and exotic animals, and they don't much care *how* they learn as long as it's, well, *cool*.

Knowledge Adventure's *Kid's Zoo* offers the excitement of multimedia—animation, video clips, sound effects, and voice narration—without a CD-ROM drive, and it's great for early readers and preschoolers.

Fortunately, the best learning software for kids rises above the borderline of dweebdom by combining great material with slick presentation. *Kid's Zoo* is a cool program for preschoolers and early readers. Published by Knowledge Adventure, the company known for its *Science*, *Space*, and *Dinosaur Adventure* lineup, *Kid's Zoo* appeals to young humans because it features young animals. Eight activities or areas put jerky movies of baby animals on the screen, ask kids to match digitized sounds with the right infant animal, quiz children on the animals' range, and more. An abbreviated encyclopedia rounds out the program by providing some basic information on the various mammals, reptiles, invertebrates, amphibians, and birds found in the program.

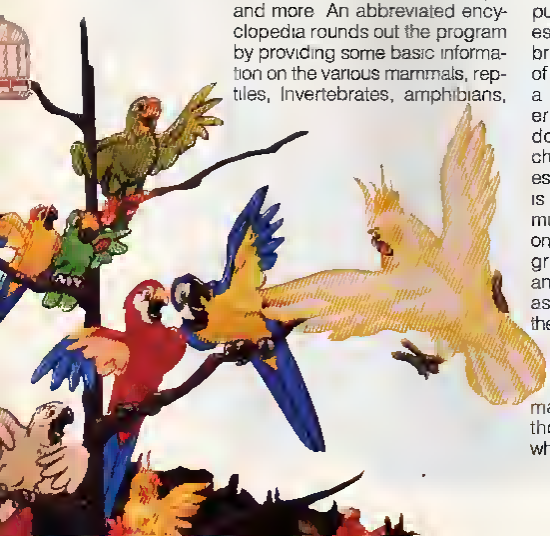
Even though *Kid's Zoo* isn't on CD, it still packs a multimedia punch. But make sure you have a good-quality sound board in your PC, for the sound effects and narration are tough to make out on some of the less expensive audio, such as the Sound Source or the Sound Blaster.

Peter Pan isn't science or science fiction (okay, call it fantasy), but it's still fun. Cool for slightly older kids, *Pan* is an interactive story that brings children into the tale by asking them to help Peter put down Hook. At various stages in the story, *Peter Pan* takes a break and asks kids to use one of its paint-box-like characters—a pencil head, for instance—to erase or paint or connect the dots. Each time kids make a choice of tool, the story branches in a different direction, so *Pan* is replayable, even suitable for simultaneous play by more than one child. This Electronic Arts program comes in versions for PC and Mac on either floppy or CD, as well as on compact disc for the new 3DO Interactive Multiplayer from Panasonic.

Shelly Duvall's It's a Bird's Life from Sanctuary Woods may carry a bit of science, though the story and art are what make this multimedia adventure cool for little ones. Actress Duvall both wrote and narrates *It's a Bird's Life*. Preschoolers and early elementary school-aged kids will enjoy this story, which takes a collection of wacky birds on a quest to the Amazon. Each screen—and there are around 60 of them—includes objects kids can click on for some surprising results. Click on a monkey, for instance, and he tosses fruit into the jaws of an alligator. This CD title for the Mac, PC, and 3DO features narration, cool bird noises, and enough other information to tempt older kids. They'll especially like the x-ray machine that lets them see bird bones.

Discover Space is a more straightforward *Omni* kind of kids' program. For this Brøderbund title takes children on an exploratory mission off Earth, into the solar system, and beyond. *Discover Space* includes a slew of information about the sun, the planets, the space-exploration program, asteroids and comets, and deep space objects. Some are just colorful slides—like the deep-space objects—but others let kids click on stuff. In the Planets section, for example, you can make the worlds rotate, balance them on a scale to compare mass, watch animations of Jupiter's moons or Saturn's rings, and view the orbital location of the planets on any given day. This PC program gets really cool, though, when you head into the Asteroids area and make one smack into the Earth.

It's crucial that you put such *cool* software in kids' hands—with it, kids will learn almost in spite of themselves. Make it cool, you might say, and they will come.



OMNI ONLINE

VIRTUAL DELIGHTS.
Your participation has made our online service a *very* lively place

By Keith Ferrell

We had a feeling last summer as we prepared to launch our online service that *Omni*'s readers would react positively to the opportunity to interact with the magazine's staff, its authors and experts, and each other. We proved to be even more right than we dreamed.

In just its first few weeks of operation, Omni Magazine Online experienced more than 100,000 visits, making it one of the liveliest online arenas around.

What goes on during those visits? Any number of things, all of them determined by you. The flexibility of the format means that you tailor your visits to your particular interests and needs.

Some people simply stop in from time to time to read the latest postings, perhaps visit the Omni Reading Room, where archived material from past issues of the magazine is stored, look in on Scot Morris's Games area for a little brain teasing, or browse through Continuum or Antimatter for a particular nugget of information. There's plenty to read and ponder in Omni Online, and we've heard from many of our readers that you enjoy simply cruising through the service.

Others take a more active approach, wading into debates and forums, enlivening the message-board areas with their comments and opinions. Our topic-oriented message boards now embrace dozens of categories, disciplines, areas of interest, debate arenas, special-interest groups, and unabashed bull sessions. New topics appear constantly, prompted by articles in the magazine, headlines and breakthroughs announced in the daily news, or simply as a result of individual interest. It only takes one person with a question or comment to launch a new thread of discussion.

The chance to sound off, as often and as loudly as you wish, seems to appeal to you. *Omni*'s readers are lively, contentious, articulate, individualistic, and gregarious, and all of those qualities are revealed in your online postings and letters to the editor. (Gary Null's November column on chelation therapy proved a particularly provocative topic.)

You also *know* a lot and are eager to share your knowledge with each other. Questions do not linger long unanswered online.

Our live sessions have also proved popular. We've held focus groups, chat sessions, question-and-answer fests, seminars, and more on subjects as diverse as the frontiers of neuroscience and the psychology of an alien abduction, from science fiction to supernaturalism. Sometimes there are several live events in a week, and attendance at these events is still growing. It's nice to see you there.

Associate Editor Erin Murphy is also our Online editor. She sees to it that the electronic version of *Omni* is as lively, provocative, and adventurous as the magazine itself.

People are discovering as well that Omni Online can serve special purposes. We've already heard of couples being introduced through our service, advice and counsel sought and received, and even informal swap meets, many of them centered around hard-to-find books and other science and science-fictional memorabilia.

In short, Omni Online was created as a virtual house of many intellectual mansions, and the reality is far more than a merely virtual delight.

A great deal of the credit for Omni Online's success should be directed toward Associate Editor/Online Editor Erin Murphy. In addition to being a terrific article editor—Erin is responsible for Continuum, among other aspects of the magazine—she possesses a real gift for understanding the nature of interactive publishing. As we've pointed out before, both here and online, the electronic version of *Omni* is intended as neither a substitute nor a duplication of the magazine you hold in your hands. Rather, it's an environment with its own nature, characteristics, and approach.

Erin has seen to it that Omni Online's approach is accessible, sensibly organized (something, to be frank, that is too often missing from online environments) and efficiently run. She also brings to the electronic world the same sense of humor and enthusiasm that enlivens our editorial offices. Omni Online can be a very *funny* place.

But it can also be a very *serious* place. Important questions are asked, vital topics addressed. Erin plays a part in all of this. Above all, Erin Murphy brings to the online environment that same sense of intellectual adventurousness and speculative boldness, coupled with a deep respect for the reader, that has always been part of *Omni*'s charter. Many of you have told me that you feel as at home in Omni Online as you do here, in the magazine's pages. Whether you knew it or not, you were thanking Erin as well as me, and it's my pleasure now to pass those thanks along to her publicly. ∞

CONTINUUM

ROOM TO RIDE

Cyclists work to make urban areas safe for bikes. Plus, plastic that may grow on trees, and why the boys of summer strike out

My bike has leather grips and fenders—a simple gear shift on the handlebar, a pants protector around the chain, and a kickstand. It's dark green. My neighbor Anne came over, ran her hand across the frame and said, "It's the coolest bike I've ever seen."

It *is* cool and part of a growing trend in bicycle design—the hybrid, the commuter bike. Bicycle manufacturers are simultaneously gearing up to meet the growing demand by building bikes more appealing to the bicyclist who isn't interested in breaking speed records or traversing primitive terrain, but just getting around. My own is a Specialized "Milano," as in European cathedrals, cobbled streets, cafes—as in urban transportation.

Specialized Bicycle Components, based in Morgan Hill, California, got the idea for the Milano after several R&D trips to Europe to look for component manufacturers for their mountain bikes. They saw stylishly dressed Italians on their way to work by bike and realized that these people had made a choice to pedal. The idea behind the Milano is that the rider can manage with no bike knowledge, with no spandex.

Think Globally, Bike Locally: The Milano is the first in a series of all-purpose urban bikes designed by Specialized Bicycle Components.

No bike lanes in your town? No problem. In 1991, Congress passed the Intermodal Surface Transportation Efficiency Act (ISTEA), a highway bill with two mandates: 1) Every state must have a bicycle and pedestrian coordinator, 2) the needs of bicyclists and pedestrians must be incorporated into the long-range plans at state and local levels. These plans might include bike lanes or paths, putting a shoulder along the highway, or bike racks on public transportation.

The money to execute such projects can come from ISTEA, which has authorized $150 billion in federal transportation funds to be spent before 1997 and does not put a cap on how much should be allotted for bicycling and pedestrian concerns. The key to getting the money and using it wisely, according to Andrew Clarke of the Bicycle Federation of America, based in Washington, DC, is self-organization at the state and local levels. "How much money is spent on making bicycling and walking more viable depends on how well we do our job," Clarke says. He suggests bicycling advocates start at home by attending state or local bicycling conferences, contacting their state bicycle and pedestrian coordinator through the Department of Transportation, or going directly to city planners.

At the national level, advocates can write their representatives in Congress to support the Bicycle and Pedestrian Transportation Improvement Act of 1993, known as the "3-Percent Solution," a bill sponsored by Representative Joseph Kennedy of Massachusetts, which requires that at least 3 percent of federal transportation funds be spent on facilities for bicycling and walking. If passed, the legislation will be incorporated into ISTEA. The bill, Kennedy says, "could dramatically improve our nation's economic competitiveness and air quality."

One group has been successful in securing money from ISTEA—the Washington-based Rails-to-Trails Conservancy. Members promote a "linear" park system by converting abandoned railroad corridors to paths for biking, running, horseback riding, cross-country skiing, and walking. Sixty million dollars from ISTEA has been spent on 95 projects, according to David Burwell, president of the organization. They now operate 541 trails in 45 states, totaling 6,749 miles. Burwell warns, however, that while 2,000 to 3,000 tracks are abandoned annually, many corridors are lost to private landowners for lack of action.

My Milano has limitations. It's a wash in bad weather, and I can't carry cargo. But I do know how to get to my favorite café on the riverfront by bike without hitting the traffic on Market Street. I can be at the library in three minutes or take the back roads from the river to the sea. No sweat.

—*JANET STITES*

For information, contact the Bicycle Federation of America (202-463-6622) or Rails-to-Trails Conservancy, 1400 16th Street NW, Washington, DC, 20036. For a directory of rail trails in the top ten states, send $2 to the Conservancy.

CONTINUUM

It's not the heat of summer days that causes sperm counts to decline but the length a scientist has found

SUMMER SEMEN

Summer wreaks havoc on semen. Research shows that semen quality drops off as the days turn hot, translating into a 20- to 30-percent reduction in sperm counts and fewer babies born during the spring in warm climates. But no one knows why.

Enter Richard LeVine of the National Institute of Child Health and Human Development, who believes that it's not heat that does in the sperm, but light.

To see how air temperature affected semen during the summer, LeVine and his colleagues studied 64 men who worked in air-conditioned offices and 76 who worked at least four hours a day in the hot sun. To LeVine's surprise, both groups exhibited equal declines in semen quality, indicating that testicular temperature was not responsible.

This finding led LeVine to a recent monkey study. When exposed to 16 hours of light per day, the monkeys' testicles shrank and produced smaller amounts of reproductive hormones. When the monkeys received light just eight hours a day, the effect was reversed. LeVine surmises that light exposure affects human testicles as well, with the longer days of summer causing sperm quality to decline.

Would living at the equator or the poles exaggerate these effects? That's not yet clear, LeVine says, although he suspects it would not, because studies have found little difference in sperm quality between summer and winter samples from men living at higher and lower latitudes in the Northern Hemisphere.

LeVine's work may prove valuable for people using sperm donations for in vitro fertilization. "If a couple obtained a sample in the winter, it might give them a little extra boost," he says.—Paul McCarthy

THE PUMPKIN HAS BEEN KNOWN TO DEVELOP ROOTS WHOSE TOTAL LENGTH REACHED 82,000 FEET, OR MORE THAN 15 MILES.

A RIVER RUNS THROUGH IT: INDIA'S SARDAR SAROVAR DAM

Global Response is an environmental group that takes action by encouraging members to write to the decision makers in charge of specific projects harmful to the environment. Omni will periodically inform readers of particular Global Response actions. To join Global Response, write to Box 7490, Boulder, Colorado 80306-7490.

India's Narmada River swells with rains during the summer monsoon season. Hindus revere it as India's most holy river. And now a giant concrete dam is rising from its bed.

The Sardar Sarovar dam is part of the Narmada River Project to harness the entire Narmada watershed. Behind its unfinished wall, villagers are threatened by its progress. Dammed water will flood their homes and fields as well as the forests where tribal people hunt and gather medicinal herbs and wild foods. It will also eliminate wetlands upstream and downstream jeopardizing native plants and animals. Some village families have vowed to leave at least one member to die symbolically in the rising water.

In March 1993, India's government requested that the World Bank cancel the undispersed portion of its loan for the dam, effectively removing the World Bank from involvement in the project. Analyzing the project, independent development-aid specialist Bradford Morse found that "the projects as they stand are flawed, ... the environmental impacts of the projects have not been properly considered or adequately addressed."

Proponents argue that the dam is necessary to provide water and electricity for India's masses. Opponents insist that the dam's costs exceed its benefits. And some activists point out that time remains in which to change the dam's design; the dam is scheduled for completion in 2000 and has reached only one-third of its full height.

Join Indian activists asking that the dam's design be reexamined and that new ways of supplying water be explored. Write to Indian Prime Minister Narasimha Rao, PM's Secretariat, South Block, New Delhi, India 110001.—Elizabeth Caile

FOND MEMORIES OF THE ODOR OF PLASTIC

What odors awaken fond memories from your childhood? Depending on your age, they could as easily be fresh paint as fresh air. A recent survey by Alan R. Hirsch, neurologist, psychiatrist, and director of the Smell and Taste Research and Treatment Foundation in Chicago, showed that people born before 1930 associate their childhoods with natural smells, such as pine, hay, horses, and sea air. But those born between 1930 and 1979 connect childhood with the more synthetic odors of plastic, scented markers, mentholated chest rub, airplane fuel, and Play-Doh.

Younger people link manmade odors to their childhood memories because they grew up in less active, indoor surroundings, Hirsch believes. And this phenomenon could indirectly pose problems for the environment.

"People tend to re-create the surroundings they're most comfortable with," Hirsch explains. "If they feel nostalgic for manmade things, they'll re-create them, and their level of commitment for the environmental movement may be lessened."

Emotion and the sense of smell are strongly linked, according to Hirsch. The olfactory bulb, which controls the sense of smell, belongs to the brain's limbic system, the origin of emotion. The limbic area may play a role in memory as well, explaining why certain odors can call forth strong, emotionally charged memories.

But such memories are not always pleasant. Of the 989 subjects interviewed by Hirsch and his colleagues, 1 out of 12 reported having an unhappy childhood. For these people, unusual and distasteful odors—mothballs, dog waste, sewer gas, body odor, bus fumes—summoned childhood memories.—Pam Brick

It may not show up in too many backyard gardens, but a plastic-producing plant has been developed

SYNTHETIC HARVEST

Imagine growing a plant in your backyard garden that produced lumps of biodegradable plastic instead of tomatoes or cucumbers.

Christopher Somerville at Michigan State University along with research associate Yves Poirier and colleagues at James Madison University has genetically engineered a plant that can develop plastic in its stems and leaves. In just ten years, Somerville predicts, scientists will create a plant capable of sprouting enough plastic "fruit" to use in the manufacture of disposable bottles and diaper liners.

Somerville and his colleagues tested their plastic-growing technique on a weed of the mustard family called *Arabidopsis thaliana*, which has the simple genetic structure they needed. They inserted two key genes into *Arabidopsis* plants, creating two new varieties. By cross-fertilizing the two lines, the researchers came up with a hybrid containing both genes that produces a type of plastic called PHB.

"It's the first time a plant has been genetically engineered to make something other than a protein," Somerville says. "Right now, we're only producing small amounts of PHB, about one-half of one percent of the plant's weight. The next step is to restructure the gene to produce PHB in the storage areas of the plant—increasing the PHB yield about thirtyfold."

"It's an intriguing idea and rather a unique approach to genetic engineering," says Nachama Wilker of the Council for Responsible Genetics. "I would raise concerns from an environmental viewpoint because it's better for us to replace plastic rather than grow more of it to place in landfills."

—Joseph Baneth Allen

"Darwin is truly great, but he is the dullest great man I can think of."
—Alfred North Whitehead

CONTINUUM

CONFRONTING BIRD AVOIDANCE HEAD-ON

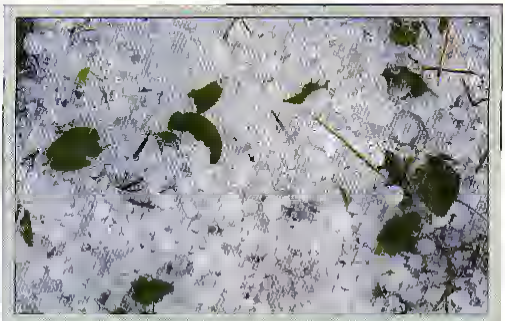
U S Air Force jets run into birds about 3,000 times a year. Although the phenomenon might seem amusing at first, the statistics do not. Since 1987, seven planes have gone down as a result of these collisions and six crew members have been killed. Annual damage typically exceeds $65 million.

The Air Force is taking the matter seriously. It has a Bird Aircraft Strike Hazard (BASH) team working to develop a computerized Bird Avoidance Model (BAM), which should be operational sometime this year. With the model, which will graphically depict bird-migration routes in the United States, pilots will be able to see where their flight route intersects major bird pathways. If the route looks risky, pilots can pick another time to fly or select an alternate route.

"We want to minimize what happens to us and at the same time minimize what happens to the birds," says Major Ronald Merritt, who heads the project from the Tyndall Air Force Base in Florida. "Either way, the upshot is the same."

Over time, the Air Force will expand the model to incorporate bird "traffic" data for the rest of North America, Europe, and other regions where the Air Force often flies. In addition, the BASH team will study bird flight patterns in political hot spots such as the Middle East and Central America. "Some parts of the world, like Panama, are on prime bird-migration pathways," Merritt explains.—Steve Nadis

Incidents in which birds collide with Air Force jets can prove just as dangerous for the humans as for the birds.



Hail does millions of dollars of damage to cars each year, driving two inventors to devise protective coverings for cars.

HAIL HOODS

Today's cars can do amazing things, but withstanding hail isn't one of them. In 1991, hail raining down on cars and house roofs across the country produced $411 million worth of damage.

Now two Colorado inventors have independently come up with hail protection for cars. Both inventions, which resemble car covers, are small, lightweight, and easy to use, and both fold into car trunks. As an added bonus, they also protect against ultraviolet rays and heat.

Jim Actor, an inventor and commercial-airline pilot, designed his Hail Buster on the trampoline principle. An outer skin of vinyl covers 25 foam bricks placed on a layer of Cross-Tuff, the swimming pool liner material. The bricks maintain a three-inch airspace between the two layers of material. Tethers, fashioned from the same material as bungee cords, hold the Hail Buster in place, and when hail hits, they "work like the shock absorbers on the wheels of your car" to cushion the impact, Actor explains.

John DuVall, an industrial engineer and plastics expert, made his Deflector 3000 in three layers: smooth black nylon on the bottom, foam padding in the middle, and a tough, tear-resistant nylon top. DuVall tested some 30 different kinds of foam to find one that would stay springy enough over a broad temperature span.

Both units can be adapted to trucks, boats, and small aircraft.

"Once your car is hail damaged, it's never the same," DuVall says. Considering that a car is a "pretty big investment, this is pretty inexpensive protection."

Prices for the Hail Buster range from $210 to $385; the Deflector runs between $320 and $400.—Peggy Noonan

CONTINUUM

ANTS AND THE DESERT

It turns out that human activity may not bear all the blame for an ecological phenomenon called desertification, which now affects one quarter of the earth's surface. A species of ant—*Genus nessor*, to be precise—also plays a role.

At least that's the contention of Harold Heatwole, a North Carolina State University zoologist and ecologist who has studied ant behavior in both the Gobi and Sahara deserts. There, the annual grasses die back during periods of drought, leaving only perennial bushes and shrubs to hold the soil in place.

That means the ants, which gather various types of seeds, have no grass with which to vary their diet, so they increase their use of perennials, storing the seeds in underground granaries far below the germination level. The practice tides the insects over until the rains return and bring back the grass, but it—along with an abundance of grazing livestock—exhausts the supply of seeds so that the plants which normally hold the soil in place gradually disappear, causing desertification—degradation of semi-arid land into vast areas where nothing can grow.

Heatwole emphasizes that overgrazing by camels, goats, and sheep is the main cause of desertification, the ants' activities during drought delay recovery of the grasses. The land can't tolerate such a combination. But knowing this doesn't make solving the problem any easier, cautions Heatwole, whose findings emerged from a joint U.S.-Tunisian study.

Baiting or spraying the affected areas isn't practical because of their size, and exterminating them may not be a good idea because the ants control a species of weed that even camels, which will eat anything, won't touch. Remove the ants, and weeds might take over," he explains.

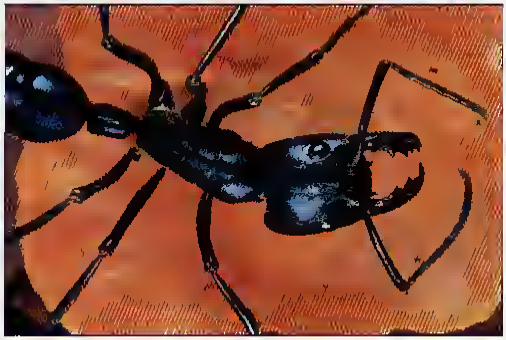
—George Nobbe

"A thing is not necessarily true because a man dies for it."

—Oscar Wilde

AT A STEADY JOGGER'S PACE OF SIX MILES PER HOUR, IT WOULD TAKE 173 DAYS TO GO AROUND THE EQUATORIAL CIRCUMFERENCE OF THE EARTH, AND MORE THAN FIVE YEARS TO GO AROUND JUPITER, THE LARGEST PLANET.

Ants contribute to desertification, an alarming process that converts semiarid land into desert wasteland



AN EYE FOR A DRILL

In cardiovascular surgery, the only constant sometimes seems to be innovation. The latest groundbreaking device is a tiny ultrasonic transmitter, resembling a thin, flexible pencil, that could make the angiogram obsolete as a method of locating plaque deposits on coronary artery walls.

The new device, still under development by Paul G. Yock at the University of California at San Francisco, is considered safer and more accurate than an angiogram because it displays on a monitor a continuous 360-degree image of the artery on which a surgeon is working. Yock designed it for use in a procedure called atherectomy, in which a high-speed drill shaves away dangerous arterial plaque.

The transmitter, called AID for Atherectomy Imaging Device, sits directly behind the rotating cutting drill at the tip of a catheter. It simultaneously emits and receives sound waves that bounce off the surrounding tissue. The drill itself is housed in a canoe-shaped capsule open only on one side, and as the drill moves from the back of the housing to the front, it cuts an area about half an inch long and less than an eighth of an inch wide.

"With this device, we can guide the drill more accurately and remove a larger percentage of the plaque," says Yock, adding that angiograms can fail to locate plaque that has built up on only one side of an artery. "An angiogram only shows you the size of the hole you're working on, but what we can get now is an always-changing picture of what the wall of the artery looks like."

The imaging device has worked successfully in laboratory experiments using arteries removed from cadavers. Pending animal tests with pigs and human clinical trials, the Food and Drug Administration could approve the device within the next few years.—George Nobbe

THE LAST GREAT EXPERIMENT OF THE 20th CENTURY

ARTICLE BY DICK TERESI

PHOTOGRAPHS BY PETER LIEPKE

It wasn't a good plan to begin with, but then Democritus was never your practical sort of fellow. The plan was this: He was going to commit suicide by fasting to death.

Democritus was a philosopher who lived in ancient Abdera on the Greek mainland. The year was 460 B.C., give or take a decade, and the old philosopher's life was saved by a clever ploy on the part of his sisters. The women's religious festival in honor of the goddess Demeter was approaching, and Democritus's sisters pleaded with him to prolong his life just long enough for them to attend the celebration. They asked only that he smell some freshly baked bread. He agreed.

The vapors from the bread not only revived Democritus physically, but gave him an intellectual reason to live on by raising the most important question he had ever asked himself: How does the essence of bread travel from the loaf to the nose? The answer is the basis of Western science. All matter, Democritus concluded, is composed of invisible, indivisible particles he called atoms—literally, "that which cannot be cut." We smell bread because particles slough off the loaf and float through the air to our noses. Democritus went on to develop the atomic theory of matter. Matter is not continuous, but lumpy, composed of tiny particles. There are a finite number of these particles, and in combination, they can be used to build anything in the universe,

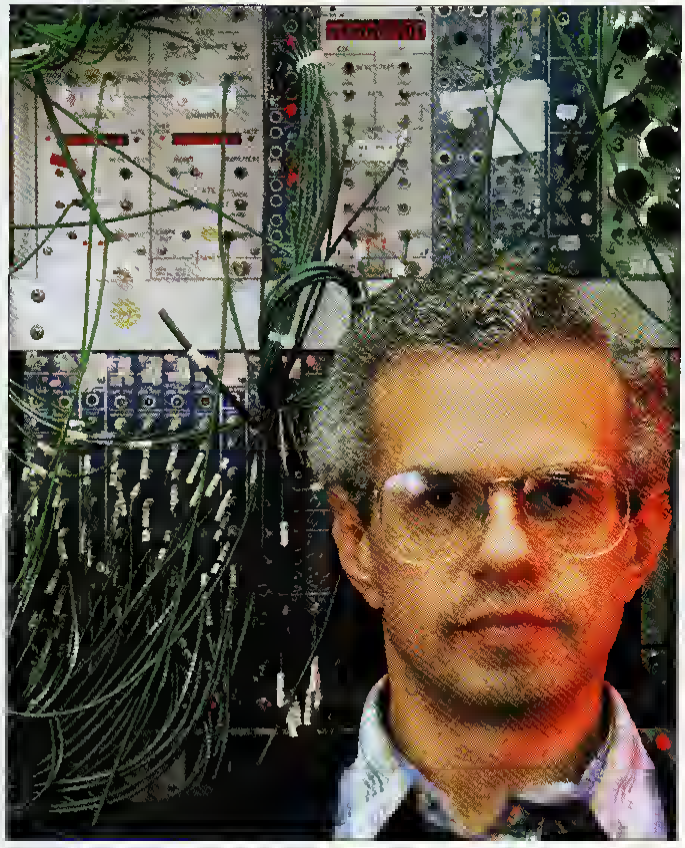
Detector wizard Alvin Tollestrup hopes to trap the heaviest, meanest quark in the universe.

GAMBLE: IF THE TOP QUARK ISN'T FOUND SOON, WE'LL WITNESS ONE OF THE GREATEST CRISES IN SCIENCE HISTORY

from soup to nuts to quasars. In its time, and for many centuries thereafter, the atomic theory was considered a crazy idea.

This past fall, physicists at the Fermi National Accelerator Laboratory (Fermilab) began an experiment that, if everything goes right, will culminate a 2,400-year-old search for Democritus's atoms. We don't call them atoms anymore—that term was appropriated by chemists in the nineteenth century to refer to the smallest units of the chemical elements, such as carbon, oxygen, and uranium. Today we call the smallest particles in the universe quarks and leptons. Physicists believe there are six leptons, six quarks, twelve elementary particles altogether. The six leptons—things like electrons, muons, neutrinos—have all been discovered. And five of the quarks have been found. One is missing, the sixth. It's called the top quark. It must be found, or Democritus will have sniffed that loaf of bread in vain.

To find the top quark, physicists at Fermilab will use the Tevatron, the most powerful particle accelerator in the world, which attains energies of 1.2 TeV (trillion electron volts), about the energy of 1.2 trillion flashlight batteries. In terms of funding and personnel, it is the biggest scientific undertaking in the world at present. About 800 physicists will be manning the detectors that sit like battleships on the accelerator tube. Another 350 will work on the accelerator itself and related equipment at the lab. The search for the top quark will be the last great experiment of the twentieth century.



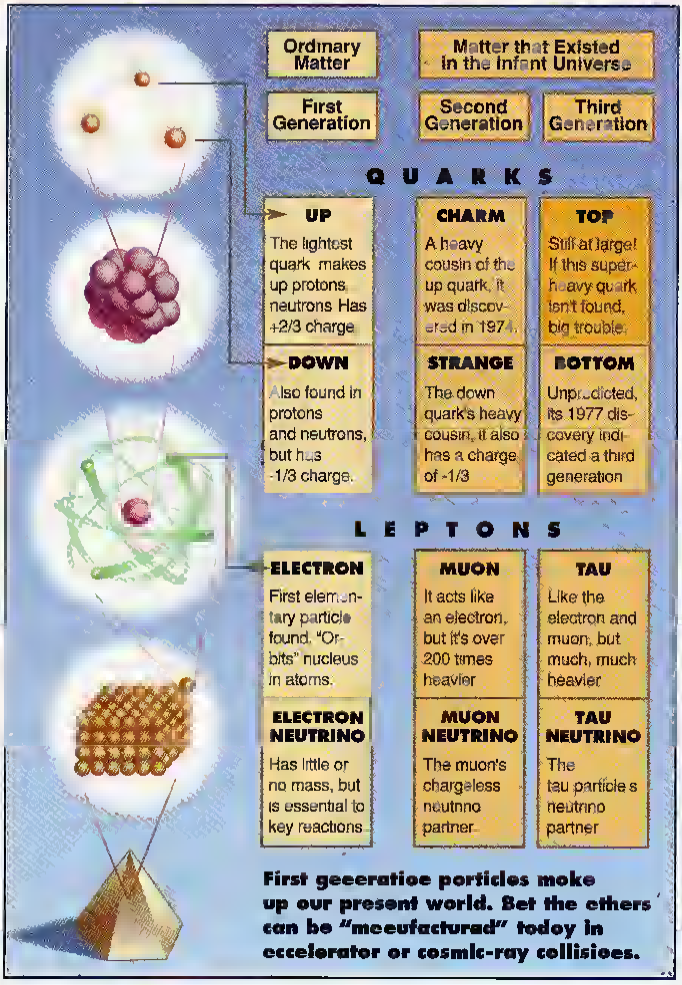
Melvyn Shochet. "Like looking for a needle in a stack of 500 billion other needles."

Halloween Event

To the untrained eye, the search should have ended with the Halloween Event, as it's now known in physics circles. On October 31, 1992, a proton and an antiproton collided in the Tevatron at a point about three stories beneath the feet of physicists sitting in the control room of CDF (Collider Detector Fermilab), the lab's $60-million particle detector. There's nothing unusual about two particles colliding. The Tevatron produces 100,000 collisions per second. But this particular collision was special. Out of the impact came two leptons, a highly energetic electron and a highly energetic muon. There were also two "jets" of hadrons—narrow, energetic streams of particles like protons and neutrons. And there was a neutrino. These particles are not important in and of themselves. Electrons, after all, were discovered in 1898; muons in 1937. Taken together, however, this particular set of particles looked suspiciously like a rare signature of the top quark.

It wasn't perfect, though. "The muon hit a crack between two calorimeters," explained Melvyn Shochet, a spokesperson for CDF. He went on to explain that detectors have "cracks," blind spots. In order to relay the information out of the detector, you need cables that lead from the various sensors to the gigantic computers that sort out the data. Alvin Tollestrup, one of the physicists credited as being a prime mover behind the building of both the Tevatron and CDF, points out that there are 30,000 wires in the detector. "The particles 'tickle' the wires, and the computers know where the wires are," explains Tollestrup. Getting the information out is the problem. This requires cables. These are the cracks, alleyways where there are no sensors, and that's where the renegade muon went.

Another potential top event, as



these things are called happened in Fermilab's other giant detector, D0 (d-zero) the following January. This collision, said D0 spokesperson Paul Grannis, was essentially like CDF's Halloween Event, but the electron and muon were even more energetic. Like Shochet, Grannis also is not ready to claim victory. "One event, like a swallow, does not a springtime make," he says.

These recent events, when added to a potential top event recorded during the Tevatron's 1988–1989 run, means that scientists at Fermilab have apparently produced a top quark on three separate occasions. So why are they still searching? It might help to look at the weird process we call particle physics. In order to find the smallest, oldest object in the universe, one must use a new, enormous machine.

The Tevatron lies 30 feet beneath the northern Illinois prairie on Fermilab's Batavia site, about half an hour's drive from Chicago. The lab is a billion-dollar complex, an almost spiritual combination of high technology and natural history. The Tevatron occupies a four-mile-around tunnel lined with more than a thousand superconducting magnets for focusing and steering the beam of particles. The 660 acres of land enclosed by the accelerator ring is planted with indigenous tall prairie grass. Surface collection lakes within the ring are inhabited by trumpeter swans, Canada geese, and sandhill cranes. Across the road from the Tevatron is a pasture where a herd of a hundred buffalo roam, animals that hadn't been seen in the area for 800 years before the physicists brought them here from Colorado and South Dakota.

In the Tevatron, events take place that haven't been seen for 15 billion years, a cosmic eye blink after the Big Bang that created our universe. The Tevatron's energies mimic conditions of a hotter bygone era, when bizarre, heavy particles like the top quark roamed the world. We get to this lost dimension via collisions. In the accelerator, six bunches of protons circulate in the beam tube, a stainless-steel oval pipe about two inches high by three inches wide. In the same tube, but racing in the opposite direction, are six bunches of antiprotons, or p-bars. (The name comes from the fact that protons are designated in reactions by p. Put a bar over it, $\bar{p}$, and you've designated its antiparticle, the antiproton, or p-bar.) The magnets contract the bunches down to the radius of a human hair and steer the protons and p-bars into each other head on at two separate points in the accelerator. It is at these two locations where one finds Fermilab's two massive 5,000-ton detectors, which [illegible] the particles that come flying out of the collisions. Tollestrup explains that the material of the tube changes from stainless steel to beryllium for the 20 feet that it runs through the detector. This special section of tube costs $100,000. Beryllium is a very light metal that is fairly transparent to the particles, allowing them to spew into the detectors unimpeded.

Here's where it gets weird. The particles produced in the collisions are sometimes heavier than the proton and p-bar that collided. This is why the term *atom smasher* is so inappropriate, because it implies that the purpose of an accelerator is to break particles apart to see what's inside. Yes, that is one role of the accelerator, but this will never get us to the top quark, because there are no top quarks inside protons and p-bars. What's inside each of them are up and down quarks, the lightest quarks, members of the first generation of elementary particles. The top quark is a third-generation quark, an elementary particle that hasn't existed since a tiny fraction of a second after the Big Bang. It's heavy. Physicists at Fermilab say its mass is somewhere between 113 GeV (billion electron volts) and 250 GeV. The mass of the proton is about 1 GeV. Obviously, this means that if the top quark is to be found, the collisions in the Tevatron must produce a particle that weighs at least 113 times more than the particles that collide in the machine. It's as if two Subarus crashed head-on and instead of

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broken glass and tires flying out of the collision, a Mack truck appeared.

This is possible (with particles, if not with Subarus) because the accelerator in effect, makes the protons and antiprotons heavier by accelerating them. Fermilab director emeritus and Nobel laureate Leon Lederman says the accelerator is really a 'ponderator.' It's a simple concept. Mike Tyson and Roberto Duran are said to have "heavy hands" not because their fists actually weigh more than other people's, but because they accelerate them more effectively.

The collision of protons and antiprotons allows the physicists to make new matter, heavier particles, by converting energy into matter using Albert Einstein's formula $E=mc^2$ (energy equals mass times the speed of light squared). The energy imparted to the protons and antiprotons by the accelerator can be converted to mass. This is why physicists use units for energy (113 GeV, 2 TeV, and so on) as units of mass also. We can say the proton weighs 1 billion electron volts (1 GeV) because Einstein taught us that mass and energy are just two faces of the same coin. Keep in mind also that because the speed of light squared (the c^2) is such a huge number, one needs an enormous amount of energy to make a tiny bit of mass, hence the need for powerful modern accelerators.

When the particles collide in the Tevatron, they can create bursts of pure energy, which very quickly coalesce back into new matter. But not all collisions are equal. Protons and antiprotons are whirling conglomerates that are composed of three quarks that dance around each other exchanging other particles called gluons, which are messengers of the strong force that holds the quarks loosely together. So when a messy proton hits a messy antiproton, the results can vary. Fermilab's Stephen Parke compares the proton to a "peach with three pits." The stringy pulp represents the gluons being fired back and forth. This means that most collisions will be inconsequential, of low energy, as pulp collides with pulp or a pit collides with pulp. But the collision Fermilab scientists find most interesting is when pit collides with pit, a quark in the proton smashes head-on with an antiquark in the antiproton. The quark and antiquark antimatter annihilate, releasing enough energy to make the massive top quark.

Even then, you don't automatically end up with the desired particle—in this case, the missing quark. The weird probabilistic rules of quantum physics allow the burst of energy to form any combination of particles it wants to as long as there's enough energy/mass to produce them all and the various quantum requirements are fulfilled (the electric-charge signs must cancel out, rules about spin and quantum numbers must be observed, and so on). In any one collision, 70 or more particles may be produced. In a few of these events, one of those particles could be the top quark. But the odds are staggering.

The traditional metaphor used is that finding a rare particle in an accelerator is like looking for a needle in a haystack. At an April 1993 meeting of the American Physical Society, Melvyn Shochet and Paul Grannis took issue with this cliché. First of all, explained Grannis, the three potential top-quark events were the result of 1.5 trillion collisions, or one event out of every 500 billion. No haystack has half a trillion pieces of straw, says Grannis.

Shochet says the problem is even worse. "In a haystack," he says, "there's a good way to tell the needle from the straw." And this explains why Fermilab has not yet claimed victory in the search for the top. To the untrained eye, the top quark is just another piece of straw. The problem is that the top quark, after being manufactured in the conflagration of the collision, exists for only an infinitesimal fraction of a second. It's estimated that it travels about the width of a proton before it decays into other, more common, particles. It's these particles—electrons, muons, hadrons, and the like—that fly out through the beam tube and into the massive detectors where they get measured and identified. "The things you actually see in an event," points out Tollestrup, "are particles we've been studying for the last forty years." Sometimes these secondary particles also decay before leaving the tube, meaning the top quark must be partially identified by particles that are really tertiary products of the collision. Inferences upon inferences upon inferences.

There are various combinations of particles, called channels, that scream 'top quark' to a physicist—for example, the energetic electron and muon and two jets of hadrons that were seen on Halloween in 1992. Since one doesn't detect the top quark directly, couldn't some other particle or process mimic this signature? In a word, yes. As kids we used to make phony bear-paw prints in the snow to scare one of the dumber neighbors. Particles do the same thing, although their motivations are hopefully more benign. They make life miserable for physicists nonetheless.

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Mundane events that mimic the new physics the experimenters are looking for are called 'background.' How many background events that mimic Fermilab's top-quark signature can one expect in a trillion and a half collisions? The lab has now calculated that number to be two to four events. And Fermilab has found three top-quark events over those same numbers of collisions. Get the picture?

This doesn't mean they haven't found it, it means they can't be sure. During the current nine-month run of the Tevatron, they need to find more top events to make the discovery statistically secure. When the top is found, it will be the final piece in a puzzle that we started putting together more than 2,400 years ago: the final proof that our universe is made out of tiny particles. And if it isn't found, we'll see one of the greatest crises in the history of science.

Atomism

The belief that matter is composed of invisible particles is almost universally accepted today. The atomistic theory first proposed by Democritus is taught in grade schools and lies at the foundation of not only physics, but chemistry, biology, and all sciences that are based upon physics (almost all formal science). Yet for most of the 2,400 years since the idea was introduced, atomism has been less than popular.

In seventeenth-century France, for instance, the punishment for believing in atomism was the death penalty. Even at the turn of the present century, feverish debates were held in Europe between the energeticists, who believed that the fundamental stuff of nature was energy, and the atomists, who believed in particles. The leader of the energetics movement was none other than Ernst Mach of speed-of-sound fame (Mach 1, Mach 2, and so on). The loyal opposition was headed by the Austrian physicist Ludwig Boltzmann. Mach admitted that diamonds, which the atomists said were composed of carbon atoms, were real, but that atoms were not. Diamonds can be polished, cut, and sold. But carbon atoms were but theoretical concepts, useful only in equations, according to Mach. Diamonds could not really be broken up into little particles. The Machian view was gaining more and more advocates in 1906, at which time Boltzmann, in poor health, became profoundly depressed that his life's work in atomism would be buried under an avalanche of energetics. In the summer of that year, Boltzmann took his family on vacation to the Bay of Duino near Trieste, and while his wife and daughter were enjoying a swim, hanged himself in his room. No one knows whether it was particles that drove Boltzmann to his death, but they have certainly caused much anguish through the centuries.

The atomistic idea went out of vogue for 2,000 years after the death of Democritus—though there was a brief revival of the theory by the Roman philosopher Lucretius—not to be reborn until the Renaissance by that grand old rascal of physics, Galileo Galilei. Higher education during those bygone days was controlled by the Roman Catholic Church, which worshipped—intellectually speaking, of course—that grand old half-wit Aristotle, who believed among other claptrap that light was a "quality," incorporeal and substanceless. Galileo, on the other hand, was an atomist. Everything, even light, had to be made out of something. In his first trip to Rome, he brought with him a little box containing barium sulfide, known in those days by the more colorful name "solar sponge." Barium sulfide, if set out in the sunlight, will later glow in the dark. This Galileo demonstrated to a learned assembly of Aristotelian scholars. His point was not lost on them, and they were disturbed. Galileo had taken something that was a quality—sunlight—stored it in a rock, and released it into the darkness. It was like bottling the sweetness of the Virgin Mary and pouring it into the hindquarters of a mule. Galileo said the solar sponge proved that there were "corpuscles of light." Today we call them photons. The Church was not pleased. Atomism challenged the doctrine of transubstantiation, that wine can be transformed into the blood of Christ. Communion was more important than science. Particles were not a concept whose time had come.

> "In seventeenth-century France, the punishment for believing in the existence of atoms was the death penalty."

But atomism wouldn't go away. Isaac Newton also believed in atoms, envisioning them as hard, massy, impenetrable particles. The English chemist John Dalton resurrected Democritus's word *atom*, declaring it to be the basic unit of each chemical element. It was a big step forward, except for the fact that Dalton thought oxygen, carbon, hydrogen, and so on, were atoms in the Democritan sense—indivisible. He jumped the gun. As we know today, chemical atoms are full of other particles: electrons, protons, and neutrons, and the latter two are further divisible into quarks and gluons.

Perhaps the most intuitive insight into the nature of matter came from a relatively obscure Dalmatian Jesuit named Ruggiero Giuseppe Boscovich. In 1763, he put forth the proposition that matter was composed of elementary particles that were in effect geometric points. Instead of the massy particles of Newton, Boscovich's particles were immaterial centers of force. Democritus envisioned a magical knife that he could sharpen and resharpen while cutting a piece of cheese into its constituents. Eventually, he said, you come to an invisible chunk that can be cut no further: the atom. But Democritus never speculated on just how small this indivisible particle would have to be. Boscovich answered that particles are points. A point is just a place; it has no dimensions. So an elementary particle is just a point with a pull according to Boscovich. It was an audacious idea. It was also a damn good one.

The electron is one of the 12 elementary particles that today we know make up the universe. Through the decades, physicists have measured the radius of the electron with increasing accuracy. As the apparatus and experiments have improved, the measurements have shrunk and shrunk. In 1990, the radius of an electron was experimentally measured at less than .00000000000000001 inches. That's about as good a zero as physics can supply. The electron has several qualities, including mass, electric charge, and spin. Obviously, there's something there. Yet every time the electron is measured, another zero or two is added past the decimal. Its size creeps toward zero. Leon Lederman compares the electron to the Cheshire Cat. Slowly it disappears until all that's left is its smile—its spin, charge, and mass.

It appears that an eighteenth-century Jesuit geometer was right. An elementary particle has virtually no dimension. Quarks are just the same. It isn't easy to find an object with zero radius.

The Standard Model

Sheldon Glashow was insistent. "It's got to be there. It's a certainty that it exists." He was talking about the top quark, and

perhaps he is insistent because he has a lot at stake. Glashow is a Harvard University theorist and is probably responsible more than any other physicist for the theoretical underpinnings of what's called the standard model, the paradigm that holds, among other things, that the universe past and present consists of 12 particles (six quarks, six leptons), which are driven by three forces (electromagnetic, strong force, and weak force).

The standard model, says Lederman, is a crisp summation of everything we know about physics, from the time Galileo dropped two unequal weights from the Leaning Tower of Pisa to the last run of the Tevatron. That includes a lot of theory, a lot of discoveries, and a lot of physicists. Even so, Lederman calls Glashow "the hero of the standard model" because of the pivotal theoretical work he did on the theory in the 1960s and 1970s.

Most physicists agree with Glashow that the top quark has to be there—even the experimenters, whose goal in life is often to crush theories, not reinforce them. Burton Richter, the director of SLAC, the Stanford Linear Accelerator Laboratory, when asked if the top exists, said simply, "It better." Richter is an old quark hunter himself, though SLAC is not involved in the top search. "I'm an experimenter," continues Richter, "so I love to smash theories. But the whole edifice would collapse if there is no top quark." Richter believes Fermilab's recent candidates for the top quark are good events, but that the lab is "not sure how many are background." (They have reason to be careful. CERN, the European accelerator laboratory in Geneva, Switzerland, announced it had found the top quark in 1984. An embarrassing second look forced them to withdraw their claim.)

Another accomplished quark hunter, Samuel C. C. Ting, like Richter, has confidence that the top will be snared. Ting is an MIT scientist working at CERN. While CERN dropped out of the race for top a few years ago because its accelerator cannot achieve the necessary energies, its experiments have helped pin down the range of possible masses for the missing quark—about 157 GeV, says Ting, plus or minus 30 or 40 GeV. "The top quark will be found," predicts Ting, "at Fermilab."

Why such hoopla (and anxiety) over this sixth quark? It is needed to fill in the final open slot in the particle picture of the standard model. The search for the 12 elementary particles has been going on for a century, although a hundred years ago scientists didn't know how many they were looking for.

CONTINUED ON PAGE 82

ARTICLE BY WALTER PARKES • PHOTOGRAPH BY ALAN WEISSKOPF

RANDOM ACCESS, REMOTE CONTROL

THE EVOLUTION OF STORYTELLING

A CLIP FROM WARGAMES: DAVID LIGHTMAN (MATTHEW BRODERICK) SEES A BROCHURE OF A COMPUTER COMPANY PROMISING A QUANTUM LEAP IN GAME TECHNOLOGY COMING THIS CHRISTMAS . . . BREAKS INTO A SYSTEM AND, THINKING IT'S THE GAME-COMPANY COMPUTER, ASKS TO PLAY GLOBAL THERMONUCLEAR WAR . . . SEES ON TV THAT FOR THREE MINUTES SAC WENT ON FULL ALERT THINKING THERE HAD BEEN A SOVIET SNEAK ATTACK . . . IS ARRESTED AND INTERROGATED BY DABNEY COLEMAN . . . BREAKS BACK INTO THE SYSTEM AND ASKS THE COMPUTER, "IS THIS A GAME OR IS IT REAL?" THE COMPUTER ANSWERS: "WHAT'S THE DIFFERENCE?"

WarGames was released in the summer of 1983—more than ten years ago. In it, the Soviets were still the bad guys, the real-estate market had an unlimited upside, and when the kids in the movie used their computer to take a fantasy trip to Europe, they booked seats on an airline called Pan Am. As this clip shows, one thing hasn't changed: People will go to great lengths to play the cool new game.

I've spent a good amount of my professional life trying to tell stories that brought issues of emerging technologies to a large public. However, the vehicle for these stories has been the most traditional of forms: the motion-picture narrative. Today we're about to have at our fingertips new tools for delivering entertainment experiences. We know these tools will allow us to play games that look and sound better than anything we've ever seen. We know they'll allow us to bring huge amounts of multimedia information into homes for educational and consumer use. We know they'll deliver existing films and TV shows and music. But what interests me, and most of my colleagues in films, is whether or not these technologies will give birth to a new kind of storytelling: one that incorporates the interactive visceral aspects of the game with the emotional values of the narrative.

Since we're breaking new ground, we first have to come up with a way of thinking about these issues. We can start by asking a basic question, which is, to paraphrase *WarGames*, "Is it a game, or is it a story?"

In terms of defining what is a game and what is a story, let's just say that *games* are nonlinear, open-ended *individually* interactive entertainment experiences that are high on process—you do a lot—and low on content, while *stories* are linear, closed-ended *communally* interactive entertainment experiences in which process is simple—you just sit there—but content tends to be complex.

Why the focus on games? For one thing, the market demands it. In 1990, revenues from domestic theatrical box offices were about 5 billion dollars; revenues from interactive arcade games topped 7 billion. With numbers like these, we'd better understand what it is about games that seems to answer the entertainment needs of an entire generation. And a good way to start is to look at some trends in entertainment over the last ten years and see how certain technological innovations have already started to affect the way movie and television stories are told.

When *WarGames* was released, all those involved had huge expectations for the success of the film. We were just catching a national wave of interest in technology and concern for the threat of nuclear war, our market research and test screenings went through the roof, and the studio really thought they had the next *E.T.* And *WarGames* certainly was a success—it made about $80 million in domestic box office and bettered that internationally—but it wasn't the runaway hit people hoped it would be.

Why? I think, despite its high-tech content, *WarGames* is the most traditional of narratives. It isn't a particularly complicated story, but it *is* something you have to follow from the beginning to end. The film's entertainment value derives more from the sequential unfolding of the narrative than from the visceral thrills or laughs of each moment and, not surprisingly, it's less interesting the second time you see it.

That summer, I heard teenagers interviewed on National Public Radio about movies they wanted to see. The kids talked about several new releases and about how you had to *think* about them and how when it came right down to it, they'd rather have a couple of beers and see *Ghostbusters* again. And why not? Being 'slimed' a second time is almost as much fun as it is the first time, since its narrative is *secondary* to the visceral thrills or laughs of its individual moments; the entertainment value isn't diminished by knowing what happens next. In this way, it invites multiple viewing.

DABNEY COLEMAN (ABOVE) CONTEMPLATES WHAT TO DO ABOUT AN APPARENT SOVIET COVERT MISSILE ATTACK THAT HAS BEEN LAUNCHED BY A SIMPLE COMPUTER GAME.

Think about *Batman*, which I contend is less a story than an *environment*—a place somewhere in imaginative space, cutting across languages and culture, without narrative requirements, without character complexities. For $7.50, you were invited to hang out in the coolest place in the world. You could talk, you could come in at the beginning or the end, you could daydream, and the basic entertainment experience was intact. You could check in on the story, and as long as Batman was chasing Joker or Penguin or Catwoman—like icons on a giant arcade game—you knew where you were. Narrative complexity gave way to *design complexity*; story gave way to a sensory environment.

Or consider *Die Hard*—with Bruce Willis skirting in and out of the corridors of the office building—a huge three-dimensional game board—trying to avoid being cut down by the terrorists. The film owes more to *Pac-Man* than to *War and Peace*. And don't get me wrong—*Die Hard* is a superb piece of popular entertainment.

So what's happening here? Why is the public tending to embrace movies that make limited story demands? I think

it's too simple to say we have a generation with no attention span—rather I think that given we live in a world full of information and easy ways of accessing it, we're developing a *different kind* of attention. Clearly, it all starts with television, and more specifically—with the remote control.

The extent to which the remote control has changed the way people watch TV came home with pathological clarity to me a few years ago when my wife found me in front of the TV late one night. We were in production at the time, and I was drained, so I had zoned out with the clicker in my hand, randomly going through 35 stations on my cable system. Then my wife noticed that the cable was out. I was randomly accessing 35 different kinds of snow. And I was totally absorbed.

Television watching has become a random-access, interactive process, one of sampling bits of information at will as opposed to committing to a half-hour or hour of concentrated viewing. Beyond making the success of MTV and CNN possible—as well as the dreaded infomercial—it has changed how television drama is conceived. Think of the breakthrough successes of the last decade—*Hill Street Blues*, *L.A. Law*, *Thirtysomething*, *St. Elsewhere*. They all present a specific emotional environment with multiple storylines and multiple characters which, rather than asking you to follow one narrative from beginning to end, invite you to check in on the proceedings at will. In the best of these, narrative complexity has given way to character complexity—and with no diminution of quality. In fact, these shows have given us some of the best television ever. Again, it's just a different kind of TV, one which allows the viewer to more freely interact with the show.

You can even look at the proliferation of multiscreen theaters across the country as evidence of a consumer tendency toward random access. Why commit to go to one theater when you can go to an environment that multiplies your choices. Think of the multiplex cinema as a large interactive system that allows the "user" to access movies or restaurants or stores at will. It's like a giant "clicker."

What I'm suggesting is that certain technological innovations—such as computers themselves, rapidly growing cable systems, and, above all, the television remote control—have started to change the way people take in information and entertainment—and that the movies and TV shows that have tended to be the most successful have allowed the viewer to interact freely and randomly with them and have not asked the viewer for a long-term—which in this context means a couple of hours—investment in a linear narrative. In short, they've been the movies that most operate like *games*. In this light, the gargantuan success of *Jurassic Park* can be seen as a further step in this evolution: that of movie as ride.

Does this mean the film narrative is dead? In no way. There will always be the need for the predictability of narrative stories—if for no other reason than that life is a random event and stories provide a structured respite from the unpredictability of our existence. There are times when we need to specifically not interact, when we need to sit back and be transported into another world. Besides, we've already seen artists—John Hughes and especially Tim Burton come to mind—who have intuited this random environmental trend in entertainment and incorporated it into the form of the traditional movie.

What I think this does mean, however, is that our goal in exploring ways of writing for new interactive technologies should not be to try to export or translate traditional narrative to them, as I've just shown. It's the *technology* that has changed traditional storytelling over the

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And a Happy New Year!"

Article By Charles Platt

PLEASE FREEZE ME

A YEAR AGO WE OFFERED THE CHANCE FOR ONE READER TO RECEIVE CRYONIC SUSPENSION AFTER DEATH. NOW WE'VE PICKED THE WINNER OF THE FUTURE.

Painting by Daniel Adel

There was an essay by a man who had suffered injuries in a car crash caused by a drunken driver, which had ruined his life as a jazz musician. He hoped that future science could make him whole again.

There was an essay by a woman who had sacrificed her creative ambitions in order to raise a family. She hoped that if she gained an extra lease on life, she'd have time for all the things she'd missed.

There were hundreds more, all of them giving powerful personal reasons for wanting to be frozen after death so that they might come back in the future and enjoy life anew.

These were the essays submitted for the Omni Immortality Contest, competing for the prize of a free cryonic suspension. As the creator of the contest, and as one of the judges, it wasn't just my duty, but my pleasure to read what every single person had written—by hand, by typewriter, and by word processor, on headed stationery or on pages torn from notebooks.

I found that literally hundreds of people were so in love with life and so excited by the future that they were not just willing, but eager to make this journey into the unknown. Almost all of the essays were sincere, thoughtful and highly personal, and they presented me with a very difficult problem: how to choose just one from so many.

On one hand, I was naturally moved by pleas from AIDS victims or patients with cancer who felt bitterly deprived of their fair ration of life and were hoping for more. I was also touched by people who asked that the prize should be awarded to friends or relatives whom they felt were too valuable, too wonderful, to be lost in conventional death.

I had to remind myself, however, of the fundamental truth of cryonic suspension. It offers *only a chance* of future life, and no one knows how good a chance it is. I myself have made arrangements to be frozen after I die, but that doesn't mean I think it's a sure thing. I know that the freezing process causes cell injury which we cannot currently repair, and there's no guarantee that future technology will know how to fix it.

Consequently, no one should imagine that the Omni Immortality Contest was an exercise in deciding who should live and who should die. The winner will gain a ticket which *may* be good for a one-way ride into the future. The rest of the entrants will be no worse off than they were before.

Bearing this in mind, I tried to retain some detachment as I read the hundreds of essays. But I found that even the calm, sober ones from healthy, happy people were often intensely moving. Many people were eloquent in their desire to fulfill future dreams.

A man from Pasadena, California, wrote, "The hope is to have the years and health to do what is impractical now. Explore the Amazon, know Shakespeare and Robert Burns, learn to play Mozart and Scott Joplin, travel the solar system and the stars, see mankind scattered safely around the galaxy, pass on my knowledge and passion for life. The chance to do all this with my loved ones is overwhelming; to lose that chance, heartbreaking."

Some essays were written by people who had no training in science, such as this from a woman in Hayden, Colorado: "I am a simple, working-class farmer/rancher with limited skills in computers and futuristic-type equipment, but I possess the skills to survive in the real world. . . . I would like the future generations to know how to run a tractor, when to plant and harvest their crops, and how to survive without machines if necessary."

And this from a man in Seattle: "Our great-grandchildren, living in a world of wealth and ease generated by intelligent machines, will never believe how we shipyard workers built ships—with our hands, in the heat and cold, the smoke, filth, and stench, the screaming noise, and the danger of injury or death at any step. Most of all, they'll never believe the bone-deep weariness of this kind of toil, year after year after year. Maybe the best I can bring to the people of the future is the memories of

AND THE WINNER IS . . .

The following essay was selected as the winner of the Omni/Alcor Immortality Contest. As the superb science fiction writer Charles Platt points out in the accompanying article, we were inundated with fine, worthy essays, each with good reasons for selecting its author as the winner.

But there is about this entry a simplicity of desire and hopefulness that singled it out and won for its author a chance at being revived in the future.

And now, at last, we'll let Immortality Contest winner James J. Baglivo speak for himself.

I am twenty-one years old. When I was nineteen, I was involved in a very serious automobile accident. I was gravely injured. Thanks to modern medical technologies and techniques, I survived. Modern technology, however, is unable to return my physical form to its once healthy state. I am sore each day and (most likely) will be until my existence ends. (I have more metal within my body than most people have in their silverware drawers!)

When I close my eyes for the "final" time, I want to die with a smile on my face, both knowledge and hope in my heart. This smile will be brought about by both the knowledge that I will be cryonically suspended, and also by the hope that I will awaken healthy and healed.

I look forward to the future. I have hope that it will not be the ignorant, opinionated, and prejudiced world of today but rather an enlightened age. I carry no sad old traits as such in my heart and refuse to bring them with me. I will, however, bring knowledge of such things. To know the mistakes of your forefathers is to prevent them from happening again.

I will bring with me hope; hope for my future and hope for all the world. I will also bring love and understanding, the two most important things I can bring.

—James J. Baglivo

This man wants to show you the future.

Hugh Hixon is a biochemist. At the Alcor Life Extension Foundation, Hugh is developing techniques for suspending human life in such a way that it can be started again, decades or even centuries in the future.

Today, doctors routinely revive patients who lack vital signs for an hour or more. Tomorrow, using nanotechnology (molecular machines capable of repairing individual cells), medicine will have far greater capabilities.

We look forward to a time when it should be possible to revive anyone whose brain still contains the information that defines personality and intelligence — regardless of other factors. And by that time, we believe science will have conquered the aging process.

How can this help you? Through cryonics.

Cryonics means freezing a patient so that future technology may give that person a new, longer life. Cryonics is a highly sophisticated medical procedure—but is easily affordable, if you pay the cost in installments, in advance.

At Alcor, we offer you a chance to achieve something that people have dreamed of for thousands of years, an unrestricted lifespan.

We are the largest provider of cryonics services in the world. If you'd like to know more, call our toll-free number anytime: **800-367-2228.**

Our staff are always standing by. And if you have any technical questions, Hugh will be happy to answer them.

Alcor Life Extension Foundation

12327 Doherty Street, Riverside, California 92503

these times.' But he also wrote: "Why be suspended at death? Because I love life! All of it!"

There were also some essays by scientists, such as this man in Saratoga, California: "My hobby is collecting information on dead or dying branches of science, medicine, and engineering, such as fluidics, insulin shock, magnetic bubbles. Most people familiar with these topics are either old or dead. Knowledge of these obscure blind alleys in the early history of technology may be useful in developing solutions to the problems which will face society many years into the future."

Some people didn't want cryonic suspension for themselves. A man in Ocoee, Florida, wrote, "A father should die before his children. If I were chosen, I would choose to place the embryos of rare and endangered species in my place."

And a man in Tarzana, California, urged that his wife should be selected as the contest winner: "After 28 years, two children, and countless adventures, Alice has fulfilled all my expectations. I have not longed for any other existence or place since being with her. I know that she would be thrilled to hopefully come back in the future. Because of her wonderful disposition and fantastic memory, she would be an asset in the future world. Therefore, with Alice's approval, I highly recommend her as a candidate to represent our generation in the future."

Most people who entered the contest were not religious, but a few were, and they saw no contradiction between their religious faith and cryonics. These words came to us from Fort Lauderdale, Florida: "I believe we all already have immortality, cryonics or not, but the freezing and revival of our bodies would allow our souls to return to the home we grew up in, where we found such love and joy."

Several people were artists, some were musicians. A woman in Arizona, who directs a chamber orchestra, told us, "One live musician, frozen in time and space, is better than the finest synthesizer or recording ever made."

Less serious entries included this one from Euless, Texas: "Perhaps I can bring humor to the future, for by the time they revive me, all the jokes I've been telling will be funny again."

And there were some skeptics. A man in Kailua, Hawaii, gently admonished us: "The purpose of every human being should not be to weasel into the future but to make the future worth living. The present should be our concern and not the machinations necessary to stow away to some distant time. If I were you, I'd pick the letter written in crayon by the child who was beaten the night before by his drunk father."

Lastly—inevitably!—there were the weird ones. One essay seriously assured me that the man who wrote it had been born in the future, had time-traveled into our time, and was now stranded. He wanted to be frozen so he could get back home. Another man, who signed himself simply as "Frank," explained that he had a psychopathic urge to kill people and that since weapons of mass destruction would be more readily available in the future, he wanted to come back then so he could rack up a higher body count.

My favorite Martian, however, was the one who told us that if he were frozen during an out-of-body experience, his astral body would remain permanently free and could give us frequent reports on the condition of his frozen physical body—"for centuries, if necessary."

When all was said and done, I found two recurring themes in the essays that I read.

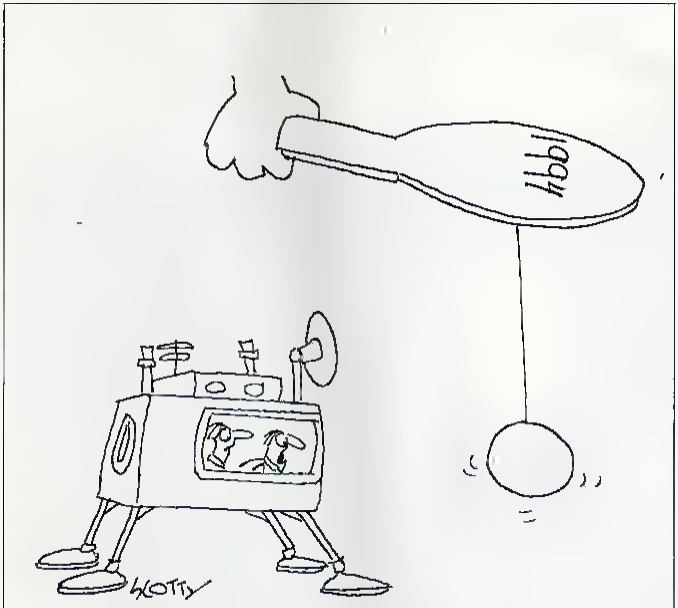
First, many people were acutely aware of the value of human experience. To them, it seemed terribly wasteful that a lifetime spent learning skills, acquiring information, and developing an understanding of life should all come to nothing. They wanted to pass their wisdom on to future generations so that it would not be lost.

Second, many people were filled with excitement about the future, which they were sure would be a place of infinite possibilities. Trapped in the twentieth century, they felt they had been born too soon. They longed for a chance to experience the universe 50 or a hundred years from now.

These were the two messages that spoke most powerfully to me and influenced me in selecting a short list of potential winners, which I then compared with my fellow judges at *Omni* and at the Alcor Foundation.

I hope you feel that our final decision was fair and appropriate. And to those who didn't win—well, this contest wasn't necessarily your only chance. Cryonics is affordable to almost anyone who can take out a life-insurance policy. Typically, the total cost of insurance plus membership in a cryonics organization is under $1,000 per year. For more information, readers may contact Alcor at (800) 367-2228.

Despite its uncertainties, I think cryonic suspension is a very special prize. And even if you have to finance it yourself, it isn't necessarily out of reach.



"We should approach it cautiously—it appears to have an erratic orbit."

FICTION BY PAUL PARK

A MAN ON CRUTCHES

I had been to Los Angeles before and hated it. Whenever I had gone to visit, I had been irritated by the sweat-stained dinginess of the place, its perpetual five-o'clock shadow. I had been irritated by the lack of seasons. But two years ago when I flew out for my father's funeral, I thought something was different as soon as I got off the plane. I rolled down the window in the taxi and the air was cold and sharp. I could see the mountains. I could smell the salt. It was Saturday morning. A woman on Wiltshire Boulevard seemed amazingly good looking, amazingly well dressed.

I have a condition which recurs every few years, and you'd think I'd learn to recognize the signs. Instead I'm always taken by surprise. The problem is the condition starts with a feeling of optimism and hope, so I don't mind. That morning in the cab, I was in a good mood. I was in a mood to be forgiving, to consider for the first time that my father might have been looking for something when he moved out here. Always I had thought about him running away, pushed instead of pulled. People had always said there was more work for him out here, but when I was a child, "more work" seemed like a bad reason to do anything. A bad reason to leave my mother and the house that he had built. A bad reason to move a continent away and live in a polluted city where the weather never changed. I was ten years old when he left, and I believe I had no conscious resentment. Already by that time he was a stranger. I barely remember him living with us, and it's not because my memory is bad. Later, I didn't miss what I had never known. My mother never spoke of him.

I checked into my hotel. I planned to spend one night, and then take a bus up the Owens River the next morning. I was too poor to come out just for the ceremony, so I had taken a few days' vacation to go hiking. When I had spoken to my stepmother on the phone, I had found myself asking her whether I could take some of my father's ashes to bury up on Darwin Bench—a place of mystical significance to me, I implied. She seemed delighted, started to cry in fact, which embarrassed me. It's just that having organized my vacation, I thought I had to make it seem as

PAINTING BY KENT WILLIAMS

if it were somehow part of the funeral, a cathartic and necessary experience, perhaps. In order to get time off at short notice I told my supervisor the same story, leaving her touched by the impression that my father and I had taken many trips together up into the mountains.

My life is full of such falsehoods, which doesn't make them easier to bear. In my hotel I laid out my camping gear on the floor of my room. I replaced the bushings on my stove, and then I washed my hands. I took out my funeral clothes from the top compartment of my backpack—a gray wool suit. I put it on, knotted my tie, and stood looking at myself in the mirror on the back of the bathroom door. I looked good in my suit, a fragile version of my father. In it I exhibited the only gift my father ever gave me, though even that had come diluted through my mother. I made faces in front of the mirror and rearranged my hair, always when I had come out to visit my father I had taken trouble with my looks, suspecting in some obscure way that this would offer a reproach to him. That it would make him miss my mother, and miss me. At home I didn't care. This suit was the only suit I owned, which made wearing it a kind of ritual.

I washed my face and washed my hands again. The air in my hotel room had depressed me, but when I stepped out into the street I felt more optimistic, clean in my uniform, mixing effortlessly with Californians on the sidewalk. I found myself in a neighborhood where all the streets were named after Eastern colleges; my stepmother had given me directions to the church. It was a ten-minute walk. As I came around the corner of Brown Street, I slowed down. I composed my face.

My stepmother was waiting in a crowd of people. She was named Barbara, younger than my father, a dark-haired woman in her fifties, a writer for a feminist newsletter. In a previous decade she had been a lawyer, and she was still active in environmental and leftist causes, all of which did not keep her from more domestic accomplishments. She was a cook, a quiltmaker. In the crowd on the church steps she stood out, sleek in a dark cape and black leather boots—clothes which, despite their evident expense, nevertheless managed to bring some echo back from 1966, when she had lived on a commune in Colorado. I walked up towards her, ignoring everybody so that I could take my place with her at the top of the hierarchy of bereavement. Tears glittered in her eyes; she reached out black-gloved hands and grasped hold of my thumbs. What was there to say? Not for me some vain condolence. I leaned down towards her, conscious of her smell—was it patchouli oil? Her almost poreless skin.

"Jack," she said. "I'm so happy you're here." She pulled me aside under the portal of the church. I shook my head. And it was lucky that my feelings were beyond words. Otherwise I might have been tempted to admit so much. I had not known, for example, that my father was a Lutheran.

"I'd like you to say something," she said. "There'll be a time when some of the people who were closest to him . . . I spoke to you about it over the phone."

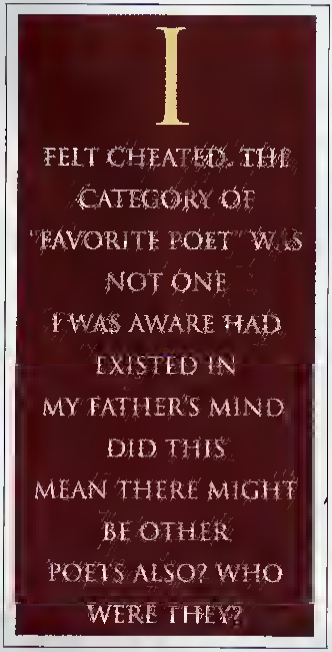
I remembered. I closed my eyes. "You probably brought something," she went on. "But I thought it would be nice if you could read a poem. You know that poem he used to love—Pied Beauty. Hopkins always was his favorite poet."

I nodded. Yet I felt cheated, too. The category of "favorite poet" was not one I was aware had existed in my father's mind. Did this mean there might be other poets also, only slightly below Hopkins in his estimation? Who were they? Sappho? John Ashbery? Alexander Pope?

"I'd like that," I said.

"I'm so glad you could come," she said again.

Half an hour later I found myself at the pulpit reading a poem. Sometimes my voice cracked with emotion—a reflex. Between the stanzas I looked out over the pews. There was a big crowd. My father had produced industrial films. Mostly he had worked as a consultant, and I guess he knew a lot of people. I guess he had a lot of friends. I stared out at them.



Later, I thought about what I saw from that pulpit. It is disjointed in my memory by the stanzas of the poem, and therefore it exists in my mind not as a continuum, but as a series of independent images. I used to examine them, searching for a clue. My father was a prominent man. There had been an obituary in the *Los Angeles Times*. Surely Jean-Jacques would have had a chance to see it, even if he hadn't called my father's office in the days after his death. How could he have kept away? And so I used to examine those images in the church, over and over again as if they were a series of photographs—the faces, the sad bodies, the rows of pews. Surely he is there somewhere. For a while, when I was at my most compulsive, I did remember a figure lurking at the back. Now I don't. Somebody once showed me how in different editions of a history textbook, the same photograph would appear, but changed somewhat, retouched somewhat to illustrate some subtle new idea. In a crowd of men, skins would darken, and then grow white again. Hair would grow longer, and then short again. Women would appear, then disappear. Memory is like history. At one time it was imperative for me to see the figure of a man, hiding in the back behind a white column. Handsome in his suit. Sometimes I could even see his crutch. Memory is like history—it absorbs the needs of the present. Now he's vanished.

After the ceremony I went to a reception at my stepmother's house, and I talked to some of my father's friends. Once I was back in the kitchen, looking for more ice, and Barbara was there, fussing with some strawberry tarts. "Jack," she said, "can you do something for me?"

She looked toward the window and then back. "I was at

your father's office yesterday, clearing some stuff out. Eddy—that's his partner—says he's got copies of everything and the rest can go. But I feel bad about asking Elaine or someone to throw it all away, without a family member at least looking through it. It's all old files." She looked at me and blinked but I said nothing.

"I don't have to explain, do I?" she went on. "It tires me out. Your father was a wonderful man. I know it's been hard for you sometimes, but you should understand—he really loved you."

"I know that," I said.

Then she was crying, and I went and put my arms around her. She was staring hard at one of the buttons of my shirt, inches from her eye. She balled up her fist and placed it carefully in the center of my chest. "It's business stuff," she said, after a pause. "The furniture's all rented. Just make sure I didn't miss anything personal. I put everything in a box as you go in."

My father had died suddenly, of a heart attack. My stepmother had been taking a bath, and had heard him crying out. I pictured her naked, wet, shivering, her arms around his glossy head.

In her house there were no photographs of him. I had walked around during the reception, trying to find one. Barbara had had her picture taken with the Berrigan brothers, people like that. But nothing with my father; in his office that evening, I picked a framed photograph out of the box by the door.

He shared space with some lawyer friends in a one-story professional building, not far from his house. I sat down at his desk with the photograph in my hands. It showed Barbara and him together. She was wearing a low-waisted dress. Her braid hung down her back. She turned toward him, smiling.

He, by contrast, looked raffish and unkempt. He stared towards the camera with a puzzled expression on his face. His black hair was uncombed. He wore an Irish sweater and his big chest bulged importantly.

I propped the photograph on his blotter and sat looking at it for a little while. Why was his hair still so black? Perhaps it was one of the things that had united him to Barbara—the fact that both of them had retained their natural hair color long after most people, my mother for example, had turned gray. I remembered searching his medicine cabinet for hair dye when I was about sixteen. I had found nothing.

It was cold in his office. I got up and pulled out a few drawers of his file cabinets, not knowing what to do. Everything was neatly labeled—copies of storyboards, records of old jobs.

Elaine, my father's assistant, had showed me the dumpster in the parking lot when she had dropped me off. I started loading the files into some trash bags, which were already half full. At first I was conscientious, glancing through each folder. It started to get dark outside, and I turned on the light.

I threw out everything from one cabinet, but the bottom drawer was locked. My father had hired Elaine only two weeks before he died; she had given me his keys, but she didn't know what locks they fit. I picked through the ring and then sat down again.

Now I can say I knew it. I knew it, I knew I had found something. And maybe Barbara, testing that drawer, had felt the same thing. Maybe that was why she'd gone away, unable to proceed. Memories of feelings are so colored by the lights thrown back on them, here, now. I can be sure I knew. I searched for the key for almost an hour. The window to the parking lot was completely dark when I found it, hanging from a nail in the closet, high up above the door frame. I knew as soon as I touched it what it was.

Almost I was afraid of finding something trivial. So at first I leafed impatiently through the models' head shots in the first part of the drawer. There was nothing distinctive about them except for the neatness with which they were arranged—Male/Blonde, Female/Blonde, Male/Dark, Female/Dark—each category in a separate hanging folder.

But the drawer slid out and out. There were short stories in manuscript, creased in thirds, as if they had been sent through the mail. I thumbed through them, looking for the seamy parts—one was full of hard homosexual imagery. It was a story about a father chastising his young son.

I found a manilla envelope containing pages and pages of small notations, all in my father's printing. "F H, 11/2/79, 1pm? #3 only"—the dates went back fifteen years. More photographs in another envelope, snapshots this time. All women, all ages, some naked, most not. I recognized some people from the funeral, also Elaine. She was standing in the woods, a red sweater tied around her waist.

The final two folders in the drawer contained letters from a single correspondent, and what looked like copies of my father's replies. At first I was excited, and repulsed also to find myself in such company—the first file was labeled "Letters, Jack." There were hundreds of them, and it took me a while

"And then in a manic high, I fly all over the world in just one night giving gifts, trying to please everybody!"

to decide that they were not from me.

My fathers' contained no salutation or signature, just a solid block of text often without paragraphs. The other man sometimes wrote by hand, the first letters were in a childish script, and they were difficult to read. Difficult even to glance at—I leafed forward to the spring of 1982, when he started using a typewriter. He said, 'Dear Jerry," which had been my father's nickname. Once: "Dear Father." Once: "Dear Dad." One was signed, "Your loving son." "Your loving son, Jack."

This was a game they'd played, perhaps in place of sex—a make-believe father, a make-believe son. "Dear Dad," one letter read. "I'm happy to have got the chance to see you when you were in town. I'm still excited from your visit, and I don't have so much to say, only that I'm glad you had a chance to see the apartment, and see I was not being so extravagant. I know you will always think I spend my money on expensive things, so I'm glad you could be with me and share my life, if only for one night. Next time you should stay for longer. Dinner was delicious. I haven't had a meal like that since the semester started."

The box by the door included an unopened phone bill. I had seen it as I came in. My stepmother had put it there, intending, I suppose, to pay it later. I retrieved it now and cut it open—pages of long distance calls, many to a single number in Oakland. My father had accepted collect calls from the same phone, sometimes twice a day.

I sat back in my father's chair. And this is the part I don't remember well—I sat there a long time. I'd like to think that I was shocked, disgusted, hurt, but I don't think it's true. Only I was looking at my father's phone, imagining his hand on the receiver, his lips so close to it—how many times? Nothing remained of any words that he had said. There was no mark on the plastic—I don't remember dialing the number, but then I was letting it ring until an answering machine picked up. This is 964-3187," it said. "If you'd like to leave a message for Jean-Jacques Brauner, please do so after the beep."

I hung up and continued reading. The last folder was labeled, "Letters, Jack (II)." And then, as if an afterthought, 'My only son—the words printed just like that in my father's intolerably precise hand.

"I'm sorry," Jacques wrote in 1987. "I know how angry you are. But I just wish you'd say it instead of brooding. If I was there you could just show me and get it over with, but I'm not, so you'll just have to.

To which my father had answered: "I think you're making a mistake. Eric is your boss, he's the one that you should worry about. Joanne's not in a position to harm you, so her opinion doesn't matter. I know you always want to accommodate everyone, but it's a trait that gets less charming as you age. You may pretend you're trying to be nice, but really, it's a form of insecurity and self-hate. I'm telling you this because I know. . . ."

When my father was dying, when he was actually dying in my stepmother's arms, was this the image in his mind? Me with this file of letters, sitting in his chair? Or Barbara? "I'm sorry to hear about Barbara's operation," Jacques wrote in 1989. "It must be very depressing to her. No matter how much you try to convince yourself that these things aren't important, it alters the way you think of yourself, like wrinkles, or losing your hair, though of course much

> "When my father was dying, when he was actually dying in my stepmother's arms, was this the image in his mind? Me with this file of letters, in his chair?"

worse. It's funny, it feels like I know her very well, enough to reassure you that I know she'll be all right, and that you're worrying about nothing. . . ."

I dialed the Oakland number again. The man's voice was pleasant, his intonation slightly strange, not quite American, perhaps. After the beep I said, "Listen, this is Jack Modine. I don't know how to say this, and maybe you already know, but my father had a heart attack on Thursday morning. I just wanted to tell you, and to ask you please not to send any more letters, because I don't want them forwarded to my stepmother. As I say, it was very sudden, and he wasn't in any pain."

I paused for a moment—it seemed so strange. I also have a tendency to accommodate, not that my father had ever remarked on it. "Don't worry about anything," I said. "I'm telling you because I guess you cared about him. If you want to know more, I'll be home after the fifteenth. My number is . . . ," I said, and I gave him the number of my apartment in Meridan.

I called him again a few weeks later and then a few times after that. I never got the answering machine again, and I never said anything either. I would just listen to him go "Hello? Hello?" and then he would hang up. After a while he disconnected his phone. But I can remember at least one time when I was at the height of my craziness, I suppose—I dialed his number just to listen to the recorded message from the phone company.

I look back on that from a life which is, if not happy, at least regular, at least full of a routine. And it contains, I feel sure, some of the ingredients of happiness. Now I am able to isolate them—friends. Sex. Work. I have hopes that someday I will learn to mix them in correct proportions. But I was desperate then, and part of the reason was that everything I had discovered about my father seemed unreal so quickly. I threw it all into the dumpster. The unknown, beating heart of my father's life—I threw it in the garbage. I didn't even read most of the letters. Late that same night I got up from the bed in my hotel and got dressed. I had some idea of finding the bus station and waiting there until morning, but instead I walked around the streets of Santa Monica, trying to retrace the way back to my father's office. I wanted to look over his letters again. I wanted to go through them and read over where he mentioned me—I remembered once I went out to visit him and Barbara. He came down into the kitchen at three o'clock in the morning to find me watching TV, and he took me to an all-night hamburger stand somewhere. "The best egg creams in California," he said. Surely, I thought, he would have told Jacques about that. I remembered the date, or at least the year.

I didn't find the office again. The vial of ashes Barbara gave me—I threw it away too. By the time I got back to Meridan that phone number in Oakland was the only thing left, and when I found out it had been disconnected, I felt as if some essential link had been destroyed. A link to urgent knowledge—now it seems obvious. Now it seems easy to say where my trouble really started. In the absence of facts, in the absence of anything to hold on to, I began to imagine a whole world.

And the moving spirit of that world was Jean-Jacques Brauner. From the beginning, of course, I had been thinking about him, trying to make a picture of him in my mind. Or rather, not trying—the picture came by itself, and I found myself looking at it hour after hour. It was so clear. I began to think it must be founded on something, some snap-

CONTINUED ON PAGE 92

INTERVIEW

HE THINKS OF THE EVOLUTION OF ROBOTS IN BIOLOGICAL TERMS: "WE SHOULD CREATE DOZENS OF ROBOT LITTERS, CARRYING THE FITTEST IDEAS FORWARD."

PHOTOGRAPHS BY ROBERT CLARK

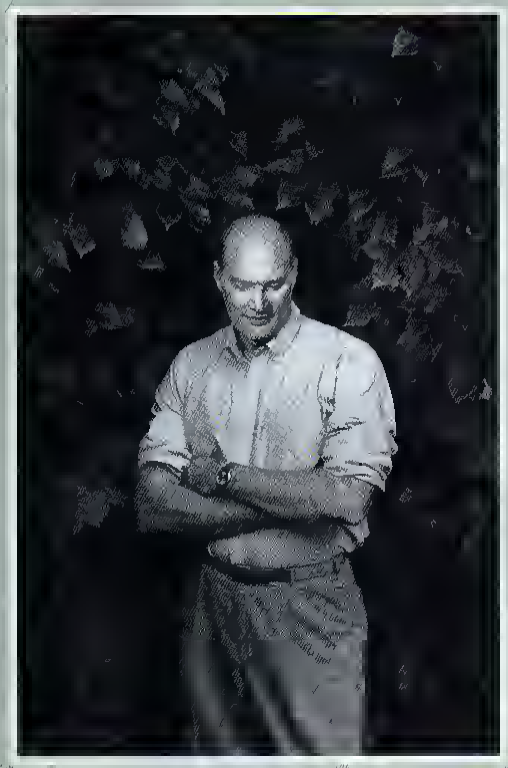
RED WHITTAKER

After working all night in his tiny, frigid basement workshop at Carnegie Mellon University Professor Red Whittaker torqued down some last bolts on his new robot. A few hours away on this winter morning in 1984 was the final test run of his reconnaissance vehicle. Whittaker was about to send his robot on a mission into the Three Mile Island (TMI) nuclear plant to explore the deadly radioactive basement of the Unit 2 reactor building. The robot would send back the first murky-green pictures, as if from another planet. Meanwhile, at the computer center across the campus, a preeminent robotics theorist was putting his little machine Neptune through its paces. It trundled down a hallway in search of a teacup to retrieve.

From the start, William "Red" Whittaker has eschewed the academic mode of building a few toylike robots and writing papers about them. He has made

mobile devices as rugged as Maytag washers and pushed them out of the lab to do real work. "In moving through the world they must cope with the unexpected," he said, "and their intelligence will evolve." By 1986, desperate for more lab space, Red saw the shell of a building the trustees had purchased from the Bureau of Mines. Late one night, he kicked in the door, claiming squatter's rights for the Field Robotics Center (FRC) he now directs. His corner office looks out on a courtyard where his machines exercise.

Vaguely resembling a six-foot-tall bug with eight purple legs, his latest piece of work, Dante, is a rock climber. Sensors in the tips of its spindly legs find footholds, and Dante uses a rope to rappel. More remarkable, Dante itself decides where to step and how to pick its way. Funded by NASA and the National Science Foundation, it was built to take instruments into the volcano Erebus on Ross Island, Antarctica.



After Christmas 1992, Whittaker and his team huddled in a primitive hut 500 feet from the 12,350-foot summit. A fiber optic tether linked computers and TV monitors to Dante, crouched at the fuming crater's rim. At Red's command, the creature slowly came to life, rising to take its first tentative steps of the descent. One day, Dante's heirs will explore Earth's polar icecaps and venture into the canyons of Mars.

Dante's forebear—Ambler—was the world's first robot to take steps on its own. Red created it for NASA as the prototype of a planetary superrover. Resembling two Snap-On tool chests stacked on six chrome stilts, Ambler is a huge machine. It reaches a height of 16 feet by raising its body on a chain drive inside each stilt to step over boulders or out of crevasses like those on Mars. Calculating 90 seconds before taking a step, it chooses its path with meticulous care.

In Red's Pittsburgh warehouse on a recent Sunday, the dolly for an acetylene torch leans against a computer console. A dozen machines stand in varied stages of their evolution. A thermal-tile inspector for NASA sits under a mock-up of the space shuttle underbelly. Whittaker pauses at a self-driving cart created to haul Dante over rugged terrain from base camp to Erebus's peak. The cart looks like an off-road dragster, with aggressive tires mounted on eight big wheels, dual chrome tail pipes. "You should see this thing go," he says.

Whittaker has assembled a gung-ho team of robot builders: mechatronic wizards, computer hackers, tinkerers. The bald and the hairy, the young and the old," he says. "An engineer to cut twenty thousand lines of clean software and a knuckle scraper to bolt up a ton of iron." The team welds theory, artificial intelligence, sensors, and gears into entities that go out on the job: unmanned coal excavators, submersible sewer cleaners, autonomous trucks hauling rock at strip mines, rovers to map nuclear-waste burial sites.

As a teenager in Hollidaysburg, Pennsylvania, Whittaker laid railroad track and did construction work. After high school, hitchhiking to New York one afternoon, he was dropped off at Princeton University. The next day he enrolled. From there he went to Carnegie Mellon for a doctorate in civil engineering and stayed on to teach. At 46, he still has some hair with a hint of the color that gave him his name. Tall and strongly built, he opens a door. "Let's go this way," he directs, "it's the same number of steps." Red's thinking like one of his robots again.

I first met Red ten years ago, reporting for *Omni* on the small army of technicians gathered to clean up TMI. Having driven his new machine to the plant himself, he was halted by the gatehouse guard who doubted that in the back of his truck was the world's first robot mobile worker. But over the next five years it and its progeny labored tirelessly as vital partners of the engineers who rescued TMI. When I saw the robot in a warehouse on the island, its stainless steel fittings glistening in the fluorescent light, it looked at me with the deep, dark eyes of its cameras. Red's creatures back then didn't exhibit intelligent behavior, yet this one seemed staunchly resolute, as if waiting to prove that it could do the job.

—Paul Bagne

Omni: Why did you create Dante?

Whittaker: To show that robots have the skills to explore in some of the harshest conditions on Earth, as a stepping stone to the planets, and to give Earth scientists new tools for studying active volcanoes. To get data to predict erup-

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tions or learn how volcanoes interact with the atmosphere, scientists must get up to the rims and down into the smoking craters. At Erebus, volcanologist Philip Kyle and his team wanted to get gas samples and take measurements at interior vents and at the surface of the rare lava lake 700 feet down. Human climbers attempted this twice, but each time they were driven out by eruptions. Once as they lowered a team member by rope to within 30 meters of the lake, Erebus let lose a storm of flying rocks that could have killed him. Dante's mission was to go where human explorers could not.

Omni: Why did other roboticists doubt you could build such a machine?

Whittaker: We'd proposed to create a robot with extraordinary capabilities in ten months. With fundamental problems on every front—perception, reasoning, and locomotion—we were really hanging our tails out there. I even had revolts in my own shop. My experts were adamant that machine perception must fail in the bright, featureless environment of the Antarctic. Some critics doubted we could even get the thing to walk. When I said it was also going to reason about handling a rope, they just shook their heads. I countered that we had to have more faith in our technology, that one day we'll have to send the robots off, like children, into the world.

Omni: Do you remember what Dante's first steps were like?

Whittaker: I watched it from the crater edge. At first, it was calibrating, testing out its sensors and computer models of the terrain, checking to see that everything was working. Its motions were tentative as it came alive. Dante was nosed down at 45 degrees. While the terrain out front appeared level through its cameras, it knew from other sensing that it was steep, yet it had no fear in looking down a volcano. Same's true in nuclear settings where humans get rattled. Taking radiation doesn't matter to the machine.

Dante next chose to lift its body up high to get a better view. Soon it was stepping ahead confidently, reaching out and planting one foot, then another—like a rafter planting a pole—to pull its body forward. It was thrilling to see Dante choosing its path and footfalls, using the rope as it rappelled.

Omni: What went wrong?

Whittaker: We designed Dante to use a lightweight climbing rope with a hair-thin optic fiber at the center. From an onboard reel, it plays this rope out as does a spider. A month before we left for Antarctica, we saw we weren't getting enough data through this filament. Unable to remake the tether in so short a time, we appended a separate fiber optic line, wrapped like kite string that unreeled as the robot progressed. It seemed simple, worked in tests, and we were off to Erebus. As the robot climbed into the crater we started losing data. After descending 21 feet, the line kinked again and snapped. Dante was cut off from the main computer in the hut and couldn't go on. The failure of the tether was like getting a flat tire in a new car.

All machinery onboard—computers, sensing, and control—were functioning. One of us climbed down to the robot and hooked in a hand-held terminal. Dante's inherent ability to climb with the rope had survived. We talked about letting it climb back up on its own but decided we had to make certain it got back safely. We commanded the robot to lift up so we could slide a sheet of plywood underneath it. Rather ignominiously, it sat down on the board and lifted its legs. Then we dragged it up with a rope and winch.

Omni: What will become of Dante?

Whittaker: Just after Erebus, eight volcanologists were killed in South America at the rims of two volcanoes that blew up in their faces. Suddenly the danger of this work really hit home. Researchers planning to enter an active volcano in the Alaskan range, who'd heard of our project, asked NASA to fund a mission for Dante to climb into Mount Spurr. So humans will not have to risk their lives, Dante and my team will be off to Alaska next summer. We're reworking the tether and designing in more autonomy, so if Dante is cut off from the main computer or faces other problems, it can still go on to accomplish some objectives.

Omni: What is the new machine you've proposed for NASA?

Whittaker: This field worthy planetary rover builds on new technologies. Akin to Dante in appearance—buglike—it's solar powered and uses miniaturized, hardened components. Project managers at NASA say, "Crawling into a volcano is cute, but so what?" They want a machine to cope with problems as they arise, traverse a thousand kilometers, and withstand Marslike conditions. For this robot, we will really tighten the rules of the game, from the temperatures to the light levels to the telemetry of an actual Mars mission. We're imposing on ourselves a standard of reliability that's a leap forward. This machine will walk alone through the Dry Valleys of Antarctica.

I'll put down 1,000 miles of footprints and do whatever it takes to convince NASA that a robot can explore Mars. It has

as much to do with machine decision making and control as it does with hardware. A robot will fail just as directly by making the wrong intellectual move—like entrapping a leg or losing balance at the edge of a cliff—as it will from a component breaking down. Looking through a monitor at a teetering machine, you want to reach out and grab it—you go right for the joystick. But in honest simulation, since the signal takes so long to get from Mars, by the time you see it, that bad step is something that happened 15 minutes ago. For planetary exploration, machine self-reliance and autonomy is critical. Humans can't be there to help.

Omni: Are machines now capable of exploring the moon and planets?

Whittaker: Robotics has sped off like a bullet train. To reach out and grasp the advances in our science and technology would rip your arms out! Not so long ago, it was a big deal to drop a shoebox of gadgets on the surface of a planet and get back some pictures and weather reports. Robots now can walk, climb, and reason. Humans couldn't risk descending steep canyon walls or climbing along lava tubes. A robot could. Sending robots is about one-hundredth the cost of sending astronauts. The ethical constraint of getting humans back makes you take along a rocket to get off the surface, extra fuel, radiation shielding, oxygen tanks, and redundant hardware. That mass costs money to launch. And we could send many robots.

Omni: How soon could an advanced explorer robot go?

Whittaker: We could put a rover on the moon within a few years, on Mars within five years. If NASA formulated a mission, we'd integrate the robot with the launch system, spacecraft, and lander. Do the science people want a core sample? We'd need a machine capable of drilling. What instruments and payloads must the machine carry? We'd develop and prototype the robot quickly, then push the things we want to do better. Instead of settling for camera vision that's already space qualified, we'd go after laser scanning. We'd push for robot autonomy because it absolutely defines what can be accomplished—how far the machine can range and the work it can do. We'd connect with experts in space telemetry, composite materials, and so on, from universities, industry, and NASA.

Omni: Why do you say science should not be the only motivation for a planetary mission?

Whittaker: I want to put a roaming eye on Mars or the moon, take a rover that could range a few thousand kilometers, give it high-resolution stereo cameras and microphones to telecast the wonders of being on another world right into our living rooms—a space mission for the people. Typical Mars scenarios driven by planetary scientists have burdened robotics initiatives. The rover sample-return mission, NASA's big motivating program for the Eighties, was finally killed because scientists wanted to search for water under Martian polar caps, extract helium 3, and put gamma spectrometry on board. Biologists said we couldn't shake up or heat the sample, so we couldn't use a drill. To get it back, we needed a rocket, fuel, and orbital gymnastics. It got so complicated and expensive that it couldn't be done.

Let's say science *is* the reason we go. I can't think of a richer source of data than a two-year telecast by a rover. Scientists could learn more by processing this video stream than from examining samples. A roving camera could drive up to an exposed canyon wall and study it for weeks. A robot with arms and manipulators like a field geologist could crack open rocks and look inside.

Exploring Earth was such a gradual thing. Discovering the continents, crossing the Atlantic, climbing the Himalayas had nothing to do with scooping up a soil sample. It had to do with being there. Machines can roam and discover things for decades. The first explorers to ascend volcanoes, wander through the valleys of ancient rivers, scale canyon walls of Mars will be robots. Of course, the robot is not going to Mars to decide on its own what to do, say, to set the record for machine speed walking. It's there to do our bidding.

Omni: What's your idea for an integrated space robot?

Whittaker: The usual scenario has a lander touching down. The doors pop open, ramps come down, and off drives the buggy. The lander is the big guy with the structure and solar panels, radio and footpads. It just stands there. Since these components are the same ones the robot needs, why not just have one machine that flies to the planet, explores, and does science? The computer you use to fly and land is the same one you use to rove.

Omni: Did the idea of a huge rover like Ambler walking across Mars come to you in a dream?

Whittaker: Here's a planet with boulders a meter high, so the robot should be tall enough to step over them. Research on Mars will often take size and force. One digs with a backhoe, drills from a platform, or gets up high to take a picture. For many reasons, bigger is better, but I'm not absolutely committed to

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ANTIMATTER

UFO UPDATE:
UFOers kicked up their heels with rock star Richie Havens at New York's hip Village Gate

UFO conventions tend to be somber affairs, with people focused on eyewitness accounts, alien abductions, and data on nighttime discs. But this past spring, a new type of UFO convention hit the floor of Manhattan's chic Village Gate, a club well known for melding music, comedy, and the politics of the liberal elite.

Setting the tone was legendary rock star Richie Havens. In a surprise appearance, Havens opened the festival with a rendition of "Blood on the Tracks." "I contacted Havens because he has an interest in UFOs from his many sightings at rock concerts," explains festival organizer Michael Luckman of the New York Center for UFO Research. "The audience loved him."

To Luckman, Havens represents the wave of things to come. "Entertainment is the vehicle for reaching the public," Luckman declares. "Festivals like this represent a future wave upon which new members of the UFO community can ride."

And judging from the crowd at the Gate, the ride will be furious and fun. In addition to Havens, those at the fest heard "the world's first UFO rock group," ALOID and The Interplanetary Invasion, performing songs from their upcoming CD, *Earthbound*, scheduled for release early next year. The crowd thrilled to the title song, "Abduction": *Gray figures in the still of the night / Flying saucers in and out of sight / Mad dog barking at the side of the road / You're paralyzed and lose all control / Abduction, taken against your will. / Abduction, was it more than a thrill.*

As it turns out, ALOID'S haunting lyrics set the stage for another work of performance art—*Believe Me!*—a UFO play by Jean Mundy, a psychotherapist and professor emeritus of psychology at Long Island University. "The play," said Mundy, "deals with a family's stunned reaction to their son's close encounter. I want the audience to realize that it's not only okay to acknowledge UFO sightings, but essential to your mental health and the health of our society."

At the Gate, that acknowledgment also found voice in the realm of crafts and art. John Tamanakis of Hudson, Massachusetts, for instance, was selling a full line of UFO jewelry, including tachyon beads that he says "work like a magnet for positive universal energy." And Manhattan art gallery owner Leslie Palanker was at the Gate to sell UFO oil paintings and papier-mâché sculptures saturated with glue. The artworks, ranging in price from $45 to a few thousand dollars, "have already been placed in several major art collections across the country," Palanker says.

The conference also premiered two new UFO films: *Are We Alone?*, a one-hour documentary based on the book *Genesis Revisited* by Zecharia Sitchin, and *UFOs: Top Secret*, a commentary on sightings in the former USSR.

What did attendees think of the festival? Anthony Brazil and Catherine Lee of Manhattan, there in hopes of meeting some abductees, said they had a great time. Chuck Walker, a real-estate broker from Port Washington, New York, called the festival "a good, small conference. Three world-class psychics told me I'd have a UFO experience in Peru." As for Luckman, he says the fest was all he hoped it would be. "I want to hold similar festivals in other cities and, ultimately, stage a UFO Woodstock-type event in upstate New York."—*ANITA BASKIN*

ANTIMATTER

FETUS FANTASY

During the course of a UFO abduction, Earthlings are allegedly kidnapped by aliens and put through various medical procedures. In the most bizarre of these, women are purportedly impregnated, only to have their hybrid fetuses disappear.

But recent research by psychologist Michael Persinger of the Laurentian University in Ontario suggests that reports of alien impregnation are greatly exaggerated, if not completely false. According to Persinger, research reveals that false pregnancy is more common than previously thought. What's more, the women who experience it are more prone to fantasy than women in the population at large. These two statistics, he adds, could account for the "lost fetus" phenomenon, attributed by some to UFOs.

To arrive at his theory, Persinger asked 106 college coeds if they had ever experienced missed periods, abdominal enlargement, morning sickness, and breast changes that they mistakenly attributed to pregnancy. Surprisingly, 22 percent said yes.

These same women, Persinger found, also tended to hold more unusual beliefs in phenomena like poltergeists and UFOs and had higher levels of temporal-lobe brain activity, indicating a higher level of imagination. Finally, the 22 percent were more likely than controls to report memory blanks and night paralysis, symptoms common to abductees.

Abduction researchers convinced that human-alien offspring are not fantasy but fact, of course, find it hard to accept Persinger's claims. But Persinger is convinced his explanation will hold. "There is a strong case," he says, "that we have discovered what is going on."—Paul McCarthy

CLOSE ENCOUNTERS OF THE PRINT KIND

If you're an E.T. living on Earth, you've probably felt lonely. But now, thanks to the entrepreneurial efforts of Manhattan Beach, California, publisher Irene Ya Ling Chen, 31, you have somewhere to turn. Chen's inspired creation, *Unicus, The Magazine for Earthbound Extraterrestrials*, launched three years ago after extraterrestrials from the Pleiades star system reportedly contacted Chen herself.

Unicus editor Robert White Eagle Stanley was one of the first staffers to come aboard. "We are becoming a race of extraterrestrials slowly but surely," Stanley asserts. That view is echoed by *Unicus* contributors, including Verlaine Crawford, who channels Ixaca, "an angelic, sixth-dimensional being," and Texas-based UFO contactee Elizabeth Berg, who says she bore a "hybrid star child" after artificial insemination at the hands of E.T.'s. Other articles cover technology from Atlantis and the new species of being scheduled to infiltrate Earth this decade.

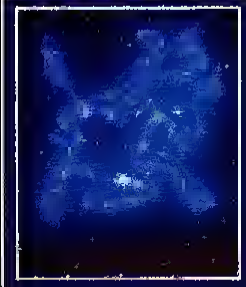
An avowed Earthbound E.T. herself, Taiwan-born publisher Chen aims to keep the quarterly magazine as otherworldly as possible. "In my soul, I am an extraterrestrial," she confesses. "But right now, I'm committed to being here on this planet to work and live and learn."

As for *Unicus*, Chen believes it will continue to

CHEN SAYS ALIENS CONTACTED HER AT 2:00 A.M., HEATING HER HEAD AND FEET AND PLANTING THE VISION OF *UNICUS*.

expand and become a radio and television empire. In fact, her UFO-induced vision of *Unicus* came complete "with a seventeen-story building off the freeway and a sign that said *Unicus International* on it." With six issues under her belt, Chen already boasts 30,000 subscribers—an impressive feat.

—Quendrth Johnson



ASTROLOGY ALERT

Reading your daily horoscope may seem like a harmless pastime, but the Committee for the Scientific Investigation of Claims of the Paranormal (CSICOP) doesn't think so. In fact, CSICOP Executive Director Barry Karr says that "when people look to the stars for control over their lives, astrology can be dangerous." So to warn the public, the Buffalo, New York–based skeptics group is urging newspapers to print this disclaimer: *The following astrological forecasts should be read for entertainment value only. Such predictions have no reliable basis in scientific fact.*

But does anyone really believe newspaper astrology predictions in the first place? "Yes," answers Dick Martin, editor of the *Kenosha News* in Wisconsin. "Whenever the horoscope's accidentally left out, people call and say they don't know how to structure their day. Publishing the disclaimer makes me feel better about running the astrology columns." The *Salem Ohio News* has also recently agreed to carry the warning. "We are in the Bible Belt, and it shows we don't take horoscopes seriously," notes managing editor Cathie McCullough.

But Barry Karr laments that few newspaper editors agree. In fact, CSICOP has thus far convinced only 60 editors to run the disclaimer. The majority, like the *Atlanta Constitution*'s managing editor John Walter, say it's not needed: "Most readers take their horoscope with an appropriate grain of salt."

—Sherry Baker

ODD OX

Picture an animal that combines the features of cow, antelope, horse, and ox. The image may be odd, but it describes, rather precisely, an animal recently found in Vietnam's remote Du Quang nature reserve, about 170 miles southwest of Hanoi. The strange beast has been designated *Pseudoryx nghetinhensis* by British biologist John MacKinnon of the World Wildlife Fund.

Although locals knew the animal existed, it was unknown to science until MacKinnon and a team of Vietnamese researchers came across a Pseudoryx skull in a hunter's hut. So far, the scientists have examined hide, teeth, and skulls from more than 20 Pseudoryx—but they have not yet seen a live one.

According to MacKinnon, DNA tests on 11 specimens show that the animal is a primitive ox that evolved about 10 million years ago. Covered with a deep-brown horselike coat, the Pseudoryx sports deerlike face glands, dainty feet, and 20-inch-long horns.

THE OXLIKE CRITTER BELOW SPORTS DEERLIKE FACE GLANDS, DAINTY FEET, AND 20-INCH-LONG HORNS

The creature's habitat, nearly inaccessible due to dense foliage and rocky cliffs, may have remained pristine for tens of millions of years, explaining why it is home to the Pseudoryx and, perhaps, other unknown species.

Adds cryptozoologist Loren Coleman of Portland, Maine, "MacKinnon's discoveries prove there could be other animals still living in uncharted parts of the earth."—Sherry Baker

THE LAST

CONTINUED FROM PAGE 47

The leptons came first. In 1897 J. J. Thomson, an Englishman, discovered the first elementary particle: the electron. Physicists at the time amused themselves by building cathode-ray tubes: three-foot-long glass tubes filled with gas, with metal electrodes at either end. Electricity from a battery would be applied and the tubes would glow (neon signs work the same way). As early as 1830, Michael Faraday had predicted that electric current was made of individual corpuscles. Thomson proved it, showed that the cathode ray in these tubes was composed of particles: electrons. The next elementary particle to be found was the muon. It was also a lepton, a heavy cousin of the electron—200 times heavier to be exact. The year was 1937, and physicists used a cloud chamber to detect the muon's presence in cosmic rays. Its purpose in the universe was a great puzzlement at the time. The physicist Isidor Rabi, upon hearing of the discovery, said: "Who ordered that?" The neutrino, another lepton, was discovered using a nuclear reactor in 1956, and a second neutrino, the muon neutrino, was discovered using an accelerator in 1962 by a team that included Lederman.

The quarks, a second variety of uncuttable elementary particles, came later. The up, down, and strange quarks were found in the late 1960s at SLAC by bouncing electrons off protons and "feeling" the smaller constituent particles inside. The fourth, the charm quark, made headlines around the world, independently discovered in the same weekend in November 1974 by two different teams—one at SLAC led by Richter, the other at Brookhaven National Laboratory on Long Island, led by Ting. The charm quark had been predicted by a number of theorists including Sheldon Glashow, and Richter and Ting's experiments convinced all doubters that quarks were real. Totally unpredicted was a third generation of matter. Lederman found the fifth quark, called bottom (or beauty), at Fermilab in 1977. Martin Perl found its accompanying lepton, the tau, at SLAC.

When you add to the above the various bosons—messenger particles that represent the three forces—you have, voilà, the standard model (see chart). It's all very neat. The first generation of matter contains those particles that are found naturally in our present universe: up and down quarks, electrons, neutrinos. We stick up and down quarks together to make protons and neutrons. Add electrons to make the atoms of the chemical elements. Neutrinos lubricate various essential reactions. For example, the sun wouldn't shine without neutrinos, which it spews out in such quantity that a billion penetrate your body each second.

The second generation also contains four particles: two quarks, the strange and the charm, and two leptons, the muon and muon neutrino. These particles existed in a much earlier universe. Today we have to make them in accelerators or observe them in cosmic-ray collisions.

The third generation is also from the very early universe and includes the bottom and top quarks, the tau and the tau neutrino. There's but one problem with this neat picture. The top quark, as discussed, is missing. If you look at the standard model chart, your intuition should swiftly tell you that it must exist.

> "I'm an experimenter. I love to smash theories. But the whole edifice would collapse if there is no top quark."

Our human sense of symmetry cannot tolerate an asymmetrical theory. A family (generation) of matter with only one quark while the others have two quarks offends our sense of aesthetics.

But there are more technical reasons. "People have tried to figure out a world in which the top quark doesn't exist," explains Glashow. "No one can do it." If this quark must exist, why is it so hard to find? Glashow compares the top quark to Pluto. The existence of the ninth, and final, planet in our solar system was deduced by the middle of the nineteenth century from the wobbly orbit of Uranus. Something had to be upsetting Uranus in its path, and Neptune, discovered in 1846, could not be the entire answer. Yet it took astronomers another 84 years, until 1930, to find Pluto, because it's so small and so far away. Pluto is smaller than some moons and nearly 4 billion miles from the sun.

The situation is much the same with the top quark. All the particles in the theoretical vacuum push and pull on each other. The behavior of the bottom quark and other particles indicates that another quark must exist. Chris Quigg, Fermilab's chief theorist, explains that the bottom quark must have a partner, otherwise it would decay differently. What makes a particle difficult to find is heaviness rather than distance (as is the case with planets). The heavier the particle, the harder it is for the accelerator to manufacture it. As mentioned, Fermilab has determined that the top must weigh at least 113 GeV. By comparison, the next heaviest quark, the bottom, weighs only about 5 GeV. Theoretically, the top could weigh as much as 250 GeV, that's more than the mass of an entire uranium atom. The heavier it is, the fewer top quarks the accelerator can produce every billion collisions or so.

"Everybody is surprised at the heavyness of the top," admits Glashow. "But then, why is Pluto so far away?" Still, it would be exciting not to find the top. If the experimenters can search the entire theoretical mass range of the quark and prove that it doesn't exist, that would be a momentous finding. The standard model would crumble. "It's a great joy for an experimentalist to prove a theory wrong," says Lawrence Berkeley Laboratory theorist Michael Barnett. "Our field is driven by the desire to improve the past."

Sheldon Glashow sighs: "Maybe we have come to the end of the road. Maybe we now know all we can know."

Rare Signatures

In the Tevatron, a proton hits an antiproton 100,000 times each second, each collision an opportunity to make a top quark. The lab's two detectors, CDF and D0, sit there watching for decay products—energetic muons, energetic electrons, jets of hadrons—that might signal the birth and almost instantaneous death of the elusive quark. How do they know when a top raises its heavy little head?

To explain, Gene Fisk, a spokesperson at D0, agreed to meet me after a lecture at a conference attended by several hundred particle physicists at Fermilab. The meeting took place in the administration building, Wilson Hall, named after the lab's first director and founder, Robert R. Wilson. Wilson, an artist as well as a physicist, modeled the building after a cathedral in Beauvais, France, begun in 1225. Wilson Hall consists of twin 16-story towers leaning toward each other like hands held in prayer. Between the towers sits one of the world's largest atriums. Wilson saw physics as a quasi-spiritual calling, his physicists as priests seeking the

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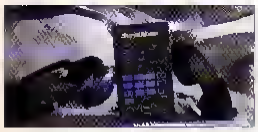

By Dane Spotts

After a stressful day at work, I put on my space age shades, plug in the 'Dreamtime" tape, and program my *SuperMind*™ computer for a "heavy-duty' Theta session. As I punch the start button I'm reminded of NASA's virtual reality machines. Those billion dollar video games that transport your consciousness into an artificial computer world you manipulate with voice commands and gestures.

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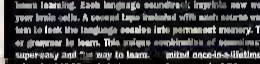

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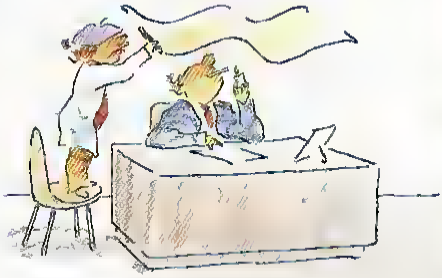

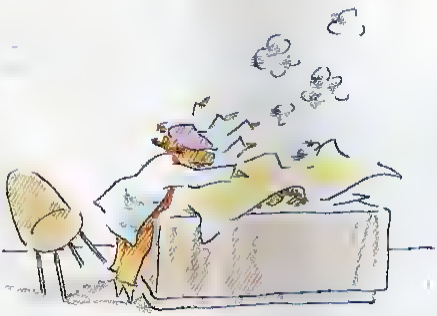

truth in a high-energy cathedral

I called Fisk to arrange a meeting. "Look for me in the atrium," he said. "I'm middle-aged, average height and weight. I have a beard, and I'll be wearing a sweater." Then he paused. "Uh-oh. I've just described seventy percent of the people at the conference."

"Okay," I replied. "I weigh two-hundred-thirty-five, have a long greasy ponytail, and I always wear bib coveralls."

"Good," he said. "I'll find *you*."

Spoken like a particle physicist. Fisk and others explained that physicists look for rare events rather than common ones. For example, a top quark commonly decays (eventually) into six jets of hadrons. But at Fermilab, they're more interested in rare signatures, such as the two-leptons-plus-two-jets mode described earlier or a single-electron-plus-four-jets or a single-muon-plus-four-jets. This is to eliminate background, those events that mimic the signature you're looking for. For example, the background ratio for the common six-jet signature of the top quark is more than 100 to 1. That is, for every legitimate six-jet top-quark event, there are 100 frauds.

So the triggers are set for rare events. A trigger is an item on a shopping list put together by the physicists that determines which events the computer should save on mag tape. Of the 100,000 collisions per second, the computer can select and store on average only four. Which four? That's the job of the triggers, which tell the computer which collisions are interesting, which are boring.

"You're looking, after all," explains Fisk, "for that one event in ten billion—or some number. A trigger is a set of conditions that an event must pass in order to fall into the sample of data that you want. Is there an electron? Is there a muon in the event? Is the electron's momentum perpendicular to the beam line? Is the muon's momentum perpendicular to the beam line? Is there a jet of hadrons? Two jets?" You're looking for a greasy ponytail in a sea of neatly trimmed beards.

Melvyn Shochet of CDF says electrons provide an important trigger. The computer is programmed to save all collisions that produce a very energetic electron—say, of 15 GeV or greater.

This complexity of triggering and mag tape ruins the Hollywood image of the scientific experiment. "Oh my God!" cries a white-coated scientist, "that inferral quark is finally mine! Stockholm, here I come!" Then the entire lab erupts in a frenzied orgasm of celebration.

This scenario is unlikely. First, they don't wear white coats. Most experimenters dress like roadies for Ten Thousand Maniacs or some other intellectual rock band. That is, they look like creative people—casual, but with a technical bent. A lot of them look like women, because they are. More important, "the big discovery" won't be made until at least a day after the event occurs as the researchers go over the tapes. And to eliminate the problem of background, several events will be needed. The scientists would also like to have events in more than one "channel." That is, they'd like to see the top reveal itself in more than one decay mode. And because Fermilab has two detectors, one would like to get substantial evidence from both D0 and CDF. Even then, the celebration may be short.

"There will be a party at Fermilab when the top is found," says Chris Quigg. "But we need to define the top mass in order to test the standard model." Quantum theory says that a short-lived particle's mass cannot be determined precisely (remember the uncertainty principle), one needs to measure several particles to define accurately a range of masses. How many? Rajendran Raja, senior physicist of D0, estimates that about 200 events would do

it. When that happens, the real celebration can begin.

As CDF's Shochet describes the thrill of discovery in modern-day particle physics: "The eureka moment is less well defined."

Napkin Story

One cannot talk about quarks without telling the napkin story. Every business has a napkin story. Physics is no different. In the 1950s and early 1960s, scientists knew about the electron, the muon, even the neutrino. Leptons: indivisible, as Democritus predicted, zero radius, pointlike, as Boscovich predicted. They were elementary particles. But what about the particles in the nucleus of the atom, the protons and neutrons? Physicists knew protons had some size; they couldn't be elementary particles. So what was inside?

Using accelerators, physicists bombarded protons with other particles, hoping to shake loose whatever little guys were hiding in there. They were in for a shock. Instead of blasting the proton into its constituent parts, the physicists merely produced new particles in the collision: pions, kaons, lambdas, sigmas, the xi-minus, and xi-zero. These are hadrons, from the Greek for "heavy," and clearly they were complicated particles, not the simple constituents physicists were looking for. We now know that a hadron is a particle composed of either two or three quarks. The proton and neutron are also hadrons, and these new Greek-letter hadrons were heavier cousins of the protons that were created out of the energy produced in the new breed of powerful accelerators of the time.

There were literally hundreds of hadrons being churned out. "Quarks don't come out when you hit the proton with electrons," explains Fermilab's current director, John Peoples. "Hadrons come out." It was depressing. Instead of simplicity—a few smaller particles—physicists were facing complexity—hundreds of large particles.

Enter Murray Gell-Mann. This Caltech theorist came up with the Eightfold Way in 1961, a scheme in which he organized all the hadrons into coherent sets of eight and ten particles (and some singlets). It was a wonderful organization, akin to Mendeleev's periodic table of the elements in the previous century. But it didn't really explain what was happening. Then came the napkin.

In 1963, Gell-Mann gave a seminar on the Eightfold Way at Columbia University. Afterwards, at lunch, Robert Serber, a Columbia theorist, asked Gell-Mann why all the hadrons couldn't be explained with three subunits. Gell-Mann grabbed a napkin and showed Serber that there was a serious problem in thinking like this. These subunits would have to have fractional electric charges, –⅓, +⅔, and so on. Particles with third integral charges had never been seen.

Electric charges in the particle world are measured in terms of the charge on the electron, which has 1.602193 × 10^{-19} coulombs. Conveniently, the proton's charge is exactly the same as is that of the charged pion, the muon, and a pile of other particles. Therefore, we call the complicated coulomb charge above simply 1. Sometimes it's +1 (as in the proton) and sometimes –1 (as in the electron), depending on whether the charge is positive or negative. Charges come in integers—0, 1, 2—of the 1.602193 × 10^{-19} unit. In 1963, it was part of the physicist's intuition that no particle could have a fractional charge.

> "None of the service plazas on the Jersey Turnpike," points out Lederman, "are named after particle physicists."

After the lunch with Serber, Gell-Mann thought over what he had sketched on his napkin, and said, basically, why not? Gell-Mann, arguably our greatest living theorist, figured out a way to explain the universe in terms of three basic building blocks. He called them quarks, after a word in James Joyce's *Finnegans Wake*, and gave them individual names as well: the up (+⅔ charge), the down (–⅓), and the strange (also –⅓). Now it all worked. All hadrons are made of quarks, sometimes three, sometimes two. For example, the proton consists of two ups and a down (two +⅔ charges and one –⅓), which is why the proton has a total charge of +1. The neutron is made of one up and two downs, which is why it's neutral, with a charge of 0. Hadrons made of three quarks are called baryons. There are also two-quark hadrons, called mesons, composed of a quark and an antiquark. A positive pion, for example, is an up quark stuck to an antidown quark.

Perhaps Gell-Mann's cleverest idea was how he got around the objection that a particle with a ⅓ or a ⅔ charge had never been seen, despite the fact it would stick out like a sore thumb. He said there was no such thing as a free quark. It was always trapped with two other quarks in a baryon or with an antiquark in a meson. This solved the problem of the quark's shyness. "If confined," Gell-Mann recalls 30 years later, "they wouldn't have to come out."

Some writers have claimed that Gell-Mann got cold feet about his own hypothesis, saying that quarks aren't "real," but purely mathematical. John Peoples recalls that when he was a young graduate student, Gell-Mann told him not to worry about looking for quarks, that they were merely "a bookkeeping device." Gell-Mann bristles at the idea now well publicized, that the king of the quarks believed it was fruitless to look for his own creations. "Most of what's been written," he asserts, "is a plain lie."

Of course, theorists and experimenters have been at each other's throats through the years. The theorists call the experimenters mere plumbers. In response, experimenter Lederman tells a story about a theorist as a young boy drawing a picture.

Mother: "Johnny, what are you doing?"

Johnny: "I'm drawing a picture of God."

Mother: "Don't be silly. Nobody knows what God looks like."

Johnny: "They will when I'm finished."

Insults aside, Gell-Mann was perhaps more right than he ever imagined. The experimenters found his quarks even though they couldn't shake them free. Bouncing electrons off protons, they detected the quarks inside. Or, in the case of the charm and bottom quark, the physicists—Richter, Ting, Lederman—created mesons in which those particles were lashed to their antiparticles. Gell-Mann's original three quarks swelled to four, then to five. "The fifth was unexpected," says Gell-Mann. "Nobody predicted it." Like all other physicists, Gell-Mann says that the fifth quark, the bottom, must have a partner, the top. If it doesn't, he adds, "A whole lot of ideas will have to be changed."

A Free Quark?

The top quark makes one a little queasy. The estimate of its mass keeps rising. The heavier it is, the harder it will be to find. If the top mass is less than 160 GeV, says CDF's Shochet, Fermilab will find it by the end of the current run, scheduled to end in December 1994. If the mass is much higher than

160 GeV, Fermilab will have to wait until its new injector is built in 1998. The injector is a separate accelerator that preaccelerates the particles before they're fed into the Tevatron ring. This will allow the physicists to put more protons into the Tevatron and increase the luminosity (the collision rate) from the present 100,000 to 5 million per second, thus vastly increasing the chances of producing a top quark.

Paul Grannis says the favored mass region for the top is between 125 and 175 GeV, and adds: "I think we'll find it at Fermilab." But if he's wrong, and the top weighs in at 225 GeV or more, then Fermilab, even with the new injector, is probably out of the picture. Then the search for the top would have to be switched to some larger machine to be built in the future. It was hoped that the Superconducting Super Collider would be that accelerator, but Congress killed the SSC this past autumn.

Even before it's found, the top quark is displaying some troubling characteristics. Remember Gell-Mann's cardinal rule: A quark is never free. Yet it appears the top quark is. John Peoples explains that the top is too massive to make a hadron. When a collision in the Tevatron yields enough energy to pop a top quark into existence, it must create an antitop as well. In the cases of every other quark, the two particles would form a meson, a hadron. "But the lifetime of a top quark is so short that it can't form a hadron," explains Peoples. "It can't go around even once. That's my definition of how long it takes to make a hadron. You have two particles going around each other. They have to go around at least once."

This makes life miserable for the experimenters. When the charm quark was discovered, it produced charmonium, a meson made of a charm and an anticharm quark. The bottom quark and its antiparticle produced "bottomonium." Shochet explains that such mesons are convenient to detect. Gene Fisk agrees, saying the top quark is fundamentally different in that it can't form these nice bound states. "There is no 'toponium,'" says Shochet.

A free quark? Such talk is threatening to the old hands. "Free schmee!" shouts Glashow. "It's like any other quark, except that it's very heavy." Even experimenter Lederman gets upset at the prospect. "No, no, no. A quark is never free!" Michael Barnett says the top quark isn't really free, it's just that it doesn't live long enough to attach itself to another quark. Talking to physicists about quark freedom or lack of same is like covering candidates on the campaign trail. "No, I didn't smoke dope, because I never inhaled," or, "I would have been a war hero had I not flunked the physical."

The top quark sounds like president Bill Clinton and Pat Buchanan lashed together. Fisk says the top isn't free because you can't produce it without making an antitop. They're "associated." As you can see, the "hard" science of high-energy physics sometimes enters the realm of philosophy when it deals with the comings and goings of individual particles.

Still, despite all the verbiage to the contrary, the top is a strange bird, making it all the more intriguing, all the more important to find. "It's the only quark we can see," says Peoples, because it never binds with its antiquark partner. Whenever one particle differs substantially from its ilk, it causes a minicrisis among physicists, who strive for symmetry, not unlike Democritus and the ancient Greeks who started this whole business. The top quark is causing that kind of unrest. With the Tevatron up and running again, this discontent will be eased if it finally definitively pins down this rogue particle—the sixth and final, bizarrely heavy, physically free but philosophically bound, top quark. Or, if after every possible search is made the physicists come up empty, science will face its greatest crisis in more than a century. The prevailing theory of the universe, the standard model, will be wrong, and there is no alternate theory standing in the wings to replace it. As Richter said, "The whole edifice will collapse."

And if it is found? Can we then disband the whole field of particle physics? No chance. Peoples explains that the top quark completes "our little periodic table of elements." But he says there are too many particles. "As soon as we have more than one, we're unhappy." No one can explain the different masses of the quarks—either why the top is so heavy or why the others are so light. No one really understands the repeating pattern of generations, two quarks and two leptons in each.

The now-defunct Super Collider was being built in Texas to address this problem. Its main quarry was the Higgs boson. The Higgs is not a matter particle like a quark or lepton, but a messenger particle that weaves a field, much as the photon creates electromagnetic fields. The Higgs field, goes the theory, gives the quarks an illusory mass. If it could be swept away, the top, the bottom, the up, the down, and so on, would be equal and massless—a simpler universe.

The dead Super Collider was also designed to beat up on the quarks and leptons, which we believe are indivisible, as Democritus insisted, and point like, as Boscovich required. The standard model doesn't explain why there are six quarks, says Glashow. Perhaps the repeating pattern hints at "prequarks" or "preleptons."

"As far as we know, there is no structure inside the quark or electron," says Lederman. "However, there may be entire civilizations in there."

Truth Quark

The bottom quark has an alias. Its discoverer, Leon Lederman, prefers calling it the beauty quark. If you subscribe to that term, then the top quark gets a street name also: the truth. Are we on the verge of the truth?

But there's a bigger question, a sociological one. When it comes to quarks and prequarks, bosons and leptons, the public asks, "So what?" Particle physics seems irrelevant to our daily concerns. 'Will it cure male pattern baldness?' jokes Peoples. Lederman points out that none of the service plazas on the Jersey Turnpike are named after particle physicists. Yet the questions that physicists raise strike directly at our notions of objective physical reality. How does the world work? How do we relate to it? Again, it all comes down to particles.

Ernest Rutherford discovered in 1911 that matter was mostly empty space. If the nucleus were the size of a pea, the electrons would be 300 feet away. The physicist and astronomer Sir Arthur Eddington, an important player in the revolution in physics that took place in the 1920s, pondered the idea of a world that was mostly empty space, solidity merely an illusion caused by particles racing madly back and forth. He said that every physicist has two tables in his mind. The first table is the commonplace object in our dining room. It's permanent and substantial. We place plates on it without fear they will fall through the wood. The second table is an object defined by twentieth-century physics. It is mostly empty space, filled in only by a gauzelike density of particles flying about. Notwithstanding its strange construction, it turns out to be an entirely efficient table,' writes Eddington. "It supports my writing paper as satisfactorily as table number one, for when I lay the paper on it, the little electrical particles with their headlong speed keep on hitting the underside so that the paper is maintained in shuttlecock fashion at a nearly steady level." Eddington goes on to say that physics has decided that table number 2 is the only one that really exists. Number 1 is a fraud. 'On the other hand,' he continues, "I need not tell you that modern physics will never succeed in exorcising that first table—strange compound of external nature, mental imagery and inherited prejudice."

It's like trying to imagine God. The "correct" answer is an abstraction. No intelligent person would describe a man with a long, white beard, yet it's hard to get that image out of one's brain.

We now all know that our world is composed of rapidly moving particles. People have suffered for this belief. Plato wanted all of Democritus's writings burned. Galileo took his lumps from the church. Boltzmann ended up on a rope. When the top quark is finally found, it will solidify a 2,400-year belief that invisible particles in constant violent motion explain the variety and complexity of our universe. It will justify the work and suffering of countless physicists over the centuries. Still, is this belief right?

We asked Fermilab's director John Peoples if he ever questioned his faith in particles, the belief upon which his science is based. He hardly paused. "Every day," he said. ☒

PARKES

CONTINUED FROM PAGE 54

past ten years. Rather, it may be more fruitful to identify certain aspects of narrative—those things that give narrative its richness and emotional content—and see if there are ways to apply them to what, at least for the next few years, is basically a game environment.

So, instead of dealing with the narrative as an unbreakable whole, let's "random access" the essential parts of narrative that can enrich the interactive experience. And wouldn't you know, they come with an acronym—the four C's of story: character, context, closure, community.

Stories deal with *characters* with their own attributes. As writers, we often deal with the issue of "character logic,' which is a fancy way of saying that people tend to act a certain way, and if you're going to write well, you have to create characters with consistent and predictable behaviors. Think of Michael Corleone's cold intelligence or Annie Hall's insouciant directness. Well-written characters act the way they want to—and not necessarily the way you, the writer, may want to manipulate them to suit your story. Games, on the other hand, deal with *icons*—two-dimensional symbols without character traits—which exist only to be manipulated by the player. They act as our stand-ins.

Stories take place in a *context*—whether factual or mythological, historical or psychological. They offer a specific, detailed world which reflects the writer's sensibilities. Games tend to be largely abstract, partially because of the present limitations of the technology but also because the emphasis in game design has been on the visceral reaction of the player. (This may account for why, despite the fun and excitement of a good round of whatever your favorite videogame is, you tend to feel buzzed but somehow empty.)

Stories have *closure*; they reach an inevitable conclusion. I'm not much interested in writing a version of *War Games* where the audience gets to decide if the world blows up. And I'm not sure if the stunning emotional power of *E.T.* would be the same if we could decide whether or not E.T. stays or goes or if Elliot could go with him. Fiction is about transcending the harsh realities of existence, if the realities are in a constant state of flux, it's hard to make a statement. This closed-ended quality—which underlies the very act of giving yourself over to the storyteller and his or her tale—might be the defining attribute of the narrative. Games, on the other hand, are open-ended. Sometimes you win, sometimes you win a little more, and sometimes you lose. Or you get a little farther in the adventure world or your *SimCity* is more populous and prosperous—but the endpoint is not predetermined.

And finally, while games are individually interactive, stories are *communally* interactive. While I do not have any effect on whether or not *E.T.* returns to his planet or if David Lightman blows up the world in *WarGames*, in another sense I interact with the story in a far more profound way. I talk about it with other people who have shared the same experience. I interpolate motives in the characters or extrapolate potential alternate storylines with the simple phrase of "What if?" I argue about a performance or an interpretation. This aspect of communal interactivity extends to television in a more immediate way;

> "We'd better understand what it is about games that seems to answer the entertainment needs of an entire generation."

I can talk to my wife about what Seinfeld just said or what the lawyer in *L.A. Law* just did without impeding the story—it moves on without my input. In fact, if you ever want to see how important this interactive aspect of entertainment is, the next time you have dinner with some friends, make the rule that no one can talk about anything dealing with movies or television shows or books they've read. It'll be a quiet evening, I guarantee. On the other hand—and this admittedly might be an adult perspective—I personally can't recall the last time I got into a heated discussion with someone about that amazing run on *Tetrus* I had last weekend. Electronic games are different every time you play them, which means they're not readily shared by your friends, your family, or an auditorium full of strangers. They are individual pursuits.

It is in these last two attributes that the inherent differences between games and stories are most apparent—and hardest to overcome. It, for example, stories derive much of their meaning and satisfaction from their sense of closure, then how can we tell a story in a medium that is by nature open ended?

One thought has been to have the interactive element deal with character and venue but have the final conclusion predetermined. Imagine a version of *The Hunt for Red October* in which you could choose to experience the story from the point of view of the Russian sub commander or the CIA analyst, from the office of president or the halls of the Kremlin, always working your way through the story to its inevitable conclusion. While this might be diverting for a while, I think it would run out of steam. Ironically, a story with a fixed endpoint may be open to infinite interpretations, but unless the pathways in an interactive experience have infinite possibilities, the player will tire of experiencing them.

So—when it comes to predictability and closure, these most defining aspects of narrative—I think we have to punt. But that doesn't mean new technologies won't allow us to inject other aspects of narrative into game playing. Take character. My understanding of 3DO technology is that it will be able to render the icon—the dinosaurs from *Jurassic Park*, for example—as fully modeled, virtually three-dimensional beings. Could we extend the notion of dimensionality to character traits as well? Instead of being just a surrogate for the player, might they not begin to have the fundamental aspects of personality: tearfulness, puckishness, deceit? Could they start to learn from the game player's tendency to respond to certain situations in certain ways and anticipate the player's action? Could an icon resist one's attempt to manipulate it because of who it is? Could it be subversive and try to trick you into making the wrong move in the game? Or, even better, could we as users become involved in creating the "personalities' of the different icons? As icons begin to take on their qualities, they'll no longer be just our stand-ins; they can become our partners in the interactive experience. They'll begin to become characters.

How about context? What is alluring about a great story is its ability to take you into another world—the success of *The Last of the Mohicans* is partially due to this. Movies and books can create an environment with tremendous detail, whereas most games tends to be abstract and quite cold. Imagine creating miniature sets, utilizing the skills and crafts that have been honed in Hollywood: fully realized, art-directed, detailed worlds. *Blade Runner* with its postmodern squalor; the witty, frightening nether world of *Beetlejuice*, or the

moody stylized atmosphere of Gotham City. How about the battlefield at Gettysburg built with stunning historical accuracy as the context for a war game? We could capture these images on video, digitize the information, and use them as the backdrop for an interactive experience with fully modeled 3-D icons as our partners in exploring these worlds. The structure of the experience would be interactive and gamelike, but the emotional involvement for the player could be of a whole other magnitude.

Finally, some words about community. I remember a few years ago the moment when my then-two-year-old daughter came to me a few months after we had taken her to Marine World and asked me the question, 'Remember the dolphin?' It was a major breakthrough in her becoming a person and in all of us becoming a family. Anticipating, remembering, and communicating shared experience gets to the heart of what culture is. Besides, I know that when I come home after work I'm looking for ways to relax and be entertained that don't isolate me from my family. There must be a way to open up the interactive experience so that it can be actively shared by a community—even if community means mom, dad, and the kids in the living room. This is an aspect of this emerging technology that deserves a lot more thought.

So, we might be on the brink of something. It's not the first time a technical breakthrough has had the potential to effect a qualitative change in how we render the world. It happened one time about 500 years ago. The time was the Renaissance, and the breakthrough was the discovery of perspective.

Painting before the Renaissance was exclusively religious in theme and two-dimensional in form. The human figure was rendered as a flat icon (there's that word again), rigid and locked subservient to the painting's inflexible structure, just as the human spirit was seen as subservient to the will of God and the dogma of the Church. Then, in the early Renaissance, painters began to discover and develop a way of seeing the world based on scientific principles that added dimensionality to their work, freeing the human figure from the ground and permitting the artists to render it with lifelike sensitivity.

Now, these artists did have the church on their backs, but they didn't have multibillion-dollar corporations trying to figure out how to best develop and exploit this new technology. And you can be sure they didn't get together to figure out what amazing new subjects they could paint with this great new tool. They kept making religious paintings. But the technique of perspective that liberated figure from ground was, in fact, a key step toward the secularization of art and the birth of humanism. What started as a better, more emotional *Madonna and Child* evolved into the *Mona Lisa* and, ultimately, a kind of expressiveness previously unimaginable.

So we shouldn't feel that by improving and enriching computer games we're missing the boat on some elusive "interactive movie" that's just around the corner. Give it time. Games reflect how we humans interact with an evolving world, one that is increasingly determined by the manipulation of information. There's no reason they can't become vehicles for emotional content, rich characterization, and shared experience. And what today might seem like just a souped-up *Super Mario Brothers* may, in fact, lead to tomorrow's interactive *Citizen Kane*. ∞

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CRUTCHES

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shot in my father's file that I couldn't quite remember. It took me a long time to realize that the model for the picture was myself. I am five-eleven. Jean-Jacques was six feet. I am handsome. Jean Jacques was beautiful. Men and women turned to look at him when he walked past.

The foreign name, the hint of foreignness in the voice on the tape, I thought must be an affectation, the residue from a privileged childhood spent abroad—he didn't really need the money that my father had been sending him. Where had he gone to college? Some expensive school, Berkeley, perhaps. No doubt he had graduated near the top of his class. No doubt he had won prizes, cash prizes which gave him the time and the prestige to pick and choose among employers. Whereas I had gone to the University of Connecticut and my mother had paid. A second-rate B.A. with third-rate grades—it was hard for me to find anything. I had a job in a health club for six dollars an hour.

This sounds carping and resentful, but in fact I did not envy his success. He was too far away. In the morning I would watch the weather channel, and it never rained in Oakland. The temperature was always fifty-seven degrees. I had never been there, but in my mind's eye I pictured it conveniently located atop the San Andreas Fault, midway between Yosemite National Park and the stupefying beauty of Big Sur. The capital of a new and perfect California, where fathers loved their sons and chastised them lovingly. Where college graduates found interesting, high-paying jobs. How could I begrudge Jacques anything? He was my counterpart, my double in that uncorrupted world.

And yet there must have been some conduit between that world and this, because from time to time I would catch sight of him. Not at first. At first all I noticed was a tension in the air, a sudden electricity. At certain moments in the street in Meridan, during my lunch hour perhaps, I would feel a new small sensitivity. I would know Jean-Jacques was thinking about me, that our thoughts were colliding like cold and hot fronts over Kansas. Colliding but not mixing—frustrated, later, by our lack of communication, I began to imagine that he was leaving me clues. Arrangements of sticks, of trash, junk mail, graffiti on the street: all seemed like messages in a language I could not decode.

But I'm going too fast. These delusions came gradually. And always there was a part of me that was still rational. I remember talking to Servando, who was an aerobics instructor at the health club where I worked before I was let go. I told him a suspicion I had that my father was still alive, that he had faked his death, faked his cremation, fooled his wife and all his creditors and was living in the Bay Area. It was just a theory. I had not come to any definite conclusion, and I was weighing the evidence with Servando, and listening to him carefully when he said it was unlikely, that it probably wasn't true. I believed him. I was reassured. But then I got to thinking about it later in the week, and it occurred to me that maybe Servando wasn't necessarily disinterested, that maybe he had received a letter from Jean-Jacques, or maybe some message in one of the arrangements of objects that I was finding so difficult to interpret. It drove me crazy, the idea that everything around me was so pregnant with information that might change my life, and yet I couldn't understand any of it.

> "These delusions came gradually. And always there was a part of me that was still rational . . . . I had a suspicion that my father was still alive."

That summer I decided to take the LSAT's. I had been fired from my job after an argument with the desk manager. I think I was probably in the wrong. Maybe I even told her that—in any case, she didn't hold a grudge. She arranged for me to receive unemployment. At the same time I got a letter from my father's lawyer, saying that I had been left a legacy of $15,000. The lawyer's name was Mr. Ordauer; he also said that my father's estate would defray the expense of any further education—it was a nice letter, and I liked the language, the formal phrases. It made me want to follow in Mr. Ordauer's footsteps. I knew being a lawyer was a good job, perhaps a better job than anything Jean-Jacques had yet achieved. I called Mr. Ordauer on the phone. "Listen," I said, "was there another legacy? Did my father leave anything to a man named Brauner, in Oakland?" Mr. Ordauer had a pleasant voice. "No," he said without hesitating. "He left no money to his business associates."

How wonderful a gift, I thought, to be able to lie so effortlessly. So I signed up to take the LSAT's at the University of Connecticut, and I bought some training books. And when I was studying them I realized that this was definitely what I was intended to do with my life—I knew every answer to every question in the sample tests without any problem at all. Those questions about the couples square-dancing, and who's next to whom. I just knew it. I could see them spinning around, coming to rest.

As I say, I had never wished Jean-Jacques any harm. But I could tell now that he was worried, anxious, jealous of me. Jealous of my closeness with my father who would be sending me to law school—I guess he decided he had to come back East and do something, because it was about that time, the third week in July, that I first saw him. As I say, I had some idea that he had been at my father's funeral, but I couldn't be sure. He was lurking behind a pillar. I hadn't seen his face. The first time I saw it: I was walking down Orange Street in New Haven, and there was a beautiful dark-haired man in front of me. His right leg was bandaged, and he was swinging himself along on crutches. He turned back to look at me.

I had gone to New Haven to visit an old friend. He had seemed concerned and upset that I was sleeping so badly, the conversation was disagreeable, and so I left.

I was walking back to where I'd parked my car when I saw this man, and even then I didn't think much about it. I just noticed his beauty, his dark eyebrows and his dark eyes. His fat soft mouth. But it wasn't until I saw the same man in Meridan, looking at me from across the street, that I knew who it was. Almost I went up to him. Almost I confronted him. He smiled at me and made a minute gesture with his hand. I thought, I won't play into his game. It's not just out of chance that he allowed me to see him. He wants something from me.

I turned around and walked away from him. But I could feel his eyes. And I could feel his presence around me, the next day and the next. During the weeks before the test, I was tormented by a series of absurd accidents. Once, an egg fell on the sidewalk just in front of me. Once, a dog barked all night, just when I was finally able to rest. I'm not saying that even at the time I held him responsible for these

events. I can't picture him limping along the rooftops, an egg in his hand. I can't picture him dragging a dog to sit outside my room, inciting it to bark. It's just that I could feel myself deflected and distracted by bad luck, just when it was most important for me to concentrate. To rest, to gather my resources, but always, every day there was something. My landlord raised my rent. I twisted my foot, stepping off the curb in front of my apartment. I sat down, holding my leg, tears in my eyes, and I could feel that sudden tension in the air. And though I couldn't see him anywhere in the street, especially not through eyes blurred by tears, I could feel his presence. Not that I blamed him—it had been my own stupidity, my own clumsiness. But in a way that made it worse—he was using my own worst flaws against me. He was making it impossible for me to hate anyone but myself.

But still, I refused to let myself be deflected. I studied the training books over and over. I memorized the responses. I could feel the tension growing all around me, on the morning of the test. I was very nervous. I got into my car. And I had had trouble driving for a few days—there was something wrong with my spacial perception, and I was always afraid that I was getting too close to things. Streets I had driven down a thousand times seemed narrow, and I was concerned that I might scrape the paint off cars parked along the curb. So I drove slowly, carefully, anxious when cars approached me in the opposite direction. Anxious when people passed me, or honked at me from behind.

That morning I had dressed in my suit. I was taking time with everything. I had given myself fifty minutes for the drive, but when I looked at my watch, I saw I had to hurry. I was out in the country by that time, driving past a golf course. It was separated from the highway by a guard rail and a steep embankment. There was a strip where you could pull over. And when I looked at my watch, I had to take my eyes off the road for a moment—I admit it. It's not as if he ran in front of the car; he was just standing with his crutches in the breakdown lane when I hit him.

I pulled over as quickly as I could and then just waited for a while. I left the car running, because I was still in a hurry. More than ever, in fact. An hour later I would blame myself by thinking that even in this matter of life and death I could be cursory and careless, just like the other cars that were rushing past me without stopping. But when I got out and looked at the bumper, there was no mark. I walked back down the strip, trying to find him, and I couldn't.

Yet I had seen him clearly, standing with his crutches. His dark hair, dark eyes. I had felt the shudder in the car as he slid off the front bumper.

But I didn't know what to do. I was already late. And it was possible that I had been mistaken. As I thought about it more, standing in the hot morning by the side of the road, it seemed more likely—what would he have been doing here? How had he gotten here? How could he have known that I would come this way? It was absurd. I went back to my car and drove to the test site without stopping. I was prepared—I had my pencils and my clock. I went in and we sat in rows, and I listened impatiently to the instructions. We were in the basement of Monteith Hall, and it was well lit down there. They passed out the test booklets, and then we started. The first section was analogies—it was harder than the sample I had practiced with, and I could feel myself making a few errors. But that did nothing to shake my confidence. It would have been silly to expect to perform perfectly, especially after such a disturbing in-

cident in the car. But I felt confident that I was able to distinguish subtle shades of meaning, even though it was hot in Monteith Hall that morning. I finished the section exactly on time.

But after a while I found it harder to concentrate, because I was thinking about Jean-Jacques. What if he was still there by the side of the road, and I hadn't seen him for some reason? Maybe I had dragged him underneath my car. Or maybe he had rolled down the embankment, or been thrown over the guard rail. I had been going almost forty miles an hour.

This was in the middle of the quantitative section. Ordinarily, it would have been so easy for me, except I couldn't concentrate. It was all pie charts and parabolas—basic stuff, but I was wondering if I could be arrested for leaving the scene of an accident. I wondered whether I'd been seen. So that when they told us to stop, I wasn't finished. And that was my best section—the next one was analytical, and the second question was about some traffic accident. I couldn't believe it. I just stared at the question.

After ten minutes, I closed my booklet. I left the pencils but I took the clock and walked out, back to my car. There was no mark on it anywhere, but even so I got in and drove back to the golf course. I thought maybe he had rolled down into some bushes near the road, or maybe he had been injured, and had managed to drag himself away into the trees. There was a copse of trees near the ninth green, I parked my car near the guard rail and climbed down the embankment. I thought maybe I would find his crutch. I poked a stick into a bush, looking for his crutches, and then I walked across the green and through the copse. I sat down on a bench on the other side, and I watched some people set up their tees. A man in a red shirt and beige pants hit a long, straight ball over the water hazard.

As I sat there, it occurred to me that Jean-Jacques had tricked me. And maybe he hadn't even been there, maybe he had never left California, but even so he had tricked me, and robbed me again. It occurred to me that he had stolen my life from me as he had stolen my father's love. That he had stolen my life, that he was living it and enjoying it, while I was sitting on this bench. I was sitting alone on the white bench, watching the man in the beige pants trudge down the hill. It was a hot, bright morning.

After a while, I got up to follow him. And I thought, it's something just to be able to get up and walk. It's something just to climb up an embankment and sit in the front seat of your car. I sat there with my hands gripping the steering wheel. I closed my eyes, and for a blissful moment I couldn't remember why I was so upset. I saw myself sitting in my father's office in Santa Monica. The fluorescent lighting overhead. The dark window and the parking lot. But this time it was different. This time a single hour had been excised from my memory, cleansing what had gone before, cleansing for a blissful moment what came afterward. Suddenly I couldn't remember whether the file cabinet had five drawers or only four. Or else the bottom drawer was locked, and I tried, and tried, and failed to pull it open.

Simultaneously, perhaps in order to replace that excised hour, I remembered something new. I slid forward on the car seat. I pulled my wallet out of my back pocket and retrieved from it a letter, written years before and never sent. I unfolded it carefully, for it was worn along the creases. "Dear Dad," it said. And then in part: "I hate you. I hate you for every bad choice I ever made."

People talk so carelessly about how life gets better, about time and patience, about bravery and strength. Be brave, they say, be strong. People connect the two. But in the real world they are opposites. They never go together. Strong people are like tank commanders driving through a field of bones. No courage is involved. Courage is the virtue of the weak.

After a while, I buckled on my seat belt. I turned on the ignition and drove home. I went indoors and lay down on my bed. All that time when I was growing up, before my father moved to California—there was no reason to remember what he did, or what he didn't do. Only later, in my mother's kitchen. Once she said: "He did the best he could. He just wasn't cut out for it. He didn't have the instinct to protect." Once she said, with no lightness whatever in her tone: "You used to bring out the worst in him."

Shortly after his death, Barbara had sent me a package containing a roll of super-8 film. They were home movies taken at my mother's house. I didn't have access to a projector, all I could do was hold them to the light. Now I took the roll from my bedside table and untaped the end. I sat up on my bed and held a strip of film up to the window. It showed a man about my age, sitting cross-legged in the grass, holding up a baby.

I pulled six or eight feet of film down between my thumbs. The image didn't seem to change. ∞

INTERVIEW

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large size and scale I've deployed robots the size of a videocassette into nuclear facilities Small machines reduce launch mass, use less power for locomotion A small machine with climbing abilities could hone to a larger machine and share resources Robot teams have merit

Omni. Why does machine intelligence come from mobility?

Whittaker. A fixed manipulator bolted to a factory floor works on a contained problem Venturing into the world, a machine encounters the unexpected The ground might collapse under its feet Work takes forceful interaction with things a robot doesn't control It may disturb the underpinnings of materials that collapse as it attempts to move them Out in the world, a machine is not alone It has to account for, interact and cooperate with people and other machines It forces the machine to think for itself in a complex world

Omni. Did you always intend to build autonomous robots?

Whittaker. I always wanted functional robots Their merit would be in what they accomplished, independent of the technologies going into them If I could get a job done with a motor, a wire and knife switch that was enough But time after time I encountered situations where the robot needed to safeguard itself or think for itself

When we went into TMI, there wasn't even a mature jargon for the idea of autonomy Even in the literature it was just blabbering Artificial-intelligence [AI] theorists who were fixated on autonomy had no idea how to accomplish it We'd be out with cameras and computers processing for hours and by the end of the day, the thing had moved five centimeters Yet having seen computers getting a fixed manipulator to pick out colored blocks in a pristine setting, the AI group decided this was the great leap that we could now build reasoning entities that would move about, fend for themselves, and serve the interests of humankind But for a machine to reason about going through the world—that's another dimension The AI people were promising more than we could deliver

Early on, we worked on primitive tasks like moving wheels and arms or picking up a block But the working world was not clamoring for a machine that picks up a block The robot would have to generate, sequence, coordinate, and execute thousands of such actions to do anything meaningful It

took brilliant minds with radical ideas and software to enable the robot to put thousands of actions together. At each roadblock we pushed through with new understandings of the control of tasks, laser scanning, neural-net computing. We've progressed from "step and stop" to a robot truck that hauls rocks at 35 miles per hour.

Omni: How does an autonomous walker think its way along?

Whittaker: Like a computer chess player reasoning out a set of moves. To a robot with six or eight legs, taking a step is like moving a piece. It can move any leg, constrained by the rules—its reach, balance, obstacles in its path. The machine chess player gets rewarded for making a good move, penalized for a bad one. A move by black to threaten a white knight might be worth five points, but if that square is attacked by white's bishop, moving there might be weighted a minus five.

Similarly, if the robot takes a long step to a place that moves it toward an objective, it may gain some points. But if the place where it wants to step looks to its computer map like a hole in the ground, it might lose points by stepping there. As in chess, it does the robot no good to look myopically at each nibbling step. It must consider a thousand steps into the future, develop a plan and strategies.

Making its way, the robot might get surprised. Setting a foot down on what looks like solid ground, it might break through the crust. Then it will assess and react. If could continue lowering its foot, seeking something solid, lift the foot and put it back, or step with another foot. It may determine that the surface ahead is too brittle to support its weight and seek a different path. As the robot moves forward, it can see more and look behind what used to be in shadow and revise its plan. Dante uses stereo cameras to know if there's something it can't yet see. It will identify that target as a place it might want to step. Not yet knowing if it's volcanic ash, granite, soft snow or hard ice, it will test it when it can.

Omni: If an autonomous walker could talk, what would it say?

Whittaker: Ambler does talk. But we listen to only a fraction of the robot's reasoning, otherwise we'd be overwhelmed by data streaming in from cameras and sensors of motion, balance, and pose that it's considering. We tap into the software that manages traffic as the components of the robot talk to each other.

The planner might request data from scanners before commanding motors to act. With its descriptive vocabulary and voice synthesizer, the wiretap software describes Ambler's intentions. If Ambler perceives a problem, like when it steps on the edge of a rock, it might say, "Whoa, something is hitting the left side of my foot." It will think about this and say, "I intend to pick up my foot and try again."

Ambler changed the thinking about walkers. Its importance was not simply as a machine that could step over things, but as a robot that can make sense of the world when traversing uneven ground, a wheeled machine crossing rough terrain that lurches up on a rock, sees the sky, then careens off and sees the ground.

A computer can't comprehend images that don't match up. A walker isolates its body from the terrain and moves in a smooth trajectory. Machines working on floors of aircraft hangers and factories or driving along roads hauling rocks will still need wheels. But walkers will be the machine of choice for rough terrain or working in places made for humans.

I remember the debates at TMI. Can the robot clear this low cable? Squeeze through that doorway? It was tough to judge dimensions and geometry with a human eye through a camera. Each decision was crucial. If we screwed up and got pinched, the robot would be lost. Today I'd send an autonomous walker into the Unit 2 basement or the Chernobyl reactor. It could squat down or rise up and look around, know for itself if an opening were too narrow, overhang too low.

Omni: How do robots learn?

Whittaker: We have a truck that drives itself along the freeway. A human takes the wheel first, but the sensors and computers follow along and train themselves. Years ago, we might have used vision techniques to pull out the edge line and broken white center line, and a controller would have used that information to say "Stay between the lines." Today we use a neural-net computer. As the machine drives, it may ignore the lines altogether. Maybe it picks up something on the other side of the road to watch or tire marks where other vehicles have driven.

Initially we built Ambler to move no faster than it could think. But soon its decision making was remarkably quick. Unfortunately it was still bound by its slow mechanisms. Traversing 500 meters could take 16 hours.

It's difficult for a machine to learn. In a simple-minded planner, a human assigns priorities. If you emphasize stability a walker will pick up one leg at a time, shift the body to keep balance,

and creep along. If you emphasize speed, the robot will push stability to the edge, get wild and crazy, and maybe tip over. In advanced planners, the robot rewards itself for a desired behavior, like keeping its head still for good balance. There is no emotion to it, no smile comes over its visage, but it gets a high score—even if this behavior is accidental.

If you reward the robot too much for one thing, you might suppress some behavior important for survival. It could be the response to a rare event that comes later as a surprise. At first, our truck-driving machine was overcorrecting with its steering, like a human with a learning permit. We added rewards for minimal activity and its driving smoothed out. But if we had trained it too rigidly to be a good robot that didn't jerk the wheel, and then, for example, a concrete block fell off the truck ahead, the robot wouldn't veer away. That would be against its reward! Humans and animals innately solve this problem of competing objectives, but it's a challenge for robots.

Omni: Why aren't humans the optimal controllers for robots?

Whittaker: When Ambler first walked, it was like a blind groping, an almost comatose action. But soon it was sensing and creating a model of its external world, putting together its plan. As it learned, adapted, became a capable walker, something very intriguing began to happen. If it confronted obstacles scattered in its way, we, the human creators, could not anticipate its actions—which leg it would pick up first, how it would balance itself. Suddenly it wasn't clear what behaviors to impart or how to refine the robot's motions. These are things that Ambler had to know for itself.

Because humans have two legs, they might not think in the dimensions of six or eight. The machine can think faster, it has a complete model of its mechanics and all the data about its interaction with the terrain. If the ground breaks from underneath or a foot slides off a rock, it could be cataclysmic for Ambler. You would never entrust its balance to a human operator. And why bother? Human interface belongs at a much higher level of command.

Omni: But don't machines sometimes think too logically?

Whittaker: Say we really challenge Ambler. We set up meter-high obstacles and pile boxes all around the room. After an hour of exhaustive search of every conceivable footfall, the robot might decide it's impossible to get across the room. But maybe there's some wild combination of moves it just flat out missed. It's like human climbers trying to scale some rock face. Nobody can do it, and it's undersfood to be impossible. Then some fast gun from Yosemite sticks his foot in a crevice beside his left ear and smokes to the top. We give our machine that confidence to sometimes throw out the rigorous planning and just try something.

Omni: Do your robots seem alive?

Whittaker: I once came up to Rex [an autonomous excavator] while it was digging away. I put my foot where it was working, it detected me, slowed its digging, and moved away. I came close again. It regarded me and moved away as if annoyed with the game I was playing. I am intrigued by the actions of these machines, how different robots behave according to their capabilities.

A robot has a measure of confidence, say in the quality of its vision model, and if its confidence is low or if the robot is facing a difficult challenge, it gives the human observer the impression of caution or uncertainty. I credit robots with the ability to move through the world; I see them reason and learn, watch them react and interact. But I know it's not black magic or machine emotion, but sensors and computers at work. At times a robot takes on the behavior of something alive, but it isn't.

Omni: What is lacking in robot sensing that you want?

Whittaker: Most researchers look to the higher processes of perception. And I, too, want vision sensors like human eyes in tiny packages, efficient and rugged. But I dream of machines with superlative physical control. A walking robot senses contact and force as it steps. That's essential, but trivial compared to what animals and humans can do. Athletes lean in certain ways and cats routinely approach the limit of their balance. They have fine sensing in their ankles, feet, toes, and inner ear. They feel texture. All of this is fully integrated. When we can give machines these rich senses like touch and balance, then we will step into the future. My ideal robot is one that's smart and agile—with the simple interfaces of a washing machine.

Omni: You worked on Ambler for five years, and now it's to be retired. Will you miss it?

Whitfaker: I try not to get emotional about a robot, the physical manifestation of our science. Imagine if Wernher von Braun had become attached to each new rocket. Somebody pushed a button, it was gone. The rocket was only the symbol of knowledge going into the next launch.

Robotics is like that. I think about the

evolution of robots in biological terms. We should create dozens of robot litters carrying the fittest ideas forward. As new entities appear, they may be quite different from their predecessors in linkages, bones, and appendages. But there is a gene pool that moves ahead—such as 50,000 lines of perception software or planning code that lets the machine see, reason, or walk. It works for a machine of any size, much like the Gulliver effect in biology where tiny rodents and giant elephants can share the same gait or vision. The robot's form can take many shapes, but the core technologies transfer to a new generation.

Omni: You were in the office until late last night, and you're back this Sunday morning. Do you ever take time off?

Whittaker: Not long ago it came to me that I hadn't been out adventuring for a decade. So I started taking time off from my research. I fell in love, got married, and bought a farm. I plan to grow alfalfa, oats, maybe corn, and later raise dairy cattle. Thinking about farmers inching along in tractors with cultivators or hooking milking devices to cow udders at dawn, I realized that robots can do these jobs. I plan to automate much of the work at my place, starting with a cognitive haymaker. Robotics could change the face of agriculture. In my lifetime, even if it's when I'm leaning back in a rocking chair, I'll see these things out in the world, plowing fields, entertaining kids at theme parks, restoring nuclear sites, exploring the planets. Not just a few, but whole families of robots—millions of individuals—whose lineage can be traced to our shop. OMNI

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GAMES

DESKTOP MAGIC
Tricks that perform themselves

By Scot Morris

In 1865, London theater audiences gasped when they saw a trick called the Sphinx performed for the first time. At center stage was a round wood table devoid of drapery and on top of it sat a lifelike human head that answered questions from the audience.

A couple of years ago, a Japanese toy company named Tenyo adapted the principle of the Sphinx table into the Art Bank. About two and a half inches square, the bank has a transparent front through which you can see an object floating in the center. The object varies from bank to bank, in the example above it's an airplane. How does the airplane float there? It's certainly not suspended on strings, because it doesn't swing about as you move the cube. If you shine a flashlight in from any angle,

you can see the plane's shadow on the back wall.

The bank grows more intriguing when you drop a coin into the slot at the top. Although you hear it fall, you don't see it. Rather than bouncing off the airplane and falling to the bottom, it disappears completely.

How does it work? You can solve this puzzle in your head, even if the bank's not in your hands. If you buy one—it sells for about $7—the instructions tell you how to get your money out but not how the trick works.

Tenyo makes many self-contained tricks available only through magic stores. They currently market more than 50 and introduce four or five new items every year. Most cost between $10 and $15 and reveal in the instructions how the trick works. The Art Bank was Tenyo's first trick that didn't include the secret, and it broke into new markets: toy stores, gift stores, novelty shops. Invented by Shigeru Sugawara, it's become Tenyo's most successful new product, selling more than 3 million units worldwide.

Tenyo was founded in 1931 by Tenyo Shoukyoku-sai, a well-known magician of that era. The company makes primarily toys and games, but it also maintains a full staff of magic inventors—the only company in the world to do so.

Tenyo recently introduced a bank for which the company hasn't yet given an English name. You see a silver ring and a satellite floating in space. A coin dropped into the slot disappears, as expected, but it also makes the spacecraft fly two or three times around the ring. The instructions tell you only how to remove the coins and change the battery.

The newest Tenyo inventor, Tooru Suzuki, created the Micro Bank (bottom left), which sells for about $15. Coins appear to shrink in size as they fall through a funnel that leads to the tiny chamber where the money stacks up. Through a window, you can see up to 16 minuscule quarters in a stack or more than 150 diminutive dimes.

Tenyo's newest twist on the trick bank is the Dracula Bank, invented by New York magician Mark Setteducati; it should be available in the United States soon. Pull Dracula all the way up and his hands fall forward to make a tray for your coin. Push him down in front of the mirror and he disappears—with your coin—because a vampire casts no reflection. Pull him up again, and the tray is empty.

These items represent a new kind of magic trick—they perform themselves, and the person who buys one may be just as mystified about its workings as anyone watching its operation. I've also seen another new trick of this type, the [biki,ni] 500 pen (below) from the Sailor pen company in Japan. It operates like any normal pen. When you push the plunger at the top, the pen tip comes out the other end. Push again, and the tip retracts.

But there's a *gap* in the center of the pen between the plunger and the pen tip. The gap, surrounded by a frame of four wires, moves with the ink tube whenever you push the plunger. The gap is real—you can stick a pencil tip through it. It isn't caused by magnetic repulsion, or you would be able to keep the pen tip retracted while you push the plunger. And the wires themselves don't move, which you can confirm by holding them tightly as you work the plunger.

What's your hypothesis? I'd like to see readers' theories of how these tricks work, or any other examples of desktop magic. If you'd like to take a look at the Tenyo banks yourself, Goldcrest, Inc. (800-922-3233) can tell you the name of the nearest store selling them. OC