

DICK CHENEY: THE FUTURE OF MILITARY POWER

OMNI

MARCH 1991

BACH TO THE FUTURE: COMPUTER MUSIC GROWS UP
ROBOTS: THE NEXT STAGE IN EVOLUTION?
WHY SUCCESSFUL PEOPLE FAIL



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FIRST WORD

DEFENDING DEFENSE

The ever-changing technological arena warrants continued advances in U.S. military forces

Dick Cheney is the secretary of the United States Defense Department.



Americans have every reason to be proud of our forces standing against aggression in Saudi Arabia and the Persian Gulf. They are dedicated and well-trained volunteers running the world's most advanced ships, aircraft, and weapons systems. What many people do not realize is that most of the technology we rely on today in the Gulf and elsewhere around the world, was developed and built years, even decades ago.

One of the first ships to respond to the Middle East crisis was the nuclear aircraft carrier USS *Enterprise* as its keel laid in 1970, before many of the young sailors running the ship were born. F-15A tactical fighters were first test-flown in 1972, and F-16 fighter aircraft first flew in 1976. We rely on these and other advanced systems to give us the edge in any potential conflict. But in today's changing world, we cannot take that technological edge for granted. We need to start building for our defense in years to come.

Our defense has long depended upon matching numerically superior enemies with qualitatively superior forces. But keeping the technological advantage requires time and effort. With a smaller American military and smaller

budgets, it is more important than ever to think in new ways about our defense requirements.

The threat to our security is changing. A growing number of countries are acquiring highly sophisticated military arsenals. By the year 2000 at least 15 developing nations will have the ability to build ballistic missiles, and more than half of these countries either have, or are near to acquiring, nuclear capabilities. Thirty countries will have chemical weapons, and ten will be able to deploy biological weapons. Advanced technology can take third-class powers into first class threats.

We cannot yet dabble the Soviet Union a large, increasingly modern nuclear force. And even with recent and projected budget cuts, production of new Soviet strategic forces is still brisk. Last year, for instance, the Soviets deployed more than 100 intercontinental ballistic missiles, we deployed none. They have a new version of their heavy SS-18 ICBM, along with two new missile types, and in their intercontinental bomber fleet, new B-11 and Blackjack aircraft are being equipped with longer-range cruise missiles.

It may be tempting to ignore these realities in light of our optimism about Soviet reform. But the fact remains that deterrence, now and in an uncertain future, depends not only on Soviet intentions, but also on Soviet knowledge of American capabilities. To keep a stable balance of forces, and to be in a strong position to encourage further arms reductions, we need to continue our program of strategic modernization.

These goals depend on our technological superiority on breakthroughs in weapons design like stealth technology. Potential adversaries must know U.S. forces could respond to aggression by penetrating high-tech air defenses. That kind of credible deterrent

will depend on new generation aircraft, ships, tanks, and other weapons systems whose configurations and special materials make them more difficult to detect and defend against.

Missile defense is another important application of advanced technologies. Recently we've been perfecting a system of missile interceptors deployed in a low space orbit, the Brilliant Pebbles concept. Each Brilliant Pebble consists of a single space vehicle with a "life jacket" that stores energy and control systems. As attacking missiles are first boosted into space, Brilliant Pebbles would find and destroy them, making a surprise missile attack on us too difficult and complex to risk.

Overall, within the U.S. Defense Department we have identified 20 critical technologies—including microelectronics, software, directed energy, robotics, and propulsion—that are essential to advance in weapons capabilities.

Army experts are thinking ahead to new, all-weather day/night sensors and low-cost tactical satellites that would enable our soldiers to detect and engage enemy forces effectively.

Innovative thinkers in the Navy and the Defense Advanced Research Projects are looking at electric drive propulsion, a concept that has the potential to revolutionize ship design and provide energy for advanced weapons systems. And finally, Air Force scientists continue to study advanced aircraft engines that provide more power and thrust with lower fuel consumption.

Some people may look at today's highly capable defenses and wonder whether research in further advances is worth the effort and cost. I hope they will look back at the investments that brought us today's strong defense. Our ability to overcome tomorrow's threats depends on what we do today. **DD**

FORUM

CAN SPACE STILL SING?

A former astronaut urges America to rediscover the romance of space exploration

When Michael Collins talks, people should listen. After all, he's been to the moon.

Collins is talking now in a good new book, *Mission to Mars* (Grove/Waldenfeld). His argument is simple: We as a nation and we as a species need to rediscover the excitement and exuberance of manned space exploration. And Mars is the goal Collins selects as most attainable and most appropriate for the next stage of interplanetary effort.

Why Mars? For Collins it was always Mars. "You might say I went to the wrong planet," he says of his Apollo mission. "I got sent to the moon, but I've been fascinated by Mars since I was a

kid." He feels, and communicates in his book, the romance that surrounds the red planet in our imaginations. Equally well communicated is the romance of exploration of humans moving out permanently through the solar system.

Many of us recognize that romance and recognize as well that the public's love affair with space exploration has grown tarnished—which is one of the reasons Collins wrote his book. The dream of space exploration by humans, so vivid during the Apollo/Skylab years, has been buffeted by tragedy, budget cuts and deficits, technological mistakes and miscalculations. A certain wariness can be felt in the general public. Why spend more money on space when the money we've already spent doesn't work? Why spend money out there when we have problems back here?

The wariness is understandable, especially in light of continuing government cutbacks and shortfalls in the domestic arena.

Critics of the federal government face challenges in taking care of citizens today," Collins says. "The problems are horrendous—crime, AIDS, education, health care. But the space program doesn't take money away from those programs and never has.

Funding for a Mars mission and the support architecture such a mission would require will be controversial. Even conservative estimates of the cost of building a space station, mounting returns to the moon, and missions to Mars call for tens of billions of dollars. No small sums in the best of times, such astronomical investments are easy targets in times of recession. But Collins is persuasive and, I think, right when he says manned space exploration and colonization is not about money. It's about the future.

A case can be made—and Collins makes it—for space being among the most practical uses of

our taxes. "It's not sensible or reasonable to spend all our resources on today," Collins says. "We've got to put aside a little bit of every dollar for tomorrow."

No question that the money needs to be well spent. We're at a crucial point in the evolution of our extraterrestrial efforts. It's a point that demands careful consideration and reflection on the part of taxpayers as well as the government and the space program itself. As we assemble a realistic vision of renewed growth and effort aimed at exploring the universe, our wisdom informed by lessons learned over the past three decades. We will be rebuilding our space program and the equipment on which it rests, but we won't be starting from scratch. Thirty years of advances in materials science, computer hardware and software, understanding of complex propulsion systems, and, yes, the lessons had learned from setbacks, mistakes, and catastrophes will all help ensure that the next generation of vehicles and missions work better, more efficiently, and more effectively than even the best of previous undertakings.

They'll have to. Upcoming space ventures will be larger, longer, and more complex than anything we've attempted. Above all, we must aim our efforts toward establishing ourselves permanently in space. We can't afford more dead-end missions aimed at political or other short-term goals. We're dealing with the future, and we must take the long view.

"Exploration," Michael Collins says, "is NASA's lifeblood." He's right. It's also the lifeblood of our species. It's a song that sings in all of us. For the species, the whole of the species, the whole of the world to prosper and grow we must continue to look outward, aim outward, move outward. Mars, anyone?

—Keith Ferrel **OC**



Mars has loomed for centuries in our imaginations. Isn't it about time the red planet became the goal of the US space program?

OMNIBUS

SHAKE, RATTLE, AND ROLL

Our writers get down and boogie at MIT and stir up some seismological dust

Do you suspect your parents omitted something when they told you about the birds and the bees? Well, don't blame them—unless they're radical thinking artificial-intelligence experts. The first international AI conference in Paris brought together researchers who have pushed aside their more-ambitious programs for something a bit more modest—Mother Nature. Contributing editor Tom Dworkitzky ("MechAnimals," page 50) explores the latest invasion of robotic birds and bees or, as AI experts call them, "animats." The AI community's efforts focus on creating animats that learn and adapt to a realistic environment—one that is not predictable. The researchers' approach is more primitive but learning and adapting may be the better part of what we call in-

telligence," Dworkitzky says. "I can envision a time when these robots will become autonomous."

The idea of autonomous robots, of course, is not new to science-fiction fans. In Isaac Asimov's 1976 short story "The Biontential Nan" for example, robot Andrew Martin fights for, and wins, equal rights. "It's not my fault if science finally catches up to my simpler notions," Asimov says in this month's pictorial (page 63) he directs his attention to "Photosynthesis."

Researchers at MIT's Media Lab are jamming to a new wave of music technology. Former *Oz* editor Gurney Williams III ("Back to the Future," page 42) met with Tod Machover, the director of the Experimental Media Facility, who introduced Williams to sounds never heard before. The

Parkfield while discussing seismology and earthquake prediction.

"Linda is kind of an old hippie who has found satisfaction in an odd manner," says Wanning, the author of *Culture Shock USA* (Times Books International), a *Max Mallowes*-like book for foreign travelers. Wanning has also written for *The New York Times* and the *San Francisco Chronicle*. She left Parkfield without trying one of the cafe's shakes.

Imagine you are a Pulitzer prize-winning journalist. Now that you have fame far beyond your wildest dreams, what can you possibly do to top it? That was the scenario psychiatrist Steven Berglas posed to Janet Bladow (Mind, page 38) to demonstrate the pressure caused by the success syndrome. "In my work I hear stories of celebrities crashing and burning at the time," says Bladow, features editor at *The Star*. "If I should get that Pulitzer, though I hope I'm grounded enough with family and friends to live through it." Bladow has written for *Blowing Woman* and *Mademoiselle* and is working on a novel.

Pat Janowski (Spice, page 22) has poked her head above the clouds, examining what's going on in the ionosphere, the 1,000-kilometer-thick layer above our atmosphere. Our atmosphere is only ten kilometers thick, says Janowski. "Down here we get snow flurries up there it's electron flurries." As one researcher told her, "It's more exciting and dramatic than this wimpy ten-kilometer thing." Janowski is a writer at the Association of Scientific/Technology Centers. Her articles have appeared in *Science*.

Writer Steven Scott Smith (Earth, page 30) has an affinity with frozen moments in time. Smith contributed to *Oz*'s Arc-to-story ("Lost Horizons," September 1990), has written a play called *Black Ice*, and is working on another titled *Antarctica*. **CC**

Contributors, clockwise from bottom: Steven Scott Smith, Esther Wanning, Tom Dworkitzky, and Pat Janowski.



technology extends anyone's musicianship," says Williams, a sixth-grade piano lesson dropout. "More important, though, the technology is nothing without human input." The coauthor of *Psychology: An Introduction* (McGraw-Hill) with Dr. Arno Wedig, Williams frequently lectures on the future.

In Parkfield, California, halfway between San Francisco and Los Angeles, the Parkfield Cafe staff awaits the next major earthquake. Outside, a sign proclaims EARTHQUAKE CAPITAL OF THE WORLD—BE HERE WHEN IT HAPPENS. Seismologist Alan Lindh (Interview, page 68) and writer Esther Wanning traipsed around



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COMMUNICATIONS

READERS' WRITES.

Of celestial reasoning, sacred groves,
and queens of the Nile

Look Up in the Sky! It's a

On behalf of like-minded readers I congratulate your December 1990 issue. You are the first credible general-interest magazine to present the issue of UFOs without condescension. In the late Seventies I interviewed Allen Hynek, the first scientist to publicly take UFOs seriously. As a result, he faced the ridicule of the scientific community for the rest of his life—a heavy price indeed. In 1900 Giordano Bruno, a Dominican monk, was burned at the stake for suggesting that life may exist elsewhere in the universe. In 1975 Hynek was merely dismissed as a fool. Now at last, as we approach the twenty-first century we reluctantly realize that we may not be alone in this vast universe. What blockheads we are!

Larry Port
Ogden Dunes, IN

Let me get this straight. A highly intelligent race of beings sends an amazingly advanced spacecraft across light-years of space. Through pilot error or catastrophic equipment failure, the damn thing crashes. You led two convincing cases of crashed landings ("Alien Almanac"). You'd think that after the first one, the extraterrestrials would issue a memo. "Watch out for Earth, it's a sticky one." Or do we live on the galactic triangle?

Eric Borkmicks
Norwood, MA

Writer Patrick Huyghe explains part of the government cover-up of UFO reports by revealing how our government cracks foreign locks. But he seems reluctant to report on secret aircraft testing that we can assume resulted in crashes. The willingness of any government to credit such occurrences to UFOs is quite normal. Their covering up may be military secrets, not UFOs.

Frank G. Pollard
Farmington Hills, MI

Thomas R. McDonough (Stark, December 1990) should have been more thorough in his analysis as to why ET has not yet phoned Earth. He offers two very plausible hypotheses, but his notion of

"included permanent ecology" is a bit out of this world. I'm not a skeptic. The odds against our tiny planet being alone in this immense galaxy are astronomical. McDonough should have taken more time in the conceptualization of his ideas and perhaps he would have thought of a few more that are more believable. For those ideas being in their sheltered ecostates, stay home and don't call us. We'll call you.

Jeffrey A. Rhoad
Solitude, MA

From the Redwood Forest.

In the article about Northern California's coastal redwoods (Continuum, December 1990) you printed a picture of a sequoia—and the caption even calls it a sequoia. Although coastal redwoods are technically *Sequoia sempervirens*, they are commonly called redwoods or coastal redwoods. We have an identity crisis already because many people think our trees are the same as the redwoods. All the residents of Sequoia National Park would be grateful if you could clear up the misunderstanding.

Theresa Walters
Sequoia National Park, CA

Relying on clones to repopulate Northern California's diminishing redwood forests is suicide. All it takes is a single virus or bug to defeat one clone, and it will defeat all clones! With the environmental mistakes we've already made, it's stupid to add another bullet to this game of Russian roulette.

Scott Tokar
Tustin, CA

Here's to You, Mrs. Ramses

An incorrect statement was credited to Farouk el-Baz (Interview, December 1990). Ramses I was not married to Nefertiti. Although they were both from the New Kingdom Period, Ramses ruled in the nineteenth dynasty, Nefertiti was the wife of Amenophis IV (Akhenaten) in the eighteenth dynasty. The first wife of Ramses II was Nefertari, for whom he built the minor temple next to his great temple at Abu Simbel.

Sylvia McDonald Bowman
Henderson, NY

FAR-OUT FORECAST

Communications and radar will benefit from space-based sensors able to warn of ionospheric changes

Partly cloudy, chance of showers. The daily weather reports help us decide what to wear and what to carry—an umbrella or sunglasses. Soon, however, we'll watch reports on space weather just as eagerly to see where to tune in our communications systems. Solar flare sparks severe storm in the ionosphere, switch to alternate satellite link.

The U.S. Navy and Air Force are working on space-based sys-

tems over a broad geographic location. When used together, the two systems will generate a three-dimensional view.

About 60 to 1,000 kilometers above the earth's surface, the ionosphere experiences weather changes just like our atmosphere. However, violent "storms" in the ionosphere do a different type of damage: They can knock out communications satellites, disrupt radio transmissions, and even cripple the military's over-the-horizon

radar. These separated electrons and positively charged ions make up the ionosphere. The thickness of the ionosphere and the number of free electrons vary as the sun emits different amounts of ultraviolet radiation during its 27-day rotation. The density of electrons can become so great that satellite signals cannot penetrate the ionosphere.

The military's optical sensors will pick up the radiant energy (photons scattered by the ions) calculating the number of positive ions and thus the number of free electrons. Notified when electrons begin building up in a certain area of the ionosphere, those using a satellite link can switch to a satellite in an unaffected part of the sky or to ground-based communications facilities.

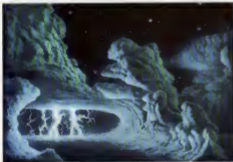
Rather than passing through the ionosphere, as satellite signals do, the signals used in over-the-horizon radar are reflected by the ionosphere—twice, in fact, as they bounce off the ionosphere to the radar's target, reflect once again off the ionosphere, and are finally captured by a radar ground station. The angle of reflection, determined by the number of free electrons in the ionosphere, must be known in order to pinpoint the target's location. "That's the rub," says Robert Weir, head of the Upper Atmospheric Physics Branch of the Naval Research Laboratory in Washington, DC. "You have to know what the ionosphere is doing way out there."

Systems that help warn of the arrival of ionospheric storms are already in place. For example, after a solar flare, alerts are sent to defense and civilian communications systems.

But the ionosphere's reactions to solar flares can vary widely from day to day. With the space-based sensors, we'll be able to keep up with them.

—Pat Jarowski

Stormy weather increases in ultraviolet radiation trigger a build-up of electrons in the



ionosphere, knocking out satellite communications and advanced radar systems.

tems to monitor the weather in the ionosphere, the layer of the earth's atmosphere that affects satellite communications. Tuned to ultraviolet and infrared wavelengths and clamped to the underbelly of weather satellites, optical sensors will orbit the earth above the ionosphere. The Navy's system, scheduled for tests in 1992, will vertically scan the atmosphere with spectrophotographs, spectrometers, and photometers to create a cross section of the ionosphere. The Air Force's instruments will look straight down to give a pic-

ture over a broad geographic location. Such storms often travel from the earth's poles toward the equator, but surprises can happen. For example, a solar flare blocked communication with Air Force One in 1984.

The ionosphere is created by high-energy rays of ultraviolet radiation from the sun that disrupt the energy balance holding together molecules of oxygen and other atmospheric gases. The radiation knocks electrons away from the protons and neutrons that make up the dense nuclei of the gas atoms. The electrons leave be-

THE SUCCESS SYNDROME.

Its victims suffer from the three A's: *al*oneness, *ad*venture seeking, and *ad*ultery

He's worth millions. He snaps his Midas fingers and people jump. He has a trophy wife or mistress. Or both. Yet just when he seems to have it all, the castle comes crashing down and everything he touches turns to garbage.

He's a victim of the success syndrome, says Steven Berglas, an instructor in the department of psychiatry at Harvard Medical School and founder of the Executive Stress Clinic in Boston. These days the victim could be Donald Trump, Michael Milken, Ivan Boesky, or Marion Barry to name a few. In 1985 Berglas presented his theory in *The Success Syndrome: Hiding Bottom When You Reach the Top*. The book was based on a study originally conducted in 1978 at Duke University that found that three qual-

ters of males who succeeded—but didn't feel they earned their success—abused alcohol. A number of studies since have confirmed the results. If a person doesn't feel his actions awarded him success, he often exhibits self-destructive behavior.

Let's say Berglas knew that before the decade was out, he'd have so many highly visible examples to prove him right. "I've since found it's more a pattern of success than any inherent character flaw in the individual prior to becoming successful," Berglas says. Americans define success basically as ranking and rewards: an income of six figures or more, prominence in a corporation or organization, and in the community.

Pat Rose appears to be a classic victim, he says. "Rose beat [Ty] Cobb's record and became the greatest baseball player alive. Going out on the ball field—or continuing writing or building a business—you have a chance to improve competency. Rose lost that capacity when he stopped playing ball. But gambling allows you the belief, /m the greatest, / can understand the game, therefore / can predict the future."

The victim risks money he doesn't have to stimulate his adrenaline, Berglas adds. Trump's art of the deal is just what Rose was doing: gambling. So did Milken. You leverage yourself to the limit, take chances, and lose perspective. "These men demonstrate the need for adventure—including secret handshakes and codes for their deals."

They are solitary operators. "Rose had a group of sycophants, but he never felt he could trust people. Milken made people adore him at a distance; he was a Pad Piper. He represents

the adulterous aspects—without the need to go to bed. Trump obviously goes to bed. Many of these men demonstrate promiscuity," Berglas concludes.

After someone reaches the heights, his or her successes often become passive ones. "Al Milken had to do what he had to do and watch his investments make money. Trump said, 'It's so good, bankers come and ask me if I want to borrow money.' When you've reached a certain level of power, things come to you. You don't have to be good anymore." The successful become subservient to their success.

The syndrome can befall any successful person. Politicians are notorious, says Berglas. "Gary Hart became so cocksure he even dared the press to follow him. For Marion Barry, buying drugs became a thrill. These things let you know you can beat the system; it's not what I am outside, but inside."

Berglas's studies indicate that up to 20 percent of all successful men fall victim to the syndrome. He predicts the percentage for children of successful or wealthy parents is even greater. Success comes to them because of their name and wealth.

Marriages and love relationships are important in preventing the syndrome, Berglas says. "Second to that is an affiliation to a group—of any stripe." Sam Walton, who believes wealth should benefit family workers and the community, is someone who's escaped the success syndrome.

The success syndrome won't vanish. "Any young individual with an affluent life-style who doesn't earn his success on his own efforts will suffer," Berglas warns. "The syndrome is like AIDS: it's a virus, a disease. Just because you practice safe sex doesn't mean it goes away, there's just a little less of it."

—Janet Badio **DD**

Consequences of success create stress, expectations, and demands, precipitating a range of psychological disorders that would not otherwise befall an individual.



EARTH

ICE CHEST

Can Greenland's treasure trove of frozen rain reveal the story of Earth's climate?

It sounds like part H. G. Wells's *The Time Machine*, part Jules Verne's *Journey to the Center of the Earth*, and part Steven Spielberg's *Back to the Future*. But the key to the future may be buried in the past—in layers of ice that comprise a frozen record of the earth's atmosphere.

That's what scientists with the Greenland Ice Sheet Project (GISP) have discovered since they began analyzing Greenland's ice samples. The first GISP came out in the Seventies and Eighties, produced samples 100,000 years old. During GISP II, a five-year, \$20 million project scheduled to break ground this spring, researchers will dig 3,000 meters into the ice and turn back the climate clock—as far back as 200,000 years. Their goal: understanding the forces behind climatic change.

Layered like tree rings, the ice allows researchers to date the atmosphere. While tree rings show changes in precipitation and temperature, ice core samples go further, reflecting the earth's global climate machine, says Paul

Mayewski, chief scientist for the project which is funded by the National Science Foundation.

Although technologies like satellite photography, now map ocean currents and other atmospheric variables, GISP II will help scientists interpret changes by providing a database of climate history. "We know, for instance, that the last ice age lasted 100,000 years and ended about 12,000 years ago, another long ice age ended about 130,000 years ago," says Peter Grootes, a University of Washington geologist involved with the project. "But the record for those periods is poorly detailed. If we learn about them, we may be able to extrapolate those cycles in the future."

Receiving less than three inches of rain a year, icy regions like Greenland and Antarctica are deserts, and preserved, representing, Mayewski says, "a phenomenal story about to be told" with a record of the atmosphere's chemical composition, human activity and other factors in Earth's history.

In preliminary findings, the Greenland ice team reported intriguing atmospheric anomalies during 1815 for example: temperatures plummeted and the period

became known as the "year without a summer." Contemporary paintings show skies with a yellowish tinge that scientists now believe represents a rise in sulfur dioxide and volcanic particles produced by the eruption of Tambora in Sumatra, Indonesia. "With a preserved 'piece' of precipitation from that year we can actually see the composition of the atmosphere," Mayewski says.

The progression of industrial pollution also lies buried in the frozen fields of the earth's history. "We can even detect when the United States put the Clean Air Act into effect," Mayewski says. The breakdown of sulfur dioxide (SO₂) in the atmosphere produces sulfuric acid that returns to the earth as acid rain. Specimens from the Greenland Ice Sheet indicate sulfur dioxide emissions have decreased.

GISP II scientists, however, will learn about the earth's climate well before the Industrial Revolution. Housed in geologic domes that resist the accumulation of snowdrifts, drills will bore 1,500 meters down to ice layers representing the earth's last 10,000 years. The next 1,500 meters of ice, where the layers are more compact, will reveal a record of the planet's preceding 190,000 years. The core samples will be cut into sections, stored at low temperatures, and shipped for analysis in labs around the world.

In a similar European venture, the Greenland Ice Project (GRIP), researchers working just 30 kilometers away will collaborate with the Americans to confirm results. Together the projects should produce a definitive climate record of the Northern Hemisphere. But Mayewski is already looking to the next stop in the frigid journey through time: Antarctica. "That's where we have the oldest ice," he says. "We can go back half a million years, maybe even two."

—Steven Scott Smith **DD**

Just the tip of the iceberg: For the very first time researchers may be able to trace the earth's climate back 200,000 years or more.





CONTINUUM

EMERALD GREENS:

Europe's plant refugees have found an Irish Ellis Island. Plus:
Billy the Kid's last face-off, British cars sans petrol

A standard stop for many an Irish-American tracing his ancestral roots is the Burren—"the world's largest rock garden," say the brochures—a bleak wind-blasted steppe of limestone jutting out of the west coast of Ireland into the Atlantic. Visitors slide up in their commodious tour buses, scamper out among the lunar limestone dotted with blue hellebore and bloody cranebill, mountain avens and maidenhair, bee orchids, fly orchids, bog orchids, returning to their custom coaches eager to quit this extra land for the nearest pint o' Guinness.

Botanists are likely to have a very different reaction. The list of the Burren's inhabitants strikes them red as cabbages. Alpine species grow side by side with flowers normally found in Spain. Arctic flowers share the same sooty soil with Mediterranean ferns; lime-loving plants cohabitate with those that thrive in acidic soils. In fact, more than 75 percent of all plant species found in Ireland are native to the 100 stark, ostensibly uninhabited square miles of the Burren.

Why do such seemingly disparate species coexist in such close quarters? Theories are nearly as plentiful as the specimens themselves.

Some botanists say seeds were blown here westward across the continent, or southward from the Arctic; other scientists assert that they were carried here in the fur of animals when Ireland was connected by land bridges to Europe, or fell here in the droppings of migratory birds or perhaps the seeds were gathered in the south by the great glacier and deposited here as the ice sheets receded northward.

David A. T. Harper, senior lecturer in geology at University College Galway, has made it his business to discover why the area is hospitable to so many species. He believes the 1,000-meter-deep limestone is the key to the Burren's diversity. Composed of calcium carbonate de-



rived from the heavily compressed shells of marine organisms deposited during the Carboniferous Period some 350 million years ago, limestone accounts for many of the Burren's unique geological features. Because rain easily erodes calcium carbonate, erosion produced the Burren's system of clints (upstanding elements) and grykes (disjunctures). Alternating bands of thick volcanic ash layered upon even thicker bands of limestone weathered in a stepped pattern because limestone and volcanic clays erode at different rates.

On top of all this, Harper says, the receding glacier at the close of the last ice age "scoured the Burren like rubbing a Brillo pad across its surface." The limestone face exposed by this geomorphic sculpting makes it attractive to opportunistic species. It retains heat, keeping its inhabitants warm through the chilly

Irish winters, the lime encourages bedstraws, which in turn provide nutrients, and the calcium carbonate allows for only a certain amount of soil to form, ensuring that the environment does not become too attractive to weeds and grasses, which would otherwise overtake the more delicate ferns and orchids.

Harper's own theory regarding the presence of the Alpine spring gentian and the Mediterranean maidenhair fern owes as much to geography as it does to geology. "Look at a globe," he says, "and you see that Ireland really sticks out into the Atlantic; the island is perched at the extreme edge of Europe."

Once the seeds were transported here, the plateaus of limestone became the final destination for a polyglot colony of European botanical emigrants. Unlike their human fellow travelers, the plants could not make the leap across the Atlantic to North America, so the ferns and flowers of Europe gathered and made their melting pot in a barren place called the Burren.—MELANIE MENAGH



CONTINUUM



Showdown at the OK computer: Legends die hard, but under the scrutiny of science, at least one will rest in peace.

ANOTHER LEGEND BYTES THE DUST

History recounts that William H. Bonney—better known as Billy the Kid—was shot dead at a New Mexico ranch in a showdown with the law on July 15, 1881. And computers have confirmed history: Legend has it, however, that Bonney then twenty-two, escaped the sheriff's bullets and fled to Texas, where he lived to a ripe old age. Further fueling

the rumor, a Texas man who died in 1960—Brushy Bill Roberts—claimed to be the grown-up Kid, even going so far as to ask the governor of New Mexico to pardon him for the murders that he had committed as a young outlaw.

Did Billy the Kid really die an old man? The claim, which periodically surfaces in the national media, has finally been settled with the aid of modern technology. Researcher Thomas Kyle of

SINGLE MEN OUTNUMBER SINGLE WOMEN SIX TO FIVE. THE U.S. CENSUS BUREAU ESTIMATES THAT THERE ARE 2.3 MILLION MORE UNMARRIED MEN IN THEIR TWENTIES THAN WOMEN.

Los Alamos National Laboratory used a computer to compare an authenticated intype photo of the Kid with a certified photo of Roberts taken late in life. "The computer," says Kyle, "can reveal more than the human eye by compensating for differences in the way photos were processed, correcting errors in focus and removing scratches and smudges on historic images." The outcome of this face-off: Brushy Bill Roberts and Billy the Kid were two different people.

"A lot of old men suffer from the same kind of delusion as Roberts," says Kyle. "A fellow in Washington, for example, was claiming to be Butch Cassidy—but once again, computer analysis of photos tells a different story."
—Kathleen McAuliffe

makes trees stiff, are used in insecticides, cement additives, and binders in animal feed. Unproductive wells are flooded with water to drive oil out of hiding before adding a lignin-based chemical that consolidates the petroleum, making it a cinch to recover.

Douglas Nasse, a research scientist with Texaco's exploration and production technology department, says this technique is not only far cheaper than similar oil-recovery methods but also opens up 150 billion barrels of American oil for easy recovery. At current rates of consumption, that's enough for 50 years. "We know what's left in the fields and we know where it is," says Nasse. "That's what makes this approach so intriguing."
—George Nabbio

OIL COMING OUT OF THE WOODWORK

Oil crises encourage some pretty ingenious ways of producing petroleum. Now a technique developed by a Texaco research team in Houston uses common chemicals from trees to squeeze oil from hard-to-reach pockets in the earth.

Trees reduced to paper pulp already yield 40 billion pounds of chemical lignins a year. Lignins, the stuff that



Pump it up: New gold from old oil frontiers.

STRESS IS STUPID

Stress can encourage heart disease, spawn ulcers, and snuff sexual desire. Now it appears that it can also make you stupid.

When humans face life-threatening situations, Stanford neuroscientist Robert M. Sapolsky points out, glands respond by pumping adrenaline and cortisol into the body to speed heart rates. This worked fine for primitive humans facing a saber-toothed tiger attack, but today the same reaction can be caused by work- or home-related stress that has nothing to do with survival.

Sapolsky found that when rats were exposed to prolonged stress or were constantly injected with steroids that include cortisol, they lost neurons in the hippocampus section of their brains. Prolong the stress or injection program and the rats are unable to find food hidden in a maze. Human evidence of a similar neuron loss is "indirect but tantalizingly scary," says Sapolsky.—Billy Altstetter



A solar system of your own: Saturn sports more satellites than any other planet. Now thanks to some fancy detective work, another member has been added to the family.

THE GOOD SHEPHERD

Talk about finding your proverbial needle in a haystack: Imagine discovering a moon so small that it doesn't even register on a photograph. That's the challenge that faced NASA researcher Mark Showalter. He succeeded, however, in finding proof of Saturn's newest

and smallest, with only a 12-mile diameter—moon in just 19 photographs snapped by the Voyager 2 spacecraft during its flyby.

Showalter might have missed his prize had it not been for the astute predictions of NASA's ring experts Jeff Cuzzi and Jeff Scargle. During the mid-1980s, the two noticed that the Encke Gap in

Saturn's A ring had a scalloped fringe. This bit of evidence suggested the presence of a shepherding moon," says Showalter.

So far, the new moon is known only as 1981S13, but Showalter has a better name in mind. He has suggested that the moon be called Pan, after the Greek god of shepherds.

—Tom De Haven

ACCENTS FROM THE VOID

University of Maryland School of Medicine neurophysiologist and epilepsy expert Dean Tippett was surprised when a thirty-three-year-old stroke patient developed a strange accent. "Instead of 'hill,' he said 'heel,' used 'da' for 'the,' and inserted vowels at the end of phrases, saying, 'How are you today a?'" Tippett says. "Although he

was from Baltimore, the patient seemed to speak with a Norwegian accent.

While reviewing the medical literature, Tippett came up with just 15 other cases of "foreign accent syndrome." Sometimes, as in the case of the Baltimore man, the accent disappears after several months. In other cases, however, patients kept their new accents until they died.

The rare condition follows a sudden head trauma or a

vascular accident, but the mechanics behind how a brain injury produces a foreign-sounding accent remains a scientific riddle. Could it be proof of "past lives" bleeding into the present? Tippett is skeptical. "The syndrome isn't complete unless someone listens to the voice and interprets it as a particular accent. The accents aren't necessarily foreign. It's just what people think they hear." —Sherry Baker

CHIMPANZEES HOLD THE SPEED RECORD FOR THE ANIMAL KINGDOM. QUICKIES: SEXUAL INTERCOURSE IN THREE SECONDS.

AFRICA'S SAHARA DESERT COVERS THREE AND A HALF MILLION SQUARE MILES, 16 TIMES MORE AREA THAN FRANCE.



CONTINUUM

WHY ROBOT?

Old may be better than new when it comes to robots, thanks to the ground-breaking research of University of New Hampshire (UNH) professor Tom Miar. "Imagine a machine that improves its own performance as more it's used," he says. "That's revolutionary."

Miar's team at UNH's Robotics Laboratory has already developed a 300-pound robot arm that actually teaches itself how to perform tasks. It employs a PC-sized computer loaded with software that's capable of what is known as adaptive learning. The heart of the system is a network that

allows the robot arm to overcome a number of key problems through trial and error. When a certain action is obtained in the future, the software looks to its memory for a suitable response. During the new activity, sensors built into the arm provide feedback so that the program can continue to adjust its directions to the arm.

In the near future Miar envisions his robots as self-calibrating machines that automatically correct their mistakes as they go along. In the long term, he hopes his work will lead to autonomous systems that excel in difficult environments—under water, for example, or in space.

—Tom DeCortezky



I think, therefore I am? Not over. Descartes, robots may reflect on, and learn from, experience.



HOT SPOTS

What caused record high temperatures across the United States last year? Possible explanations range from simple chance to the growth of cities and the greenhouse effect. Recently another theory was added to the list: Maybe the thermometers were just plain wrong.

Residents of Tucson, Arizona, first brought up the possibility after they noticed something peculiar about the weather last summer. A hot spot had developed at the local airport. It appeared to be getting warmer and warmer out there. In the course of the year, one third of the temperature records were

broken," says National Weather Service surface program manager Joe Schiel. "It would be a hundred and ten degrees at the airport and a hundred degrees elsewhere."

An investigation showed that it was unusually hot at the airport due to an increase in paved roads that reflected heat. Nonetheless, a new electronic sensor that replaced the traditional mercury-and-glass thermometer was suspect.

Schiel admits that while the instruments, called thermometers, are accurate to within one tenth of a degree under laboratory conditions, they have problems in real weather situations. "We have to cover these things to protect them from rain, spiders, dust, everything out there, but sometimes the sun shining or wind blowing on the boxes produce a fluctuation inside the box," he says.

Even so, Schiel says a warming trend is real. "We have a network of ten thousand people taking thermometer readings every day across the country," he says. "That's where we get our climatological data, not from the thermometers. The warming appears to be a real trend. It can't be blamed on our electronic sensors."

—Sherry Baker

IN 1967 SCIENTISTS EXTRACTED 10,000 YEAR-OLD SEEDS FROM A FROZEN LEMMING BURROW IN THE ARCTIC TUNDRA. FORTY-EIGHT HOURS LATER THE SEEDS BEGAN TO GERMINATE.



CONTINUUM

MOONSTRUCK

Iowa State University mathematician Alexander Abian thinks we should blow up the moon. "We have been hostage to the same orbit for five billion years," says Abian. "There is no reason to believe that it is an optimal one as far as the

ecology of the planet Earth is concerned."

Abian asserts that by altering the gravitational parameters governing the movement of the earth, we could shift our planet into a more desirable orbit, eliminating scorching summers and brutal winters caused by the 23° tilt of the earth's



SUPER TRIKE

In the high-rolling Eighties, the Sinclair C5 looked rather pathetic. Moving at a toped 15 mph and requiring vigorous pedaling to negotiate steep hills, the electric-powered tricycle met with great when unveiled by Sir Clive Sinclair in 1984. But Ray Harper, who runs a tricycle shop in Kent, England, bought 600 of them with an eye toward the future. Now the nonpolluting, efficient C5 sells for up to \$4,800 and economy-minded Brits are clamoring for it.

Meanwhile Harper and

his team go on a two-man crusade to prove the potential of electric motor-cars. Their updated C5, four times more powerful than the original, accelerates from 0 to 60 mph in eight seconds. "That compares favorably with the best sports cars," says Ray Harper. They've broken the 75 mph barrier with a C5 and are now at work on a new electric vehicle designed to travel at a record-breaking 200 mph. Encouraged, the Harpers plan a line of 40 mph "commuting cars" designed to ease urban pollution and congestion.

—Curt Wohlschlag



They're fast, they're fast, and they're for sale. Britain's mighty bike-eating pedal yet acceleratorless trike is a sports car.

axis. The easiest way to do this is by manipulating the moon in one of five ways: reducing its mass, splitting it into two or more pieces, altering its orbit, getting rid of the moon altogether, or landing part or all of the moon on the earth, probably the Pacific Ocean near Antarctica.

The hardest part, the mathematician concedes, may be persuading a skeptical world to sacrifice the moon and temper with the earth's climate. "We're used to our orbit like an old pair of shoes," he says. "Many people are reluctant to change their shoes."

—Curt Wohlschlag

UNIVERSAL SOLVENT

Bernard Yurke, a physicist at AT&T Bell Labs, builds universes, fashioning a model of the cosmos in a miniature crystal.

Yurke's universes, about one eighth of an inch thick and the size of a pancake, are filled with the same liquid crystal used to display numbers and letters in pocket calculators. When prodded, the crystal exhibits cracks and imperfections

ON A CLEAR, MOONLESS NIGHT AND WHEN THERE ARE NO OBSTRUCTIONS, THE HUMAN EYE CAN SEE THE LIGHT OF A SINGLE MATCH UP TO 50 MILES AWAY.

MARIE CURIE, CO-DISCOVERER OF RADIUM, WAS THE FIRST PERSON KNOWN TO HAVE DIED OF RADIATION POISONING UNTIL HER DEATH. SCIENTISTS DIDN'T KNOW RADIATION'S DANGERS.

that may be similar to events thought to have taken place moments after the Big Bang.

Liquid crystal was chosen as a medium, says Yurke, because the mathematical equations that describe its transition from a uniform solid to a cracked state are similar to some equations for events after the Big Bang. "The equations theoreticians deal with are so complex, it's hard to have a simple physical system to try ideas out on," says Yurke.

—Steve Nadis



CONTINUUM



Rock and roll never die, especially when it exuberantly boogie productively in the workplace.

THE MATHEMATICAL ADVANTAGE OF ROCK AND ROLL

To play music or not to play music: That is the question office, warehouse and retail managers have asked for years. Now new research from Florida State University in Tallahassee says that even if employees can't like the background music, it may still increase worker productivity.

As with previous research showing that supermarket shoppers buy more goods when the music is slow and that restaurant diners eat to the beat, instructor Sherry Moss and Connie Mayfield found that when they played fast music, their student volunteers correctly calculated 33 percent more math problems than when they played slow music. In fact, science yielded a better response than slow music—157 correct answers for slow

music compared with 180 for no music.

"The slow music had a calming, relaxing effect, making the individual more laid-back and far less hurried," says Moss. The heartbeat music seemed to kill them, while the driving beat of fast music disrupted their equilibrium and humed them up. —Vincent Buzzo

THE ENERGY IN TEN MINUTES OF ONE HURRICANE IS EQUAL TO THAT OF ALL THE NUCLEAR WEAPONS IN THE WORLD

AN ATOM IS ONE MILLION TIMES SMALLER THAN THE THICKNESS OF A HAIR, THE ATOM'S NUCLEUS IS 10,000 TIMES SMALLER THAN THE ATOM ITSELF

SPERMBUSTERS

Birth control for men may be emerging from the dark ages with a promising alternative to condoms and vasectomies. According to a recent study supervised by the World Health Organization (WHO), injecting men with a synthetic hormone may be a more effective means of birth control than female contraceptive pills.

The hormone, testosterone enanthate, works like the Pill: It stops sperm production by fooling the body into thinking it has more than enough. Seventy

percent of the 228 men receiving weekly injections became completely spermless within six months, after 12 months with no other form of contraception, only one of the 157 supposedly spermless couples conceived a child.

Some minor side effects such as acne and weight gain appeared in some test subjects but were not considered dangerous. WHO is now developing a form of the drug that would require injections only once every three months. They hope it will be available within five years.

—Billy Aistebler

TRUTH IN PALMISTRY

Can palm readers really predict how long we will live from the length of our lifeline? The longstanding opinion of the scientific community has always been no. But a study by a not-Norwich, general medical senior registrar at the Royal Hospital of

Devon and Exeter in England, offers at least partial vindication of the palmists' claims. "I thought it would be fun to debunk a popular myth," he says. "It was sort of a medical joke." Newark observed the lifelines of 100 corpses—old and behold, the length of the line did indeed correlate with life span.

His finding notwithstanding, Newark is still far from convinced that the future can be read in our palms. "The most likely explanation for the data is that aging causes a change in the length of the line—in other words, the hands grow more wrinkly as we get older," he says. Anyone concerned about the length of life would be better off "examining their life-style, not their lifeline."

—Kathleen McAuliffe



Is your future resting in the palm of your hand?



A new generation of hyperinstruments will produce unique new sounds, play unerringly by themselves, and take us

BACH TO THE FUTURE

ARTICLE BY GURNEY WILLIAMS III

In the middle of a pale opera performance at the Pappadou Center in Pens, the electronic percussion instrument that made cymbal crashes, cracks, sizzles, and bells began producing music—on its own.

At the conductor's stool, largely hidden from the audience except for his unshined Beethoven hair and waving hands, composer Tod Machover had been waiting to wait onstage. He had written himself into the cast of his opera *VILLIS* as Mini, a semi-disabled computer-music creator.

The libretto Machover wrote for the opera explained his four-and-a-half-minute scene: "Mini appears to be sourcing sounds,

PHOTOGRAPHS BY PETER MENZEL



setting off musical structures with the flick of his hand—he seems to be playing the orchestra of the future.”

So much for the script! Before Machover could make his entrance, the percussion instrument began ringing out like no one had written.

Oh, shit, Machover thought. The instrument's playing itself. Computer expert Joseph Chung, sitting to Machover's left, quickly turned off some circuits. The phantom music stopped before anyone in the audience of 1,500 noticed. Chung later traced the problem to a

glass globe: High voltage inside the ball had sent signals to the instrument—a rare glitch that underscored the potential for magic in the music of the future.

Today, at MIT's Media Lab, Machover and Chung are designing instruments that will do what the electronic drum only seemed to do: artificially think and act like a veteran musician. The new instruments, dubbed hyperinstruments, are essentially collections of electronic components orchestrated to work with a central computer or two.

Typically hyperinstruments don't play a note until they're

plugged in and attached to speakers. Then they hold a considerable edge over most pieces in today's ensembles. Using a single hyperinstrument, Machover can compose, conduct, perform, or make new instrument sounds, all at the very same time.

The versatile new instruments are helping Machover and Chung take musical risks. Already the musical innovators are creating sounds that no one has ever heard and presenting them to potentially stuffy international audiences. And they're teaching such estab-

lished performers as cellist Yo-Yo Ma to play the new instruments as well.

Even music critics are applauding the new noise. After a controversial opening of *WALLS* in Paris in 1987, Machover is now enjoying a crescendo of acclaim. "One of the brightest and most intelligent of new American composers," writes a *New Yorker* critic. And a *New York Times* reviewer predicts, "By the year 2000, *WALLS* will probably be seen as the first populist, rock-influenced, computer-driven opera."

The lab in Cambridge, Massachusetts, where *WALLS* was

spawned is one of a few dozen facilities around the country where serious composers are playing computer and piano keyboards, side by side. What is more, the lab's technology is mature enough to allow listeners today to hear and see prototypes for the smart instruments of 2010.

By then, predicts Max Mathews, hypermusic designer and professor emeritus of music at Stanford University, "almost all music will be made electronically, by digital circuits." The new instruments will never go out of tune, adds Mathews, a former Bell Labs engineer and pioneer in computer music. They'll unerringly produce the right notes in the right rhythm, "so musicians will devote less time to these technical details and more time to getting out pre-

Composer and hyperinstrument designer Tod Machover, top left and right, conducts a



magical stream of original computer music at the Massachusetts Institute of Technology.

pare kinds of sounds and phrasing and musical ideas." In fact, Mathews predicts, the hyperinstrument of the future will be so versatile that it will be capable of simulating virtually any musical arrangement or style. Its range should include anything from whole classical orchestras to rock groups to a single trombone, every user will be able to program his hyperinstrument for jazz, rock, rap songs, or Berlioz's Ninth.

Within a decade, future automated orchestras will offer a menu of interpretations to a composer or conductor, predicts

John Rejn, professor of music at the University of Washington in Seattle. Simply by talking to a voice-sensitive computer, musicians will be able to choose the orchestra size and sound that best matches what the composer is writing. And if none of the options work, the music machinery of 2010 will take orders for entirely new sounds that will exist largely in digital codes.

Machover has already given the downbeat to some of these instruments at the Media Lab, where he is a professor and director of the Experimental Media Facility. In a fourth-floor studio on the MIT campus, he strums low G on a reconfigured 88-key electronic keyboard known as the Kurzweil Midboard, named for its inventor. When a musician plays the Midboard, there is at first no

sound, instead the Midboard sends alert signals to a Macintosh computer.

In the windowless, dimly lit room the Mac processes the signals, feeding them to an array of synthesizers—an electronic drum machine and other pieces of hardware that together are responsible for most of the jazzy thump, brass, and plunk of a full orchestra. The silent electronic pulses from the synthesizers race on to two mixers that control the blend from the electronic ensemble. Slider switches on the mixers can bring up the vibraphone, say, or damp-

Hyperinstrument designer Max Mathews (at right) is shown conducting his computer orchestra with a ribbon used since the new instruments will seemingly produce the right notes in the right rhythm. Mathews says musicians will be able to pay more attention to musical ideas.



on the drums, or crank all the volume up to fortissimo. In a final step, speakers convert the electronic output from the music to rich sound that fills the room.

To start the process, Chung sits down at the Mac and types a few commands about how the system as a whole should respond when someone hits a key on the Midboard. For the demonstration, low C is a trigger. Pressing the single C sets off an arpeggio—a catchy succession of about 16 notes, starting with C, that sound like the bass line for a far-out rock song.

Machover starts hitting C's all over the Midboard. The notes he plays produce volleys of arpeggios, high-end lows, supplied by computer from a speaker around the room. The stream of notes speeds up the faster he plays the keys until the tempo is almost inhuman. The computer supplies the velocity, letting Machover concentrate on other parts of the music: he controls

loudness and softness; for instance, by altering the pressure he puts on the keys.

The real virtuosity of the hyperinstrument appears in another demonstration in which an amateur musician takes over the keyboard to try some of the chords from "Suffering Song"—a haunting, girly daction from WALS. The chords are simple enough for a sixth-grade piano-lesson dropout to read from sheet music. Most of the chords at the beginning of the piece have just three or four notes, not much trickier than Chopsticks. "But when they're played on the keyboard, the system produces a skirt bot of lightning-fast computation and analysis. And—like the strange bells of Min's performance—the instrument itself becomes a lifelike extension of the performer.

As soon as the first chord from "Suffering Song" is struck, the computer identifies the notes and silently searches

through all of the music Machover wrote for the system, looking for the location in the composition where the chord appears. Once it finds the place, the computer checks out its instructions about what it's supposed to do with the chord. In other cases, the Mac has been programmed to splinter the chord into a pattern of separate notes in a tricky rhythm, set by Machover as composer.

The system makes it impossible to play a note that isn't in rhythm. In fact, to an amateur, it seems to make performing a little too easy. The notes come so fast, with so little effort, that at first players are likely to think they're in Machover's Sorcerer's Apprentice nightmare. The instrument's playing itself.

"A lot of people say, 'Oh, yeah, this is absolute bullshit,'" Chung says, conceding. "They argue that all we're doing is taking the musicianship out of playing music, and making these toys so that anyone could produce music."

"They're wrong," Chung says. "That's certainly not what we're trying to do." Instead, Machover says, the whole point of all the technology of the future "will be to sensibly enhance and expand the expressive power" of individual players.

As Machover points out, the new instruments will enable human users to concentrate on whatever aspects of musical creativity they choose. If the computer wishes to alter the nature, or timbre, of notes—for instance, whether they should sound like piano notes or vibrato notes—she can focus on just that aspect while the digital system takes care of speed, rhythm, melody, and everything else. "I ask my computers to do only the things I don't want to do," says Max Mathews. "Anything that I enjoy doing or wish to express myself with, I do myself and don't program that into the computer."

This approach, Chung notes, proved especially fruitful during work on WALS. "Once we took out the dimension of rhythm—one if no longer mattered when you played things—all of a sudden your musical mind was much more free to think of other things."

The "other things" are appar-

ent in the CD recording of WALS (from Bridge Records, New York). As played by a keyboard pro, the notes from the opening of "Suffering Song" seem to be coming from hybrid instruments, exotic and changing combinations of mandolin, guitar, vibraphone, and bell. The reason is that the computer program allowed pianist Emma Stephenson to virtually change instruments on the spot by pressing harder or softer on the keys. Normal pressure on the keys produces the sound characteristic of a vibraphone. More pressure creates the timbre of a bell, turning the keyboard into a percussion instrument for a note or two. Like pianist Stephenson, drummer Daniel Campiolo gets back-up from the computer, too. The Mac keeps metronome-perfect time while he produces different timbres by hitting rectangular rubber pads arranged to look like oversized piano keys on a wood board. The sounds, all electronic illusions, range from the timbre of bongos to wood blocks to strings.

Electronic illusions are flowing from another hypermusic technology recently developed by Machover at the Media Lab as well. In this innovation, musicians enter a kind of message through what the researchers call a "double instrument."

Playing a drum, one partner produces pitches—musical frequencies or tones—with a keyboard. These chords and melodies are not broadcast through speakers; however, instead, they travel silently to a second instrument—usually a percussion device like the one used by drummer Campiolo. Nobody hears the melody from the first device, the keyboard, until the percussionist strikes the pads, adding rhythm and timbre. Only then does the musical combination from the two partners go on to a synthesizer and come out of the speakers as music.

Machover has already begun using another piece of futuristic musical technology as well—a \$30,000 metal glove that magnetically tracks the position of ev-

ery joint in the hand that wears it. Wires trail away from the hand like support lines leading to an IBM-compatible computer. The IBM then sends information on the finger position to an Apple Macintosh. The Apple interprets the movements, controlling the sound that ultimately emerges from synthesizers. With subtle finger weaving, Machover can alter the instrument's volume levels and frequencies and even create the illusion of musical "panning," in which sound seems to travel around the room.

Double instruments and glove conducting can be heard on Machover's latest CD recording, *Piano from Bridge Records*. And the MIT composer says that these hyperinstruments may lead to others, musical tools so sophisticated they will make Min's glass globe look like something from an old Frankenstein movie.

While Machover today plays music with the help of a glove, for instance, hypermusicians of COMPLEX OR PULSE 84

With subtle finger weaving, Machover can create the illusion of panning, in which music seems to travel around the room.

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ARTICLE

In the continuing quest for artificial intelligence, researchers around the world believe that a little child, or even a lower-order life form, will lead the way to a new breed of robot workers and warriors

BY TOM DWORETZKY

MechAnimals

The little three-wheeled robot is the size of a cigar box. It has only two missions in life. When it hears noise, it hides in a corner of the room. When all is quiet, it scampers around looking for light, then races to the source. It

may sound pretty mundane, but the sound-averse, light-attracted creature represents the cutting edge of artificial intelligence. In the near term, this little robot may form the basis of a vacuum cleaner that stays out of the way and works automatically only when no one is in the room. In the long term, it could lead to robot workers that build cities, fight wars, or install scientific monitoring equipment in space.

When you think about artificial intelligence (or AI), what pops to mind is usually some Hal-like omniscient device capable of beating chess, misanthraps at their own game, providing insight into the most subtle bits of science or history, writing poetry or tell jokes and suitably equipped with the right and effectors (arms and such)—a watch or clock, a soufflé—a device that can think, create, and even feel. In other words, a perfect imitation of a human being.

Unfortunately, real AI efforts have fallen short of these lofty goals. The reason, many experts now say, is that in the race to create higher life forms, AI researchers have lost sight of the basics. As a recent powwow in Paris, in

fact, the critics declared that instead of tackling the highest levels of human mentation, AIers should be examining fundamental questions of perception, learning, and adaptation. Scientists at the meeting, the International Conference on the Simulation of Adaptive Behavior, even had a name for the lower AI creatures they hope to build—animals, tiny artificial animals that will scamper across laboratory floors or computer screens. According to researchers, they will study these

frisky critters in their "natural habitats," much the same way an entomologist, biologist, or psychologist might study an animal or human being. As AI experts come to understand these artificial animals, they will liberally help them to evolve into more sophisticated forms. The result, says Stewart Wilson, the scientist at the Rowland Institute for Science in Cambridge, Massachusetts, who coined the term animal, will be truly machine creatures far more intelligent than any AI systems that have come before.

The idea for the animal actually dates back to 1950, when the legendary Alan Turing laid out two possible approaches to machine-based intelligence in one approach. Turing suggested providing machines with the best sense organs that money could buy, then liberally teaching them to understand and even speak English. "This process," Wilson says, "follows the normal teaching of a child."

In the early years, both approaches competed for the bright

est minds and the biggest funding. But by the Sixties, researchers modeling specific human abilities had won out over attempts to understand natural intelligence at a more primitive level.

During the Seventies, however, AI efforts hit the wall. A lot of money had gone into the work, but little real-world value had come out. The knowledge-based programs, although powerfully capable in very specific, rigidly controlled (and artificial) environments, had big problems in the real world. Their emphasis on exact reasoning at the expense of perception and adaptation made them brittle and arbitrary. In other words, they found it impossible to operate in domains even slightly different from the ones for which they were programmed, and their internal reasoning bore no resemblance to the physical world.

The animals are now attempting to escape the trap of mimicking high-level mental competence by turning to Turing's second suggestion—the child machine, teased from the start in a real sensory environment and programmed to learn through experience. Today's animals, whether simulated or real, are of course closer to Pac-Man, bacteria, or, at their most evolved, simple insects like ants. The basic strategy by definition is to work up to sophisticated intelligence from below. Toward that end, Wilson says, researchers take the holistic approach: "The animals, like animals, exist in realistic environments," he says. "And as they evolve, they cope with more and

more problems presented by the natural world."

To help the critics negotiate worldly terrain, animal developers like MIT's Rodney Brooks have endowed them with a number of task-specific computerized boxes. Each box produces a straightforward behavior, from following walls to avoiding collisions to moving toward light sources. As Brooks's creatures go about their business, they seem to be planning and learning. But as Brooks points out, "You can't point to one piece in the code—any of the specific boxes—and say that is where the higher-level brain activity takes place. Rather, the more sophisticated activity emerges from the interaction of all the simpler parts."

One of the most sophisticated characteristics being programmed into animals is the ability to evolve. Federico Cecconi and Domenico Parisi of the Institute of Psychology in Rome, for instance, have created a computer simulation based on two types of simple organisms—one that can grasp an object only at a precise reaching distance and a second that can move to approach an object and extend its arm to grab it. When the simulation starts, the population contains individuals with randomly different levels of grasping proficiency. After Cecconi and Parisi's system has run for one generation, only those with the best performance are allowed to reproduce, making copies of themselves for the next generation. Each time a copy is made,





the computer alters it slightly, mimicking the random genetic mutations of real evolution.

The simulation works like life itself. After evolving for 65 generations, the population on-screen has an abundance of successful grasping. What's more, the ability to learn is programmed into more offspring as a result.

To truly perfect the art of grasping, of course, animals will need to recognize the object to begin with. That's why one of the most important challenges facing future animal builders will be the development of intelligent sensors that recognize patterns and even the meaning of events.

With this goal in mind, AI student Dave Cliff at the University of Sussex, England, is developing a computer model of the hover fly's eye. The interesting thing about the hover fly, says Cliff, is that it focuses on information at the center of its visual field, paying less attention to images at the periphery. Cliff's model further narrows down visual signals by eliminating redundant information, thus revealing underlying patterns in the images.

To the hover fly's eye, Cliff says, "the world looks like a Mondrian painting. The eye detects only the edges between blocks of

color. Without all the redundancy, you save valuable resources, such as processing time, that you would otherwise waste on things you already know."

Cliff's hoverfly eye, thus far, is a simulation on a computer screen that can see where it's going and correct its course itself. Once the eye or one like it has been built and fit onto an animal, it will help the creature navigate the world. In fact, because the hoverfly eye is so intelligent, the animal brain processing the visual input can be a little less smart.

Even with such smart sensors, however, animals will have trouble negotiating the world without inner motivations of their own. That, at least, is the view of Patric Meeus, a researcher at the AI laboratory at the University of Brussels in Belgium and the AI laboratory at MIT. In her new computer program, movable creatures have a range of drives from eating, drinking, and sleeping to fighting, fleeing, and exploring. These drives help them face a complex environment that includes food, water, obstacles, and other animals. According to Meeus, behavior patterns emerge as the computer animals react to conflicting drives in the face of varied and complex situations.

The animals are motivated to ward any given behavior. Meeus says, by what is called an activa-

tion level. For instance, the presence of food will activate eating; eating, in turn, will activate behaviors such as drinking or sleeping. Yet other behaviors may be deactivated, or inhibited. For instance, fighting will inhibit the drive to flee. In this way, Meeus says, the computer animals are internally motivated by internal and external factors to behave in a variety of complex ways.

In the future, motivated animals like those designed by Meeus will leap from the computer screen in 3-D, nuts-and-bolts splendor to sense the environment, adapt to the world and travel around it well. These smart and flexible creatures may eventually clean our homes, deactivate bombs, and traverse the endless void of space. Whether their tasks are mundane or downright dangerous, the animals are sure to become our trusty assistants. They will ultimately perform in ways no conventional robot could master, releasing us from the many unpleasant activities we reluctantly accept today. And judging from their capabilities, who knows how far evolution will take them? Some pundits suggest that let loose in space or under the sea, advanced animals might possess the independence and adaptive ability to develop vibrant colonies over civilizations of their own.



Inspired by the notion of robots modeled after the myriad creatures in nature, artist and animal



systematician Louis Bec has generated a new body of work—as he calls it, a zoology of change. Bec's colorful, futuristic creatures, shown above, were spawned by the



artist along the border zone of technology and biology, imagination and art.

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OHNI'S CATALOG OF ANIMATS

Animats in AI labs around the world are currently simple creatures. But in the future, they will find their way into our everyday lives. To learn about future animat species, we've polled the experts and gazed into our own crystal ball. A collection of potential animats follows below.

PETMATS

The first animats may be toy pets that perceive the environment through sensors modeled on those of real animals. Their individual behavior patterns will evolve during their own lifetimes, as their neural networks build up memories of past situations.

Calmats, the first petmats to be built, will be designed with eyes that are especially acute at night. These animats will perform a double duty as both affectionate pets and stalkers of household pests such as rodents and roaches. To accomplish the latter task, their neural networks will help them identify unwanted animals, as well as each species' patterns of flight and avoidance.

With different neural circuitry, dogmats will play catch and hunt animats such as rabbits. Components of their brain circuits will make the sense of smell the most acute of their senses.

Birdmats, a possibility for future amusement parks, will fly in flocks according to primitive behavior patterns that make them follow the bird directly in front of them. To accomplish this, their eyes will work much like those of the hover fly.

DOZERMATS

Some day hordes of tiny, bulldozer-like autonomous robots may construct vast habitats for humans. These could be as small as an inch on a side and powered by solar cells. They could even create a moon base, for example, a suggestion put forward by MIT's Brooks. His dozermats would carry out only simple actions, such as digging and picking up piles of dirt. Together, however, they would proceed, like ants building their hills, to construct vast, intricate structures. Dozermats could also find uses on Earth, building and maintaining roads.

Variations on dozermats, equipped with different attachments, could also function as robotic loggers and farmers. Their mental circuitry could identify trees and plants appropriate for harvesting, navigate difficult terrain, plow, and plant new growth.

WORKERMATS

Applications for animats would crop up in environments from the home to the bottom of the sea. Workermats could carry your drinks from the kitchen to the liv-

ing room but would also have many more important functions. Consider a contaminated nuclear power plant. Workermats could withstand high heat and lethal radiation to perform their cleanup duties. Their bottom-up mental logic would allow them to navigate the unpredictable terrain of a severely damaged facility with much greater adaptability than any robot relying on a preprogrammed floor plan. They would be equipped with radiation detectors, vision sensors, and pressure-sensitive "skin" to alert them to potential obstructions.

The workmat's brain would consist of a variety of modules each motivated to survive and accomplish tasks. Specific mental components—collision avoidance, power replenishment, and debris collection, for instance—would run parallel, each competing for control over the wheels and arms of the animat.

BOOBTUBERMATS

These are a favorite fantasy of MIT's Brooks. He envisions tiny robots that would live in a corner of the screen when the set was on. When it was turned off, they would scurry around on its surface cleaning the dust. They would be cheap, perhaps a few dollars for a vat of 50 or 100 of the creatures. For power, the boobtubermats would have their

CONTINUED ON PAGE 94



The work of artist Louis Bec suggests that the animat may one day be as hardy for survival as lions, leopards,



or even the indestructible bacteria. Bec says that his array of creatures, including those shown above, illustrate the variety of creatures scientists may create through the powerful technique



of technosymbiosis, when technology and biology join hands.

The city on the other side of the bay was putting on its best show that morning: shimmering and glistening in the clear December sunlight. Lowly old San Francisco, capital of the Empire, now and always. Carotta, reading her great-great-mother's old photo for his first trip over there in forty-three years, looked up to take in the view from the picture window of the Berkeley War Veterans Center, where he was the only remaining resident: green hills rising far in the distance, the twentieth-century white towers of the downtown buildings closer in, the bay, sparkling speckled of the New Bay Bridge, running parallel to the majestic stupor of the old one.

"Isn't it beautiful?" she said, turning him in his wheelchair so he could have a look at it, too.

"What?"
"The city San Francisco. You see it there, don't

you?" She touched the vitreous nodes that jutted like a tiny terrarium mushroom from his left temple, giving it a quarter turn. Maybe the shyness was off a little. Sometimes the old man fiddled with his nodes while he slept. "We're going across in a little while."

"At this way to the city, are we?"

"You know. For the ceremony. The anniversary of the end of the war. They're going to give you a medal. Don't tell me you've forgotten already."

The homeless leech, leechily but supple, stretched and twisted like jelly, rearranging its sallow sagging folds into a smile. "The war's over? It's a civilian affair?"

"You bet you are, Uncle."

The wrinkled eyelids made three or four quick tentacles of the hard-colored fiberglass bundles that were his optical inputs.

"When did all that happen?"

"The war's been over for a hundred years, Uncle James. A hundred years today."

"No shit?" Muscic alabro moved slowly around in the crepey convolutions of his cheeks. "Imagine that. A hundred years. That's one goddamn long time." Then he said, after a moment, "Who was?"

"We did, Uncle."

"We did? You sure?"

"We're not a free country, aren't we? Nobody tells the Empire of San Francisco what to do, do they? We're the most powerful country in Northern California, isn't that so?"

He sagged that. "Yeah. Yeah, of course we won. I knew that. Really I did."

He sounded a little doubtful. His generosity did. Well, he had it right. He was one hundred forty-three years old, give or take a few months, and most of him

was machinery now, practically everything except the kooky old grey brain behind his optical inputs. His wrists were aluminum selenator, his terraria were polyurethane and cobalt-chromium, his eardrums were Teflon and platinum. His molecular joints were silicone with titanium gemmets. His elbows had plastic bushings; his re-



dominal walls were Deacon. And so on, and on, and on. Why anyone wanted to keep someone who that long was more than Gravitia could figure out. Or why the serken wanted to be kept. But she was only nineteen. She allowed for the possibility that she might take a different view of things when she got to be as old as he was.

"We're just about ready to go, now. Let's do the checkout, all right?" Obviously he held out his arm. She opened his instrument panel and began keying in the life-support readouts that ran like a row of bright metal facets from his wrist to his elbow. "Respiratory—circulatory—metabolic—osteoblast—there, that's a good reading—audio apparatus—optical apparatus—biochip autostimulator—amine—hemoglobin—enzyme renase—glucose level..."

There were two dozen of

THE LAST SURVIVING VETERAN OF THE WAR OF SAN FRANCISCO

FICTION BY
ROBERT SILVERBERG

All you have to
do to become a hero is
live long enough

ILLUSTRATIONS BY
MICHAEL MAIER

them, some of them pretty level. But Carlotta obviously ran down the whole list, tapping it a query and getting a green light, like a little readout plate. It took close to ten minutes. The newer-model senior-rehab equipment had just a single readout, which gave you a go or a no go, and if you got the no go you could immediately request data on specific organic or pseudo-organic malfunctions. But Uncle James was one of the early models, and there was no money in the rehab budget for updating citizens left over from the previous century.

"You think I'll live?" he asked her, suddenly feisty.

"For another five hundred years, minimum."

Outruly, dutifully, she finished the job of making him ready to go out. She disconnected the long, treacherous line from the wall and put him on portable. She disabled his chair control override so that she alone could guide the movements of his voiceless, remote implant in her palm. She locked the restraining bars in place across his chest to keep him from attempting some sudden, certain, unannounced exit on foot out there. More than ever now, the old man was the prisoner of his own life-support system.

Just as she finished the job Carlotta let a strange inner twisting and jolting as though an earthquake had struck the unexpected sickening sensation of seeing herself in his placid and weathered and afluttered and motionless and helplessly in the grip of a life-support. Her long slender legs had turned into prehistoric, her golden hair was thick, colorless straw, her smooth oval face was a mass of dry warts and creases. Her eyebrows were gone, her chin jutting



WHEN SHE'D FIRST COME TO THE CENTER THERE HAD BEEN SEVEN VETERANS LIVING THERE, BUT ONE BY ONE THE OLD GUYS HAD HAD RANDOM MALFUNCTIONS, AND ONLY JAMES WAS LEFT.

like some old witch's. The only recognizable aspect of her was her clear blue eyes, and those, still bright, still quick and sharp, glared out of her sunken face carrying such a charge of hatred and fury that they burned through the air in front of her like twin lasers, leaving trails of white smoke.

Not me, she thought. Not over, not like that.

She pressed down hard on her palm implant, and sent the old man's chair rolling toward the door, which opened at his approach. And out they went into the hallway.

Carlotta had been working as a nurse at the center for a year and a half, ever since she'd left high school. It wasn't the kind of work she had hoped for. She had imagined doing something with singing, or music, or maybe acting, at least. When she had first come to the center there had still been seven veterans living there and a wall of health, but one by one the old guys had undergone random system malfunctions, probabilistic events that became statistically unavoidable the deeper you got into your second century and now only Uncle James was left, the last survivor of the army of the War of San Francisco. The staff was down to four: Dr. McClintock, the doctor, three nurses. But everybody understood that when Uncle James finally went they'd all lose their jobs.

That morning, when Carlotta showed up, there was a note from Sanchez, the night nurse, waiting for her in the staff room. GO-HUP YOU IN SIXTYMIN WAITING TO YOUR UNCLE IN THE CITY TODAY.

"Hot weather today," Uncle James said, as they emerged from the building. "Very nice for December, yes."

"Hot. Not just nice. Hot. It must be a hundred degrees."

"A hundred's impossible, Uncle. It doesn't get that hot even in Death Valley. A hundred and the whole world would melt."

"Bullshit. It was a hundred degrees the day the war started. Everyone remembers that. The fourteenth of October, hot as blazes, a hundred degrees smack on the nose at three in the afternoon. When those Mar Suikas started coming over the horizon like bats out of hell."

"Nazis?" she said.

"What Nazis?"

"The invading force. Heiser's Wehrmacht."

"That was a different war, Uncle. A long time before even you were born."

"Don't be so smart. Were you there? Like apples, they were, those planes. Moreover, they straddled us for hours in that Mhyheer Blum Blum Chik-chik-chik-chik! Blam!"

He glowered up at her. "And it's a hundred degrees right now, too. If you don't think so, you're wrong. I know what a hundred degrees feels like."

The temperature that morning was about eighteen, maybe twenty. Very nice for December, yes. But then Carlotta realized that the degrees he was talking about were the old kind, the Fahrenheit kind. One hundred on the old scale might be forty or forty-five real degrees, she figured. But he might be having some perceptual trouble, or maybe even a boil-over in the metabolism line. She listened over and checked the master chair readout. Everything looked okay. He must just be excited about getting to go to the city.

The car that the Amistice Centennial people had sent was waiting out front. It had a hinged gate and a wheelchair ramp so



she could roll him right into it. The driver looked like an android, though he probably wasn't. Uncle James sat quietly, murmuring to himself, as the car pulled away from the curb and headed down the hill toward the freeway.

"We in the city yet?" he asked, after a time. "We're just reaching the bridge, Uncle."

"The bridge is broken. That was the first thing they bombed in the war."

"There's a new bridge now," Carlotta said. The new bridge was older than she was, but she didn't see much purpose in telling him that. She swung him around to face the window and pointed it out to him, a delicate, flexible ribbon of any suspension cable weaving in the breeze. It was like a bridge of glass. The shattered pylons of the old bridge that rose from the bay alongside it seemed as ponderous as dinosaur thighs.

"Some bridge," he muttered. "Looks like a piece of rope."

"It'll get us there," she told him.

According to the center records, he had been taken to San Francisco for his hundredth birthday. He hadn't been much of anywhere since. Just sitting in his chair, doing nothing, living on and on. If you called that living. Old James had outlasted his son by more than a century—he had been killed at the age of something like twenty-two in the War of San Francisco, during the raid by the Free State of Mendocino. He had outlived his grandson, too, victim of an unexplained sniper attack while visiting Monterey. Half of a thing to outlive your own grandson. James's closest relative was his great-granddaughter, who lived in Los Angeles and hadn't come north in decades. And then Carlotta.

She felt sorry for the old man. And yet he had managed to have one big thing in his life, the war. That was something. His one moment of glory.

Her life had had nothing in it at all, so far, except the uneventful getting from age zero to age nineteen, and that was how it looked to remain. The world was pretty empty, locally, these days. You couldn't expect much when you lived in a country thirty miles across, that you could drive from one end of to the other in an hour, if you could drive. At least Uncle James had had a war.

They were on the bridge now, meshed with its transport cables, whizzing westward at a hundred kilometers per hour. Carlotta pointed out landmarks on the way in case he had forgotten them. There's Alcatraz Island, do you see? And that's Mount Tamalpais, away across on the Marin County side. And back over there, behind us, you can see the whole East Bay—Oakland, Berkeley, El Cerrito.

The old man zoomed interested. He responded with a jumble of military his-

tory, hazy memories intermixed with scrambled details out of the wrong way. The Mendocino people came in right through there, where the San Rafael bridge used to be, maybe two hundred of them. We fixed their wagons. And then the Japs, General Togo and Admiral Mitsuhashi, but we drove them back, we nuked their asses right out of here. Then a week afterward there was a raid by San Jose, came up through Oakland, we stopped them by the Alameda Tunnel—no, it was the bridge—the bridge, right, we held them, they were cursing at us in gock and when we went in to clear them out we found that Charlie had planted Bouncing Betties everywhere, you know, antipersonnel mines.

She didn't know what he was talking about, but that was all right. Most of the time she didn't know what he was talking about, nor, she suspected, did he. It didn't matter. He rambled on and on.

She could see the sleek Brazilian in the crowd. He was staring at the old man as though he were a mound of emeralds. Then he flicked his gaze toward Carlotta.

The bridge crossing took ten minutes—there was hardly any traffic—and then they were gliding down the ramp into the city.

Carlotta felt a little wave of excitement stirring within her. Approaching the city could do that to you. It was so lovely, shimmering in the bright sunlight with the waters of the bay glistening all around. A place of such infinite promise and mystery.

Let me have an adventure while I'm over there, she prayed. Let me meet someone. Let something really unusual happen, okay?

She hadn't been in the city herself in six or eight months. You tended not to, without some special reason, if only she could park the old man for a couple of hours and go off to have some fun, see the clubs, maybe check out the new styles, meet someone lively. But that wasn't going to happen. She had to stick close by Uncle James. At least she was here, a perfect day, blue sky, warm breezes blowing. The city was where everything that was of any interest in Northern California went on. It was

the capital of the Empire of San Francisco and the Empire was the center of the action. Everything else was small-time, even if the small-time places wanted to give themselves fancy names: the Republic of Monterey, the Free State of Mendocino, the Royal Domain of San Jose. Once upon a time, of course, it had all been a lot different.

"San Francisco," Carlotta said. "Here we are, Uncle."

They came off the bridge at the downtown off-ramp. There were bright banners everywhere, the imperial colors, green and gold. Crowds wore in the streets, waving little flags. Carlotta heard the sound of a brass band somewhere far away. The driver was taking them up the Embarcadero now, around toward the plaza at Market Street, where the Emperor was going to preside over the ceremony in person. Because there was just about the only car in the vicinity, the spectators had figured out that someone important must be riding in it, and they were cheering and waving.

"Wave, Uncle! They're cheering you! Here, let me help you." She touched her finger to his motor control and his right arm came stiffly up, fingers clenched. A little line tugging and she had the fingers open, the palm turned outward, the arm moving back and forth in a nice, sprightly wave.

"Smile at them," she told him. "Be nice. You're a hero."

"A hero, yes. Purple Heart. Distinguished Service Cross. Croix de Guerre. You ought to see my medals sometime. I've got a box full of them." He was leaning forward, peering out the car window, smiling as hard as he could. His arm jerked convulsively, he was trying to move it himself. Good for him. She let him override her control. He waved with surprising energy, a jerky wave, almost robotic, but at least he was doing it under his own power.

They had a big platform made out of polished redwood up at the plaza, with a crowd of VIPs already there. As the car approached, everyone made room for it, and when it halted just in front of the platform, Carlotta hopped out and guided Uncle James's chair down the car's wheelchair ramp and in to the open.

"Ned Towens," a fat sandy-haired man with a thick brown mustache told her, pushing his face into hers. "Impartial adjudicator. Splendid if you can come. What a grand old soldier he is! He gave Uncle James a sidelong glance. "Can he hear anything I say?" He leaned down next to Uncle James's ear and in a booming voice he followed. "Welcome to San Francisco, General Crawford! On behalf of His Imperial Majesty Norton the Fourteenth, welcome to—"

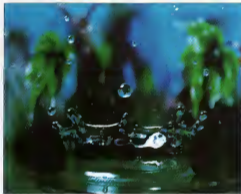
Uncle James shot him a withering

ESSAY BY ISAAC ASIMOV

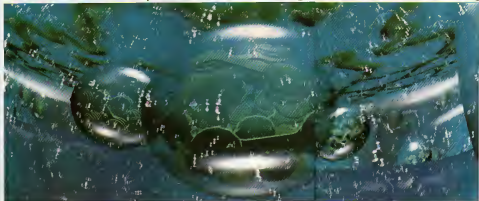
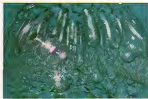
Computer-enhanced photos of
nature hard at work.

PHOTOSYNTHESIS

CAPTIONS BY KELLE MONAHAN



THE WORLD'S LEADING SCIENCE WRITER ASKS US
TO REFLECT WITH HIM ON HOW SIMPLE MATERIALS
SUCH AS THE DROPLETS OF WATER ABOVE COMBINE
WITH OTHER ELEMENTS IN A PROCESS THAT GIVES
US THE FOOD WE EAT AND THE AIR WE BREATHE.



1 ALL LIVING THINGS ARE DRIVEN BY CHEMICAL ENERGY. THE SOURCE OF THAT ENERGY IS A PROCESS THAT TAKES PLACE IN ALL GREEN PLANTS. **2** ROOTS ABSORB WATER AND CARRY ITS MOLECULES THROUGH PASSAGEWAYS CALLED XYLEM. WATER MOLECULES THEN ENTER THE PLANT'S LEAVES. **3** LEAVES SOAK

IN CARBON DIOXIDE FROM THE ATMOSPHERE. THE STAGE IS SET FOR PHOTOSYNTHESIS TO TAKE PLACE. **4** A FLOOD OF LIGHT MAKES THE ACT COMPLETE. LIGHT'S ENERGY POWERS A VARIETY OF CHEMICAL REACTIONS. **5** THE REACTIONS INVOLVE CHLOROPHYLL AND A HOST OF OTHER CHEMICALS AND ENZYMES.

Think for a moment of the things you don't think about. You are breathing and, with every breath, you consume oxygen and produce carbon dioxide. The process is absolutely essential to life, and you have been doing this during all your existence. So has every other person on Earth. In fact, all animal life, from whales to water fleas and from bulls to beetles, has been doing this very same thing and has been doing it for at least 2 billion years.

The question is, How is it that we've never used up all the oxygen and died for lack of it?

Again, it is essential for life that we eat, and what we eat is food (never mind the chemistry). In order to get the energy we need to maintain life, we combine the food with oxygen to produce water and carbon dioxide. We all do it constantly. Why haven't we run out of food as well as oxygen?

Obviously, the only answer is that something exists that reverses the process. All animal life is marked by the following: Food plus oxygen forms water plus carbon dioxide.

Somewhere on Earth, therefore, there must be a reverse process that can be described as water plus carbon dioxide forms food plus oxygen.

And there it! Green plants, exposed to sunlight, convert water and carbon dioxide into food and oxygen.

6 AS A RESULT, WATER AND CARBON DIOXIDE ARE TRANSFORMED INTO SUGAR AND OXYGEN. THE ENERGY FROM LIGHT IS NOW STORED AS CHEMICAL ENERGY. **7** PLANTS, WHETHER DIRECTLY EATEN BY HUMANS OR FED FIRST TO FOOD ANIMALS, HOLD THE SUN'S ENERGY IN RESERVE FOR US. **8** THE STORED ENERGY EN-



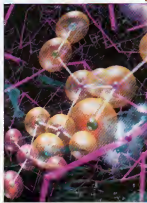
and the balance has thus been preserved through all the existence of life on our planet.

Since the conversion of food and oxygen to carbon dioxide and water produces the energy that maintains animal life, the reverse process—conducted by green plants, must consume energy. (You get nothing for nothing in this world.) Where does the energy come from? It comes from the energy of visible light. As an energy source, light is perfect for two reasons. First, it is unimaginably copious. The earth is constantly bathed in sunlight. Second, visible light is a mild, unintrusive form of energy that does little or no harm.

About 2 billion years ago, tiny bacteri-like cells called cyanobacteria (which still exist on Earth) developed the chemistry to handle sunlight and make use of its energy to form food and oxygen. The ocean slowly filled with food, and the air slowly filled with oxygen, and eventually the groundwork was laid for the development of life more complex than bacteria.

Some of the complex life forms that eventually formed were green plants, and some were animals. Between the two of them the balance was maintained.

What is it in green plants that does the trick? It is a compound called chlorophyll, which rather resembles the heme in animal hemoglobin. Chlorophyll is a bit more complicated and has a magnesium atom where



TERS OUR SYSTEMS AS FOOD, CARRIED THROUGH THE BLOOD-STREAM. **9** SUGARS IN THE FOOD ARE ONCE AGAIN BROKEN DOWN INTO ENZYMES AND CHEMICALS. **10** OUR MUSCLES RELEASE THE ENERGY STORED DURING PHOTOSYNTHESIS. WE EXHALE—AND RELEASE CARBON DIOXIDE. THE CYCLE BEGINS ANEW.



heme has an iron atom. But it is not simply chlorophyll that does the trick. If it were, we could isolate chlorophyll and put it to work. Instead the chlorophyll exists in intricate and complex little organelles within the cell, organelles called chloroplasts, and it is these that perform the process called photosynthesis ("put together by light").

Using modern techniques—powerful microscopes, radioactive tracers and so on—chemists have managed in the last generation to work out many of the detailed changes that take place within the chloroplasts. They have learned how certain chemicals change into others and how units of sunlight are incorporated into the process so as to supply the necessary energy.

However, we have not learned how to repeat this process with anything less complex than a chloroplast, so that not all the knowledge we have yet gained will suffice to have us replace, or supplement, the work of the green plants.

This is not to suppose that someday we won't, that the day might not come when we can set up artificial systems for the conversion of water and carbon dioxide into food and water; if so, it is precisely such artificial systems that may make long human flights through space possible and may enable us, someday, to reach the stars. **DO**



Earthquake depths are less accessible than the moons of Jupiter, says a top seismologist, who predicts a one-in-five chance of a Big One in the San Francisco Bay Area in the next five years

INTERVIEW

ALLAN LINDH

In 1953 Allan Lindh forecast the Loma Prieta earthquake. He did not, of course, say it would occur on October 17, 1989—as it did—nor even that it was due before the turn of the century. What he said was he saw a 50 to 90 percent chance of a major quake in that California segment of the San Andreas Fault within the next 30 years.

Lindh, a top seismologist with the U.S. Geological Survey (USGS), was not alone in his suspicion of that particular segment of the San An-

dreas Fault. In the 16 months before the Loma Prieta earthquake, the USGS issued two warnings of increased risk in that area. Afterward most agreed that the earthquake "took place" as colleague Wayne Thatcher put it.

In the fall of 1990 Lindh did not predict a 50 percent chance of an earthquake along the New Madrid Fault on December 3; in fact, he thought it highly improbable that an earthquake would occur in that south-central

PHOTOGRAPH BY RUVEN AFANADOR

area at that time. When December 3 came and went and there was no quake, Lindh took this fact to be a "direct sign of the existence of God, who chose to signal that She was on the side of the real seismologists."

Earthquake prediction is still a novelty in the world of respectable science. Until a few decades ago the mere idea of a scientific basis for forecasting was a laugh. "Only fools, charlatans, and liars predict earthquakes," said Charles Richter. But growing knowledge of plate tectonics in the Seventies gave some rationale to the sudden ruptures of the earth. We now understand that an active fault zone is the result of two continent-sized plates grinding by each other. In some places movement is gradual; in others rocks lock together until the pressure becomes overwhelming, whereupon an earthquake snaps them past each other.

So earthquake prediction should be simple. All you have to know is how fast the plates are moving and how much plate divergence leads to a quake, and you've got it. But even with adequate earthquake history and good measurements (very tricky), the result is still approximate. The current idea of a prediction, or "forecast," is to point along the lines of a 30 percent chance in the next 30 years.

Lindh is trying to narrow the span. A

leading force in establishing the USGS's Parkfield Earthquake Experiment. Today he is lobbying to wire the San Francisco Bay Area with earth movement analyzing instruments. Calling it "the earthquake capital of the world," Parkfield (population 34) in central California averages a medium-sized quake about every 22 years. In 1985 the federal government issued its first official earthquake prediction—a 90 percent chance of a magnitude six by 1993—based on research at Parkfield. The last Parkfield quake was in 1966, and the next is overdue. Mainframe several million dollars worth of measuring devices have been sunk into the Parkfield earth in the hope that after the quake is over, Monday-morning quarterbacks will be able to sort out the signals unique to imminent earthquakes.

Lindh, forty-seven, has spent his career with the USGS in Menlo Park, California. Having received his Ph.D. at nearby Stanford, he lives with his family about half a mile from the San Andreas Fault. A beeper on his belt informs him of most significant quakes in Northern California. Lindh admits that his career as a seismologist began with cleaning ducks at age five. The route from ducks to seismology was not direct. After dropping out of college during the Cuban Missile Crisis, he spent the next decade driving a garbage truck, work-

ing in a Canadian oilfield, and arguing with his draft board. When he finally arrived at the University of California at Santa Cruz, Lindh studied geophysics. Part of the appeal of seismology, he admits, was that so little was known about it then a young man in a hurry could pick it up pretty fast.

San Francisco writer Esther Werning toured Parkfield with Lindh—and his office, where newspapers, unfired reports, and rolled-up charts made a landfill that raised the floor level several feet. Like many people too busy to organize, Lindh demonstrated an uncanny ability to dive through the crust and produce the article under discussion. A path led to the desk, where a PC with ties to earthquakes worldwide reigned. On Werning's second visit, Lindh, in deference to an out-of-kilter beeper, stretched out with his head nearly under his desk and the tape recorder resting on his stomach.

Two beepers sounded and seismologists from all over the building converged on a set of seismometers recording quakes. As neither disturbance proved alarming, the crowd quickly departed. But every little quake adds to the big picture. The USGS center in Menlo Park issues a weekly seismicity report for Northern California—enviably, nurtured, and written by Lindh. The report, which describes the past week's rumblings and the changing prognosis for future quakes, is widely circulated and nervously watched by the media. For Al Lindh, earthquake prediction is anything but academic.

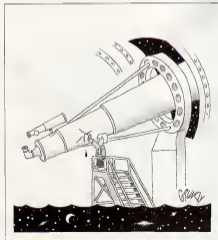
Qmm: When climatologist Iben Browning predicted the quake on the New Madrid Fault, his theory correlated earthquakes with high tidal forces. Were you nervous he might be right?

Lindh: No. I knew the odds were no different for December third than for any other day, when they are probably about one in a hundred thousand. In fact, I've never seen such a low level of seismicity around the world as there was during this five-day period. I doubt if anyone will ever take seriously again the question of tidal triggering of earthquakes. Careful examination of earthquake data over decades shows that there isn't anything to it. Theoretically, it's plausible. The sun and the moon do distort the earth, and one would expect that tides would trigger a quake some of the time. The mystery is that they do not.

Qmm: Browning supposedly had predicted previous earthquakes.

Lindh: If you predict enough events, some of them are bound to be right. Then if you selectively recall the ones that correspond with something, you can claim with a straight face that you can predict earthquakes.

Qmm: Why was he taken seriously?



Lynch: Because the low-rent journalists who picked up the story wanted headlines and filled them with irresponsible distortions. The good science reporters adamantly avoided the topic.

Omni: Where were you when the quake of October 17, 1989 struck?

Lynch: In my truck with my feet hanging out, watching my son's soccer game. The field was in the middle of a primeval forest, and the trees swayed back and forth along with my truck. I enjoyed it. I had no idea what it was. It seemed too small to be the one we anticipated on the Hayward Fault, and too big for Loma Prieta. With so many faults close at hand there was no way of knowing immediately.

Omni: But you'd predicted it.

Lynch: That's putting it too strongly. Prediction is not a black-and-white issue but a long continuum of grays from long-term projections to short-term stuff. If you take predictions on a scale of one to ten, we got a three for Loma Prieta. In 1982 we specified an earthquake on the Loma Prieta segment in 1988—plus or minus seven years. But we became more waxy-waxy in the intervening years. We hit the spot right, but the earthquake slipped more, went deeper. So our projected 6.5 turned out to be a 7.1 [on the Richter scale].

Earthquake depths are less accessible than the moons of Jupiter. With action taking place ten or twelve kilometers down, the seismic signals are hard to measure because they decay quickly. Even for large events, the surface manifestation is very small. Quakes are the archetypal nonlinear process. The earth takes hundreds of years storing vast amounts of energy and then gives it all back in seconds. You don't need chaos theory to tell you that if you don't know much about the input parameters you won't know much about extreme nonlinear behavior. That's the downside. The up side is that foreshocks, occurring within the prior twenty-four hours near the epicenter, tell us there's action before a quake. It's like when you bend a stick, you hear crackling before it snaps. If it weren't for foreshocks, prediction might still be something of a bad joke. Another problem is that each segment probably has different characteristic symptoms.

Omni: Then what do you go by?

Lynch: The starting point is to divide the amount the earth moved in the last quake by the slip rate. That's very approximate, and you can only expect to get within about ten percent of the recurrence time. We can measure ground movement with lasers and satellites to find how fast the plates are moving, but we only have a vague idea what the critical point for rupture is.

We knew the Loma Prieta segment was dangerous because the northeast-propagating rupture of the San Andreas



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ANTIMATTER

UFO UPDATE:

Are new UFO photos evidence of E.T.'s or the work of a keyboard con artist?

Fake photographs have always given UFO researchers fits. In the past, of course, analysts could usually pull the wheel from the chair! But those days may soon be coming to a close.

An ultrasophisticated digital image processing machine, the experts say, can now gobble up reality and spit out alarmingly authentic, possibly undetectable illusions.

It's really a question of the computer operator's skill, says Brad Dorn, president of Probase, Inc., in New York. Dorn usually uses his \$2 million worth of electronic gizmos to generate ad images for Madison Avenue. But he could also use his machines, Dorn says, to manufacture a UFO photograph that would pass muster with even the best analysts around.

Although he works with star-wart-quality equipment, Dorn thinks that close insidiers of the photographic land could also be counterfeited on a home computer. While the quality of the outcome depends on the ability of the hoaxer, he says the forgery would simply take longer on a low-end system and "you'd have to know more about what you were doing."

So let's say that you have chosen your ideal UFO model, suspended it from a string, snapped a picture, and now want to get out the links. To begin with, Dorn suggests sticking to a black-and-white image. "There's just less there," he says, "so it's easier to do a better job."

You also need an input device such as a video scanner or video camera to transfer the photo to your computer. The scanner digitizes the original photo, turning each line into electronic numbers, and these are copied onto the computer's hard disc. From there the image is summoned up on the screen just as you would any ordinary graphics file.

Then, using paint software, the digitized image could



be moved, shaded, removed, or enhanced, and alternative artwork may be inserted in the scene. You could, for instance, remove the string from your dangling spacecraft and shade in some sky as well. You could also paint in the appropriate cloud cover and shadow for any given hour of the day or night.

According to Steve Gutman, product marketing manager at Adobe Systems in Mountain View, California, the computer itself can range from a PC DOS desktop machine to a Macintosh on up to a mainframe. With Adobe's Photoshop

software, for instance, only a few keystrokes stand between the hoaxer and his great reality. Other software paint packages are effective as well.

"You work on it until you like it," Dorn says. Adds Adobe Systems' Gutman, "The more you understand how shadows are cast, the better the outcome will be."

Physicist Bruce Maccabee, chairman of The Fund for UFO Research and an expert in photo analysis, agrees that the gee-whiz technology is sophisticated. But he doesn't think that he's been duped by it yet.

How can he be so certain? Maccabee says he knows what to look for in such photographs, although he refuses to give examples and thereby reveal his game plan to a potential hoaxer.

What's more, Maccabee says, tough cases turn on interpretation of the photographer, not the photo. "Once the photo has passed some basic tests, the photographer has to tell a convincing story about the UFO experience. It must be logical and consistent, but not illogical." So while Maccabee agrees that it's easier to fudge a photo today, he still thinks it would be difficult to fool the experts with a hoax.—PAUL MCCARTHY



ANTIMATTER

CREAM DE LA CREMORA

Last spring a strange, powdery substance floated over the small South Carolina hamlet of Chester. Moistened by morning dew, it hardened like concrete on car windows and the siding on homes. When it rained, the mysterious substance left stains on streets and sidewalks.

But according to South Carolina Department of Health and Environmental Control air quality specialist Steve Spagner, the stuff was not a dangerous chemical or even heavy pollen. Instead, you might call it the cream de la Cremora of air pollution.

Spagner says that Borden operates a Cremora factory in Chester. Occasionally the plant's air vent chims become clogged, releasing Cremora clouds. The airborne cream, made of



"I'VE WASHED MY CAR AT NOON, AND AT 1.30, I'D HAVE TO GO OUT TO SCRUB IT OFF THE WINDSHIELD WITH STEEL WOOL AND SPIC AND SPAN," SAYS GRACE DOVER, A RESIDENT OF CHESTER, SOUTH CAROLINA. "OFF AND ON FOR TEN YEARS, I'VE SEEN THE FACTORY STACKS YONDER BELCH THAT STUFF OUT LIKE A VOLCANO."

sodium silicoaluminate and corn syrup solids, "is not harmful from a health standpoint," he says. "But when it gets damp, it can really gum things up."

Grace Dover says that's an understatement. "I've washed my car at noon, and at one-thirty, I'd have to go out to scrub it off the windshield with steel wool and Spic and Span." Not only does the creamer stick like glue to the outside of her home, she adds, but the sugary substance also attracts mold.

Cremora plant manager Donald Eifer says, "We don't intentionally release the

powder, and we've only had one or two complaints about it in the last two months."

Grace Dover agrees the situation is better. But she's decided to move to the country. "Off and on for ten years, I've seen the factory stacks yonder belch that stuff out like a volcano," she says. "That's enough."

—Sherry Baker

BIGFOOT IN EUROPE

The giant ape-like creature known as Bigfoot supposedly roams the deep forests of the northwest in United States, while its Asian counterpart, the yeti,

is rumored to stalk the Himalayan Mountains. And now translator and anomaly researcher Ulrich Magin of Mulfersbadt, Germany, has collected reports of a similar creature roaming Europe as well.

Some of the first reports, Ulrich says, describe an "erect, hairy" creature who left humanlike footprints in Germany's Odenwald Forest in the Seventies. Later, witnesses reported a one-eyed ape-man near Aachen at the German-Dutch border. Recently, Ulrich says, a Scottish man took photographs of what he said were Bigfoot footprints near the Mann Stoch mountain ridge in Scotland.

Are these accounts proof that the Abominable Snowman has a European cousin? Ulrich says that the answer is no.

"European tabloids invent all kinds of good stories," Ulrich says. "I'm afraid there will never be a real Bigfoot photo for scientists to examine. And the yeti is clearly a myth, related to the mountain giants and goblin myths that you find all over the world."

Ulrich notes that in recent years European Bigfoot sightings have often been linked to UFOs—a fact that doesn't surprise him. In these reports, the anomaly researcher says, "man's oldest living relative, the ape, steps out of a flying saucer, the symbol of future space exploration. The past, present, and future of man are contained in a single mythic motif. It's almost like a dream." —Sherry Baker

A DYING ART

The underworld is meeting the computer world thanks to Jim Falvino of Monumental Computer Applications, Inc., in Cherry Valley, New York.

Stonecutters who do artwork for burial markers are a dying breed, Falvino says. So when his chief cutter threatened to retire and apprentices found the work dull, Falvino had a better idea. He yoked a 386 desktop computer and plotter to a computer-aided design (CAD) software package, called it MONUCAD, and turned out his own tombstone art.

Each design is a separate computer file that can be produced 16 times faster than by hand, says Falvino. The artworks, including images from praying hands to a hunter with his beagle, are then transferred to adhesive-backed rubber

mat and sandblasted into the headstones. MONUCAD, says Falvino, will soon reduce prohibitively expensive detailed etchings to down-to-earth prices.

Falvino has already sold 67 of his MONUCAD systems to monument companies throughout the United States, Canada, and Europe. He also maintains an electronic bulletin board so MONUCAD users can call up his computer and borrow from or add to his data base of designs. "As companies swap art," he says, "local designs are moving from California to New York."—Paul McCarthy

CLOSE ENCOUNTERS OF THE VALIUM KIND

Could some UFO abduction reports, especially those involving claims of sexual assault, be mere fantasies induced by the



tranquillizer Valium?

Maybe so, says the *MUFON UFO Journal*. According to Dennis Stacy, the journal's editor, the theory stems from sexual assault charges brought against British doctors and dentists by patients who had been sedated with intravenous Valium or a related compound before undergoing a procedure.

Studying the reports, MUFON meteorologist J. W. Dundas found 43 such cases where the patients could not have been assaulted because witnesses were present. His conclusion: The patients had experienced a drug-induced fantasy.

Could a similar phenomenon explain reports of alien

abduction? Probably not, says J. Theodore Jastak, professor of surgery at the University of Oregon Health Sciences Center. Sexual fantasies under various anesthetics have been reported for 100 years, he says, but the effect usually lasts a few hours at most. As for fantasies produced by oral doses of Valium, he says they could occur, "but I've never heard of it."

David Jacobs, abduction researcher and professor of history at Temple University, agrees. He says not only do few abductions have a sexual component, but of the 47 abductions he has worked with, "none have been specifically on Valium."

—Paul McCarthy





ANTIMATTER



GHOST VOICES

Spooky-looking figures have occasionally been photographed in allegedly haunted houses. But now Adrian Poulton, who heads a Hollywood, Florida, group of "metaphysical consultants" known as the Psi Associates, says he has come up with better proof of the spirit world beyond. He has, he says, recorded the voices of ghosts.

Using an ordinary cassette tape recorder, Poulton first picked up what he calls "electronic voice phenomena" in 1975. "It was a case I call 'The House That Wouldn't Die,'" he says. "Some people in upstate Massachusetts contacted us because they were having disturbing dreams of apparitions. They said their children were actively communicating with entities. Toys and books were mysteriously disappearing. Ioo."

In hopes of finding the source of its ghosts, Poulton visited the home and went into a trance state. He claims he psychically "saw"

an old man and his wife, who explained that they did not want the house to be rehaired. No one else in the room saw the ghosts. But when Poulton played back the cassette that had been running during the séance, his associates say they heard unspoken voices.

In a more recent case, Poulton says he taped the ghostly voices of a man and woman who were haunting a New York apartment. "They both gave the same story: 'They told they had been lovers at one time.' It's another haunted house investigation, Poulton supposedly recorded a message from a teenage suicide victim who apologized for taking his life.

State University of New York at Buffalo philosophy professor Paul Kurtz, who heads CSICOP (the Committee for the Scientific Investigation of Claims of the Paranormal), points out that tape-recorded "voices of the dead" are nothing new. "The subject has been investigated exhaustively. It turns out that a tape recorder can act as a receiver for background noise and pick up CB and radio transmissions, which some people have mistaken for the whispery voices of ghosts," he says.

"The recordings in question were not done under controlled conditions, so these claims don't mean anything," Kurtz says. "They are simply uncorroborated anecdotes."

—Sherry Baker

SURVIVAL CIPHER

Can a one-word puzzle prove the existence of life after death? Parapsychologist and attorney Arthur S. Berger, president of the Survival Research Foundation in Hollywood, Florida, believes it can. The foundation has offered \$1,000 to the first person who solves a word puzzle left behind by Arnold Barber, a recently deceased member. The puzzle is part of an experiment devised by Berger in an effort to obtain what he believes would be hard evidence of survival beyond the grave.

Under the terms of the experiment, individual foundation members have prepared secretly encoded messages meant to be deciphered after their deaths. The key to each message is a single word known only to the person who prepared it. Arnold Barber was the first experimental participant to die. Berger says, "Barber intended to communicate the secret key that would decipher his message after his death," adding, "The receipt of the key to Barber's message would be a finger pointing at his survival."

Psychologist Charles T. Tart of the University of

California, Davis, does not necessarily agree. "If a person with psychic abilities tried to solve the puzzle before Barber died," he says, "you might be proving the existence of psi phenomena, not life after death."

But skeptic Bob Stinner, founder of the California-based Bay Area Skeptics and a fellow of the Committee for the Scientific Investigation of Claims of the Paranormal, doesn't believe that psychic talents or survival after death necessarily have anything to do with solving the puzzle. "If the puzzle isn't capable of being solved by knowledge and logic," Stinner says, "then how will we know when someone gets the correct answer? On the other hand, if it is capable of being solved by knowledge and logic, then nothing supernatural will have been demonstrated or proven by getting the correct answer."

No one has yet decoded Barber's puzzle. But please send any suggested solutions, along with a description of how and when they were obtained, to the Survival Research Foundation, Box 8563, Pembroke Pines, FL 33064.

Prospective puzzle solvers who believe in life after death might, for example, like to quiet their thoughts and imagine themselves actually communicating with the spirit of Arnold Barber. Those committed to a more mundane view of the here and now might prefer to just pick the first word that comes to mind.

—Keith Haring

THE SURVIVAL RESEARCH FOUNDATION SEEKS MESSAGES FROM THE DEAD AND PROOF OF LIFE BEYOND THE GRAVE.

LAST VETERAN

CONTINUED FROM PAGE 32

sook!

"You don't have to shout like that, boy!" Uncle James said. "I can fucking well hear better than you can."

Townes reddenied, but he managed a laugh. "Of course. Of course."

Carlotta said, "Is the Emperor here yet?"

"In a little while. We're running a bit late, you understand. If you and the general will take seats over there until we're ready to call him up to receive his medal—well, of course, he's seated already but you know what I—"

"Aren't we going to sit on the platform?" Carlotta asked.

"It's afraid it's reserved for city officials and dignitaries."

She didn't move. "Uncle James is a dignitary. We came all the way from Berkeley for this, and if you're going to shunt him into some corner for hours and hours while you—"

"Please," Townes said.

"He's a hundred forty-three years old, do you realize that?"

"Please," he said. "Bear with me." "He looked ready to cry." "The Emperor himself will personally decorate him. But until then, I have to ask you

He seemed so desperate that Carlotta gave in. She and Uncle James went into a roped-off area just below and to the left of the platform. Uncle James didn't seem to mind. He sat quietly, lost in dreams of God-knows-what moment of antique heroism, while Carlotta, standing behind his chair, kept one eye on his systems reports and look in the sights of downtown San Francisco with the other, the huge tapering buildings, the radiant blue sky, the unusual trees, the shining bridge stretching off to the east.

Uncle James said suddenly, "What are all these foreigners doing here?"

"Foreigners? What foreigners?"

"Look around you, girl."

She thought at first that he meant people from the neighboring republics and kingdoms: San Joaquin, Santa Cruz, Monterey, Mendocino. It wouldn't be surprising that they'd be here, considering that this was a celebration intended to commemorate the signing of the Armistice that had ended the war of everybody against everybody and guaranteed the independence of all the various Northern California nations. But how could Uncle James tell a Serris Guzman or a Montereyan from a San Franciscan? They didn't look any different down there. They didn't dress any different.

Then she realized that he meant visitors from the countries beyond the seas. And indeed there were plenty of them all around the plaza, a lot of exotic people carrying cameras and such: Japanese, Indians, Latin Americans, Afrikaners. They were wearing exotic clothing, most of them. Many had exotic faces. The old man was staring at them as though he had never seen tourists before.

"San Francisco is always full of visitors from far away, Uncle. There's nothing new about that."

"So many of them. Gawking at us like that. They dress like geeks, girl. Didn't we fight that war to keep San Francisco for the San Franciscans? A pure nation of pure people. Look at them all. Look at them!"

"It's the most beautiful city in the world," Carlotta said. "People have been coming from all over to see it for hundreds of years. You know that. There's nothing wrong with—"

He was raging, though. "Yellow people! Black people! Brown people! Why not green people, too? Why not purple people? Their faces! Their eyes! And the clothes they wear! Who let them in? What are they all doing here?"

"Uncle," she said, reaching down surreptitiously to give his adrenaline dumper a little downward



"Splenda! How soon can you start work with us?"

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Leave that thing alone, girl! I don't want you getting all worked up." Look at them," he said again quietly.

They seemed to have noticed now that the celebrated last surviving veteran of the War of San Francisco was right down here among them at street level. They came crowding in suddenly from all sides of the plaza, five or ten of them at first, then a couple of dozen at least, maybe more, an eager horde, crossing into the roped-in area, pushing, jostling, pointing, grinning, waving at the old man as though he were some zoo creature. Carlotta understood now why Uncle James had begun to get so upset. These people looked really strange. The Bay Area was full of people whose ancestors had been born in distant countries, but time had blurred their genes and they simply looked like people. These were different, the authentic original foreign from mysterious, alien. She found herself engulfed in a sea of disturbingly unusual faces, odd-shaped noses, gleaming intense eyes. And everybody jabbering in different languages, everybody shouting questions she couldn't comprehend. It was like a frantic carnival scene, some wild festivity in some remote tropical land. The closest ones

rubbed their hands curiously along the wheels of Uncle James's chair, touched his sleeves, even reached out to finger his peculiar rubbery cheeks. Cameras clicked and buzzed, a swarm of goggle-eyed lenses, wide-hole solids. Microphones sprouted like toadstools in a rain forest. Everyone wanted a piece of Uncle James.

Carlotta made angry shooing gestures at them. Get back! Get back! He's a very old man! You'll scare him! He'll have a stroke! Give him air! Give him air!

Parade marshals helped her push them away. They rebelled reluctantly but good-humoredly, continuing to jabber in unknown languages and snapping pictures of Uncle James every step of the way. After a few moments of continued confusion they were all outside the ropes again.

The old man seemed okay. He was sitting forward alertly in his chair, beady-eyed, staring his fist, shouting curses at them.

But somehow one of the foreigners had avoided the marshals and was still within the enclosure, right next to Uncle James. He was tall and stately, a portly man of great presence and authority, some sort of Latin American, from the looks of him, with a soft pudgy dwe-

ltoned face and glossy black hair. His skin and his hair were very black, as though he dined them daily. He was deceptively dressed in a way that no local could afford: gray cashmere trousers and a finely cut camel-hair jacket, and there was an emerald the size of an eyeball in a ring on his plump hand.

Carlotta went over.

"Your pardon," he said at once. "This is the celebrated veteran of the famous war, who will be honored here today?"

"He's General James Crawford, yes." "Obrigado. A grand pleasure to make his acquaintance."

"Listen, you aren't supposed to be—"

"One moment only. You will permit me? I am Humberto Maria de Magalhães, of Minas Gerais, which is in Brazil. I am visiting here, a trade delegation. Your city is so splendid. I love it so much. I reverse it. Its beauty is long tormented history."

She looked around for the marshals but they had moved on. "You really aren't supposed to be—"

"Yes. Yes. With your permission, if I could speak with the general after the ceremony?" He indicated an elaborate recorder, easily a ten-thousand-dollar job. "The study of history is my passion. Your history, the tragic tale of

your country, its greatness, its downfall to speak with the general, to hear from his lips the reminiscences of his days of battle, the actual descriptions of the warfare—it would be ecstasy for me. Ecstasy. Do you understand my words?"

"His imperial Highness Norton the Fourteenth!" cried a man with an enormous voice. Carlotta looked around. A ground-effect palanquin be-decked with gaudy banners was floating solemnly up the street toward the plaza.

"You've got to go now," Carlotta said. "Look, the Emperor's arriving."

"But later, perhaps?"

"Well—"

"It is for the sacred purpose of scholarship only. Half an hour to speak with his great man—"

"All welcome His Imperial Highness!" the immense voice called. "Later!" the Brazilian said urgently. "Please!" He slipped under the rope and was gone.

Carlotta shrugged. If the Brazilian only knew that nothing Uncle James said made sense, he wouldn't be so eager. She turned to stare at the Emperor, atop his palanquin. She had never seen him live before. The Emperor was a surprisingly small man, very frail, about fifty, with pale skin and tiny hands, which he held extended to the crowd in a kind of imperial blessing. The palanquin, drift-

ing a little ways above the pavement came forward to the rowing stand and halted like an obedient elephant. Members of the imperial guard helped him out, and up the stairs of the platform to the position of honor.

Someone began a long droning speech of welcome. The mayor of San Francisco, Carlotta supposed, it went on and on, this grand occasion, the triumphant day of the commemoration of the hundred-year peace, on and on and on, yawn and yawn and yawn. The foreigners' cameras and recorders whirred diligently. Uncle James seemed to be asleep. Carlotta's attention wandered. Now and then a cheer rose from the assembled citizens.

She could see the sleek Brazilian in the crowd. He was staring at the old man as though he were a mound of emeralds. Then he noticed Carlotta watching him, and he flicked his gaze toward her, letting his eyes rest on her in a warm insinuating way, and smiled a sleek smile that gave her shivers. As if he was buying her with that smile.

What did he want, really? Just to talk?

Uncle James was awake again. Instead of looking at the Emperor, who had begun to speak in response to the mayor's oration, he was peering at the rows of foreign tourists, gaping at them as though they came not merely

from other continents but from other planets. In a way Carlotta thought, they did. Who could get to Japan or Brazil or Nigeria from here? They come to us, we don't go to them. It used to be different, she knew. Hundreds of years ago, before everything fell apart, when America had been all one country of incomprehensible size that stretched from ocean to ocean, its citizens had gone everywhere in the world. But now there were thousands of little principalities where America had been, and no one went anywhere much.

"A century ago," the Emperor was saying, "the fate of this entire area was at stake. Every man's hand was raised against his neighbor. Once that long had lived in peace had gone to war against their fellow cities. But then, on this day exactly one hundred years ago, the climactic battle of the War of San Francisco was fought. This city and its valiant allies in the East Bay and Marin stood firm against the invaders from the outlying lands. And on that day of triumph, when the peace and security of the Empire of San Francisco was made certain forever—"

"Start moving the old man up to the top of the platform," Ned Townes whispered. "He's going to get his medal now."

Uncle James was asleep again. Carlotta gave him a little adrenaline pill.

"It's time, Uncle," she whispered. They had a ramp around back. She touched her palm control and the wheelchair began to glide up it. The big moment at last.

The Emperor smiled, shook Uncle James's hand the way he would shake a turkey's claw, said a few words: this gallant survivor, this embodiment of history, this remnant of our glorious past, and put a sash around his neck. At the end of the sash there was a multi-colored medal the size of a cookie, which seemed to have a portrait of the Emperor on it. That was it. Carlotta found herself wheeling Uncle James down the ramp a moment later. Evidently the old man wasn't expected to say anything in reply. They couldn't even stay on the platform.

For this they had traveled all the way from Berkeley? "Will you find us our driver?" she said to Ned Townes. "We might as well go back home now."

Townes looked shocked. "Oh, no! You can't do that. There are further ceremonies, and then a banquet at the palace this afternoon for all the celebrities."

"Uncle James doesn't eat banquet food. And he's getting very tired."

"Even so, it would be terrible if you left now," Townes tugged at his jowls. "Look, stay another hour, at least. You can't just grab the medal and disappear. That's the Emperor up there, young lady."

"I don't give a damn if he is—"



But Townes was gone. The Emperor was wearing another medal, this time to a wide-shouldered woman who already was wearing an assortment of decorations that had a giftier Southern California look about them.

"Permit me," a deep confident voice said. The Brazilian again. Leaning over the rope, tapping her on the shoulder. Carlotta had forgotten all about him.

"Is it possible to discuss now an opportunity for me to record the great general's reminiscences, perhaps?"

"Look, we don't have time for that. I just want to get my uncle out of here and back across the bay."

He looked distressed. But before you leave—half an hour—fifteen minutes.

She glanced down at the emerald ring. A gleam came into her eyes. "There's a fee, you know. For his time. We can't just let him talk to people for free."

"Yes. Yes, of course. Why should there not be a fee? It is no problem. We will discuss it." He offered her an engraved card, holding it close in front of her face as if he wasn't sure she knew how to read and holding it close might help. "This is my name. I am at the Imperial Hotel. You know that hotel? You will come to me when this is over? With the general? You agree?"

Sorry as a marshal said. This an-

el is for official guests only."

"Of course. Understood." The Brazilian began to back away nodding bowing, smiling brilliantly. To Carlotta he said, "I will see you later? Yes? I am very grateful. Obrigado? Obrigado?" He disappeared into the crowd of foreign visitors. Behind her, on the reviewing stand, the Emperor was giving a medal to a man in a uniform of the San Jose Air Force.

It was almost noon now. People were coming out of the nearby office buildings. Some of them were carrying sandwiches. Carlotta began to feel fiercely hungry. Townes had talked about a banquet that afternoon, but the afternoon seemed a long way away. Uncle James got led by obsequious line, but she needed real food and soon. Emperor or no Emperor, she had to get out of here, and Townes could go whistle. Maybe the thing to do was find the Brazilian, strike a deal with him, let him take her to his hotel and buy her lunch. And then he could interview Uncle James all he wanted, as long as the old man's strength held out.

"All right," she thought. Let a get moving.

But where had the Brazilian gone? She didn't see him anywhere. Leaving Uncle James to look after himself for a moment, she slipped under the

rope and went over to the place where the foreign visitors were clustered. No, no sign of him. People began to jabber at her and take her picture. She brushed her hand through the air as though they were a cloud of gnats. Producing the Brazilian's card, she said, to no one in particular. "Have you seen Humberto—Humberto Jose de Magal—Magal—?" It was a struggle to pronounce his name.

He must have gone, though. Perhaps he was on his way to his hotel to wait for them.

She rushed back to Uncle James. Some people had crept into the roped-off area and were pushing microphones into his face again. Angry Carlotta hit her palm control, backing up his wheelchair and pulling it toward her right through the flimsy rope. At a break pace she headed across the street to the parking area where she hoped the driver was waiting. Ned Townes, red-faced, materialized from somewhere and furiously wigwagged at her but she smiled and waved and nodded and kept on going. He shouted some thing to her but didn't pursue.

The driver, miraculously was still there. Imperial Hotel, she said.

"Where?"

"Imperial Hotel. Downtown, somewhere."

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"I'm supposed to take you back to the East Bay."

"First we have to go to the Imperial. There's a reception there for my great-uncle."

The driver sullen and stoical, looked right through her and said: "I don't know about no reception. I don't know no Hotel Imperial. You're supposed to go to the East Bay."

"First we stop at the Imperial," she said. "They're expecting us. I'll show you how to get there," she told him grandly.

To her amazement he yielded, swinging the car around in a petulant U-turn and shooting off toward Market Street. Carlotta studied the signs on the buildings, hoping to find a marquee that proclaimed one of them to be the Imperial, but there were no hotels here at all, only office buildings. They turned right, turned left again, started up a steep hill.

"This is Chinatown," the driver said. "That where your hotel is?"

"Turn left," she said.

That took them down toward Market Street again, and across it. At a stop-light she rolled down the window and called out: "Does anyone know where the Imperial Hotel is?" Blank faces stared at her. She might just as well have been speaking Greek or Arabic. The driver, on his own, turned onto Mission Street, took a left a few blocks later, turned left again soon after. Carlotta looked around desperately. This was a district of battered old warehouses. She caught sight of a sign cranking tail to the Bay Bridge and for a moment decided that it was best to forget about the Brazilian and head for home when unexpectedly a billboard loomed up before them, a glaring, six-color advertisement, of all things, the Imperial Hotel. They were right around the corner from it, apparently.

The Imperial was all glass and concrete, with what looked like giant mirrors at its summit, high overhead. It must have been two or three hundred years old. They hadn't built buildings like that in San Francisco for a long time. Carlotta got Uncle James out of the car, told the driver to wait across the street, and signalled to a doorman to help them go inside.

"I'm here to see the man," she announced, producing Magalhães's card. "We have an appointment. Tell him that General James Crawford is waiting for him in the lobby."

The doorman seemed unimpressed. "Wait here," he said. Carlotta waited a long time. Uncle James muttered restlessly.

Some hotel official appeared, studied the Brazilian's card, studied her, murmured something under his breath, went back inside. What did they think she was—a prostitute? Showing up for

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a job with an old man in a life-support chair to keep her company? Another long time went by. A different hotel person came out.

"May I have your name," he said, not amiably.

"My name doesn't matter. This is General James Crawford, the famous war hero. Can you see the imperial medal around his neck? We've just been at the Armistice celebration, and now we're here to see the delegate from Brazil, Mr. Humberto Mans—"

"Yes, but I need to know your name."

"My name doesn't matter. Just tell him that General James Crawford—"

"But your name—"

"Carlotta," she said. "Oh, go to hell, all of you." She pressed the pain control and started to fum Uncle James around. There was no sense enduring all this grief. Just then, though, an enormous black limousine glided up to the curb and Humberto Mans de Magalhães himself emerged.

He sized up the situation at once.

"So you have come after all! How good! How very good!"

The hotel man said, "Senhor Magalhães, this woman claims—"

"Yes. Yes. Is all right. I am expecting. Please, let us go inside. Please. Please. Such a great honor. General

Crawford! He extended his arms in a gesture so splendid that it would have been worthy of the Emperor himself. "Come," he said. He led them into the building.

The lobby of the Imperial was a great glittering cavern, all glass and lights. Carlotta felt dizzy. The Brazilian was in complete command, shepherding them to some secluded alcove, where waiters in brocaded livery came hustling to bring champagne, little snacks on porcelain trays, a glistening bowl brimming with fruit. Magalhães pulled a recorder from his pocket, a handheld scanner, and two or three other devices, and set them on the table before them.

Now, if you please, General Crawford—"

"The fee," Carlotta said.

"Ah. Yes. Yes, of course. Magalhães pulled crumpled old dirty bills from his wallet: imperial money, green and gold. "Will this be enough, do you think?"

She stared. It was more than she made in six months. But some demon took hold of her and she said, recklessly, "Another five hundred should do it."

"Of course," the Brazilian said. "No problem!" He put another bill on the edge of the table and aimed his lens at the old man. "I am so eager to re-

cord his memories. I can hardly tell you. Now, if you would ask the general to discuss the day of the famous battle first—"

Carlotta bent close to the old man's audio intake and said, "Uncle, this man wants you to talk about your war experiences. He's going to record a sort of memoir of you. Just say whatever you can remember, all right? He'll be taking your picture, and this machine will record your words."

The war? Uncle James said. And immediately leaped into silence.

The Brazilian watched, big-eyed, holding his breath as if he feared it would interfere with the flow of the old man's words.

But there were no words. Carlotta, who had tactfully left the Brazilian's money on the table, thinking it would look a little better not to pocket it until after the interview, began to wish now that she had taken it right away.

The scene became very long indeed.

She reached down and gave the old man a little squirt of haptacholinase through the IV line. That seemed to do it.

"—the invasion," Uncle James said, as if he'd been speaking silently for some time and only now was bolting to come up to the audible level. And

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then words poured out of him as she had never heard them come before: a bubbling nonstop spew. It was like the breaking of a dam. We were dug into the trenches, you understand, and the Echo infantry came sneaking up at us from the east, under cover of mustard gas—oh, that was awful, the gas—but we called in an air strike right away, we hit them hard with napalm and antipersonnel shrapnel, and then we came ashore with our landing craft, hit them at Anzio and Normandy both. That was the beginning of it. Our error strategy, you understand, was built around a terminal nuclear hit at Bull Run, but first we knew we had to close the Dardanelles and knock out their command center back of Cam Ranh Bay. Once we had that, we'd only need to worry about the Prussian cavalry and the possibility of a Saracen suicide charge, but that wasn't a real big risk, we figured, all the Rebels were pretty well demoralized already and it didn't make sense that they'd have the balls to come back at us after all we'd thrown at them so—

"What is he saying, please?" the Brazilian asked softly. "He speaks so quickly. I am not quite understanding him. I think."

"He does sound a little confused," said Carlotta.

"Well, we drove the Turks completely out of the Gulf of Corinth, and were heading on toward Lepanto with sixty-four galleys full steam ahead. Then came a message from Marlborough, got our asses over to Blenheim fast as we knew how, the French were trying to break through—or was it the Poles—we'll hell it was a mess, the winner was coming on, that lunatic Hitler actually thought he could take out Russia with a full offensive and damned if he didn't get within eighty miles of Moscow before the Russians could stop him, and then—then—" Uncle James looked up. There was a stunned expression on his face. All his indicators were flashing in the caution zone. His cheeks were flushed and he was breathing hard.

Carlotta let her hand rest lightly on the little stack of bank notes.

"He's very overexcited," she explained. "This has been a big day for him. He hasn't been in San Francisco for forty-three years, you know?"

"Wait," Uncle James said. He stretched a hand toward the Brazilian. "There's something that I need to say."

There was an unfamiliar note in his voice suddenly, a forcefulness, a strange clarity. The cloudiness was gone from it, the husky son-of-a-bitchiness. It sounded now like the voice of someone also entirely someone a hundred years younger than Uncle James.

The Brazilian nodded vigorously. "Yes, tell us everything, General! Everything!"

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Uncle James smiled. There was an eerie look on his face. "I wasn't a general for one thing. I was a programmer I never fought an actual battle. I certainly never killed anybody. Not anybody it's all a lie that I was any kind of hero. It was just an error in the computer records and I never said anything about it to anybody, and now it's so long ago that nobody remembers what was what. Nobody but me! And most of the time I don't even remember it myself!"

"Uh-oh," Carlotta thought.
 As secretly as she could manage it, she slid the bills from the table into her purse. The Brazilian didn't appear to notice.

Uncle James said, "It was only a two-day war, anyway. A lot of reasonable skirmishes between a bunch of jerkwater towns gone wild with envy of what they each thought the other one had, and in fact nobody had anything at all. That was what ended the war, when we all figured out that there was nothing anywhere, that we were wiped out from top to bottom." He laughed. "And here I was in the command center at the university the whole time, writing software that was how I spent the war. A hundred goddamn years ago."

The Brazilian said, "His voice is so clear, suddenly!"

"He's terribly tired," said Carlotta. "He doesn't know what he's saying. I should have just taken him right home. The interview's over. It's too much of a strain on him."

"Could we not have him continue a small while longer? But perhaps we should allow him to rest for a little," the Brazilian suggested.

"Rest?" Uncle James said. "That's all I fucking want. But they don't ever let you rest. You fight the Crusades, you fight the Peloponnesians, you fight the Civil; you get so tired, you get so fucking tired. All those wars I fought 'em all, they're one of them at once. You run the simulations and you've got the Nazis over here and Hannibal there and the Montezuma crowd trying to bust in up the center, and Hastings, and Tours, and San Jose—Grant and Lee—Charlemagne—Napoleon—Eisenhower—Patton."

His voice was still weary, tired and strong.

But it was terrible to sit here listening to him babbling like that. Enough at enough. Carlotta decided. She reached down quickly and hit man cerebral and put him to sleep. Between one moment and the next he shut down completely.

The Brazilian gasped. "What has happened? He has not died, has he?"

"No, he's all right. Just sleeping. He was too tired for this. I'm sorry Mr. Maggal—Maggal—" Carlotta rose. The money was safely stowed away. "He's badly in need of rest, just as you heard

him say. I'm going to take him home. Perhaps we can do this interview some other time. I don't know when. I have your card. I'll call you, all right?"

She flexed her palm and sent the chair moving out into the main lobby of the hotel, and toward the door.

The driver, thank God, was still sitting there. Carlotta beckoned to him.

They were halfway across the bay before she brought the old man back to consciousness. He sat up rigidly in the chair, looked around, peered for a moment at the scenery, the afternoon light on the East Bay hills ahead of them, the puffy clouds that had come drifting down from somewhere.

"Pretty," he said. His voice had its old muddled quality again. "What a goddamn pretty place! Are we on the bridge? We were in the city, were we?"

"Yes," she told him. "For the anniversary of the Armistice. We had ourselves a time, too. The Emperor himself hung that medal around your neck!"

"The Emperor, yes. Fine figure of a man. Norton the Ninth."

"Fourteenth, I think."

"Yes. Yes, right. Norton the Fourteenth," the old man said vaguely. "I meant Fourteenth." He fingered the medal idly and seemed to disappear for a moment into some abyss of thought where he was completely alone. She heard him murmuring to himself, a faint indistinct flow of unrecognizable sound. Then suddenly he said, rearing once more to that tone of the same strength and lucidity that he had been able to muster for just a moment at the Imperial Hotel, "What happened to that sick-looking rich foreigner? He was right here. Where did he go?"

"You were telling him about General Patton at Bull Run, and you got over-excited, and you weren't making any sense, Uncle. I had to shut you down for a little time."
 "General Patton? Bull Run?"

"It was that time you nuked the Rebels," Carlotta said. "It's not important if you don't remember. Uncle. It was all so long ago. How could anyone expect you to remember?" She patted him gently on the shoulder. "Anyway, we had ourselves a time in the city today, didn't we? That's all that matters. You got yourself a medal, and we had ourselves a time."

He chuckled and nodded, and said something in a voice too soft to understand, and slipped off easily into sleep.

The car sped onward, eastward across the bridge, back toward Berkeley. **□□**

Robert Silverberg is the author of *Lord Valentine's Castle*, *Dying Inside*, and *Nightfall* (in collaboration with Isaac Asimov). He is a nine-time winner of the Hugo and the Nebula awards.

the future will use the whole body, modulating arrangements with a sort of dance.

As Meachover sees it, the typical concert of 2010 may be a hybrid of visual and aural sensations, an extension of today's choreography and laser pyrotechnics at a rock show, but with two differences: The creators of the performers will make part of the music. And most concertgoers will see and hear it all from their own homes.

At 7:55 PM, five minutes before the concert, you'll put on goggles and a headset. They'll be connected through your home computer to a telephone or cable TV line fed by cameras at a distant site. Screens inside the goggles, one for each eye, will reveal the performers in 3-D.

They won't be tuning their instruments as today's players do before a concert, because the computers will keep their instruments in perfect pitch. The major action at the remote studio will be typing by a computer programmer, making last-minute changes in the database holding all the notes written by the composer. As you turn your head, your hardware will sense your movement and change the scene before your eyes, as if you were there.

When the music begins, the performers themselves will determine what you see as well as what you hear. As virtual reality guru Jaron Lanier, founder of VPL Research, Inc., in Redwood City, California, sees it, avatars or horns will create scenes as well as notes. For instance, he says, in addition to following a written musical score, the horns will blow majestic mountains with flaps, or sandstorms in C minor right on to the giant screen in your room. Musicians in funny artificial reality DataSuits could be the horns. Lanier says. Their total body movements—an extension of Meachover's finger flairs—will translate into sights and sounds.

That means that many more people, and possibly animals, will be able to play along. Lanier says he has long dreamed of building instruments for infants who would control a flow of notes by sucking on an electronic nipple. Among animals, he adds, goats have the most potential. They relate well to flutes," he says. But how would they make music? By chewing on an electronic cud. Lanier even predicts that some future orchestra could include a chorus of kids—goats and human babies. "It'll probably top the charts in 2005," he says.

Ultimately sensors in home hypomusic systems will pick up brain wave patterns and feed them to a computer conductor. If you choose, your central

nervous system will change the colors, shapes, and sounds of an incoming concert to match your moods. Your anger, for example, could tinge what you see with violent red.

In fact, even after the concert, speakers in your house will continue to produce background music that reflects your mind's interior landscape—up-tempo hits when you're happy, a deep to match your blues.

Music that moves with the listener may be part of the score of Meachover's next opera, tentatively titled *Can We Change Our Minds?* Working with artificial intelligence pioneer Marvin Minsky, Meachover plans to set the opera in a "malleable" concert hall so that what you hear would depend on where you walked.

Audience actions in one part of the listening space would affect the sound in other areas. Only in one designated area would you be able to see and hear the music in its entirety and watch how the complicated parts come together in a curious harmony. Only there would you get an overall glimpse of the opera's main character, the human brain.

Like the best music of the twenty-first century, the opera will draw audience members into a greater awareness of their own listening patterns, Meachover says. More than that, the music will be a magic mirror, revealing deep secrets about the listener. Standing in the middle of that future concert—in the midst of music you control—you'll know something of what Mozart and Bach felt as they listened from their lowering podiums. From that spectacular vantage point, Meachover says, "you'll find yourself thinking about your mind in a whole new way." □

CREDITS

Page 6: **clockwise from top left:** Takashi Yamazaki; **Four Menzel:** Michael Water-River; **Alamodar:** page 10; **Paul D. Gord:** *Sygnis*, page 12; **Kazuo Yamazaki:** *Art International*, page 14; **left to right:** Gary Litan, Marcia Lieberman, Gary Litan, Mike Machell; **page 22:** Geoffrey Chandler; **page 26:** Jon McNelly/Sygnis; **page 30:** Ken Schaefer/Peter Arnold; **page 35:** Clayton Anderson; **page 36:** Corbis; **page 25:** *Nature*; **livestock/Space Art International:** Takashi Yamazaki; **page 38 top:** Takashi Yamazaki; **page 38 bottom:** Adam Harper/Cybernetic/HighMarket Publishing; **page 40 top:** *National Geographic*; **page 40 bottom:** Reuters; **page 50:** Takashi Yamazaki; **page 52 top:** Takashi Yamazaki; **page 52 bottom:** computers painted by Louis Bacc; **page 54 top:** Takashi Yamazaki; **page 54 bottom:** computer graphics by Louis Bacc; **pages 63-67:** excerpts from *Scenes of the Sun*/Ryuzo Umetani; **page 73:** Tom White; **page 74:** ZANI Productions; **page 75 top:** Tom White; **page 75 bottom:** *Freelance Photography*; **page 76:** Jim Warren; **pages 102-103:** *clockwise from left:* Vaseury Products; Hitachi; *Tom Harris*; Fisher Minolta; *Sci Daily Photography*; **page 196:** Makis; **page 198:** John Saut.

mental functions broken down into simple behavioral units that competed for control of the entire creature. These behaviors would include collecting dust, avoiding collisions, and recharging power packs. Bootstrumats would differ from traditional AI robots in that they would have no internal representation of the TV screen and would not actually know that their combined behaviors worked to clean the set.

VACUUMATS

A robotic cleaner the size of a cat might be just the thing to cut down on human-powered housework. It would hide in a corner of a room whenever someone was moving around, then go around sweeping when alone. After collecting a sufficient pile of debris, it would take it to a receptacle for future pickup by an artificial creature programmed to move through the house emptying the trash cans. For these tasks, the vacuumat would need sensors that could detect sound, motion, and obstacles. It would also need behavior modules for avoiding obstacles.

AUTOMATS

Imagine stepping into your car, telling it where to go, then sitting back and letting it drive. Such a vehicle would be equipped with sufficient artificial intelligence to plot its course and follow it efficiently, avoiding obstacles and other automats. Some versions might look like today's cars, but others might have sets of legs to negotiate rough off-road terrain. The internal logic of such a device would allow it to sense velocity and to maintain safe speeds, using inhibition modules to monitor traffic, balance, and road conditions.

SOLDIERMATS

Take a worksmat and give it a gun and you've got a soldiermat. Additional mental components would be added to permit the animat to differentiate between friend and foe and to aim its weapon at the enemy. Navigation, obstacle avoidance, balance, and other mental components standard to animats would make this a formidable—and expendable—adversary. Such an animat could fight on modern high-risk atomic, biological, and chemical battlefields.

LABANIMALMATS

Living only in the memory banks of computers, these virtual creatures would be another breed of animat. They would be carefully modeled to mimic the precise physiology of various animals and humans. Using these animats, scientists could run simulations of drug tests without risking human life or sacrificing real creatures. Researchers could also use populations of labanimats to study evolution, epidemiology, and ecology. □

INTERVIEW

CONTINUED FROM PAGE 71

ran out of steam there in 1906. The northern end of the fault slipped about six to ten feet in 1905, whereas the Loma Prieta segment slipped only four and a half to seven feet. The 1969 quake was making up some of the shortfall. We don't expect another quake on the northern end for a hundred years.

Orsi: Why have you turned your attention to the Hayward Fault?

Lindh: The Hayward Fault runs right through old urban areas in Oakland and Berkeley and is very close to San Francisco, so a big earthquake will be a monumental tragedy—the war, with caskets lining the roads and gymnasiums stacked with body bags. The fault produced big quakes in the last century, but we don't know on exactly which segments.

Other seismologists and I have focused a proposal for installing instrument clusters along two or three sensitive fault segments in the Bay Area. Next I'd visit the San Bernardino area in Southern California. The most dangerous part of the southern San Andreas, in the Coachella Valley, is quite a ways from Los Angeles. The threat to L.A. depends on whether three segments down there go as one. If they do, L.A.

gets hit hard. But the San Bernardino Mountains are a tremendous unknown in the fault. Whether the San Andreas can rupture through those mountains is one great quake is an open question.

Orsi: What are the odds for a major earthquake in the Bay Area?

Lindh: Our latest estimates are sixty-seven percent for a major quake in the next thirty years. That's twenty-eight and twenty-three percent for the northern and southern segments of the Hayward Fault, and twenty-three percent for the San Francisco peninsula segment of the San Andreas. The odds for the peninsula segment went up after Loma Prieta, as we assume Loma Prieta put more pressure on the segment north of it. It's reasonable to speak of a one in five chance for a major quake in the region in the next five years. Partially because in the past, earthquakes on the San Andreas and Hayward faults seem to have come in pairs. Possibly though, that's just coincidence. We do know that recently we've entered into a seismically active period.

Orsi: It gives me chills.

Lindh: Me, too. In a big quake on the Hayward Fault, we'll see ground motion maybe five times as great as Loma Prieta, and it'll go on much longer. The nineteenth-century quakes did a lot of damage, and there was wilderness

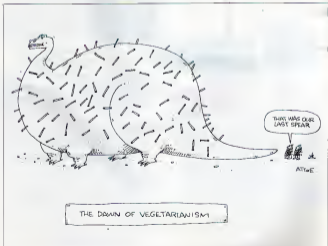
where there are now major cities with lots of people packed into old buildings. And because of the amount of landfill, there's great liquefaction potential along the waterfront. A state of California scenario for a magnitude 7.5 on the Hayward estimates up to four thousand dead and injured in the tens of thousands. A lot of the energy from a quake on the Hayward Fault will end up in the soil structure, the freeways and bridges are built on. These cities will suffer from both ends of the fault.

Orsi: Why are there so many other faults out there?

Lindh: Because the earth has a crust like rain pudding. It's got four billion years of history and it's very complicated in the upper hundred kilometers. In Iowa the crust is a pretty solid structure, but in California it's been holy hell for the last hundred million years with the plates moving apart and smashing together. The fault would like to be straight and clean from Mexico to Oregon, but things like the Sierras get in the way, so it zigs and zags. Earthquakes take the path of least resistance through the rain pudding.

Orsi: What are the odds of an earthquake east of the Rockies?

Lindh: One magnitude seven per century isn't a bad guess. But nobody knows where or when Florida doesn't



seem to have many, and some of the cold, stable Midwestern states don't produce many dots on the map. Heaven only knows what's providing the strain energy driving Eastern quakes. Apparently they occur on what's called failed rifts, places where at some time a continent started to split, then stopped and left a defect. There've been only two major quakes recorded east of the Rockies: Charleston, South Carolina, in 1886, and New Madrid, in 1811. They were both felt over most of the East because the East transmits seismic energy very well. The New Madrid quake rang church bells in Boston.

Omni: What about an earthquake in New York City?

Lindh: A large quake is unlikely and the unlikely event would be at most a magnitude seven. But should such a thing happen, it would be too terrible to think about. The Eastern building codes have paid little attention to earthquakes. If these buildings had been on the West Coast they'd have fallen down long ago. So in a magnitude seven earthquake, tens or hundreds of thousands of people could die. New York City is capable of the kind of disaster that occurred in Iran [in 1990]. But you'd have to get an extremely improbable event in exactly the wrong place.

We're miserably failing to give seismic hazards in the East the study they

deserve. It's scandalous. Over the past twenty years we've started to build a fragmentary picture. But that work was driven almost entirely by the rush to build nuclear power plants. Now that they're unfashionable, there's little funding. This is grossly irresponsible. You can't wait until 2050 to record the macroearthquake that occurred in Ohio in 1991. Our children and grandchildren will not have the data needed to make hard decisions about where to put critical facilities, and they'll end up making the same stupid decisions we do. The pity of it is that continuing the existing network of seismometers would be such a cheap and simple thing to do. You could do it for the kind of money that it takes to water the fowers around the headquarters of nuclear power plants.

Omni: In what part of the earth's crust do earthquakes occur?

Lindh: It's the upper twenty kilometers in the cold, brittle part. Below that, it's so hot there can't be the sudden slip that causes quakes. It's probably more like hot taffy and the movement goes on all the time. We don't know how the brittle surface faults are connected to what's going on down below—is it pushing or pulling or is there a complex interaction? But if I had a series of pictures of earthquakes over the last few thousand years, I think the answers would be self-evident.

Omni: Can't you discover earthquake history by digging trenches?

Lindh: Kerry Sieh of Caltech and a few others have dug trenches in carefully selected places and studied the upper ten to twenty feet of sediments. Sediments adjacent to faults are disturbed over time there's a big quake, and in lucky circumstances the record is preserved. Then more sediments are laid on top. What you get is like a very complicated tape recording of what happened. But sometimes sediments wash away. Life organisms stir them up, or the sedimentation is not the right type. There are a million reasons why trenching might not work. Still, some very smart young geologists are out there year after year doing the dirtiest, most disgusting work a geologist has to do.

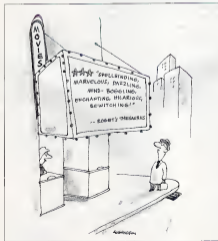
Geologists like to walk around on granite in the Sierra. They don't like to set scaffolding and shore down nice water-filled trenches where every now and then a geologist is killed. Trenching is a dreadful business, but it provides a unique picture. In one place Kerry Sieh has gone back two thousand years and can now tell when an earthquake occurred to within fifty to a hundred years. His work mainly has given us a prognosis for a sixty percent chance of a quake in Southern California in the next thirty years. Trenching is a gamble, though cheap. With four or five good people working for four or five years, we might be able to answer the critical questions about the Hayward Fault. It takes a funny group of people and hard work to make a run at earthquake prediction. Right now at the USGS we still have the best—maybe the second- or third-best—bunch in the world working on prediction. But if four thousand people die along the Hayward Fault tomorrow, many of us will feel personally responsible.

Omni: What good will prediction do us? You can't stop an earthquake.

Lindh: As many as one quarter of the homes in the Bay Area are not bolted to their foundations, which means twenty-five percent of the people don't understand their life savings—usually the equity in their homes—can disappear in seconds. Their negligence is criminal. There's a lot of sloppiness in implementing building codes. Often buildings don't have any bracing to support the beams or joists underneath. Persuading people that there's a concrete reason for taking care of these little things is about our most important function.

Omni: Do you think Bay Area chambers of commerce prefer not to emphasize the coming quake?

Lindh: Well, too bad. People squawk about the money, but they forget, or never heard, that the San Andreas is the single greatest economic boon to California. The movement of the plates creat-



ed the fault, but also the harbors, agricultural valleys, mountains that store snow so you can irrigate the desert lands, the folds that produce gas and oil, the coastline and everything that makes California such a wonderful place. How many tourists would come here if it looked like central Nevada?

Omri: Why do some people close to the fault have so little damage, and others farther away have a great deal?

Lindt: Part is serendipity. Earthquakes don't send energy out uniformly in all directions. In the Loma Prieta quake some really good houses above Los Gatos were shattered. Those people were just unlucky. The earthquake appears to have focused a lot of energy on that sharp pointed ridge. They may have experienced the highest intensities anywhere in the country has ever known. Houses leapt off their foundations, people were thrown into walls and through windows, and refrigerators flew back and forth across kitchens. Nonetheless, no one died there because the houses were well built.

Omri: What have you learned from the Parkfield Earthquake Experiment?

Lindt: We're trying to dope out how the long-term strain accumulation and release cycles work, interact, and when they'll next reach the failure point. But since we haven't had the earthquake yet, we haven't learned how to predict them. We see strain building up little creep events, a shift in seismicity.

We're looking for any gradual failure. Before a fault slips fast—as in the earthquake—it will have to slip slowly. We're looking for foreshocks or anything on the strain meters that might go along with them. There's evidence that suggests there's some action in the hours and minutes before. Slip is what we're looking for. That's why we're trying to build good strain meters and put them down in holes where they get away from the earth's surface movement.

The important things to measure is the deformation of the earth, the earthquake machine down at depth is bending the rocks all the time. We measure this deformation at Parkfield with a two-colored laser measuring movement of the plates millimeter by millimeter. Day in and day out we see plate tectonics in action. Also people sometimes see a decrease in background activity before earthquakes. Then the foreshocks, if there are any, come out of the blue. We don't know if this change we've seen in the last few years means anything.

Omri: Three hours before the Loma Prieta quake, the intensity of electromagnetic waves skyrocketed.

Lindt: If we get an electromagnetic signal before the Parkfield quake like that of Loma Prieta, the world of prediction will change very much. It won't solve the whole problem. But you'd have more hope that when you got down to the

last few days, you'd be able to give people something concrete.

Omri: What about the contention that animals sense coming earthquakes?

Lindt: The evidence is less than persuasive. Now it may be that water-level changes before quakes have driven snakes and rats out of their holes. But if strain changes are so gross that you can see them in shallow water, then we could put in instruments that would be cheaper and more reliable than animals. But since the stories about electromagnetic waves came up, it's been running through my head that perhaps some animals, some of the time—and even people—directly sense changes in electromagnetic radiation. If true, and if there are big electromagnetic frequency changes before quakes, it will reopen the question of animal behavior before earthquakes.

Omri: How do the citizens of Parkfield feel about their coming quake?

☛ Earthquakes occur in the upper twenty kilometers of the earth's crust. Below that it's so hot it's probably more like taffy, and movement goes on all the time. ☛

Lindt: They rather enjoy the notoriety.

Omri: Are they afraid?

Lindt: Nah. If you're a cattle rancher, you've got more worrisome things on your mind. Nobody's ever died in one at Parkfield. You'd have to be very unlucky to be killed.

Omri: Will you ever be able to say "Three days hence there will be an earthquake in such and such a place"?

Lindt: I don't worry where the process will end up. We're decades from that kind of capability.

Omri: We the public thank you for going to tell us so we can plan for the day.

Lindt: You're wrong. We've misled you. Moreover, you're not ready for it. If we could, you wouldn't know what to do.

Omri: Well, tell us.

Lindt: No, we don't have any idea what you should do if told when quake day was. We're all in this together.

But even if I thought there was only a one-in-a-thousand chance of really predicting earthquakes, I'd still try for a way of understanding the problem. Besides, earthquake research has led to seismic engineering and building codes that

have made quakes much less dangerous. And there's our responsibility to the rest of the world. Roger Bilham at the University of Colorado has pointed out there's a dreadful tendency for the superstates that are growing up—especially in the Second and Third Worlds—to be located in tectonically active areas. In the future we may see millions, rather than thousands, die in earthquakes and the accompanying fires. Our effort to understand earthquakes could be a greater contribution to people in the Third World than the millions we send in relief after a catastrophe.

Omri: But is it feasible to have some sort of real-time thirty-to-sixty second warning system?

Lindt: Maybe. Because the shear waves that carry most of the energy travel more slowly than radio waves, we could detect an earthquake and radio ahead to warn people at a distance from the epicenter of what's coming. The instruments are the same as those for prediction. When you build the prediction network, you build into it the capacity to respond in a few seconds.

In the Midwest people buy radios that kick in with emergency tornado warnings. For quakes, we'd provide the signal and electronics stores could sell little receivers. Within seconds we could provide an estimate of how big the ground motion was going to be and how long it would go on. People could hook computers up to this system to park decks. If'd warn people in chemical plants and refineries and probably be used to close some valves automatically—and give people time to run when a chemical vat ruptures. The guy working under his car would beat it, too.

Omri: How did the Native Americans deal with earthquakes?

Lindt: The Kwakiutl, a Vancouver Island tribe, apparently built quake-safe lodges. They also had quake dances that were very elaborate, complete with simulations of shaking people and buildings. I think those dances may have been a rough-and-ready hazard reduction practice. After all the real trick isn't how to build safe buildings, it's remembering to do so. People know damn well how to build, but they forget what they know. The Armenians have two thousand years of recorded history and yet in the Sixties and Seventies they went right ahead and put up buildings that killed as many as fifty thousand of them in 1988. The Kwakiutl appear to have built good buildings.

The short attention span of humans is a fundamental problem in dealing with long-term hazards. When transferring knowledge from generation to generation, you need not just the knowledge, but the emotional content so that it gets acted upon. We're great at information nowadays, not so great at passing along emotional content. ☐

STAR TECH

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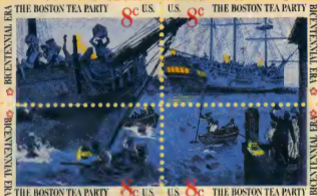
The FVC-880 two-headed camcorder's fuzzy logic means no fuzzy videos. Cost: \$999. Contact: Sanyo Fisher, Chatsworth, CA; (818) 998-7322.



GAMES

POSTAL SCIENCE

If you can't trust the facts on stamps, is it any wonder your letter takes a week to get across town?



The U.S. postal service's first airmail stamps, issued in 1918, appropriately depicted an airplane. Through a printing error, however, the Curtiss Jenny appeared upside down on one entire sheet of 100 stamps. Philatelists like his Zwerfisch prize such stamps, and just one "Inverted Jenny" has a catalog value of more than \$200,000 today.

Past president of The Collectors Club, the preeminent organization of stamp collectors, Zwerfisch specializes in "mistake stamps," which include the samples from his personal collection on these pages. These

stamp errors are not in spelling, dates, or face values, but in the artwork itself. Each contains a scientific error, a physical impossibility, or a commonsense goof. Can you detect the mistakes?

STAMP OUT ERRORS

1. United States, issued July 4, 1973. One stamp in this block of four shows a physical impossibility.
2. Luxembourg, 1936. This stamp was issued to aid the International Fund for Professional People.
3. United States, 1944. The scene commemorates the "golden spike" ceremony on the completion of the

transcontinental railroad.
4. Switzerland, 1909. The boy holding the crossbow is supposed to be William Tell's son.

5. Minnesota, 1969. The portrait of U.S. president Dwight Eisenhower was part of a set to publicize the Fifth International Philatelic Exhibition in New York.

6. Italy, issued in 1957 to publicize a campaign for safe driving.
7. Jaipur, India, 1931. Seven horses lead the chariot.
8. St. Kitts-Nevis, 1933. Columbus peers through a telescope on his voyage of discovery.
9. France, 1953. A woman



an axis back to the sun sets (or rises).

10 Germany, 1919, from that country's first set of airmail stamps.

11 Saudi Arabia, 1949. Another airmail stamp.

12 Monaco, 1947. Franklin D. Roosevelt, one of The Collectors Club's past members, examines his stamp collection. This was part of a set commemorating Monaco's participation in the Contemporary International Philatelic Exhibition in New York.

ANSWERS

1 On the upper right stamp, part of the rigging on the three-masted British flag

2a The passage behind the crescent moon.

2 The name of the newspaper, *Journal*, is printed on the back page.

3 The smoke from the train blows in one direction, the flag in the other.

4 The crossbow's string is on the underside of the stock. A corrected version was issued in 1910.

5 Eisenhower's coat buttons with the right lapel on top, the way a woman's jacket buttons, instead of left on top, like a man's coat.

6 The red light is at the bottom of the traffic light, rather than at the top, as is the international convention.

7 The seven horses pulling the chariot have a total of only four legs.

8 The telescope wasn't invented until the seventeenth century.

9 Judging from the way her hair and dress are blowing, the woman is sailing *seeds* into the wind.

10 With no propeller and a minuscule vertical stabilizer or airfoil tail, this plane would never be able to fly.

11 There are no propellers on this pre-jet age airplane, and the tail fins are not realistic. The plane would crash.

12 His left hand has six fingers—Scott Morris. **OO**



GAMES

ELECTRONIC ECSTASY

Last year's best computer entertainment includes prodigious details and masterful fantasy

Computer entertainment took a mature turn in 1990. It meant fewer brainless blasters for game players and an upswing in brilliantly detailed strategy, role-playing, and simulation games. MS-DOS computers also took their place as the leading computer game machines. Excellent products continued to appear for the Commodore Amiga, but the dropping prices and enhanced technology of PC-compatibles made them the number one platform for computer entertainment. Many gamers achieved electronic ecstasy using a \$665K-based PC-compatible with 256 color VGA graphics and a Sound Blaster audio card.

GAME OF THE YEAR Wing Commander (Origin Systems for MS-DOS) Start with the most stylish graphics and animation yet to appear in a computer game. Add a vivid point-of-view spaceflight simulator. Bring them together with edge-of-your-seat drama and a heart-trumping musical score. The game charts a course toward the interactive video of the future in this watershed action/strategy game.

BEST ARCADE GAME Shadow of the Beast II (Psygnosis for Amiga) The original was unbelievable. This sequel is even better. Only arcade venues are up to the difficulties of this brutal jump-and-punch spec-

tacular. But even the defeated return again and again to roam eerie caverns, challenge horrifying monsters, and savor animated graphics that rank with the finest fantasy art.

BEST SHOOTER Xarcian (Interphase for Amiga) It's fast. It's colorful. It's non-stop destruction. Once again the action masters of Interphase take honors for a futuristic laser fest. The task is simple: Chase robotic bad guys through 13 levels while wielding an array of high-tech firepower.

BEST ROLE-PLAYING GAME Ultima VI (Origin Systems for MS-DOS) Richard "Lord British" Garriott reaffirmed his role playing brilliance with the sixth and best Ultima yet. Ultima VI: The False Prophet boasts an ingeniously improved interface, remarkable 256-color graphics, and a vast world of prodigious details.

BEST PUZZLE GAME Pipe Dream (Lucasfilm Games for Macintosh, Amiga, MS-DOS) Green slime oozes relentlessly through the sewer system. Only you can pull new pipes off the assembly line and keep the gunk contained. It's a disgusting proposition that remains endlessly fascinating.

BEST STRATEGY GAME Railroad Tycoon (MicroProse for MS-DOS) Some kids dream of becoming Donald Trump; others with computers emulate J. P. Morgan, probably stretching a ribbon of rails from coast to coast. The re-creation of railroad empire building is remarkably deep, yet instantly accessible.

BEST SIMULATION SimEarth (Maxis for MS-DOS) The follow-up to the admired SimCity is an enormously comprehensive world simulator. It takes a probing mind to control the ecological, sociological, and geographical depths in the scientifically accurate simulation. Even so, SimEarth remains the best way to amuse yourself while training for employment as a divine being.

BEST SPORTS GAME Indianapolis 500: The SimuSport (Electronic Arts for MS-DOS, Amiga) Eye-popping 3-D graphics allow you to watch the race from the sky, from the stands, or from behind the wheel. State-of-the-art computer technology combines with a fine-tuned driving "feel" to make Indianapolis 500 a freewheeling thrill, particularly when you accidentally spin 180° and drive straight at your oncoming competitors.

BEST ADVENTURE GAME The Secret of Monkey Island (Lucasfilm Games for MS-DOS) This tongue-in-cheek send-up of pirate lore is one of the most laugh-filled, engaging adventure games ever made.

SPECIAL ACHIEVEMENT AWARD Wings (Coreware for Amiga) is the first war game with a conscience. This interactive drama and flight simulator conveys both the triumphs and loss experienced by World War I pilots. Thrilling, touching, and enlightening, Wings tempers and intensifies its action sequences with vivid flashes of humanity.—Bob Lindstrom **CD**



LAST WORD

DEATH BY SHAKESPEARE

Reading may be fundamental, but too much could be detrimental to your health

In 1991 no one could have imagined the ramifications of people's eyeballs darting back and forth in uncontrollable spasms. Ten years later it's accepted as just one more weird symptom of what is now known as compulsive literacy disorder (CLD), a disease that compels people to read themselves to death.

CLD victims, of course, don't succumb to the illness itself but to complications produced by reading everything that falls into their hands. Having ploughed through the complete works of Franz Kafka in the course of an afternoon, for example, one rising young comic committed suicide. And a particularly desperate young man died suddenly of a brain aneurysm after reading a 1,000-page legal brief belonging to a contract lawyer.

While books can be had at a premium, patience is in short supply. A public recitation of nearly

900 pounds of poetry published by Vanity Press was cut short when, halfway through the last volume, the reciter was mercifully shot. Other less discriminating listeners then proceeded to acquire his books.

Christian fundamentalists cite Scripture as evidence that CLD is divine retribution for the sin of seeking original thought. But doctors tracking CLD now believe a recombinant computer virus, scrambled with an Evelyn Wood speed-reading program, was "accidentally" transferred to humans.

The latest conspiracy theory: The government, frustrated with the poor quality of our education system and Japan's dominance in every field, actually planted the virus in segments of the population. Neurologists, however, speculate that the transfer occurred in the same way that physical therapy forges new neural pathways in the brain of a stroke victim—by exercising the affected limbs. Certain sequences of keystrokes on a computer keyboard, they suggest, created a route for the virus to find a home in the nervous system.

Progress in the treatment of CLD has been slow and the fallout has been devastating. Libraries are looted, people mug each other in the streets for as little as a paragraph, and violent domestic quarrels erupt over who has reading rights to the printed material on the backs of milk cartons and cereal boxes.

According to some estimates, moreover, nearly 4 million people have earned the equivalent of a Ph.D. in one field or another, virtually overnight. With no jobs for these people, thousands of them have been rounded up and canned off to "think tanks."

To meet the growing demand, newspapers in New York, Chicago, and San Francisco have dramatically increased their press runs. Dates now put

out morning, afternoon, and evening editions. The tragic result: Forests are clearing. Paper isn't being recycled because people hang on to any scrap with something printed on it.

The phenomenon has led to all sorts of human rights abuses. Writers are blamed and persecuted on one side and hunted by professors on the other. Some have been kidnapped, shackled to writing desks, and forced to produce, day and night, regardless of inspiration. Others, working at computers, contract the disease themselves and quit, writing to join the roving hordes of what one editor called "gluttons for publisher's." One popular author, prolific under the best of circumstances, churned out a 20,000-page novel in a single weekend. The impatient mob of fans on his front lawn roiled when the apocalypticly combusted on Sunday night.

Reading treatment centers are popping up everywhere, but their staffs' efforts to wean people from the printed word and reintroduce them to television and videos have backfired. Patients routinely fast-forward through taped programs to get to the credits.

Even so, researchers are nowhere near a cure and paranoia runs rampant. People don't dare pull their own reading material out in public anymore, especially on the subway. Indeed, as a result of increasing subway crime, people have returned to cars in droves, clogging the nation's highways and byways. The congestion is exacerbated by the collisions that regularly occur around billboards and traffic signs.

And what do the victims do while they're waiting for ambulances? They read bumper stickers, which often run to several paragraphs. Three of the most poignant examples, however, state simply: **KNOWLEDGE IS BLESS. JUST SAY NO TO BOOKS. AND BETTER READ THAN DEAD. DO.**

Khepri's Burns is a freelance writer with a love of reading an extremely large audience.

