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As the next millennium nears, *Omniv* seeks answers to tomorrow's questions: What new technologies will excite us? Who will own the rights to our intellectual properties? Who will own the rights to our past?

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# FIRST WORD

## SUPPOSING SOMETHING DIFFERENT Reconciling science and the afterlife

By David Darling

**I**s death the end—or a new beginning? Can we even make progress toward finding an answer? My belief is that we can but only if we are prepared to challenge two basic “facts” about the world which have long been held in the West to be incontrovertible.

The first of these is that the self is real. As Descartes put it “I think, therefore I am” (but what if Descartes were wrong? Increasingly, neurologists are coming to the conclusion that there is no “Cartesian observer” in the brain, no central overseer that can be identified with “you” or “I.” Instead, what we imagine and feel to

be the self stems from activity spread all over the cortex. Further evidence for this is that damage to part of the brain, through accident or disease, often results in a permanent change to the person we once believed ourselves to be.

Yet all is not lost. I mentioned that there were two facts that we need to challenge if we are to progress in our understanding of the mystery of death and the afterlife. The second fact that is taken for granted in our culture is the assumption that consciousness is produced by the brain.

According to mainstream opinion, matter, over billions of years, organizes itself into more and more ornate forms until, eventually, it achieved sufficient complexity to give rise to consciousness. Working under the assumption a growing number of scientists are now busily rummaging around in the brain trying to explain how the trick of consciousness is done. Researchers of the stature of Francis Crick, Daniel Dennett, Gerald Edelman, and Roger Penrose have recently come forward with a range of ingenious theories. All purport to explain, in one way or another, consciousness as an epiphenomenon of physical and chemical processes taking place in the brain—and all fail utterly. They fail not because their models are insufficiently accurate or detailed, but because they are trying to do what is from the outset, impossible.

The truth is that no account of what goes on at the mechanistic level of the brain can shed any light whatsoever on why con-

sciousness exists. No theory can explain why the brain shouldn't work exactly as it does, yet without giving rise to the feeling we all have of “what it is like to be.” And there is, I believe, a very simple reason for this. The brain does not produce consciousness at all. Any more than a television set creates the programs that appear on its screen. On the contrary, the brain filters and restricts consciousness, just as our senses limit the totality of experience to which we might otherwise have access.

Again, this is no revolutionary new insight—like though it may be in coming to the attention of science. The idea that mind is a fundamental, all-pervasive property of the universe lies at the heart of mystical traditions stretching back over 2,000 years. Nor is the direct experience of what, for want of a better term, we might call “cosmic consciousness” restricted to meditating monks and purveyors of New Age therapies. It comes in flashes to many ordinary folk. And it comes most telling to people during near-death experiences at the very time when brain activity has virtually ceased. If the brain really were responsible for consciousness, why should consciousness be found to expand so dramatically at the point when the brain has all but stopped working?

Soon, perhaps, human inquiry will broaden to allow a concerted exploration of the undiscovered land that lies beyond death. Then we may arrive at a true Theory of Everything, one that satisfies the spirit as well as the intellect. ☐

David Darling's most recent book, *Soul Search* (Villard Books, March 1995) explores the intellectual, scientific, and philosophical implications of defining the soul.

To understand the soul, death, and the possibility of an afterlife, David Darling believes we must look at the brain as it really is.





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# WAVES

## SUDDEN DEATH

A new verdict for an ancient mystery

By Paul Kvinta

**T**wo hundred and fifty million years ago, the teeming plankton of the earth's oceans mysteriously began to vanish. The die-off quickly spread up the food chain. Corals and clams disappeared, then snails and starfish, followed by varieties of squid and octopus and soon whole schools of fish simply expired. Ultimately as the earth concluded the Permian period and began the Triassic, 95 percent of all marine species became extinct.

"It was the mother of all extinctions," says geochemist Kun Wang, noting that the die-off dwarfs all others in the planet's history, including the more celebrated extinction of the dinosaurs 65 million years ago. Paleontolo-

geochemical approach to produce some compelling evidence that the die-off happened suddenly.

Wang's team located a section of ancient rock that once lay at the bottom of Williston Lake in northeastern British Columbia. Inside the rock they found a rare sample of well-preserved organic carbon called kerogen, which forms when plankton drifts to the basin floor and becomes incorporated into sedimentary rock. When Wang analyzed the kerogen with a mass spectrometer, he discovered an abrupt decrease in the number of carbon-13 atoms right at the border between the Permian and Triassic periods.

To make sense of the drop the researchers considered photosynthesis. Carbon is composed

of two isotopes, carbon-12 and carbon-13. During photosynthesis, phytoplankton compete for their preferred isotope, the carbon-12. But since competition for this isotope is typically intense, the plants usually settle for some carbon-13 as well. If the competition for the carbon-12 suddenly thinned, the surviving phytoplankton would absorb only carbon-12 and pass on carbon-13 altogether. Wang concludes that the abrupt drop in the carbon-13 content of phytoplankton at the Permian-Triassic boundary means that a massive extinction took place, and it happened quickly.

The question now is, what caused the crisis? Wang says the die-off could be linked to the heavy volcanic activity that was occurring at roughly the same time in Siberia, where constant eruptions produced basalt outpourings about the size of Alaska. But a more likely scenario, according to Wang, is that a meteor smashed into Earth and created a huge crater. All of the displaced dust would have blocked sunlight for several weeks and severely limited photosynthesis. "It could have been a meteor like the one that just hit Jupiter," Wang says. "If we had that kind of impact, it would have killed off a lot of life."

But Douglas Erwin, a paleontologist at the Smithsonian Institution and an expert on the Per-

These tiny spheres may hold the key to the events which wiped out



95 percent of all marine life at the beginning of the Triassic era.

gists have long hypothesized that the extinction of marine life unfolded gradually and quietly over several million years. But now Wang, a researcher at the University of Ottawa, is bucking that conventional wisdom.

"It was a sudden change, not a gradual change," he contends. "At most it took a few thousand years, but it could have been instantaneous."

Scientists first discovered the Permian-Triassic extinction in the 1950s, but since then, incomplete fossil records have kept paleontologists from determining the abruptness or duration of the extinction. Wang, in contrast, used a

geochemical approach to produce some compelling evidence that the die-off happened suddenly. Wang's team located a section of ancient rock that once lay at the bottom of Williston Lake in northeastern British Columbia. Inside the rock they found a rare sample of well-preserved organic carbon called kerogen, which forms when plankton drifts to the basin floor and becomes incorporated into sedimentary rock. When Wang analyzed the kerogen with a mass spectrometer, he discovered an abrupt decrease in the number of carbon-13 atoms right at the border between the Permian and Triassic periods. To make sense of the drop the researchers considered photosynthesis. Carbon is composed

The question now is, what

man-Triassic extinction, maintains that the die-off occurred over a significant period of time, possibly as long as three million years. "We just don't have any direct data on a time frame for the extinction at this point," Erwin says.

Wang, however, may be on the verge of collecting just the evidence he needs to prove his theory. He is currently investigating clay samples which may contain tiny spheres of microtektites, or pieces of rock that would have suddenly melted and splashed into the clay. Significantly for Wang, it is a condition that could only have been caused by meteor impact. □



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# BOOKS

## THE INTERACTIVE SCIENTIST

A new look at some familiar faces

By Janet Shtes

**T**heoretical physicist Richard Feynman died of cancer at the age of 70 in 1988, but his voice lives on. For that matter, so do his jokes. Addison-Wesley Publishing Company has recently released a condensed version of *The Feynman Lectures on Physics* titled *Six Easy Pieces: Essentials of Physics Explained by Its Most Brilliant Teacher*. But the traditionally conservative publishing house didn't stop with the print version. Accompanying the text is an audio version that allows the listener to get a sense of what it must have been like to be one of Feynman's young students in the early Sixties.

From 1961 to 1963, Richard Feynman taught the freshman physics course at California Institute of Technology. Because of Feynman's reputation as a prankster and congenial showman and because the "Genius," as he has become known, rarely taught classes, the course has become a part of physics folklore and is a great source of pride for Caltech. To give it even more weight, the series culminated in a three-volume book *The Feynman Lectures on Physics*, which has become standard reading for budding physicists.

The staff of Addison-Wesley had the inspiration for the

project after a former Caltech doctoral student told them that the university still had 150 tapes from the lecture series in its archives. "We had always assumed that the tapes had been destroyed," says Jack Repcheck, a former Addison-Wesley editor, who is now an editor at Princeton University Press. "When we found that was not the case, we wanted to give people a taste of them."

The *entertainer* Feynman seems a good study for a project combining science and the CD-ROM industry. Robert Brown, president of W. H. Freeman Publishing, advocates the use of CD-ROM in science. "CD-ROM and science make sense when you are able to show something that is important to a concept or idea," he says.

Brown is an encouraging his editors to look for books which would translate well to CD-



ing to Brown, the CDs offer on-screen tutorials and projection capabilities that can be used to instruct an entire class. Brown explains that while the CD-ROMs are expensive to develop, the process and final product are fascinating.

The attributes of mass multimedia and science are certainly not lost on CD-ROM publisher Voyager. The New York-based company has published a series of science discs called "First Person," in which users have the

opportunity to hear scientists "think out loud." Indeed, Marvin Minsky invites the user into his own living room and, using video and graphics, leads the student through the text of "The Society of Mind." On his CD titled "On Evolution," Stephen Jay Gould helps the user hunt for answers to such notions as "Who was the naturalist on board the Beagle?" and "Why didn't Darwin use the

**We are targeting books which we think can communicate better through the power of CD-ROM and moving objects**

word 'evolution'?" Donald Norman acts as a video host for his CD "Defending Human Attributes in the Age of the Machine."

It's clear from these CDs that fans of science have much to gain as publishers explore the potential of the technology, as science writers begin to write with the medium in mind, and as scientists move beyond the blackboards and the books and come out of the laboratories.

W. H. Freeman has already published a number of CD-ROMs for its textbook division. Accord-

ing to Brown, the CDs offer on-screen tutorials and projection capabilities that can be used to instruct an entire class. Brown explains that while the CD-ROMs are expensive to develop, the process and final product are fascinating.

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# EMPIRES

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## UTTER AMORALITY

Can psychopaths feel emotions?

By Steve Nadis

Most people are affected when they view unpleasant scenes. But psychopaths appear to react in the same way to a plate of food as to a mutilated body.

**H**uman conduct, though often mystifying, is never so perplexing as in the case of the pure psychopath—a “cold-blooded” person who instinctively resorts to lying, cheating, stealing, and perhaps murder without a trace of remorse. How can one in 100 people, by some estimates, turn out this way incapable of experiencing normal emotions, incapable of feeling love or compassion for others—traits considered the essence of humanity? The answer may lie in faulty mental wiring. Numerous experiments show psychopaths have different physiological responses to stimuli from normals and also employ different mental processes while performing simple tasks.

For more than 25 years, University of British Columbia psychophysicologist Robert Hare, author of *Without Conscience*, has been probing the minds of psychopaths. In experiments in the Sixties, he and his colleagues measured the responses of psychopaths and normal subjects prior to administering mild electric shocks. Unlike the normals, the psychopaths showed no anticipatory anxiety (measured in terms of sweaty palms) before the shocks. “They weren’t apprehensive at all,” Hare says. “One might infer that threats of punishment have little effect—something that seems to be true in the real world as well.”

Like many other research psychologists, Sven Christenson at the University of Stockholm believes conventional emotional constructs don’t apply to psychopaths. In a study with Hare, Adele Forth of Carleton University and others, Christenson showed participants 15 color slides and

later tested their memory of the scenes. The eighth slide appeared in two versions: one showed a woman riding a bicycle in front of two cars, the other the same woman lying beside the bicycle with blood oozing from her head, the same two cars in the back-



ground. Normal subjects remembered the emotional slide more vividly and paid more attention to more central rather than peripheral details. Psychopaths did not show the same focus and so didn’t remember one slide better than the other. “Since the psychopath feels nothing for the woman immersed in blood, he doesn’t find the image noteworthy,” Christenson says.

Another study by Hare and his group points to similar emotional defects in a lexical decision task: subjects were presented a string of letters and asked if it were a word or not. Response times and brain waves were measured. Nonpsychopaths identified emotionally charged words like “cancer” or “rape” more quickly than neutral words like “tree” or “plate.” And their EEG responses

to the emotional words were larger and more prolonged. “When you see the letters c-a-n-c-e-r,” says Hare, “you say ‘Yes, that’s a word,’ but you also conjure up images, make associations.” Psychopaths don’t do that. Whether the word is “paper” or “murder,” their response times and EEG patterns do not differ.

At the Bronx VA Medical Center, assistant chief of psychiatry Joanne Litrator and her colleagues used a SPECT imaging machine to measure blood flow in the brains of both psychopath substance abusers, nonpsychopath substance abusers, and control subjects who were asked to perform a word-identification task. Psychopaths used a different strategy to identify emotional words compared to the other groups. “This and other studies suggest that psychopaths process and use language and emotion in a very ‘superficial’ manner,” says Hare, a collaborator.

Control subjects showed coordinated activity in the frontal cortex, temporal lobes, and amygdala, areas thought to play a role in the integration of thoughts and feelings. “We seem to be targeting the same areas other researchers think may be important for the development of a moral sense and conscience,” Hare adds.

Hare and his colleagues are conducting MRI studies to determine whether the anomalies in mental processing are due to underlying structural or functional problems. “New techniques from cognitive neuroscience are opening a window into what’s going on here,” Hare says. “It looks like there might be a neurophysiological basis for this cold-blooded, predatory behavior that has baffled us for so long.” □

# LEARNING

## STRIKING A NEURAL CHORD:

Musical links for scientists and mathematicians of tomorrow

By A. J. S. Rayl

**W**hen all is said and sung, kiddie pop—from Bananys' "I Love You" to old standards like "Twinkle, Twinkle, Little Star"—may be brain food for the scientists and mathematicians of tomorrow. If, that is, the preschool children listening sing along and take up keyboard lessons.

According to a recently published study from the University of California-Irvine, preschoolers who participate in keyboard instruction and group singing dramatically enhance the intelligence network required for high-level math and science. Basically, these musical activities appear to strengthen links between brain neurons, building neural bridges used for spatial reasoning, says co-investigator, psychologist Francois H. Rauscher, formerly of the university's Center for Neurobiology of Learning and Memory.

This and other studies now underway emanated from earlier work of co-investigator, physicist Gordon L. Shaw UC-Irvine Shaw and former graduate student, Xudong Leng, created a neuronal



L.A. County preschools. Nineteen were provided with eight months of weekly keyboard instruction and daily group singing sessions. 14 did not receive any musical training.

In the 30-minute, daily singing sessions, the preschoolers chorused a variety of songs, from new hits to classic favorites. For the keyboard instruction, Eric L. Wright of the Irvine Conservatory traded

pieces into familiar objects) from the Wechsler Preschool and Primary Scale of Intelligence Revised Performance Subtest, and "Absurdities" (verbal descriptions of what is "wrong" or "billy" about a given picture) from the Stanford-Binet Intelligence Scale.

The results: 17 of the 19 kids who received music lessons increased their spatial-temporal IQs by a 45 percent mean. Those children who received no music lessons only improved by a 6 percent mean, which is less than expected by chance. The study further suggests, says Rauscher, that other tasks which depend upon spatial-temporal processes—chess, geometry, sculpture, and the computer game Tetris—will probably also be enhanced by music training.

And even if your child shows no signs of becoming the next Mozart or Elvis Presley, the genius of an Albert Einstein or Madame Curie may be hiding behind those missed notes or sour chords just waiting to burst into equations. **Q&A**

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Rauscher advises parents to sing with their kids, and invest in piano lessons or a musical keyboard.

Music is a very powerful tool which can be used to ensure **every child reaches** his or her potential in math and science.

model of the cortex. This model proposed that musical activity and higher cognitive functions share inherent neural firing patterns which are organized in a highly structured, spatial-temporal code covering large cortical regions.

While neuroscientists have yet to really look at the brain on a micro level, they can observe patterns. Still, the only way now to determine how certain activities influence others within the brain is to study the resulting behavior.

The preschool study set out to do just that. The study involved 33 youngsters enrolled at two

in the traditional A-B-C method of piano teaching and developed a series of mathematically oriented keyboard exercises. Numbers were assigned to fingers—the thumb being 1, index 2, and so on—as well as to the keys—C-1, D-2, and so on. "When you look at music, it truly is a mathematical production, we wanted to see the impact this mathematical approach would have," says Wright.

Rauscher then tested the children's spatial reasoning with a series of five tasks, including object assembly and animal parts (assembling cardboard puzzle

# STARS

## ASTRONOMY BY NUMBERS

Scientists digitize the sky to reveal its hidden secrets

By Steve Nadis

**A**ny theory attempting to explain the universe must rely on a special kind of inventory—a comprehensive survey of the celestial objects adorning the heavens. Just as a storekeeper regularly re-visits and refines his inventory, astronomers have begun to update theirs, making new maps of the sky in wavelengths ranging from radio to x-ray. In contrast to traditional astronomical surveys, which photograph the entire sky in numerous, overlapping segments, most of the new surveys either in progress or planned will be digitized. Rather

than just taking snapshots with cameras, astronomers now employ advanced detectors that measure the amount of light reaching us from all parts of the sky and then combine that information arithmetically to produce detailed images of the stars and galaxies distributed above.



than just taking snapshots with cameras, astronomers now employ advanced detectors that measure the amount of light reaching us from all parts of the sky and then combine that information arithmetically to produce detailed images of the stars and galaxies distributed above.

While some astronomers move forward with these new surveys, others work "backward" in a sense, digitizing old-fashioned photographs by translating the information they contain into a string of numbers that can be analyzed and manipulated by computers. A team at Maryland's Space Telescope Science Institute (ST ScI) is currently digitizing recent pictures of the Southern Hemisphere sky taken by an Anglo-Australian observa-

tory, as well as the contents of the Second Palomar Observatory Sky Survey, a new atlas that includes nearly 3,000 photographs of the northern sky. (The first Palomar survey was completed in 1957.) Interestingly, these pictures are stored on glass plates rather than film because film can bend and thus distort the positions of celestial objects. The ST ScI group expects to finish scanning both sets of plates by 1995 or 1999.

The ST ScI-Palomar collaboration makes tremendous sense to George Djorgovski, an astronomer at the California Institute of Technology and the Palomar Observatory. Computer technology, he says, provides "a way of miking the data for all its worth and, in fact, more than it was worth originally."

Once digitized, the Palomar survey will contain an unprecedented amount of astronomical data—three terabytes, enough information to fill six million books. The project will ultimately identify two billion stars and 50 million galaxies.

The big challenge comes in

Computer technology provides

"a way of **miking the data** for more than it was worth originally."

trying to process all that information. "In the past, people haven't been able to analyze data as fast as they can collect it," says Usama Fayyad, a computer scientist at the Jet Propulsion Laboratory in California. To avoid a similar bottleneck, Fayyad, Djorgovski, and Nick Weir, an as-

tronomer formerly at Caltech and Palomar, have developed a new software program called SKUCAT that automatically finds and classifies sky objects while noting their position and brightness. In the old days, astronomers spent untold hours staring at plates through a microscope or magnifying glass, counting little dots and charting their position with a ruler. SKUCAT not only automates the process, it also does the job more quickly and more accurately than humans. "Historical classification tasks that took years can now be done in a matter of hours," Weir says.

ST ScI intends to put the catalog online, making them accessible to anyone with a modem. And after the second Palomar photos are completely digitized, Djorgovski and his colleagues at Caltech plan to digitize the first Palomar survey. By comparing recent pictures of the sky to those taken years ago, astronomers can study transient phenomena such as supernovae, bursts, quasars, and variable stars. "Who knows what was in the sky back then?" Fayyad muses. The extended time coverage also permits scientists to chart the motions of stars, which offer clues about the structure of the galaxy.

Eventually, astronomers hope to unearth secrets lurking in other

plate collections scattered around the world. "These plates won't last forever, especially if exposed to air pollution," Lasker warns. "We should digitize them now, while we still have the chance." □

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Storing astronomical data on photographic plates like these may soon be obsolete, as astronomers go digital.

# WIHEELS

## FIXING THE FUTURE

A tour of a high-tech research lab hints at driving's future

By Jeffrey Zymbont

**T**he top brass at Ford had good reason to preen during the public dedication of the company's new Scientific Research Laboratory, held in Dearborn, Michigan, at the end of 1994. The expanded lab culminates a \$1.2 billion investment in R&D facilities that began more than five years ago.

John McTague, Ford's vice president of technical affairs, put the expenditure in a business perspective: "The rapid development and application of advanced technologies are fast becoming one of the key competitive advantages a company can have," he said, spinning off that old adage, "You have to spend money to make money."

But the payoff from this brand of research comes far down the road, only after a particular product or process is perfected to the point that dozens or even hundreds of thousands of them can be knocked off flawlessly and inexpensively and millions of car owners will find the ideas useful enough to purchase.

Carl Johnson doesn't think car plants will employ the liquid com-

posite molding technique for plus-to-body parts much before the next century. Still, he directs his research with urgent determination to contribute to a motor-scene anxious for light, fuel-thrifty cars.

His task is to discover fast, low-cost ways to mold plastic around pre-shaped mats of glass or carbon reinforcement that make the finished pieces at least as strong as steel, but up to 60 percent lighter. Johnson oversees four technicians in a material-science lab as large as a tennis court, stretching upward nearly three stories, where it's capped by a tangle of catwalk, gantry crane, and ductwork large enough to make a good venue for a chase scene in a James Bond flick. The lab is packed with refrigerator-size industrial computers, toolchests, wires, hoses, conduits, cables, and three big molding machines. The largest one, big enough to fit a suburban garage, presses out liquid composite molded lenders in trial runs, letting out a persistent hiss and whir that's punctuated by the occasional pneumatic-robotic whoosh of serious machinery.

Across the building, in the chemical engineering department, the labs are smaller but the discovery continues with the same earnest anticipation in the atmospheric chemistry lab. Tim Wallington has built a 140-liter smog chamber to test the environmental impact of new fuels. Looking like a seven-foot-long glass thermos bottle, the chamber takes ultrapurified air and then mixes in nitrogen monoxide, an engine by-product. A cylindrical band of UV lights wrapping the thermos bottle mimics the sun, turning the mixture to nitrogen dioxide—smog. Wallington then runs the brew through an infrared spectrometer, revealing

its precise chemical nature.

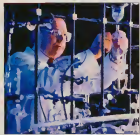
A few doors down, simulators in the catalyst research lab pipe gases through reactive compounds to find the formulas that scrub the air cleanest. Four orange-red, tabletop infernos burn in minifurnaces encased in glass and fed by a tangle of cables, tubes, and cords.

Of course, Ford isn't alone in this type of work. Across town, General Motors operates its own future-focused R&D lab within the GM technical center which is housed in a square-mile campus configured by the wacky architect Eric Saarinen. Honda conducts R&D in Torrance, California. Marysville, Ohio, and at its home bases in Wako and Tochigi, Japan. Virtually every automaker pours millions—sometimes billions—of dollars into scientific inquiry. Separately, their efforts push and pull the companies into greater or lesser positions within the ever-changing competitive hierarchy. But collectively the research advances the state of automobility everywhere.

Accordingly, in Ford's catalyst research lab, Dr. Haren Gandhi swirled 10.5 grams of black liquid in a beaker to represent the pollutants emitted each mile from the average automobile of the 1960s. His pride apparent, Dr. Gandhi next held up a small cylinder with just a splash of black in the bottom. That, he said, is the output from a contemporary car. To illustrate the eventual output from an ultra-low-emission vehicle, he let a tiny drop fall from a glass pipette.

"Being part of that improvement," said Dr. Gandhi, who joined Ford research in 1967 and who now manages the chemical engineering labs, "even in a small way—you can't help but feel good about your work and how it helps society." □

Researchers and technicians laboring at Ford's new science factory in Dearborn are developing the future—today.



# ELECTRONIC UNIVERSE

## SPACED-OUT SCENARIOS:

*Doom*, and *Descent*, and *Star Trek* . . . oh my!

By Gregg Keizer

**F**irst-person science-fiction action games are bad for your health. They keep you up all night in front of the computer or TV, run up your phone bill when you make the leap to multiplayer mode, and crank up your virtual violence level to that of a digital Ted Bundy. But hey, they're fun, right?

*Doom*, which started the whole mess, begat a legion of in-your-face games. Not surprising for they're as visceral as gaming gets in or out of the house. With claustrophobic sets, threatening situations and enemies, limited resources and above all, a view that puts you in the shooter's seat. *Doom* and its ilk break sweet titilar than any other kind of game.

*Doom* and the next-of-kin *Doom II: Hell on Earth* (id Software/GT Interactive) are the best places to start. You're a space marine wandering through a Mars moon station (*Doom*) or a cavernous Earth-based locale (*Doom II*) armed to the teeth and lookin' for trouble. A cast of bad things fills your sights from zombie-like humans to grotesque demons; but a few rounds from a shotgun or plasma rifle and they're toast! The plot is simple: Survive long enough to get to the next level. Play on a network or across phone lines via modem, and these games feel like you're a character in *Alien*. If you have a Sega 32X system, you can also play Sega's version of *Doom* in front of the TV.

Compared to *Doom*, Interplay's *Descent* drops you into freefall. That's because you've got a full range of motion both horizontally and vertically, without

any gravity constraints. If you get nauseous on the ferris wheel, stay away from *Descent*. You're driving a robotic spaceship

Plenty of Imperial **Stormtroopers** managed to die in *Star Wars*, but not like this. ***Dark Forces* packs more violent behavior** in a half-hour sitting than you saw in all three movies.

through corridors, blowing away enemy ships, and trying to get to the next of 30 levels. The perspective's slick and the freedom of movement extraordinary. Still, since the threats are machinery, not embodied evil, it's tougher to get scared by this one.

Adding the ability to look up

the *Next Step: Mars?* CD-ROM from NI Publishing. Perfect for kids (but filled with enough info to keep most adults interested).

*Next Step: Mars?* is a gentle but thorough Martian expedition. The premise is goofy—you're enlisted by an intergalactic Council to research Earth and its plans to head to Mars, then report back with your findings—but the interface is slick. There's the 3-D Village of Knowledge, where rooms

are filled with objects and data. Narrated reports, video, text, still images and away-from-the-computer activities take you from the history of our thoughts on Mars to future possibilities of travel.

On the Internet, if the only thing about *Star Trek: Voyager* that's scarier than Kato Murgrow's steel wool-edged voice is the possibility of missing an episode, you need to hit the Web page at <http://voyager.paramount.com>. Using an interface, you can pull up brief summaries of already-aired episodes; read short bios of the crew (and longer bios of the actors); and download audio and video clips from the series. It's mostly fluff, but it's worth adding to your Mosaic or Mosaic hostlet when you forget to punch Record on your VCR. **GO**

Please visit our World Wide Web site at <http://www.ornimg.com>.



In these software designers' worlds, space is jam-packed with dangers, darkness, and dark nightmares that creep up on you from behind.



and down and jump to the first-person viewpoint, *Dark Forces* manages to evoke the world of LucasArts while stashing on the firepower. The corridor mazes are complex, the sound effects almost overwhelming (this is on CD, so audio is excellent), and though it's only single-player, the heart-pounding meter is near the red zone.

**Mars Needs Women** (and Kids). Going to Mars would be a frighteningly difficult job, but learning about the Red Planet is a lot less scary, especially with



# CONTINUUM

NOT JUST A BILL ON CAPITOL HILL

Puling for the NIE. Plus, watching fruitflies copulate, and using zebra mussels as water filters

Establishing a new science institute? It doesn't sound like something the polarized sides of the new governmental order would approve of. Nevertheless, a proposed National Institute for the Environment (NIE) is shaping up into something both sides of the debate can love: a nonregulatory, national granting institution that will streamline America's environmental research efforts and ultimately result in better, cheaper science policy.

A Washington, DC-based committee has been lobbying for the NIE since environmental scientist Henry F. Howe and Stephen P. Hubbell first proposed the idea back in 1989. Today, NIE supporters include Dow Chemical, the World Wildlife Fund, the National Council of Negro Women and Newt Gingrich. This almost inconceivably diverse alliance speaks to the universally recognized need for a single entity—one that will distribute data among existing environmental agencies, fill in crucial gaps in research, and provide the balanced, credible information needed by policymakers to solve environmental problems before they escalate into costly crises. In addition, plans for the NIE call for it to take responsibility for environmental education and data dissemination, providing a mechanism to link working scientists with each other and with the public.

Legislation to establish the NIE has historically enjoyed broad bipartisan support in Congress. Minority leader Tom Daschle, a Democrat, is considering the reintroduction of the NIE bill in the Senate, while Republican Jim Saxton leads the effort in the House. The current administration, however, does not think creating and funding such a new entity is desirable at the time, preferring to rely on the already-established Committee on Environment and Natural Resources (CENR), according to statements made by John H. Gibbons, assistant to the president for science and technology.

"There's a general consensus that CENR has not been very effective at coordination in these times of budget austerity," says Hubbell, an evolutionary biologist at

Princeton University and chairman of the Committee for the NIE. He notes that the NIE would ensure that policies are enacted appropriately without regard for who happens to be in office.

Hubbell envisions the NIE serving as a unifying force, driving a continuing, comprehensive analysis of interdisciplinary environmental problems. For example, some scientists maintain that chlorine mingled with pesticides can mimic the effects of estrogen, causing feminization of wildlife. One theory holds that the declines in the Great Lakes' fish populations can be attributed to related losses of function. The NIE would have a broad enough mandate to link, say, neuroendocrinology with environmental science to help examine the varied science issues in such a case.

Rather than operating completely independently of existing programs such as the EPA and the U.S. Fish and Wildlife Service, the NIE would instead be tightly linked with them. The NIE planners want research directors of federal agencies to serve on an advisory panel so that they can prevent duplication of effort and ensure that the NIE's work complements existing federal research programs. The NIE scenario also calls for the institute to help coordinate research with education, a key service that no existing agency provides.

But wait—there's more. The plans for the NIE include the establishment of the National Library for the Environment, which would house relevant information on issues ranging from wetlands protection to toxic-waste cleanup. The library would be open to everyone with a stake in an issue, from business leaders to local governments to homeowners.

Indeed, this new institute may end up making everybody happy. For now, its future is in the hands of legislators. Against the backdrop of the budget debate, Saxton says, "the NIE presents an opportunity for the United States to reinvent environmental science."

—PAT JANOWSKI





## CONTINUUM



Wise enough of the "right" pheromones, male flies can be fooled into mating with females of the "wrong" species.

### THIS FLY WALKS INTO A CROWDED BAR . . .

Watching flies copulate is an important part of recent work refuting the idea that species arise only via many changes of small effect. In some instances very small genetic changes have profound effects, says Jerry Coyne, professor of ecology and evolution at the University of Chicago.

Numerous barriers discourage species mixing, one of the most important of which is sexual isolation, where species differ in mating behaviors, says Coyne. For example, female fruit flies (*Drosophila*) attract males

with chemicals (pheromones) in the waxy substance covering their bodies, which stimulate chemoreceptors in the male's forelegs and mouth.

Coyne's group studied four species in two males and females both wear tricosene and males will court these females, but not females of the other two species, which wear heptacosene. Males of these latter two species wear tricosene and will court any of the females.

However, the discriminating males can be fooled. A female of the "wrong" species crowded among "right" ones can obtain enough pheromone to be sexually interesting—even if dead. And hybrid females, with half the

correct fragrance, receive about half the courtship attention. Pheromones can also change males' from becoming really attracted to a female to being com-

### THE LARGEST CREATURE WITHOUT A BACK BONE IS THE ATLANTIC GIANT SQUID, WEIGHING 2.5 TONS

pletely averse to her," explains Coyne.

Of *Drosophila*'s four chromosomes, "only a single small region of a single chromosome was responsible for this difference," states Coyne, who believes this tiny genetic difference "is a very important contributor to the origin of these species."

—J. Blake Lambert

### WIND BREAKER

As a particle physicist and senior safety officer at Fermilab, Hans Joslin has to worry about lofty matters like confirming the existence of the top quark as well as mundane issues like protecting his colleagues from harm. The latter concern weighed heavily on him, especially when he thought of Lab 8, a poorly constructed industrial building that would offer little protection in the event of a windstorm or tornado.

Joslin spotted the solution to his concerns in the form of concrete chunks lying alongside the roadway—chunks which might be fash-

ioned into a nifty wind shelter. He met with representatives of the Chicago Precast Products Company of Naperville, and an inspired collaboration soon began.

The result of this cooperative venture, the FermiShelter, now sits next to Lab 8, ready in theory to comfortably hold 60 people while withstanding 300-mile-per-hour winds and lending off flying objects such as trees or cars. The structure, arguably the first above-ground tornado shelter, has a curvy "wind-shedding" shape with no sharp edges or indentations for the wind to grab hold of. It's a sleek, 25-foot-long tunnel made out of 11-inch-thick reinforced concrete slabs, welded into the shape of an arch.

Structures like this make sense in places where basements may not be feasible," explains Luz Rubenstein, a marketing engineer for the company. "The whole thing is portable and modular, making it easy to add or subtract concrete sections." —Steve Nadis





## WIPP SMART

In 1988, the Department of Energy (DOE) planned to begin depositing plutonium-contaminated wastes from U.S. nuclear weapons plants 2,000 feet below the earth's surface in salt deposits near Carlsbad, New Mexico. The DOE postponed those plans as a response to environmental criticism, and seven years later the facility called the Waste Isolation Py-



rit Plant (WIPP) remains unused. Astronomers hope to take advantage of this unique, abandoned site to study supernovae and the elusive neutrinos from those violent stellar explosions.

A neutron observatory

background of any place we know of on earth," says UCLA physicist David Cline, a member of the astrophysics team that wants to install hundreds of neutron detectors in the subterranean facility. The basic idea is that neutrinos from a supernova explosion might pass through the salt beds, unleashing neutrinos that could be picked up by an array of instruments.

By measuring the exact timing of the neutron sightings, scientists hope to learn how fast neutrinos travel and by inference whether those particles have any mass. Its a point of major cosmological significance, since that single measurement could mean the difference between a universe that expands forever or one in which matter eventually begins to collapse.

Cline and his colleagues still need to secure permission from the Department of Energy, as well as raise additional funds. "The biggest problem is not money but finding a place where we can set up our equipment



Subsized transports may finally join the skies—if they fly around at the right altitude.

## SAFE FLYING ZONE

During the late 1960s and early '70s, the U.S. government financed the design of prototype supersonic aircraft and planned to build a fleet of 40 airplanes. This vast fleet never materialized, due to concerns about sonic booms, air pollution, and ozone depletion. (Three-panel models predicted that 10 percent of the entire ozone layer would be destroyed by nitrogen oxides released in the stratosphere.)

NASA and the aircraft industry have attempted to revive the concept, citing developments that may make the idea more viable. On the drawing board are new engines that would emit several times less exhaust than the Conquents, the only commercial supersonic transport (SST) now flying. Also, NASA conducted dozens of research flights in the stratosphere in 1993 and 1994 to measure concentrations of various gases and the results are encouraging. "The effects of nitrogen oxides on ozone are not nearly as large as

we thought they were just a few years ago," says Richard Stolarski, a researcher scientist at the NASA Goddard Space Flight Center.

Cruising altitude may be the key factor. "There appears to be an altitude where large fleets of SSTs would not harm the ozone layer," says Haeckel Johnston, an atmospheric chemist at the University of California, Berkeley. This so-called "safe flying zone" is thought to lie between 17 and 20 kilometers in altitude, although an exact cut-off point has yet to be established. Scientists are also trying to determine the extent to which aircraft exhaust gases will drift upward in the atmosphere to altitudes where damage to ozone will be more substantial.

Ozone, of course, is not the only environmental issue. "We need to look at how other things in the exhaust—water, acid, and sulfur—might affect the climate," Stolarski says. "By once, we're trying to figure this out in advance, rather than just going ahead and seeing what happens."

## VENUS, WHICH SHINES BRIGHTLY ENOUGH TO BE VISIBLE DURING THE DAY, ACCOUNTS FOR ABOUT 25 PERCENT OF UFO SIGHTINGS

must be underground to provide shielding from cosmic rays. Low levels of background radioactivity are also essential. According to preliminary measurements, WIPP scores well on both counts. In fact, this site has the lowest radioactive

and leave it alone, possibly for decades," he says. The hope is that a nuclear waste disposal facility—storing materials that will stay radioactive for tens of thousands of years—just might be around for a while.—Steve Nadis



## CONTINUUM



Italian filmmaker (holding) with 11,000 feet down along the East Pacific Rise: octopuses aren't picky

### STRANGE LIAISONS

A group of scientists 10,000 feet down along the East Pacific Rise in the deep-sea research submersible *Alvin* were recently startled by the sight of two male octopuses of different species, their arms entwined in amorous embrace.

"It raises all sorts of questions about what's going on down there," says octopus specialist Janet Voight of the Field Museum of Natural History in Chicago, who was summoned to analyze 16 minutes of videotaped footage of the X-rated encounter: the first of its kind spotted in the wild. If you're going to see one, and only one act of mating behavior between deep-sea octopuses, you would not

**ON AN EMPTY STOMACH, ALCOHOL IS ABSORBED INTO THE BLOODSTREAM IN LESS THAN A MINUTE**

expect to see this.

The lurid film was shot in the Hole-to-Hell, west of Guanamala along the mid-ocean ridge that extends up into the Gulf of California, according to marine ecologist Richard Lutz of the Institute of Marine and Coastal Studies at Rutgers University. The smaller partner, a 16-inch white octopus, was of a species that had not previously been seen. One of his groped arms had a cup-shaped grasper at the end. Males use this to insert a

spermatophor protein packet into the female's oviduct. That's exactly what he was doing to a much larger seefoot, grayish-brown octopus when the *Alvin* arrived to record the deep-sea mating ritual between the two males.

Since cephalopods aren't hermaphroditic, Voight theorizes the odd coupling occurred because every time octopuses meet at such lonely depths, each must explore the possibility, however remote, that the other might be a female. Just they miss a rare mating opportunity—George Nobbe.

If A equals success, then the formula  $A=X+Y+Z$ . X is work. Y is play. Z is keep your mouth shut.

—Albert Einstein

### SOOT FINGERPRINTS

Using heavily magnified pictures taken from a transmission electron microscope, or TEM, scientists at the Massachusetts Institute of Technology can now "fingerprint" individual soot particles. This technique may eventually enable them to trace soot to its source, whether that is a particular type of combustion engine or a specific factory's smokestack.

Soot from different sources has distinctively different characteristics, according to chemical engineers Adal Sarofim and John Vender Sande. They enlarged the TEM pictures roughly 2.5 million times and then produced digitally enhanced images of single layers, which form the particles.

The MIT scientists then compared the enhanced images with the originals and discovered that the spacing between the layers varied with the type of fuel that produced the soot. In other words, soot produced by diesel fuel has a uniquely different layer structure from that produced by anthracene.

"Fingerprints" from fuels may help pollution fix.







ARTICLE BY ROBERT K.J. KILLHEFFER

## REBURYSING THE PAST

ILLUSTRATION BY AMY CLUIP

A  
s far

back as the Depression-haunted 1930s, the Dickson Mounds site near Lewistown, Illinois, had been a popular local tourist attraction, famous for its exhibit of over 200 exposed Indian graves, the skeletal remains of their occupants revealed as they had been found years before. The landowner, Don Dickson, had begun excavating the burials in 1927—at least partly

## The repatriation of Native American burial relics is a source of

out of professional interest as a chiropractor (he wanted to examine the bones)—and in those days, the Dickson Mounds attraction was little more than a wood-frame shelter over a hole in the ground.

Trouble began in the early 1970s when the state built a new museum on the site. Native Americans, upset by the exploitative exhibit, threatened to protest at the museum's dedication ceremony. The protest never occurred, but complaints continued intermittently until 1989 when, sensing the shifting tide of public opinion, Judith Frank, the museum director, recommended to the governor of Illinois that the exhibit be closed.

But that wasn't the end of the trouble. When the local Lewistown public heard of the plan to close the site, they protested in return. The Illinois Department of Natural Resources held hearings. Dickson Mounds became a battleground of the 1990 Illinois gubernatorial campaign, and the decision was reversed—the exhibit would stay open. Native American groups demonstrated outside the museum some looped into the pits and covered the skeletons with blankets and the verdict was changed again. In April 1992, the site was officially closed to the public: a concrete slab was laid over the pit of open graves, and with that the last exhibit of Native American remains in the country was sealed. The governor committed \$4 million to renovate and expand the museum as a solace to the angry residents of Lewistown, but hardly anyone was pleased by the compromise—Native Americans wanted the bones reburied rather than simply covered over; scientists wanted more time to study the remains; and the local townspeople still felt their interests had been mishandled by outsiders.

The bitter conflict at Dickson Mounds is just one of many such clashes that have plagued museums and archaeologists over the



cans have demanded the return (or repatriation!) of remains and artifacts held by the nation's museums, and more sensitive exhibits on Native American culture. During the nineteenth and early twentieth centuries, archaeologists and agents for such prominent institutions as the Smithsonian and the American Museum of Natural History were digging up relics from Native American burial grounds and hiding for artifacts on reservations. Vast collections of material—from prehistoric pottery and bone carvings to leather headaddresses, mummies, and skeletons—ended up in the display cases and storage boxes of museums. As Native American activism grew during the 1960s and 1970s, pressure on museums to return such objects—particularly the human remains—grew as well.

The repatriation issue reached a watershed in the 1980s, when archaeologists and museum curators, who had largely remained passive before (hoping, perhaps, that the issue would blow over in time), started to give Native American claims serious consideration—and in some cases, to agree to return all or part of their collections to the tribes. California's Department of Parks and Recreation, which held hundreds of skeletons, was one of the first yielding to pressure in 1983, but challenge from archaeologists held the repatriation back for many years. As the decade progressed, the weight of opinion began to shift toward the Native American view, and other institutions such as Stanford University and the University of Nebraska agreed to return collections. Most significantly, the Smithsonian Institution, which had held out under increasingly ardent protests for years, signed an agreement with two national Indian organizations in September 1989, providing for the return of some of its 18,500 Native American "specimens" and their associated funeral objects.

ILLUSTRATION BY JUDITH K. HARRIS

## challenge and conflict for museum curators and archaeologists.

archaeologists and museum curators who favor repatriation has grown so far, it has a very personal brand of passion on both sides. Normally polite academic papers in journals such as *American Antiquity* drift at times toward insult with terms like "immoral" and "hypocritical" and phrases like "the anthropological trap of cultural relativism." The Council for West Virginia Archaeology and the Society for West Virginia Archaeology jointly sued the state of West Virginia over a plan to excavate a burial mound at College—they felt the state plan gave too much power to a coalition of Native Americans who had voiced concern. Not content with a court battle, the plaintiffs fought it out in the press as well. "I saw things that were vitriolic against me personally in artifact-leader magazines and collector magazines," recalls William G. Farrar, deputy commissioner of the West Virginia Division of Culture and History, with some amusement and a touch of old irritation.

In keeping with the trend, the state won the case and a subsequent appeal. "We established that repatriation is a program that's here to stay," says Farrar. Bit by bit, a consensus is forming, says Anthony Klesert, director of the Navajo Nation Archaeological Department in Window Rock, Arizona, that indeed these things are the property of Indian tribes. That consensus is what scares some archaeologists and museum professionals: If objects are returned to Native Americans, there's no way to ensure their fate. "They'll have the right of determining what happens to them," says James Brown, chairman of the anthropology department at Northwestern University, "including the right to sell them." The Yup'ik natives of St. Lawrence Island, Alaska, recently took to raiding their own archaeological sites and selling the valuable artifacts to dealers.

But resale isn't the most disturbing (or likely) possibility by far. Much of the material returned to Native Americans will be destroyed in one way or another. The human remains and funeral objects will be reburied. Other objects, such as the striking wooden war-god sculptures crafted by the Zuni, will simply be exposed to the elements to decompose naturally, as they were originally intended to do by Zuni custom.

Certainly, some of the resistance to repatriation derives from ambivalence but it's the loss of scientific data and access to precious archaeological resources that will hurt the most. "When a new advance comes along," Brown explains, "it's precisely those well-known, well-documented collections that the

promoters of the new methodology or perspective go to in order to verify and affirm the usefulness of their approach." Over time, such benchmark collections, which have been analyzed and reanalyzed by dozens of different techniques, become ever more valuable to researchers. "In that light," says Brown with a note of regret, "the consignment of the collection to oblivion is rather unfortunate."

The trend toward repatriation and the accommodation of Native American concerns reflects a general shift in public opinion toward respecting the viewpoints of historically oppressed minorities. The same cultural forces that have brought team names like the Washington Redskins under fire have bequeathed a powerful moral force to the proponents of repatriation. "For so long archaeologists have taken a really colonialistic attitude toward Indians and their remains," says Anthony Klesert, "to a certain extent we've got it coming." But there's more to it than fashionable group guilt. Anthropologi-

calists don't like professional archaeology."

That becomes a particularly important distinction when issues of respect for Native American beliefs tread on some of our own most treasured principles. One of the points in the College burial mound dispute was a request by the Native American group that female researchers working at the site not handle the burial materials—the human remains and related funeral objects—while they were menstruating. "My immediate reaction," says Farrar, "was well, you can ask, but I'm not going to enforce it, and I don't know if anyone will agree to that."

The issue was resolved, however, without conflict. The spokesperson for the Native American group (a woman) talked it over with the head of the archaeological team (also a woman), and she agreed to honor their request. She said she'd been in that situation on several reservation digs," Farrar recalls. "That it wouldn't interfere with their work, and it would foster good relations, so no sweat."

## The trend toward repatriation reflects a general shift in public opinion toward respecting the viewpoints of historically oppressed minorities.

cal ethics dictate a stance of neutral cultural relativism and noninterference, Klesert explains, "which means taking into account the world-view and the point-of-view of the people who generated these objects." Looked at that way, repatriation seems less like a betrayal of scientific principles than fidelity to scientific ethics, even if it means precious relics and valuable evidence must be destroyed. "From an anthropological point of view, maybe that's what should happen," Klesert suggests. "If the makers, the designers, the users of the items want them destroyed, that's the way it should be."

"If that were my grandmother's head up on the shelf," says William Farrar, "I'd be incensed and so would most of the people in the state of West Virginia." But Klesert points out, it's not enough to support the Native American viewpoint only when one's own gut-level response agrees with it. "That's missing the point—it's not a question of how would you feel, it's how do they feel," Farrar elaborates. "I don't have to believe in it, but I have to respect their beliefs, the same as I would respect the beliefs of professional archaeologists even if I

dislike the sensitive issue of confidentiality—what critics would call censorship—raises the hackles of Americans wearied on the first amendment. "Confidentiality is an important respect of a lot of sacred places and sacred ceremonies," says Anthony Klesert. "It has to be respected." Native Americans are often loathe to share information about sacred topics at all, and when they do, they want to have a say about its publication and dissemination. Photographs and other documentation of burial sites may offend some Native Americans, who would rather no such records were kept, even for scientific purposes. Robert Masiowski, president of the Council for West Virginia Archaeology, claims that the original plan for the College mound excavation would have returned all the materials—even the scientific records—to the Native Americans for disposal, though in the end no such action occurred, and Farrar denies that he would ever have endorsed such a plan. "I will not stand for censorship on anything that comes through this office, period," he insists.

The 1990 Native American Graves

Protection and Repatriation Act (NAGPRA) brought some much-needed structure to the morass of ethical debate. While it essentially favors Native Americans requiring repatriation of several categories of material and establishing procedures for handling burials discovered on federal or tribal lands, NAGPRA also set some limits on Native American demands. It covers only a narrow range of relics and requires Native American claimants to demonstrate some "cultural affiliation"—a "reasonable" link (not necessarily based on direct genealogical descent) between their ancestry and the remains or artifacts in question. NAGPRA has become a reference point for both scientists and Native Americans—a "middle ground," says Richard Stoffle of the University of Arizona's Bureau of Applied Research and Anthropology, where the opposing parties can meet to resolve the specific terms of the act itself as well as the larger issues of their relationship.

NAGPRA specified that any facility

between what was left in the past and who lives today." Over the centuries, many different tribes may have occupied a particular area, and records for some regions (and some collections) are hopelessly spotty. Stoffle and his colleagues have conducted several cultural affiliation studies, some in connection with NAGPRA, to help institutions determine which living people might be related to their collections. "A cultural affiliation study tells you who to talk with," Stoffle says. "We take the broadest possible net, and we look at a place and say who could possibly have lived here in whatever time period, and we argue for the involvement of all those tribes."

But then all that remains are representatives from the various affiliated tribes not a solution. Critics question how well anyone's concerns will be addressed by such a process, and whether Native American groups are going to make wise decisions about the long lists of artifacts museums are sending them. But archaeologists who have worked closely

way for archaeologists and museums to keep their precious materials. "Gave me a break," says Anthony Klesert. "What is clear is that these things aren't related to us, European-stock archaeologists."

NAGPRA itself may be limited to specific categories of materials and to the holdings of federally funded institutions, but it also served as a catalyst for discussing and resolving wider issues of respect for Native American concerns. The American Indian Religious Freedom Act of 1978 (AIRFA) mandated protection for a much broader range of materials and issues related to Native American culture. Rather than just burial sites and funeral objects, AIRFA encompasses such things as important wild plants and animals, and what Richard Stoffle calls "traditional cultural properties," sacred sites which may show little or no evidence of human habitation, and so are not often protected from development or intrusion. AIRFA didn't have the "teeth" of NAGPRA, with its very specific requirements, deadlines, and penalties, but many institutions are taking the opportunity to comply with AIRFA's terms as they come into compliance with NAGPRA. "That's good," says Stoffle. "From a Native American standpoint, I think it's a lot better to have AIRFA compliance."

Such broad consultations will likely be NAGPRA's most important and lasting effect. "Its purpose is certainly not to loot museums," says C. Timothy McKean, the National Park Service program leader for national implementation of NAGPRA. "The legacy of NAGPRA will be that it mandates dialogue between museums and Indian tribes." Once archaeologists, museum curators, federal land managers, and others start talking to concerned Native Americans and exchanging views, problems can be resolved before they start. "If NAGPRA works, there will be a better partnership between museum professionals and the tribes," says Richard Stoffle.

That partnership will do a lot more than help in avoiding future problems. The adversarial relationship between archaeology and Native Americans has left archaeologists working without the benefit of one of the best potential sources of information—the Native Americans themselves. When it comes to interpreting finds, says Anthony Klesert, "they have the inside track." NAGPRA-mandated consultations could yield a wealth of information about museum holdings. "You put Indian people on archaeological materials," says Richard Stoffle, "and do so in a manner in which their information is

## Native Americans are exceptionally careful. The last thing they want to do is bring somebody else's body back to their reservation.

receiving federal funds had to make an inventory of its Native American holdings, determine (in consultation with Native Americans and scientists) which tribes might be culturally affiliated with their objects, inform the tribes of their findings (by November 16, 1995), and return to them any affiliated items in several categories. Generally, NAGPRA demands the return of human remains and associated grave goods (unassociated grave goods (objects of a funeral nature but not accompanied by any remains in the collection), sacred objects—meaning materials vital for the practice of Native American religion—and objects of "cultural patrimony," a vague term alluding to culturally important items which belong to the tribe as a whole, and therefore should never have been traded or sold by individual tribe members.

In many ways, NAGPRA has only refined the debate, not resolved it. Its gray areas leave room for widely varying interpretations. The requirement of cultural affiliation is a knotty problem that it might seem. "From an archaeological standpoint," says Richard Stoffle, "it's very hard to make a connection

with Native Americans think they'll be exceptionally careful in going over museum inventories and claiming items. "In most cases they're really conservative," says Richard Stoffle. "The last thing they want to do is bring somebody else's body back to their reservation."

Still, NAGPRA's necessarily vague definitions allow museum directors to view cultural affiliation as narrowly as possible—indeed, professional ethics may require them to do so. Museums have a "public trust," explains Judith Franke, and whatever the personal feelings of curators, they can't just give objects in their care to whoever makes a claim. Others feel that NAGPRA ought to be interpreted as broadly as possible. For instance, says Richard Stoffle, "we believe that unrecognized tribes have a right to participate." He and his colleagues recommend that unrecognized tribes, not technically covered by NAGPRA, be included in museum consultations. "Simply because the federal government currently doesn't recognize them should not disqualify them from the process," he says. For some spitting hairs over the degree of cultural affiliation is nothing but a cynical

desired for its protection, and they'll share knowledge that archaeologists are hungry for." As NAGPRA deadlines have come and gone, Timothy McKeown has fielded pained calls from small understaffed museums with less-than-thoroughly documented collections. "The Indians are coming," they say, McKeown recounts. "What should we do? I tell them I'd listen attentively, and I'd jot things down, because you're about to learn a lot about your collection. The experts are coming to you."

Native Americans can also learn something from talking with museum staff and archaeologists. For decades the federal government pursued a policy of assimilation and suppression of Native American cultures, and museums and anthropologists were often the only parties (save the Indians themselves) interested in preserving a record of those endangered societies. Particularly in the East and Midwest, where Native Americans were forcibly removed from their lands, and their cultures were sharply disrupted by European invasion, archaeology can provide a unique and vital link to the past.

William Farnar recalls that during the occupation at Colgate, "there was a lot of Native Americans who came down to the site to see what was going on and who understand that what the archaeologists are bringing out is also teaching them about their past civilizations." First-hand exposure might even inspire more Native Americans to take up archaeology or anthropology as a profession, which could only be a great boon to research as well as to the ongoing dialogue between the two camps. There are all too few American Indian archaeologists and anthropologists at least in this part of the country," says Judith Franko.

Anthony Klesert helped establish two programs for training Native Americans as professionals: one at Northern Arizona University and the other at Fort Lewis College in Durango, Colorado, but they're small and poorly funded, supported as they are by the Navajo Tribe itself. "We're laying some groundwork here," Klesert says, but anthropology departments need to be focusing on recruiting Native Americans themselves.

NAGPRA has already had some mutually beneficial side effects. The Arizona State Museum now has a committee of Native Americans who consult not only on NAGPRA issues, but on the collection as a whole and on the presentation of Native American culture in the museum's exhibits. The museum's going to be a better place because Indian people and museum profession-

als have gotten together," says Stoffa.

NAGPRA also specifies that if a burial is discovered anywhere on federal or tribal land, work at the site must stop for 30 days to allow Native Americans and archaeologists to study the remains and determine their disposal. That clause might actually lead to the completion of more archaeological research. Under NAGPRA, contractors will have an interest in commissioning comprehensive archaeological surveys of potential construction sites, says Timothy McKeown, because "the last thing they want to do is put a construction project through a place where there are burials, and have to wait 30 days every time they hit one." Anthony Klesert recalls one recent case in which the Peabody Coal Company arranged for an exhaustive survey of an Archaean burial ground before they started digging. "If NAGPRA hadn't been passed," says Klesert, "those remains would have been plowed under by the drag line."

Museum curators and archaeologists would be wise to focus on such discouraging reports. Klesert for one believes that substantial reparation is inevitable, and that opposing it will only hurt more in the end. "The more people dig their feet, the more we start looking like the bad guys in the public eye

and the public is the source of our funding. We depend on the good impressions of the public, and by golly they're going to side with the Indians—they will. There's no question about that."

The power of the Native American appeal comes down to two factors: the volume of the complaint, and the moral force behind it. No outcry arose over the handling of the well-preserved body of the now famous Ice Man found in the Alps a few years ago, though at only 5,000 years old and with such good preservation, it might have been possible to determine likely relatives with far more accuracy than in most Native American cases. "They have all sorts of Neanderthal human remains on display in Europe," Klesert points out, because nobody complains. "Had some of the Swiss descendants" of the Ice Man raised a protest, perhaps his remains would have been promptly reburied as well.

Native Americans occupy a unique position in the moral history of our country, a position which invests their feelings with a profound force few other interest groups can match. "It's a question of respect," says William Farnar, "and until you can figure out a better way to handle that, reburial is what's going to happen." □

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## WHOSE IDEAS ARE THEY ANYWAY

### Intellectual Property in the Information Age

When inventors and artists assign copyrights and patents have been seized, no shots fired. Now, the government is trying to protect intellectual property rights: the obscure, obscure, and obscure, determined with some analysis, the profits from ideas. Yet the outcome of the government's efforts to protect the future of the future, where a monolith.



corporate state owns everything, from the deepest reaches of cyberspace to each base pair on the human genome.

"Billions of dollars are at stake in what is essentially the ephemeral, but enormously powerful, domain of human creativity," says Fred Warshofsky, author of *The Patent Wars*. "That creativity, in the form of ideas, innovations, and inventions, has replaced gold, colonies, and raw materials as the new wealth of nations." Advances in biotechnology—as well as in software development, in computer technology, and in the creation of the information superhighway—are testing the limits of our intellectual property laws, which govern patents, copyrights, trademarks, and trade secrets. These rules determine when an idea is so novel that it is patentable, and provide legal mechanisms for collecting the profits generated by this creative capital. "Intellectual property is a hot topic right now because it's part and parcel of the second industrial revolution we're going through," says Bruce A. Lehman, U.S. Commissioner of Patents and Trademarks. "Property has always been the essence of capitalism. The only difference a property is changing from tangible to intangible. Today, the only wealth there is in the world is the wealth that comes from the human mind." In recognition of this, provisions for safeguards for intellectual property rights became a linchpin of U.S. endorsement of the General Agreement on Tariffs and Trade (GATT).

But there's growing concern that the in-

creased complexity of technology and the law increasingly erode the vectors in these undeclared wars may be those who can afford the heaviest artillery. "Large, powerful companies can bury their smaller opponents in a tidal wave of expensive litigation," says Fred Warshofsky. These legal battles may create what Warshofsky calls "intellectual property cartels," where behemoths like Microsoft and Intel erect interlocking hardware-software monopolies reminiscent of AT&T's hammerlock on telecommunications prior to the breakup of Ma Bell.

As we construct the scaffolding of the information superhighway—which will have the capacity to transmit mountains of data at gigabit speeds—government policymakers, consumer watchdogs, telecommunications industry officials, creative people—artists, writers, musicians—and even librarians are attempting to formulate guidelines to determine who owns all those digitized bits of information. Their debates echo controversies that have split scientists into warring camps over patenting biotechnology products and DNA, the very essence of life. And the outcome of these seemingly arcane disputes may well decide what the world will be like in the next millennium.

This paradigm shift has its roots in a 1980 Supreme Court decision that changed patent law in the same way that *Roe v. Wade* forever altered the abor-



## Can our current legal system

keep pace with all the rapid advances in technology?

credibly swift pace of technological development is fast outdistancing our delicately balanced legal system's ability to protect the rights of artists and inventors, to give industry an incentive for innovation through patent protection, and, at the same time, to safeguard the public interest. The rapid proliferation of technology has become an unstoppable runaway train, and critics fear we're hurtling at warp speed into a legal abyss. And it seems that the minute one problem gets resolved, a dozen more crop up. No wonder lyricist Hal David ("Promises, Promises") lamented that artists have become "road kill on the information highway" because they have no protection against cyberthieves who appropriate their work.

What's equally disturbing is that as the

technology becomes more complex and the law increasingly erodes the vectors in these undeclared wars may be those who can afford the heaviest artillery. "Large, powerful companies can bury their smaller opponents in a tidal wave of expensive litigation," says Fred Warshofsky. These legal battles may create what Warshofsky calls "intellectual property cartels," where behemoths like Microsoft and Intel erect interlocking hardware-software monopolies reminiscent of AT&T's hammerlock on telecommunications prior to the breakup of Ma Bell.

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a living creature is no different than a toaster oven or a computer," he recalled in a recent interview. He remembers predicting that "this decision will open up the floodgates for the commercialization of the gene pool, which inevitably leads to the patterning of life itself."

At the time, Rifkin sounded like a raging fanatic. But he proved prophetic. A subsequent 1987 Supreme Court ruling extended patent protection to genetically altered animals. Then, in August 1993, the Rural Advancement Foundation International (RAFI) discovered the U.S. government had filed a patent on the cell line, which contains our entire genetic code, of an Indian woman from Panama who is stocky with leukemia.

This Guaymí woman, like others in her tribe, carries a unique virus and antibodies that may be useful in combating AIDS and leukemia. There's also a community in Africa's Sudan that has a genetic resistance to malaria, inhabitants of Umbone, Italy, harbor a gene that protects against heart disease, and some prostitutes in Nairobi may be immune to HIV. Each of these unique genetic traits has obvious commercial value. But the idea of patenting these cell lines, which contain human DNA, the key to life itself, ticks up a horrid list of legal and ethical issues—not the least of which is the specter of Americans plundering the DNA of Third World people. "The human genome is the common heritage of our species," says Jonathan King, a biology professor at MIT. "The notion of granting patents on human cell lines is comparable to a corporation owning the oxygen in the air. We have numerous examples in history of what happens when you allow humans to be commodities—it's called slavery."

The patent application for the Guaymí woman was dropped after strenuous protests by Panamanian officials. But that didn't stop other U.S. government agencies from filing similar patents on cell lines from people in Papua New Guinea and the Solomon Islands. They think the controversy is utter nonsense. "This sensational talk about [using this technology] to clone human beings who will live their lives in servitude is garbage," counters Patent Commissioner Bruce Lehman. "We're talking about a technology that creates a biological invention—and patents are simply a commercial mechanism for people to get paid for their innovations."

The 1980 Supreme Court ruling—dubbed the *Chakrabarty* decision after the General Electric scientist who concocted the oil-eating microbe—was probably inevitable, however given the

scientific revolution that had its genesis in 1972. That's when Herbert Boyer of the University of California at San Francisco and Stanford's Stanley Cohen, while wailing down corned beef sandwiches on the patio of a *Waikeu* deli-catessen, figured out a way of plucking a gene from one organism and patching it into the DNA of another. The hybrid organism they created would then churn out the substance ordered up by the implanted gene.

Gene splicing, as this technique came to be known, was the first fundamentally new drug-making approach in decades, and it equipped scientists with the tools to mine the world's best pharmacopoeia for combating disease: the human immune system. Now drugs could be devised from bodily chemicals—precisely targeted therapeutics that were the Holy Grail of medicine.

Stanford University officials convinced Stanley Cohen to apply for a patent for this technique. Cohen and Boyer waived their own rights to royalties from the invention, which has since

patent was based on papers published in the early 1970s by Nobel laureate Har Gobind Khorana, who was then at MIT, which discussed possible methods of synthesizing multiple copies of small strands of DNA. "Genus" contention was Mullis took elements that already existed in biology, like the polymerase enzyme that can copy DNA, and saw that they could be turned into a powerful new tool to exponentially amplify DNA," explains Paul Rabinow, a University of California at Berkeley anthropologist and author of an upcoming book on PCR's history.

U.S. patent law rejects patent claims if a description of the invention was published more than one year before the patent application was filed. If the court held that Khorana's work did, in fact, outline a method for using an enzyme to amplify DNA, that would mean the idea for PCR was in the public domain. But when Mullis took the stand in the 1991 court battle, jurors were enthralled by the folksy Southern-bred scientist, as he spun out the tale

## Science is an incremental process. When is a discovery such a quantum leap forward that it qualifies as a patentable invention?

generated more than \$20 million in royalties to Stanford and UC-San Francisco, but their fellow scientists were indignant. Hundreds of researchers working at dozens of institutions over three decades had contributed to the body of knowledge that led to this discovery. For two institutions to claim all the credit, not to mention millions in royalties, was unconscionable.

This has been the crux of many biotech patent disputes ever since. Science is an incremental process, with each advance built upon the bricks of the last. So when is a discovery such a quantum leap forward that it qualifies as a patentable invention? That was the central issue in the more recent skirmish between DuPont and Cetus over the rights to Polymerase Chain Reaction (PCR). Devised by Kary Mullis while he worked at Cetus, PCR is a simple process to amplify even the tiniest bits of DNA. This technique revolutionized genetic research, spawned a billion-dollar industry, earned Mullis a Nobel prize, and was a source of much debate and contention in the recent *O. J. Simpson* trial.

DuPont's challenge to Cetus's PCR

of how the concept behind PCR came to him in a blinding flash during a midnight drive up the northern California coast in the spring of 1983. He convinced the six-member panel that PCR was indeed the product of his—and only his—favored imagination.

Kary Mullis's creation of the PCR technique was obviously a conceptual breakthrough. But in other instances, how key a role an individual scientist has played in unearthing something new is not quite so clear-cut. That question was at the heart of the controversy that erupted in 1991 when the National Institutes of Health applied for patents on nearly 3,000 gene fragments discovered in the labs of one of its biochemists, J. Craig Venter, who had devised an ultrafast, automated method of gene sequencing. "There was a mother lode of information some part of which will have phenomenal commercial potential," explains Reid Adler, a Washington attorney who was then head of the NIH's Office of Technology Transfer. "We wanted to keep options open because no one had thought about how to best transfer this technology. Once data is published, it

mission of copyrighted work should be considered infringement. But critics contend this sweeping mandate is based on obsolete concepts of intellectual property—where original works like books, films, records and paintings could be contained in a neat package—that don't reflect twenty-first century realities. They also believe the radically tips the balance of power in favor of the publishers, and that draconian controls on electronic dissemination of information could turn millions of E-mail users into criminals. "The report assumes that increasing enforcement will protect copyright on the Net," says Mike Godwin, staff counsel for the Electronic Frontiers Foundation, a civil liberties group launched by Lotus founder Mitch Kapor. "But the last thing we want is a law that recognizes what people are doing in their living rooms." Adds Prudence S. Adler, assistant executive director of the Association of Research Libraries: "We're trying to develop some alternative cost recovery schemes—aside from the pay per use of copyright—that don't interfere with public access."

It may be tough to enforce stricter rules in the electronic realm, though. Some music industry trade groups like ASCAP and BMI routinely deploy spies to discos, radio stations, and even dance studios, to ensure song royalties are paid. And Microsoft and other software makers, says Fred Warshawsky, "have formed alliances such as the Software Publishers Association (SPA) and the Business Software Alliance (BSA) that have over the past several years made a number of highly publicized raids on companies looking for illegal copies of computer programs." But dispatching cyberbods to patrol the electronic frontier for copyright violators seems wildly impractical. How do you police the millions of computer users who can make instantaneous copies with a keystroke? A better solution might be along the lines of the compromise reached by VCR-makers and movie producers, who recognized the impossibility of halting illicit taping: VCR firms pay into a royalty pool—these payments are added in to the VCR's cost—which is distributed to the motion picture producers association.

What's more, emerging nations in the Pacific Rim like Korea, Malaysia, Singapore, and Taiwan and in Latin American countries such as Brazil and Argentina, don't recognize discoveries or inventions as private property. Instead, they've benefited up their economies by copying, adapting or simply stealing technology in government-sanctioned raids called "free

riding." In the future, developing nations may become electronic havens in cyberspace for intellectual property plunderers. A Cayman Islands for data thieves akin to what author Bruce Sterling envisioned in his futuristic cautionary tale, *Islands in the Net*.

"That's why it's so important to get a global consensus," says Pamela Samuelsen, a professor of law at the University of Pittsburgh Law School. "It doesn't make any sense to try to solve problems domestically if everyone can log on to off-shore sites." In fact, provisions in GATT are designed to circumvent situations like this. The 118 nations in the trade pact have agreed to uniform rules regarding protection of patents, copyrights, trade secrets and trademarks in all fields of technology ranging from electronics and information technologies to biotechnology and pharmaceuticals. Poachers will be hit with stringent sanctions.

An eleventh-hour intellectual property agreement reached between the United States and China in February 1995 narrowly averted an all-out trade war. American officials were ready to impose prohibitive tariffs on Chinese imports and block China's admittance to the newly formed World Trade Organization, which Beijing bureaucrats be-

lieve is a prerequisite to modernizing their economy. At stake was nearly \$3 billion worth of sales American companies lost each year because of the theft of intellectual property in China, where a thriving black market did a brisk business in pirated U.S. goods—ranging from CDs, laser disks, video games, movies, and software to counterfeited copies of jackets bearing the names of professional sports teams.

But while the Clinton administration boasted of its great victory with the recalcitrant Chinese, many privately wonder how vigorously the Beijing government will pursue violators.

Indeed, the world may be getting wired, but the law lags far behind the technology. It may be several years before we understand how to devise sensible mechanisms for protecting the fruits of our imagination. "It's still the Wild, Wild West on the electronic frontier," observes Burk, with bandits lurking on highway shoulders and cyberbushes displaying vigilante justice. But one thing is certain: With brain power becoming such a coveted currency, the twenty-first century will witness the real revenge of the "nerds" and Nobel laureates may—finally—command bigger bucks than NFL running backs. □



"He really does have a heart of gold!"

## BATTELLE'S BEST GUESSES

**N**o one future is inevitable,' says Stephen Millett, whose job it is to forecast the future. "Many different futures are possible at any given moment. But if you recognize



bus Ohio. His clients, ranking among the world's largest corporations, prefer futures that are prosperous; therefore, they're hungry for tomorrow's strategies today. To accommodate



than Battelle. Since 1929, the world's largest nonprofit research lab—with 8,000 technical workers in offices around the world—has been a trading post of ideas on the frontier



dominant trends, you can create strategies that lead you toward the future you prefer." Millett is head of technology intelligence and management at Battelle Memorial Institute in Colum-



bus. 11 of Battelle's senior researchers and managers gathered recently to name the 10 most influential technologies of the next decade. Who should know better



### THE TOP TEN TECHNOLOGIES THAT WILL SIGNIFICANTLY INFLUENCE OUR LIVES IN THE NEXT DECADE

Assembled by **BENNETT DAVIS**

Interviewed by **SANDRO**



in a range of technological research. But in the last six years the government has been going out of the research business in a big way. This shifting of research to private industry results in less emphasis on basic research and a greater focus on practical problem-solving. As industry becomes more involved, a greater proportion is becoming overtly more commercially oriented."

So what is the proper role for government in technology research? "Developing technology for public infrastructure in the broadest sense, such as intelligent highways—interactive roads that exchange data with smart cars," Millett replies, "There's research in embedding sensors in concrete to read stresses continually in bridges. Any time government builds a transportation or communication link it's a big deal. The interstate highway system and the Internet were government projects, and both changed the nature of society. But government involvement in research is likely to be smaller than in the past."

In spite of this, Battelle named a government project—the mapping of the human genome—as the most important strategic technology of the coming decade. When asked about this choice, Millett responded, "The mapping itself will have no intrinsic commercial value. The government is underwriting this research as a part of the national health infrastructure, and the results will be readily available to everyone. But applying this information to create ways to identify genetic markers within an individual has potentially enormous commercial applications. Knowledge of the genome is the key to curing and eventually eradicating hundreds of diseases, perhaps even slowing the aging process itself."

According to Dr. Craig Hassler, a physiologist, the mapping project is at the point now that the microprocessor industry was in 1982—when people were just beginning to understand what "microprocessor" meant. "There are already striking examples of diseases we can identify by their genetic signatures," states Hassler. "That list will grow steadily, and in 10 years people will see practical results. Genetic counseling initially will be probabilistic—telling someone they have this great a chance of getting a particular disease by a particular age. As we get better at understanding what gene markers mean, we'll be able to give increasingly accurate predictions."

But ethicists and policymakers have long worried about the social impacts of the power to predict. The good news is medical insurance will be very cheap

for some folks. The bad news is the ones who'll need it most are those for whom the price will be astronomical. As Hassler explained, "The financial impact on society could be tremendous. Isolated instances already exist of people having insurance problems because of genetic indicators. These people could become part of a genetic underclass. If commercial companies refuse to insure people showing a strong likelihood of developing a particular condition, we might have to adopt some form of government health care funding. If private industry can't figure out an equitable way to blend higher and lower risks, the government becomes the insurer of last resort, and the only fair way to do it might be for everyone to pool the cost."

"There are also indications that mental abilities, artistic talents, or physical skills might be genetically influenced. One always wonders if the next Einstein is living in an obscure place where he or she won't get the opportunity to become the new Einstein. Should we devise a way to genetically

We can laugh and joke about the flip-out communicator on *Star Trek*, but technology seems to be moving very strongly in that direction.

identify talent and direct people into particular pursuits to which they're genetically suited instead of adhering to the ethos that in the United States you can become whatever you want? If we're lucky we won't map the genome until we've figured out how to settle these issues, but technology always seems to move faster than politics."

After counseling the next application of genome technology will be diagnostic techniques. "We're constantly discovering new substances in the body," says Hassler. "By knowing your level of a particular enzyme or other biochemical, doctors will be able to diagnose a particular condition. Eventually, from a blood or skin sample a doctor could tell you which diseases you're most likely to get. There's no reason why we couldn't see at-home diagnostic kits, although probably not by 2006."

"A third area is genetic therapy and pharmaceuticals, which will evolve more slowly," continues Hassler. "The process of infusing people with new genetic material is barely in its infancy, so much of the work that needs to be done will just be getting under way between now and 2006."

The second most influential technology on the list is super materials, specifically matrix materials and molecular composites. Chemist Dr. Vince McGinness explains the concept. "In matrix materials, manufactured fibers—carbon, glass, silicon carbide, or some high-strength metal—are embedded in a flowable ceramic or metal. Matrix materials have tremendous strength, can stand up to intense heat, and are lightweight. The Air Force, the motorator behind matrix materials, is testing them in parts of jet engines, and other applications. One Japanese car company has used matrix materials to reinforce cylinder wall linings. Matrix materials are finding their way into a few products now, and we'll see much more of them in the next few years. Today the process of manufacturing matrix materials in quantity is still complex. Fibers thrown into a resin aren't happy. So you have to treat them with special linking agents to hold them in the flowable matrix material. That interface is where the problems show up—stress or water comes in and breaks

the fiber. Because strength in matrix materials comes almost entirely from fiber and very little from surrounding material, you lose all the strength."

Molecular composites, however, are more durable. In fact, according to McGinness, they're the next generation of engineered materials. With matrix materials, we make two separate things and put them together. In molecular composites, we design everything—the rigid, fiber-like segments, the flexible material—into one molecule. Polyethylene is like that. Low molecular-weight polyethylene is an oil, a little higher weight gives you paraffin waxes, higher still and you have Baggies. Going higher, you get crystalline materials with fiber stronger than steel. That's what racing sails are made of.

"Because a molecular composite is joined to itself, molecule by molecule, making something becomes a matter of arranging the microstructure. Using the computer to model the structure of specific molecules, we see how they can be joined to other molecules. As recently as three years ago, when a client asked us to engineer a new material, we'd head for the lab. Now we

as television is allotted now. But the FCC has ruled HDTV has to fit in the same airspace now occupied by conventional TV signals. To meet that requirement, researchers have developed a compression technique that cuts those billion bits by a factor of 60. Then, by modifying hardware, they've compressed the signal enough more to meet the FCC's mandate.

"This is an incredibly oversimplified explanation," Ridgway states, "but if I transmit a picture of something that doesn't move—say, a flower—I only have to send it once. If I send a picture in which some parts are moving, I only have to send the picture parts that are changing. Things in a television picture usually move slowly enough that not every point in every picture has to change every microsecond. In tests, companies are now proving even things like sporting events and car races can be transmitted by HDTV."

Ridgway has called HDTV "a breakthrough for American manufacturers. It gives the United States the chance to become the world's leading manufacturer of electronics again," he believes. "More than 90 percent of U.S. homes have TV, only 30 percent have computers. The United States continues to be the world leader in computers and software, and when you're talking about digital HDTV, you're talking computer and software technology."

But many believe the Japanese have already left the United States behind in high-definition video. "The Japanese were among the first to produce a high-definition TV system, but they made the decision early on to go with analog technology—the same as today's TVs are based on," responds Ridgway. "A group of U.S. companies, known as the Grand Alliance (including AT&T, Zenith, General Instruments, Philips of North America, and others), banded together in May 1993 to pursue a digital approach. Digital technology won out in FCC trials, and the Japanese withdrew their application to market analog HDTV in this country."

"Digital technologies continue to evolve and converge—the information highway, fiber optics, and so on," explains Ridgway, "and their merger is still in its infancy. Eventually, you'll have a box in your home connected to the world, probably through an optical fiber. Instead of watching an HDTV show when it's broadcast, you might download it to watch later. Because the program's in digital format, it can be stored in digital form. If you want a visual image in vastly more detail than the small, low-resolution VGA monitor your home computer can provide, you

send the image to your digital HDTV for a better look."

"Most of us would love an affordable motion picture screen in our houses," adds Millett. "That alone would be a multibillion-dollar HDTV industry. But this technology also can have an enormous impact on the quality of big-screen movies or any display of enormous size, or great detail. Imagine all your family photos preserved forever in perfect clarity on one CD."

When will consumers benefit from this new format? Ridgway calculates that "once the FCC defines the standard set of technical specifications HDTV will be based on, companies in the Grand Alliance aren't going to sit around. We'll see the first consumer

products in two or three years, but these early products will be expensive. You can't receive HDTV signals on the TV set you have now. Rather than suddenly switch from one technology to the other, for some time both regular signals and HDTV will be broadcast. The shift from one kind of TV set to the other will be gradual. But by 2005, HDTV will be as common as CD players and home computers are now."

With on the Top Ten list as the miniaturization of electronics. How small is small? As small as "a wireless handheld, interactive computer accessing and transmitting data at a distance," responds Millett. "We're getting close to the day when we can combine voice

CONTINUED ON PAGE 110

# Don't Decide Now, Sleep On It!



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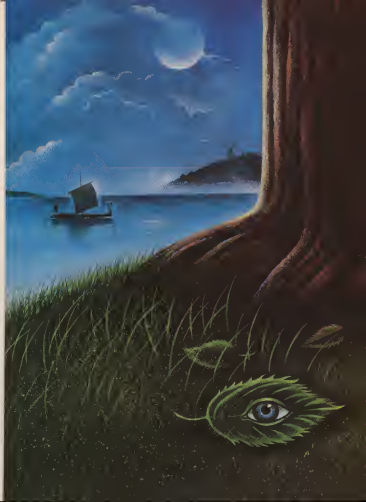
The moon slips and shines in the  
wrinkled mirror before the prow,  
and from the northern sky the  
Bright Companions shoot glancing  
arrows of light along the water. In  
the stem of the boat the poleman  
stands in the watchful solemnity of  
his task. His movements as he  
poles and steers the boat are slow,  
certain, august. The long, low

Fiction by Ursula K. Le Guin

# OLDERS

Painting by Wendell Minor

channelboat slides on the black  
water as silently as the reflection it  
pursues. A few dark figures huddle  
in it. One dark figure lies full length  
on the halfdeck, arms at his sides,  
closed eyes unseeing that other  
moon slipping and shining through  
wisps of fog in the luminous blue  
night sky. The Husbandman of  
Sandry is coming home from war.



They had been waiting for him on Sandry Island ever since last spring, when he went with seven men following the messengers who came to raise the Queen's army. In midsummer four of the men of Sandry brought back the news that he was wounded and was lying in the care of the Queen's own physician. They told of his great valor in battle, and told of their own prowess too, and how they had won the war. Since then there had been no news.

With him now in the channelboat were the three companions who had stayed with him, and a physician sent by the Queen, an assistant to her own doctor. This man, an active, slender person in his forties, cramped by the long night's travel, was quick to leap ashore when the boat slid silently up along the stone quay of Sandry Farm.

While the boatmen and the others busied themselves making the boat fast and lifting the stretcher and its burden up from the boat to the quay, the doctor went on up to the house. Approaching the island, as the sky imperceptibly lightened from night-blue to colorless pallor, he had seen the spires of windmills, the crowns of trees, and the roofs of the house, all in black silhouette, standing very high after the miles of endlessly level reedbeds and waterchannels. "Hello, the people!" he called out as he entered the courtyard. "Wake up! Sandry has come home!"

The kitchen was set already. Lights sprang up elsewhere in the big house. The doctor heard voices, doors. A stableboy came vaulting out of the loft where he had slept, a dog barked and barked its lady warning, people began to come out of the house-door. As the stretcher was borne into the courtyard, the Farmwife came hurrying out, wrapped in a green cloak that hid her nightdress, her hair loose, her feet bare on the stones. She ran to the stretcher as they set it down. "Fame! Fame," she said kneeling, bending over the still figure. No one spoke or moved in that moment. "He is dead," she said in a whisper, drawing back.

"He is alive," the doctor said. And the oldest of the stretcher-bearers, Pask the saddler, said in his rumbling bass. "He lives, Makah-dam. But the wound was deep."

The doctor looked with pity and respect at the Farmwife, at her bare feet and her clear, bewildered eyes. "Dema," he said, "let us bring him in to the warmth."

"Yes, yes," she said rising and running ahead to prepare

When the stretcher-bearers came out again, half the people of Sandry were in the courtyard waiting to hear the news. Most of all they looked to old Pask when he came out, and he looked at them all. He was a big, slow man, grithed like an oak, with a stiff face set in deep lines. "Will he live?" a woman ventured. Pask continued looking them all over until he chose to speak. "We'll plant him," he said.

"Ah, ah!" the women cried, and a groan and sigh went among them all.

"And our grandchildren's children will know his name," said Dyadi, Pask's wife, bosoming through the crowd to her husband. "Hello, old man."

"Hello, old woman," Pask said. They eyed each other from an equal height.

"Still walking, are you?" she said.

"How else get back where I belong?" Pask said. His mouth was too set in a straight line to smile, but his eyes glistened a little.

"Took your time doing it. Come on, old man. You must be penishing." They strode off side by side toward the lane that led to the saddletry and paddocks. The courtyard buzzed on, all in low-voiced groups around the other two returned men, getting and giving the news of the wars, the city, the marsh sales, the turn.

Indoors, in the beautiful high shadowy room where Fame now lay in the bed still warm from his wife's sleep, the physician stood by the bedside, so grave, intent, careful as the poleman had stood in the stern of the channelboat. He watched the wounded man, his fingers on the pulse. The room was perfectly still.

The woman stood at the foot of the bed, and presently he turned to her and gave a quiet nod that said, Very well, as well as can be expected.

"He seems scarcely to breathe," she whispered.

Her eyes looked large in her face, knotted and clenched with anxiety.



"He's breathing!" the doctor assured her. "Slow and deep. Come, my name is Harmed, assistant to the Queen's physician, Dr. Saker. Her majesty and the Doctor who had your husband in his care, desired me to come with him and stay here as long as I am needed to give what care I can. Her majesty charged me to tell you that she is grateful for his sacrifice, that she honors his courage in her service. She will do what may be done to prove that gratitude and to show that honor. And still she bade me tell you that whatever may be done will fall short of his due."

"Thank you," said the Farmwife, perhaps only partly understanding, gazing only at the set, still face on the pillow. She was trembling a little.

"You're cold, dams," Harmed said gently and respectfully. "You should get dressed."

"Is he warm enough? Was he chilled, in the boat? I can have the fire lit—"

"No. He's warm enough. It's you I speak of, dams."

She glanced at him a little wildly, as if seeing him that moment. "Yes," she said. "Thank you."

"I'll come back in a little while," he said, laid his hand on her heart, and quietly went out, closing the massive door behind him.

He went across to the kitchen wing and demanded food and drink for a starving man, a thirsty man leproscamped from crouching in a damned boat all night. He was not shy and was used to the authority of his calling. It had been a long journey overland from the city and then poling through the marshes, with Broad Isle the only hospitable place to stop among the endless channels, and the sun beating down all day and then the long dream-like discomfort of the night. He made much of his hunger and travail to amuse his hosts and to divert them, too, from asking questions about how the Husbandman did and would do. He did not want to tell them more than the man's wife knew.

But they discreet or knowing or respectful asked no direct questions of him. Though their concern for Faine was plain, they asked only, by various indirectness: if he was sure to live, and seemed satisfied by that assurance. In some faces Harmed thought he saw a glimpse of something beyond satisfaction: a brooding acceptance in one, an almost cunning intelligence in another. One young fellow blurted out, "Then will he be—" and shut his mouth under the joined stares of five or six older people. They were a group from the Sandy Islands. All that were not actively young looked old, seemed,

weatherbeaten, brown skin wrinkled and silvery, hands gnarled, hair thick, coarse, and dry. Only their eyes were quick, observant. And some of them had eyes of an unusual color, like amber. Faine's wife Dyadi, and several others, as well as Faine himself. The first time Harmed had seen Faine, before the coma deepened, he had been struck by the strong features and those light, clear eyes. They all spoke a strong dialect, but Harmed had grown up not far inland from the marshes, and anyone had an ear for dialects. By the end of his large and satisfying breakfast he was glottal-stopping with the best of them.

He returned to the great bedroom with a well-packed tray. As he had expected, the Farmwife, dressed and afoot, was sitting close beside the bed, her hand lying lightly on her husband's hand. She looked up at Harmed politely but as an intruder, please be quiet, don't interrupt us, make him be well and go away. Harmed had no particular eye for beauty in women, per-

haps having seen beauty too often at too short a distance, where it deceives, but he responded to a woman's health, to the firm sweet flesh, the quiver and vigor of full life. And she was fully alive.

She was as tender and powerful as a red-deer doe, as unconsciously splendid. And he wondered if there were fawns.

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"Harmed-dam," the Farmwife said—despite her absorption in her husband she had caught his name, then, with the desperate keen hearing of the sickroom, where every word carries hope or doom—"I still cannot see him breathe."

"Lay your ear against his chest," he said, in a tone deliberately louder than her whisper. "You'll hear the heart beat, and feel the lungs expand. Though slowly, as I said. Dams, I brought this for you. Now you'll sit here, see, at this table. A little more light, a shudder open, so. It won't disturb him, not at all. Light is good. You are to sit here and eat

he had already relinquished.

"I am going to examine and dress his wound," Harmed said. "Will you watch, dams, or come back?"

"Watch," she said.

"Good," he said. Taking off his coat, he asked her to have hot water sent in from the kitchen.

"We have it piped," she said, and went to a door in the farthest shadowy corner. He had not expected such an amenity. Yet he knew that some of these island forms were very ancient pieces of civilization, drawing for their comfort and provision on inexhaustible sun, wind, and tide, settled in a way of life as immemorial as that of their plowlands and pastures, as full and secure. Not the show-wealth of the city, but the deep richness of the land, was in the steaming pitcher she brought him, and in the woman who brought it.

"You don't need it boiling?" she asked, and he said, "This is what I want."

She was quick and steadily relieved to have a duty to be of use. When he bandaged the great sword-wound across her husband's abdomen he glanced up at her to see how she took it. Compressed lips, a steady gaze.

"This," he said, his fingers above the long, dark, unhealed gash, looks the worst, but this, here, is the worst. That is superficial, a mere slash as the sword withdrew. But here, it went in, and deep." He probed the wound. There was no shivering or quaver in the man's body; he lay insensible. "The sword withdrew," Hamid went on, "as the swordman died. Your husband killed him even as he struck. And took the sword from him. When his men came around him he was holding it in his left hand and his own sword in his right, though he could not rise from his knees. Both those swords came here with us. There, you see? That was a deep thrust. And a wide blade. That was nearly a deathblow. But not quite, not quite. Though to be sure, it took its toll." He looked up at her openly, hoping she would meet his eyes, hoping to receive from her the glance of acceptance, intelligence, recognition that he had seen in this face and that among Sandy's people. But her eyes were on the purple

locked room. Closing her ears in case the word is spoken.

He found he had taken a deep breath and was holding it. He washed the Farmwife were older, tougher that she loved her former life. He wished he knew what the truth was, and that he need not be the one to speak it.

But on an utterly unexpected impulse, he spoke: "It is not death," he said, very low, almost pleading.

She merely nodded, watching. When he reached for a clean cloth, she had it ready to his hand.

As a physician, he asked her of her pregnancy. She was well, all was well. He ordered her to walk daily, to be two hours out of the sickroom in the open air. He wished he might go with her, for he liked her and it would have been a pleasure to walk beside her, watching her go along tall and lithe and robust. But if she was to leave Fane's side for two hours, he was to replace her there, that was simply understood. He obeyed her implicit orders as she obeyed his explicit ones.

to her, he would not go behind her back, asking the others if there was any truth in this tale.

Of course there isn't, he told his conscience. A myth, a rumor, a fable of the "Old Islanders" and the word of an ignorant man, a saddler. Superstition! What do I see when I look at my patient? A deep coma. A deep, restorative coma. Unusual, yes, but not abnormal, not uncanny. Perhaps such a coma, a very long vegetative period of recovery, common to these islanders, an inbred people, would be the origin of the myth, much exaggerated, made fanciful.

They were a healthy lot, and though he offered his services he had little to do, once he had reset a boy's badly splinted arm and scraped out an old fellow's leg abscesses. Sometimes little idi tagged after him. Clearly she adored her father and missed his company. She never asked, "Will he get well," but Hamid had seen her crouched at the bedside, quite still, her cheek against Fane's unresponsive hand. Touched by the child's dignity, Hamid asked her what games she and her father had played. She thought a long time before she said, "He would tell me what he was doing and sometimes I could help." Evidently she had simply followed Fane in his daily round of farmwork and management. Hamid provided only an unsatisfactory, makeshift substitute. She would listen to his tales of the court and only for a while, not very interested, and soon would run off to her own small, serious duties. Hamid grew restive under the burden of being useless.

He found walking soothed him, and went almost daily on a favorite circuit down to the quay and along the dunes to the southeast end of the island, from which he first saw the open sea, free at last of the whispering green levels of the meadows. Then up the steepest slope on Sandry, a low hill of worn granite and sparse earth, for the view of sea and tidal dunes, inland fields and green marshes from its summit, where a cluster of windmills caught the sea wind with slender vanes. Then down the slope past the trees, the Old Grove, to the farmhouse. There were a couple of dozen houses in sight from Sandry Hill, but the farmhouse was the only one so called as its owner was called the Husbandman, or Farmer Sandry, or simply Sandry if he was away from the island. And nothing would keep an islander away from his island but his duty to the crown. Rooted folk, Hamid thought wryly, standing in the lane near the Old Grove to look at the trees.

Elsewhere on the island, indeed on

His eyes never opened. Once or twice, she said, in the night, he had moved a little. Hamid had not seen him make any movement for days.

and livid wound, and her face was simply intent.

"Was it wise to move him, carry him so far?" she asked, not questioning his judgment, but in wonder.

"The Doctor said it would do him no harm," Hamid said. "And it has done none. The fever is gone, as it has been for nine days now." She nodded, for she had felt how cool Fane's skin was. "The inflammation of the wound is, if anything, less than it was two days ago. The pulse and breath are strong and steady. This was the place for him to be, dam." "

"Yes," she said. "Thank you. Thank you, Hamid-don." Her clear eyes looked into his for a moment before returning to the wound, the motionless muscular body, the silent face, the closed eyelids.

Surely Hamid thought, surely if it were true she'd know it! She couldn't have married the man not knowing! But she says nothing. So it's not true, it's only a story. But this thought, which gave him a tremendous relief for a moment, gave way to another. She knows and is hiding from the knowledge. Shunting the shadow into the

His own freedom was considerable, for she spent most of the day in the sickroom and there was no use his being there, too little use his being there at all in fact. Fane needed nothing from him or her or anyone, aside from the little nourishment he took. Twice a day, with minute patience, she continued to feed him tea or a dozen sips of Dr. Baker's rich brew of meat and herbs and medicines, which Hamid concocted and strained daily in the kitchen with the cooks, interested aid. Aside from those two halfhours, and once a day the bed-pot for a few drops of urine, there was nothing to be done. No chafing or sores developed on Fane's skin. He lay unmoving, showing no discomfort. His eyes never opened. Once or twice, she said, in the night, he had moved a little, shuddered. Hamid had not seen him make any movement for days.

Surely if there was any truth in the old book Dr. Baker had shown him and in Pask's unwilling and enigmatic hints of confirmation, Makah would know? But she said never a word, and it was too late now for him to ask. He had lost his chance. And if he could not speak

all the islands, there were no trees to speak of. Scrub willows down along the streams, a few orchards of wind-dwarfed, straggling apples. But here in the Grove were great trees, some with mighty trunks, surely hundreds of years old, and none of them less than eight or ten times a man's height. They did not crowd together but grew widely spaced, each spreading its limbs and crown broadly in the spacious aisles under them grew a few shrubs and ferns and a thin, soft, pleasant grass. Their shade was beautiful on these hot summer days when the sun glared off the sea and the channels and the sea wind scarcely stirred the very air. But Hamid did not go under the trees. He stood in the lane, looking at that shade under the heavy foliage.

Not far from the lane he could see in the grove a sunny gap where an old tree had come down, perishing in a winter gale maybe a century ago, for nothing was left of the fallen trunk but a grassy hummock a few yards long. No sapling had sprung up or been planted to replace the old tree, only a wild rose, rejecting in the light, flowered homely over the ruin of its stump.

Hamid walked on, gazing ahead at the house he now knew so well, the massive slate roofs, the shuttered win-

dow of the room where Makai was sitting beside her husband, waiting for him to wake.

"Makai, Makai," he said under his breath, grieving for her, angry with her, angry with himself, sorry for himself, listening to the sound of her name.

The room was dark to his still sun-bedazzled eyes, but he went to his patient with a certain decisiveness, almost abruptness, and turned back the sheet. He palpated, auscultated, took the pulse. "His breathing has been harsh," Makai murmured.

"He's dehydrated. Needs water."

She rose to fetch the little silver bowl and spoon she used to feed him his soup and water, but Hamid shook his head. The picture in Dr. Saker's ancient book was vivid in his mind, a woodcut, showing exactly what must be done—what must be done, that is, if one believed the myth, which he did not, nor did Makai, or she would surely have said something by now! And yet, there was nothing else to be done. Farre's face was sunken, his hair came loose at a touch. He was dying, very slowly, at first.

"The bed must be tipped, so that his head is high, his feet low," Hamid said authoritatively. "The easiest way will be to take off the footboard. Tebra will give

me a hand." She went out and returned with the yardman, Tebra, and with him Hamid briskly set about the business. They got the bed fixed at such a slant that he had to put a webbing strap round Farre's chest to keep him from sliding quite down. He asked Makai for a waterproof sheet or cape. Then, fetching a deep copper basin from the kitchen, he filled it with cold water. He spread the sheet of oxskin she had brought under Farre's legs and feet, and propped the basin in an overturned footstool so that it held steady as he laid Farre's feet in the water.

"It must be kept full enough that his soles touch the water," he said to Makai. "It will keep him cool," she said, asking, uncertain Hamid did not answer.

Her troubled, frightened look enraged him. He left the room without saying more.

When he returned in the evening she said, "His breathing is much easier."

No doubt, Hamid thought, auscultating, now that he breathes once a minute.

"Hamid-dem," she said, "there is something I noticed."

"Yes."

She heard his ironic, hostile tone, as he did. Both winced. But she was startled, had begun to speak, could

## G R E A T M O M E N T S I N S C I E N C E

**D**espite conjecture, most ornithologists agree that the probable cause of the extinction of the rock-nesting red-crested gabbitt might be due in part to the bird's precarious nesting habitude.



**J**ust as the others realized that Dr. Boyd was an imposter, the fraudulent physician discovered that you do have to be a brain surgeon to perform brain surgery.



SATIRE BY ERIC JAY DECETIS

only go on.

"His... She started again. "It seemed..." She drew the sheet down farther exposing Fane's genitals.

The penis lay almost indistinguishable from the testicles and the brown grained skin of the inner groin, as if it had sunk into them, as if all were returning to an indistinguishable unity, a featureless solidity.

"Yes," Hamid said, expressionless, shaded in spite of himself. The process is following... what is said to be its course."

She looked at him across her husband's body. "But—Can't you—?"

He stood silent a while. "It seems that—My information is that in these cases—a very grave shock to the system to the body,"—he paused, trying to find words—"such as an injury or a great loss, a grief—but in this case, an injury, an almost fatal wound—A wound that almost certainly would have been fatal, had not it inaugurated the... the process in question, the inherited capacity, propensity."

She stood still, still gazing straight at him, so that all the big words shrank to nothing in his mouth. He stooped and with his deft professional gentleness opened Fane's closed eyelids. "Look!" he said. She too stooped to look, to

see the blind eyes exposed without pupil, iris, or white, a polished featureless brown bead.

When her indrawn breath was repeated and again repeated in a dragging sob, Hamid burst out at last: "But you knew, surely! You knew when you married him?"

"Knew," said her dreadful indrawn voice.

Then he stood up on Hamid's arms and scalp. He could not look at her. He lowered the eyelid, then and still as a dry leaf.

She turned away and walked slowly across the long room into the shadows.

They laugh about it," said the deep, dry voice he had never heard, out of the shadows. "On the land, in the city, people laugh about it, don't they? They talk about the wooden man, the blockhead, the Old Islanders. They don't laugh about it here. When he married me—" She turned to face Hamid, stepping into the shaft of warm light from the one unshuttered window so that her clothing glimmered white. When Fane of Sandry Fane Older courted me and married me, on the Broad Isle where I lived, the people there said don't do it to me, and the people here said don't do it to him. Marry your own kind, marry in your own kind. But what did

we care for that? He didn't care and I didn't care. I didn't believe! I wouldn't believe! But I came here— Those trees, the Grove, the older trees, you've been there, you've seen them. Do you know they have names? She stopped and the dragging, gasping, indrawn sob began again. She took hold of a chairback and stood rocking a back and forth. "He took me there. That is my grandfather," she said in a hoarse, jeering gasp. "That's Aoi, my mother's grandmother. Down from her mother four hundred years."

Her voice failed.

We don't laugh about it," Hamid said. "It is a tale—something that might be true—a mystery. Who they are, the— the others, what makes them change, how it happens. Dr. Saker sent me here not only to be of use to you, to learn, to verify, the process."

"The process," Nivek said.

She came back to the bedside, turning him across it, across the stiff body, the leg in the bed.

"What am I carrying here?" she asked, soft and hoarse, her hands on her belly.

"A child," Hamid said, without hesitation and clearly.

"What kind of child?"

"Does it matter?"

She said nothing.

"His child, your child, as your daughter is. Do you know what kind of child it is?"

After a while Makai said softly, "I know. She does not have the amber eyes."

Would you care less for her if she did?"

"No," she said.

She stood silent. She looked down at her husband, then toward the window, then straight at Hamid.

"You came to learn," she said.

"Yes. And to give what help I can give."

She nodded. "Thank you," she said. He laid his hand a moment on his heart.

She sat down in her usual place beside the bed with a deep, very quiet breath, too quiet to be a sigh.

Hamid opened his mouth. He is blind, deaf, without feeling. He doesn't know if you're there or not there. He is a log, a block, you need not keep this vigil! All these words said themselves aloud in his mind, but he did not speak one of them. He closed his mouth and stood silent.

"How long?" she asked in her usual soft voice.

"I don't know. That change... come quickly. Maybe not long now."

She nodded. She laid her hand on her husband's hand, her light warm



# GROLIER INTRODUCES A BREAKTHROUGH THAT'S OUT OF THIS WORLD



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**GROLIER**  
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touch on the hard bones under hard skin the long strong, motionless fingers. "Once," she said, "he showed me the stump of one of the older ones that fell down a long time ago."

Harold nodded. Thinking of the sunny clearing in the grove, the wild rose.

"It had broken right across in a great storm, the trunk had been rotten. It was old, ancient, they weren't sure even who the name—hundreds of years old. The roots were still in the ground but the trunk was rotten. So it broke right across in the gale. But the stump was still there in the ground. And you could see. He showed me." After a pause she said, "You could see the bones. The leg bones. In the trunk of the tree. Like pieces of ivory inside it. Broken off with it." After another silence she said, "So they do die. Finally."

Harold nodded.

Blonde again. Though he listened and watched almost automatically. Harold did not see Farrow's chest rise or fall.

"You may go whenever you like, Harold-dam," she said gently. "I'm all right now. Thank you."

He went to his room. On the table under the lamp when he lighted it, lay some leaves. He had picked them up from the border of the line that went by the grove, the grove of the older trees.

A few dry leaves, a twig. Whether box-wood was, that he did not know. It was summer between the flower and the seed. And he dared not take a branch, a twig, a leaf from his living tree.

When he joined the people of the farm for supper old Pask was there.

"Doctor-dam," the saddler said in his rumbling bass, "is he turning?"

"Yes," Harold said.

"So you're giving him water?"

"Yes."

"You must give him water, dema," the old man said relentlessly. She doesn't know. She's not his kind. She doesn't know his needs."

"But she bears his seed," said Harold, smiling suddenly, fiercely, at the old man.

Pask did not smile or make any sign, his stiff face impassive. He said, "Yes. The girls not, but the other may be older. And he turned away."

Next morning after he had sent Mikal out for her walk, Harold studied Farrow's feet. They were extended fully into the water as if he had stretched downward to it, and the skin looked softer. The long brown toes stretched apart a little. And his hands, still motionless, seemed longer, the fingers knotted as with arthritis, yet powerful, lying spread on the coverlet at his sides.

Mikal came back ruddy and sweetly from her walk in the summer morning. Her vitality, her vulnerability were mindfully moving and pathetic to Harold after his long contemplation of a slow, inexorable toughening, hardening, withdrawal. He said, "Mikal-dam, there is no need for you to be here all day. There is nothing to do for him but keep the water basin full."

"So it means nothing to him that I sit by him," she said, half-questioning, half stating.

"I think it does not. Not any more."

She nodded.

Her gallantry touched him. He longed to help her. "Dema, did he do anyone ever speak to you about—if this should happen—? There may be ways we can ease the change, things that are traditionally done—? I don't know them. Are there people here whom I might ask—Pask and Gynd—?"

"Oh, they'll know what to do when the time comes," she said, with an edge in her voice. "They'll see to it that it's done right. The right way, the old way. You don't have to worry about that. The doctor doesn't have to bury his patient after all. The gravediggers do that."

He is not dead."

"No. Only blind and deaf and dumb."

and doesn't know if I'm in the room or a hundred miles away." She looked up at Hamad. Is a gaze which for some reason embarrassed him. "I stuck a knife in her hand would he feel it?" she asked.

He chose to take the question as one of curiosity, desire to know. "The response to any stimulus has grown steadily less," he said, "and in the last few days it has disappeared. That is, response to any stimulus I've offered." He took up Farné's wrist and pinched it as hard as he could, though the skin was so tough now and the flesh so dry that he had difficulty doing so.

She watched. "He was scakish," she said. Hamad shook his head. He touched the sole of the long brown foot that rested in the basin of water. There was no withdrawal, no response at all.

"So he feels nothing. Nothing hurts him," she said.

"I think not."

"Lucky him."

Embarrassed again, Hamad bent down to study the wound. He had left off the bandages for the slash had

Hamad went out of the house and walked his circuit, went to his own room to read. Late in the afternoon he went to the sickroom. No one was there with Farné. He pulled out the chair she had sat in so many days and nights and sat down. The shadowy silence of the room soothed his mind. A healing was occurring here, a strange healing, a mystery, frightening, but real. Farné had traveled from mortal injury and pain to this quiescence, had turned from death to this different, this other life, this older life. Was there any wrong in that? Only that he wronged her in leaving her behind, and he must have done that, and more cruelly, if he had died.

Or was the cruelty in his not dying?

Hamad was still there, pondering, half asleep in the twilight serenity of the room, when Mekak came in quietly and lighted a dim lamp. She wore a loose night shirt that showed the movement of her full breasts, and her gauze trousers were gathered at the ankle above her bare feet. It was a hot night, sultry, the air stagnant on the salt marshes and

filled his world suddenly and entirely and when she laid her hands on his shoulders he reached up to her, sinking upward into her, pulling her down onto him to drink her body with his mouth, to impale her heavy softness on the aching point of his desire, so lost in her that she had pulled away from him before he knew it. She was turning from him, turning to the bed, where with a long, creaking groan the stiff body trembled and shook, trying to bend to rise, and the round blank balls of the eyes stared out under lifted eyelids.

"There!" Mekak cried, breaking free of Hamad's hold, standing triumphant. "Farné!"

The stiff half-lifted arms, the outspread fingers trembled like branches in the wind. No more than that. Again the deep creaking, creaking groan from within the rigid body. She huddled up against it on the tilted bed, stroking the face and kissing the unblinking eyes, the lips, the breast, the scarred belly the lump between the joined, grown-together legs. "Go back now," she murmured, "go back to sleep. Go back, my dear, my own, my love, go back now, now I know now I know."

Hamad broke from his paralysis and left the room, the house, striding blindly out into the luminous midsummer night. He was very angry with her, for using him presently with himself, for being usable. His outrage began to die away as he walked. Stopping, seeing where he was, he gave a short, useful, startled laugh. He had gone astray off the lane, following a path that led right into the Old Grove, a path he had never taken before. All around him, near and far, the huge trunks of the trees were almost invisible under the massive darkness of their crowns. Here and there the moonlight struck through the foliage, making the edges of the leaves silver, pooling like quicksilver in the grass. It was cool under the older trees, windless, perfectly silent.

Hamad shivered. "He'll be with you soon," he said to the thick-bodied, huge-armed, deep-rooted dark presences. "Fark and the others know what to do. He'll be here soon. And she'll come here with the baby, summer afternoons, and sit in his shade. Maybe she'll be buried here. At his roots. But I am not staying here." He was walking as he spoke, back toward the farmhouse and the quay and the channels through the reeds and the roads that led inland, north away. "If you don't mind, I'm on my way, night away."

The elders stood unmoved as he hurried out from under them and strode down the lane, a dwindling figure, too slight, too quick to be noticed. □□

## The slash had closed, leaving a clean seam, and the deep gash had developed a tough lip all around it, a barky ring well on the way to sealing it shut.

closed, leaving a clean seam, and the deep gash had developed a tough lip all around it, a barky ring that was well on the way to sealing it shut.

"I could carve my name on him," Mekak said, leaning close to Hamad, and then she bent down over the inert body, kissing and stroking and holding it, her tears running down.

When she had wept a while, Hamad went to call the women of the household, and they came, gathering round her full of solace and took her off to another room. Left alone, Hamad drew the sheet back up over Farné's chest. He felt a satisfaction in her having wept at last, having broken down. Tears were the natural reaction, and the necessary one. A woman clears her mind by weeping; a woman had told him once.

He flicked his thumbd hand against Farné's shoulder. It was like flicking the forehead: the right table—his nail stung for a moment. He felt a surge of anger against his patient, no patient, no man at all, not any more.

Was his own mind clear? Why was he angry with Farné? Could the man help being what he was, or what he was becoming?

the sandy fields of the island. She came around the bedside. Hamad started to get up.

"No, no, stay. I'm sorry, Hamad—dem. Forgive me. Don't get up. I only wanted to apologize for behaving like a child."

"Grief must find its way out," he said.

"I hate to cry. Tears empty me. And pregnancy makes one cry over nothing."

"This is a girl worth crying for, dem."

"Oh, yes," she said. "If we had loved each other. Then I might have cried that bean full." She spoke with a hard lightness. "But that was over years ago. He went off to the war to get away from me. This child I carry, it isn't his. He was always cold, always slow. Always what he is now." She looked down at the figure in the bed with a quick, strange, challenging glance.

"They were right," she said. "Half-alive shouldn't marry the living. If your wife was a stick, was a stump, a lump of wood, wouldn't you seek some friend of flesh and blood? Wouldn't you seek the love of your own kind?"

As she spoke she came nearer to Hamad, very near, stooping over him. Her closeness, the movement of her clothing, the warmth and smell of her body



# OMNI'S PROJECT OPEN BOOK



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Catherine just can't explain it. She has no idea why she felt so compelled to keep on driving that night after leaving the Boston nightclub where she worked as a receptionist. It was after midnight and she had driven past Somerville, where she lives. Nor does she know why she got off the highway about 10 miles to the north, or why she drove around Saugus and momentarily got lost in a wooded area. But after finding her way out, she noted that it was 2:45 in the morning—at least 45 minutes later than it should have been.

Feeling anxious, she roared back home. The next day, on local news, she learned that dozens of people throughout the North-east had reported a UFO, including a policeman and his wife who had seen an object stop overhead and shoot a light on them. Astronomers said the object was a shooting star.

A few weeks later Catherine decided to contact Harvard psychiatrist John Mack, author of the 1977 Pulitzer Prize-winning biography of T. E. Lawrence and known most recently for his outspoken interest in the UFO abduction phenomenon. In a series of hypnotic regression sessions, Mack helped Catherine unlock a lifetime of apparent abduction memories, beginning at the age of three and culminating in that

## THE SECRET INVASION DOES IT ADD UP?



ARTICLE

BY PATRICK HUNGHE

DO REPORTS OF  
MULTIPLE  
ABDUCTIONS PROVE  
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OF A HAUNTING  
PHENOMENON  
OR MASS ILLUSION  
FLAMING  
OUT OF CONTROL?

murky night just weeks before at the age of 22.

Catherine did not enjoy tracing out what had happened to her in the woods on the night of March 6, 1991. "I don't want to be there," a very frightened Catherine told Mack while under hypnosis. "I want to drive out."

But she could not. Her car had apparently come to a stop and her body had gone numb. Then suddenly her door had opened. "There is a hand reaching out to grab me," Catherine recalled. "It's long and thin and I only got three fingers." A

being with huge black almond-shaped eyes then took her from the car and the two of them were swept up in a beam toward a huge metallic ship.

The alien abductor the story goes, then took Catherine inside, into a hallway where four other beings were waiting. When they began pulling at her clothes, she got annoyed. "Stop it," she recalled thinking. "I'm perfectly capable of doing this myself, thank you." Once naked, Catherine was led into an enormous room "the size of an airplane hangar."

She saw rows and rows of tables everywhere. "There are hundreds of humans in here," she told Mack under hypnosis. "And they're all having things done to them. The rows were about five feet apart; she noted and anywhere from a third

to half the tables had humans on them. She estimates there were between 100 and 200 people in that room. But in the mass of bodies and blank faces she remembers one of them specifically—the one on the table to her left. He was a black man with a beard.

Catherine was forced to sit up on her table and the beings then began running their fingers down her spine. The terrifying examination had begun.

The rest of Catherine's traumatic UFO experience appears in John Mack's controversial book, *Abduction: Human Encounters with Aliens*, and is rather typical of such stories. But one detail in her story stands out like a Gulliver in Lilliput: her bit about the hundreds of other humans she now aboard the alien craft that night. And Catherine is by no means alone among alleged abductees in reporting the presence of large numbers of humans aboard the alien crafts.

What accounts for these suggest is that the phenomenon actually involves mass abductions. It appears as in Catherine's tale that large numbers of people are being taken one by one to central locations that serve as holding facilities for dozens, perhaps hundreds of others during the same period of time. If the other abduction stories are true, moreover, sometimes entire groups of peo-



ple are taken all at once.

Reports of this phenomenon in fact confirm some people's worst fears about the alien endeavor. Could we all be pawns in some weird extraterrestrial breeding scheme to repopulate a dying alien world? Or is the entire human race being unwillingly drafted into some hideous alien genetic experiment to produce alien-human hybrids? Whatever the case, one thing seems clear: Quite a large number of us are potential targets.

"The phenomenon is not as the general public tends to believe, an occasional 'thor's on a lot, got him' sort of thing on the part of the aliens," explains David Jacobs, a Temple University historian specializing in twentieth-century U.S. history and the author of the book *Secret Life*. Instead, he asserts, we have a mass abduction program taking place covertly. The notion of a secret mission inevitably springs to mind.

"What we have here," says Jacobs, "is a continual abduction scenario. It's very much like an assembly line. The aliens get them in. They go into a waiting area where they see other people sitting around. They get shown to a table. There are all sorts of people lying on the tables at various stages of different procedures are being run on them. Then they get them up, get them out, and new people arrive. It's a revolving door."

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The extraordinary number of people supposedly going through that revolving door should, it seems, help cement the case for the reality of the phenomenon. If multiple participants are involved in an abduction, the logic goes, then the experience cannot be the product of one individual's fantasy or hallucination. In fact, the mass abduction cases seem to offer believers a golden opportunity to cross-check the details of the abduction experience from independent perspectives and develop the proof the critics have always demanded.

These mass abductions certainly appear to take place often enough. Jacobs estimates that abductees see other humans aboard the craft in half of the cases. And one out of every four alleged abduction episodes involves multiple participants, according to Thomas Bullard, a folklorist whose 1987 University of Indiana doctoral dissertation exhaustively analyzed about 300 published abduction accounts.

Bullard found that while approximately half of these multiple-participant abduction cases involved just two people—usually family members or friends—the other half involved either three, four, or more people who claimed to have been taken at once. There are even cases in which seven or more people have report-

edly been abducted in a single episode. The situation led Bullard to lament early that apparently "there's just no safety in numbers."

One of the earliest mass abduction cases on record actually involved nine people and took place one summer some 40 years ago near Crater Lake, Oregon. It was not, however, reported to a UFO organization until 1982. The participants were a 30-year-old woman known only as Mrs. R, her 15-year-old brother, 10-year-old sister, two daughters and a stepdaughter, aged 10 to 13, two younger nephews, and Mrs. R's 53-year-old mother.

The witnesses remembered that while looking for a gas station they had come upon what appeared to be a restaurant. Their car engine sputtered and coasted into a parking area where three or four other cars were parked. The "building" was round and lighted and the interior was circular. Mrs. R remembered commenting to her mother that the place was "really unbelievable." The family then sat down at one of the tables and apparently ordered a meal from short, slender people with blond hair who all looked alike and wore identical silver uniforms and boots that sported the same emblem. "When I think about it now," said Mrs. R's mother almost two decades later, "I have a funny feeling like maybe

we were a surprise to them.

Mrs. R. thinks they ate and paid their bill before leaving. Though the car would not start immediately, it sort of "coasted" onto the highway first and only then got underway. When the family reached the next town, Mrs. R. discovered that they had not spent any money and that no one in town had ever heard of such a restaurant. Though the family returned to search for it, they never found it.

"I know I was in a UFO," said Mrs. R. almost three decades after the experience, though that realization did not begin to register with her until about 1969 when she started recalling the incident and discussing it with her family.

Perhaps the best documented of all mass abduction cases involves four young men who were canoeing along the Allagash Waterway in the wilderness of northern Maine on August 26, 1976. Under hypnosis, all four experienced missing time and relived a detailed and amazingly similar UFO abduction episode. This case, which was thoroughly investigated by Raymond Fowler, is unique in the annals of UFO research in that it provides four separate, mutually corroborating accounts of the same event.

It went something like this. On the fifth day of their canoe trip, Jim and Jack

Wiener, Charlie Foltz, and Chuck Rak decided to replenish their now scarce food supply by doing a little night fishing. Before sliding their canoe into the water, they prepared a large bonfire in order to find their way back to camp in the pitch dark wilderness.

They were halfway across a cove when they saw a silent, large, bright sphere of colored light at treetop level about 200 yards away. When Charlie began flashing his flashlight at it, the object began moving toward them. Then, as the sphere—now only about 50 feet above the water—approached, the canoeists decided to head for solid ground and began paddling quickly toward shore. Their paddling became increasingly frantic when the object emitted a beam of light that advanced on their canoe.

The next thing Charlie Foltz and Jim Wiener remembered was standing at the campsite watching the object move away. Chuck Rak remembers staying in the canoe and watching it disappear. Jack Wiener remembers first merely trying to outrun the beam of light, then calmly getting out of the canoe.

He finds it odd that they would be in such a hurry one moment and so calm the next. After the object disappeared, the four walked up the beach to find that the huge bonfire they had left just 15 or so minutes before

was now all coals. Jim thought the large logs they had set on the fire should have burned for two to three hours.

The four men had no memory of what happened during the time it took the bonfire to burn down. And several years would pass before Jim and Jack began to experience a series of strange dreams of alien abductors that would eventually lead them to seek help from UFO investigator Raymond Fowler in May 1988. Over the next two years, Fowler hypnotized each of the four men independently and elicited a strangely congruent testimony about being plucked from the water by a beam of light, taken aboard the craft, and forced to undergo medical examinations by aliens.

Each of the four men recalled seeing the other three on board the alien craft. "They were all made to sit on a bench in the nude," says Fowler, and they watched one after the other being taken off the bench. Some of the examination was done within eyesight of the others and some of it was done after they were taken around the corner from the bench. But when you put it all together like a picture puzzle, you find that everybody is describing the same event from different standpoints."

Fowler went on to produce a 10-volume, 702-page study of this case and

subsequently published a book, *The Allagash Abductions*, as well. "All of the Allagash witnesses are of sound mind and reputation," concludes Fowler.

They not only tell essentially the same story, but under hypnosis they relive it with all the trauma and emotions that would be expected of a real physical event. I think the evidence here is undeniable and would stand up in court if we were only dealing with an automobile accident or something like that. But when you are talking about something as bizarre as UFO abductions, people find that very very hard to believe."

Even harder to believe is a case that appears to involve a mass abduction of hundreds of people in New York City late in the summer or early fall of 1992. The case is currently being investigated by Budd Hopkins, who is probably better known as a UFO researcher than as a modern artist these days.

The story first emerged during one of Hopkins' support group meetings for abductees. One person, Mary, was telling the group about a very vivid dream she had had, though she wasn't sure it was a dream. She recalled being in some sort of huge space filled with what appeared to be "people-movers" and many many humans, all completely naked. The scene somewhat resembled the



physical at a selective service exam. And there was a kind of escalator, taking people up to another floor.

At that point, two other abductees in the group, Bill and Joan, became extremely agitated and said, "Oh gee, I've had a dream just like that."

Hopkins immediately cut off the conversation so that he could explore their experiences individually. Later when Hopkins probed into Joan's dream under hypnosis, she recalled the same large space, a strange chart on the wall, and, most incredibly, seeing both Mary and Bill there as well, totally naked. Typically, both looked "out of it" to her.

"Carl Sagan always has the idea that you are going to dash around and steal an alien cocktail napkin or something for evidence as you dash out of the place," notes Hopkins, "as if abductees had all their senses intact. But in this, as in other situations, the abductees were in an altered state."

Joan remembers having a perfunctory conversation with Mary in which they expressed surprise at seeing each other there. Hopkins then asked Joan what Mary looked like naked. Joan said that Mary was very round-shouldered and that she had a big long scar at the bikini line.

Mary, as it happens, is extremely round-shouldered and always wears shoulder pads. And she does have a

big long scar: it comes from a bladder operation she had as a child. Joan did not see Bill closely, but Hopkins asked her if he had much chest hair. Joan said no, and in fact he doesn't.

Bill's description of the experience under hypnosis was much the same as Joan's. He also saw a chart on the wall, and though his recollection of it is somewhat different, Hopkins is convinced they are describing the same object. Under hypnosis, Mary was less clear about the episode than the other two, but, as Hopkins points out, she generally doesn't have the recall that other people tend to have.

Hopkins has not explored how the three were "abducted" or how they were returned, and he will not describe the strange chart seen by Bill and Joan, nor the "space" the event took place in, he prefers to keep such details to himself as a check on the authenticity of future cases.

"It's a very good case," explains Hopkins, "because there is literally no way that they knew about this stuff. None of the three is a friend of the other two in any intimate way. They only know of each other from the support group. So here we are again stuck with one of two possibilities. Either they have cooked this up as a hoax in which case you have three virtual sociopaths because there is nothing in it

for them. Or it happened.

While it's certainly difficult to believe that vast numbers of humans are being abducted in this way on a regular basis, there is surprisingly enough some data to corroborate these harrowing anecdotal reports. Several surveys conducted over the past decade indicate that millions of Americans have experienced something that UFO researchers think suggests the possibility of abduction by alien beings.

In a 1991 Roper survey, the most impressive of the polls, 119 people of the almost 6,000 questioned revealed they had experienced what UFO investigators call an alien abduction. If the numbers are extrapolated to the entire population of the United States, this translates to a staggering five million abductees.

The Roper poll, of course, is problematic. It has been severely criticized on the grounds that the five so-called key indicators of an abduction experience—reporting unusual lights in a room, missing time, flying through the air without knowing why, paralysis in the presence of strange bedroom figures, or puzzling scars on the body—may not in fact mean that an abduction has occurred. Psychologists point out that most of these experiences can also be caused by the little-known but quite common phenomenon of sleep

paralysis and the various kinds of hallucinations that accompany it.

But David Jacobs, one of the authors of the poll, begs to differ with his critics. He and Hopkins Jacobs explains, had thoroughly pre-tested nine of the eleven abduction-related questions on that poll. And those nine were questions most frequently answered positively by abductees, not nonabductees. (The other two questions tested the reliability of the poll. One of them, for instance, was a fake question which gave the pollsters an idea of how many people had the impulse to answer positively no matter what was asked. The responses from the 1 percent who responded positively to this question were not included in the final results.)

"When we first got the numbers, the raw statistics," says Jacobs, "the numbers were ridiculously high—7 percent, 8 percent. It was politically unacceptable. So we decided to look only at the answers to the last five questions—those we considered to be the highest indicators for an abduction—and didn't consider people potential abductees unless they answered four or all five of those questions positively. By doing that, we got the numbers down to a politically acceptable 2 percent. The best we can say is that about one out of every 50

Americans has had experiences consistent with what abductees have had. That indicates that an awful lot of people out there have had abduction experiences. And this of course is consistent with what the abductees themselves tell us. They come into a room and they see 50, 75 or 100 other people lying on tables and they report a constant stream of people. And we figure its twenty-four hours a day seven days a week.

But to critics, millions of abduction reports actually prove the opposite—that there are just too many of them for the phenomenon to be real. That's what Robert Durant, a commercial pilot with a long interest in UFOs, thought at first. But when he decided to put his doubts to the test by figuring out how large a work force the aliens would need to carry out the millions of abductions the Roper survey suggested were taking place, he began to think the mass abduction scenario was at least plausible.

"I began very skeptically," notes Durant. "I thought no way could these numbers be correct. But I decided to work through the math to see what I would come up with. I began by assuming that abductions are real physical events carried out systematically by a large work force. If this is the case, then the shop-floor parameters relevant to

a shoe factory or medical facility ought to apply equally well to the case of an alien abduction program carried out on a host planet."

To avoid comparisons with other fanciful exercises like counting the number of dancing angels on the head of a pin, Durant searched the literature for actual data points to plug into his equation. How often does the typical abductee claim to be abducted? Though this varies widely, he found that 10 times was not an unreasonable number. At what age do abductions begin and cease? Typically, they begin around age 5 and end by age 55, he discovered. How long do abductions take to accomplish? The periods of missing time reported by abductees range from minutes to days, but most are on the order of two hours. How many aliens does it take to perform an abduction? It's rare, he learned, for more than six aliens to be involved in any one abduction event.

Based on that data, Durant came up with some hair-raising numbers about the required alien work force. If five million abductees have experienced 10 abductions over the last 50 years, then an astonishing one million abductions take place per year, or 2,740 per day in the United States alone. If a team of six aliens is required to perform each two-hour abduction,

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tion, Durant figured that each team could then perform 12 abductions a day. So to perform 2,740 abductions a day, he calculated that the aliens would need 288 teams, or a total of 1,730 aliens.

Even if you double these figures to account for the fact that most abductions take place at night rather than 24 hours a day, the bottom line, Durant discovered, was that about 500 crews, totaling about 3,000 aliens could do the job. While these figures may appear large, if you compare them with the numbers needed to man naval vessels, says Durant—5,500 for an aircraft carrier and about 350 for a destroyer—the whole thing begins to look well plausible. The way the math worked out kind of knocked me back a bit, he admits.

This is extremely troubling to me because while I'm a total believer in UFOs, I don't buy the physical abduction scenario. And there's no way I'm saying my analysis proves abductions are real, because after all these years, we still don't have a shred of tangible proof.

But Durant's number-crunching exercise was just the beginning. Before long, Dennis Stacy, editor of a monthly UFO publication, *The MUFON Journal*, had picked up the ball. Doing some math of his own, he came to conclude the numbers didn't work.

By his reckoning, in fact, the alien work force required was way beyond the limits of possibility.

"If the phenomenon is global in nature, as it appears to be," says Stacy, then the 1 million abductions a year in the United States grows to 22 million abductions worldwide. You would then need at least 11,000 alien crews for a total of 66,000 aliens to carry out the task, and of course, 11,000 UFOs overhead at any given hour. And if you take into account the need for support crews, reasonable shifts, and such notes Stacy the numbers, like the Eveready Rabbit, keep on growing and growing."

For Stacy, the ridiculously large numbers point to an obvious conclusion:

"There must be a terrestrial that is psychological in nature, rather than extraterrestrial origin to the abduction experience," he says. The argument that some 200 million people have been abducted aboard physical flying craft in say the last decade or so, is simply unsupported in terms of common sense and logic. What imaginable need of non-terrestrial science would necessitate such a task?

The logistics such a fantastic undertaking would involve, UFOs would be stacked up over the world's major metropolitan areas,

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awaiting landing and abduction rights like so many 747s. The scale of such an invasion would be impossible for any government to plausibly ignore or cover up."

If the numbers don't make sense, then how do we explain the mass abduction memories of people like Mary, Bill, Joan, Jack, Jim, Chuck, and Charlie? William Cone, a clinical psychologist with a private practice in Newport Beach, California, has done a lot of research on abductees and thinks that while some cases of mass abduction are quite impressive, many can be explained as "contamination."

Look for instance, he says, at the Allegash case—the one involving the four men in the canoe. "It's interesting that all of these guys were heavily interested in UFOs and abductions before ever going to see Fowler. They all knew about abductions, and they walked in to Fowler, who they knew had written other books on the subject. They walked in with a preset mind of 'We saw something, we have missing time, so we must have been abducted. And this happens again and again.' I find it interesting that they didn't worry about it, until they read some UFO books."

"The other thing I find incredible," Cone contin-

ues, "is that these four guys who have been buddies for all these years go through abduction regression therapy, get all these memories, and manage not to talk about it to their buddies for a year, until they've all been hypnotized. If you were my buddy and that had happened to me, I think I'd tell you. So when they say we didn't talk to each other, I don't buy that. But I think they really did see something. They really did have an experience. But whether it's an abduction experience, I don't know."

Cone ventures a similar explanation for the mass abduction case of 1992 in New York City, which first appeared in a support group meeting of abductees at Budd Hopkins' home. "There is a great deal of contamination in this field," notes Cone, "especially in support groups. We've known since the days of the nineteenth-century French physician Jean Martin Charcot that support groups contaminate memory. It's no secret, but somehow UFO researchers, not being mental health professionals, have never bothered to look at this. They think these people are getting support, but what they're doing is reaffirming their own fantasies. I hear this all the time in hospitals. I work at. You put somebody in the support group, and



It was the notion, Sherlock Holmes who noted that "the game is afoot" (he didn't have UFOs in mind, obviously, but a more elusive quarry could hardly be imagined).

If modern-day UFO detectives are to be successful, they'll want to bring the best available hardware and software to bear on their prey. In this installment, we'll review the basic hardware you'll want to carry into the field. From flashlight and camera to the always handy compass, we'll describe the basic equipment any self-respecting UFO hunter needs. As we focus on tools in the months that follow, we'll supplement this basic tool kit with user-friendly software, a high-

tech wish list, an access guide to a plethora of research tools from maps to mailing lists and databases, and even instructions for procuring government documents and powering onto the Internet.

While some tools are absolutely required, others are optional. Some are easy to come by—the basic compass, for instance—while others can be acquired only after careful research or trips to a specialty store. In the chapter that follows, we'll make general recommendations. Remember, however, especially where electronic and optical equipment is concerned, that prices and quality can vary widely. Also, there's no requirement that you pay retail

## THE OMNI OPEN BOOK FIELD INVESTIGATOR'S GUIDE: PART THREE



ARTICLE

BY DENNIS STACY

dollar for any specific tool. Bargain around out there, from the classified section of your local newspaper to specialist mail-order catalogs, discount warehouses, and army surplus stores. The sky's the limit when it comes to UFO-detection equipment, but so is personal creativity. Some of you may even want to build or jury-rig tools of your own. In the end, your basic UFO tool kit can be as simple or sophisticated as you like, depending on your budget and your needs. But no UFO sleuth can skip the essentials, and that's where we begin.

The absolute necessities of any UFO investigator's tool kit start with what I call the three Ps—pen or





pencil and paper. A written record of your investigation, which includes personal notes and witness interviews, is absolutely essential. No matter how reliable the brand name, electronic equipment is always subject to potential disaster. Tapes break, batteries fail, cameras and recorders get dropped (especially under field conditions). And while cameras and camcorders can offer documentary exactitude, the sun sets and it can also rain—all outside your control.

The paper, of course, should be in notebook, as opposed to loose-leaf form. I prefer a little 5-by-8-inch pad, instead of letter or legal sizes, because it's easier to drop in a vest or jacket pocket when you're done with it.

And please remember when you're out in the field. Your notebook can double as a sketchpad. Alongside your own written notes, be sure to sketch the horizon of the sighting scene, noting any visible landmarks such as power lines, trees, or water towers. Then ask the witness or witnesses to draw in the shape of the object when first sighted and its trajectory, and ask them to date and sign it.

A reliable compass will come in handy at this point. Determine magnetic north and indicate some on your sketch. Directional findings are most useful for eliminating known objects and phenomena like planets,

airplane light patterns, and so on, but they can also literally point you in the direction of additional witnesses. Like pocket change, a good compass can serve two utilitarian purposes. Besides giving directions, it can also act as a crude magnetometer, a device for measuring changes in local magnetic fields, although obviously it can't determine the strength or degree of that change.

But assume that you're investigating a UFO case in which associated electromagnetic effects have been reported, such as the stalling of a car's engine or the failure of its electrical system. It's still possible to make a preliminary assessment of magnetic-field fluctuations or variations using nothing more elaborate than a good reliable compass, previously calibrated or confirmed as indicating true north. The technique is fairly simple. In fact, it was even laid out as early as 1938 in the University of Colorado Scientific Study of Unidentified Flying Objects, otherwise known as the Condon Report.

Here's how it might work. Take the car (or any other nearby piece of metal) reportedly affected, and using your compass at a distance, note its present magnetic orientation. Now take at least ten or fifteen similar readings at evenly spaced intervals, say every ten to fifteen inches, around the perimeter of the hood or trunk of the car. If you're

facing the car, for example, take your first measurement just behind the front left headlight and proceed parallel to the left side of the car until you reach the hood hinge in front of the windshield. Continue to take and record readings from the left side of the car to the drivers' side, then proceed forward until you are just behind the right headlight, having executed an upside-down U. Carefully record magnetic north or the deviation from magnetic north at each point.

Crude as they may be, these 15 or so soundings represent a sort of magnetic "signature," so to speak. To confirm that any significant magnetic field was actually encountered (or altered), a comparison test should be run on a control car of the same year and model, using the same compass and taking readings at the same evenly spaced points or intervals. Remember to orient the control car (or other metallic object) in the same direction as the originally affected car. Another word of caution: Don't place the compass directly on the car hood or other metal object being tested; instead, insert your paper notebook (or some other non-conductive material) between the two.

(Expect to pay no more than \$10 for a good-quality compass. For another \$20 or so, Forestry Suppliers (800-363-7788) an engi-

neering supply house, offers compasses calibrated to the northern hemisphere with luminous dials and built-in clinometer for measuring heights and slopes of up to 90 degrees. In addition, the company also sells a 214-page instruction manual for beginners unfamiliar with how to read maps and compasses (\$11.95).

Next month we'll cover the subject of maps in detail, but for now, sketch out your own map, indicating any prominent landmarks. If you happen to have a detailed map of the region, make notations on that as well.

The witness should also indicate the angle at which any UFO was seen. This can only be an approximation at best, obviously, but it still remains useful in post-investigative terms. For example, if Venus or the brightest star in the heavens, Sirius, can be shown to have been in the same general direction and altitude at the same time as the reported UFO, then Venus or Sirius becomes at least a possible candidate or suspect. Again, this can be determined by handing the notebook to the witness and letting him or her determine the angle as best as possible. Later, a common plastic protractor, available from graphic and art supply houses, can be used to arrive at the approximation.

For the next tool of the trade, just look in your pocket. I'll bet anything you

can stick your hand in and pull out a few coins. Take that dime and simply ask the eyewitness to hold it at arm's length and compare it to the apparent size of the object seen and reported. Was the UFO smaller or larger? (You may be surprised to find that two full moons can easily hide behind a single dime.) If distance can later be established with any degree of certainty, this could permit a reliable approximation of the object's actual size or diameter. You may substitute pennies, nickels and quarters—or even the lid of a styrofoam cup as the situation warrants.

Another basic is also readily available: a supply of plastic bags, preferably ones with a zip closure, especially if the UFO is reported to have impacted the environment, leaving behind crushed vegetation or ground indentations. Mark each sample bag with a permanent laundry marker or masking tape and pen. Be sure to collect several control samples as well, beginning nearby and moving progressively further from the reported contact or landing site, carefully labeling each one and indicating its position on a map, hand-drawn or otherwise of the immediate area. Ideally, these samples should be turned over to a laboratory for analysis as soon as possible. If you can't afford to hire a private laboratory

on your own—and most of us can't—try inquiring at the relevant department (biology, chemistry or physics) of your local college or university. You may also wish to contact one of the established UFO organizations to see if they have someone on the staff willing to assist in any material analysis. Request a copy of the final report in exchange for your samples.

I would also recommend two flashlights—one pen light and one regular-size—with back-up batteries for both (as well as for any other battery-operated equipment). In a pinch, the pen light can be clamped between your teeth for note-taking or compass-reading at night. If your compass has luminous markings, they can be charged with a brief exposure of light. The larger light can be used for everything from illuminating a distant tree line to changing a flat tire in the middle of a field.

Some hunters like to pack a powerful, hand-held searchlight as a means of "signaling" any approaching UFO. Readily available commercial models range in luminosity from 100,000 candlepower up to one million candlepower. The latter 25 times brighter than an automobile headlight on high beam, is capable of spotting objects up to ten miles away. The Forestry Suppliers catalog carries spotlights ranging in price from approximately \$30 to \$85, al-

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1,000,000  
CANDELPWER.**



though accessories like spare batteries and bulbs and a car cigarette-lighter attachment can add another \$30 to \$45 to the final cost.

The basic UFO hunter's field kit should also include an audio tape recorder and a camera of some sort. These should be regarded as necessary accessories to, not substitutes for, the already-mentioned tools. I prefer a mini-cassette recorder because, like the smaller notebook pad, it can easily be slipped into a shirt or coat pocket. Get one with the most advanced features you can afford, beginning with voice-activation and counter. The counter will prove extremely helpful when it comes to transcribing your interviews later. Observe the Boy Scout motto to always be prepared and never venture into the field with new equipment, electronic or otherwise, which you haven't previously tested and familiarized yourself with.

Like tape recorders, cameras come in a bewildering cornucopia of choice, each with its own advantages and drawbacks. Instant photographic process cameras, for example, convey immediacy at the expense of resolution and other photographic factors. They serve best as a sort of surrogate notepad. Photograph the site during daytime and have the witness draw the UFO on the actual print, then have him or her

indicate the angle above the horizon of the UFO with an outstretched arm. Take two photographs of each scene...if you don't want the original marked over. If physical side effects have been reported, by all means document them with the camera if that's all you have. A picture, worth a potential thousand words, is better than no picture at all.

Thirty-five millimeter cameras have proliferated to such a degree in recent years that it would be impossible to single out any specific model as the agreed upon "best" for this or that purpose. Some so-called "point-and-shoot" auto-focus cameras with built-in zoom lenses and pop-up flash attachments virtually rival their manufacturer's professional lines in terms of the final product. Again, assume that much or most of your investigation will be conducted under less than ideal conditions. Where photography is involved this means low light levels. Consequently your camera should have a built-in flash or a "hot shoe" for attaching a separate flash unit. Flash photography is notoriously tricky, however, and once again you should familiarize yourself with taking pictures under various lighting conditions before venturing into the field. This applies even to the newest generation of

allegedly "idiot proof" cameras. I would also recommend you keep your camera loaded with a relatively high speed color negative (as opposed to slide or transparency) film, one with an ASA rating of 1000, 1600 or higher, especially if you think you may have the opportunity to actually photograph a UFO yourself. What you lose in terms of resolution you'll more than gain back in terms of light-gathering capabilities. As with batteries, always take more film than you think you'll need.

Photography is an art that can't be taught here but you should be aware of at least two techniques. First, if at all possible, be sure to include some reference point (a house or tree) in any UFO picture. A small speck of light against a dark backdrop is almost useless for analysis; no matter how big it's blown up or enlarged. If you don't see any immediate reference point through the viewfinder, try turning the picture angle from the normal horizontal view to a vertical one. If that doesn't work, try zooming back from the UFO until a reference point does appear in the frame and snap your picture then.

The range of a typical zoom lens is from 28mm to 35mm (wide angle) to 105mm to 135mm when fully zoomed or tele-scoped. If you plan to use

a larger telescopic lens, say 200mm to 300mm, in order to achieve maximum magnification, be aware that you'll probably need a lightweight tripod for steadiness. If you're caught in the field without a tripod, steady the camera against some solid object, the roof of a car, for example, if available. In a pinch use someone's shoulder.

Videocameras have advanced by leaps and bounds in recent years as well, as far as basic features and capabilities are concerned. Most of the major electronic manufacturers—Sony, Panasonic and so on—now offer off-the-shelf CCD (charge-coupled device) camcorders with 12x zoom lenses capable of capturing reasonable images in low light conditions, usually one lux or better. Such cameras can typically be found within the \$700 to \$900 price range, depending on included features. If your budget permits, get one with "steady-cam" (to counteract vibration) and auto-focusing capabilities already on board.

Whether you're using a still camera or videocamera, I recommend that you take along a lightweight tripod. This will not only provide increased stability (and therefore sharpness) for any pictures taken, it will also free your hands and eyes for other activities. A tripod should be

considered especially if your investigation involves an alleged UFO "hot spot" that is circumstances under which a UFO is said to be roaming the immediate area and could conceivably reappear at virtually any moment.

Finally, you'll want a pair of binoculars with neck strap and a star chart. Edmund Scientific (809-673-8858) carries the latter for only \$2.75. As with cameras, binoculars come in a bewildering variety and price range. Opt for a comfortable combination of weight and optical quality and expect to pay anywhere from \$75 to \$300. Binoculars are described by both their magnification power and lens diameter, thus 7x50 binoculars give you a 50mm lens diameter with seven power magnification, adequate for UFO hunting.

Most independent investigators should be able to put together the basic kit above for about \$1,000, assuming they start completely from scratch. But for those who already have a camera, binoculars and mini-cassette recorder, start-up costs will be correspondingly lower.

Next month, look for our UFO hunters' wish list of the best high-tech goodies. But meanwhile, don't waste any time getting started. As one famous detective was fond of saying, "The game is afoot." **100**

# IN HER OWN WORDS: AN ABDUCTEE'S STORY



ARTICLE BY  
PATRICK HUYGHE

Meet one Katharina Wilson: an attractive, intelligent, apparently well-adjusted, 34-year-old woman. Born in a small college town in the Deep South, Wilson now lives in Portland, Oregon, with her second husband, Erik. She sees herself as "an average American woman," a fitting self-description marked by just one fact: She also claims to be a UFO abductee.

At first glance, Wilson's story sounds rather typical of other abduction lore. She claims to have been abducted and reproductively traumatized since the age of six by small alien creatures with large black eyes. Then, in her late twenties, she decided to come out of the UFO closet and tell all.

What's different about Wilson's abduction, however, is in the way it comes to us—straight up. She has





told her story—all of it every dirty detail—on her own. It does not come to us secondhand through a Budd Hopkins or a David Jacobs, to name just two of the most prominent UFO abduction researchers in this country. Instead, the story comes to us pure and wholly unfiltered in a book Wilson has written and published herself.

Why is this so important? Because hearing about alien abductions directly from experiencers reveals aspects of the phenomenon long ignored—or perhaps just swept under the carpet—by most researchers. And in the end these regularly hidden details may be vital in determining the cause of the UFO abduction phenomenon.

Indeed, as a journalist who's investigated more than my fair share of UFO abductions, I've learned that many aspects of the so-called abduction phenomenon just don't make it into print. Instead, most investigators inevitably process the stories, molding the accounts to fit the theories they favor or the patterns they expect to find. Things that don't fit their preconceived notion of what's really happening out there are often deliberately left out of subsequent retellings of the tale.

In the standard abduction scenario, a person may or may not have seen a UFO but is somehow whisked

away from his or her home or car by small gray creatures and forced to undergo some sort of medical examination aboard a spaceship. The incident usually turns out to be one of many in the person's past involving a variety of reproductive assaults—semen sampling, artificial insemination, and fetus removal—resulting in the production of human/alien hybrids that the ETs keep.

Generally lacking in the standard scenario, however, is the wide variety of other phenomena that the person often claims to have experienced as well—the psychic perceptions, the premonitions, the bedroom encounters with dead relatives, the ghosts, the time travel and more. Despite what is often a nearly mind-numbing display of high strangeness, you would be hard pressed to find such descriptions in the published accounts.

In the standard abduction scenario, as brought to us by the "experts," these messy details are summarily expunged. What we are left with is a cleaned-up story, a tale that stays unerringly "on mark," thus fitting the desired "alien" mold.

Of course, to some extent information selection happens often unconsciously in every field of human inquiry. But in a particularly sinister of ways, where the basic data is itself a subject of contention,

the sort of filtering is particularly damaging.

Now all this has changed, thanks to *The Alien Jigsaw*. Katharina Wilson's courageous effort to buck the wave of censorship and tell all. In this brutally honest firsthand account, Wilson describes a harrowing lifetime of encounters with what she sincerely believes are aliens. She holds nothing back and provides numerous surprises along the way. To begin with she tells us of not one, or two, or a dozen abduction episodes but an astounding 119 of them, occurring in a span of just 26 years. And her experiences involve not just your typical aliens but also encounters with the dead, time-travel episodes, psychic experiences, and even a vision of an eight-foot-tall floating penguin—everything you can imagine and a whole lot more.

In the middle of one abduction episode, for example, Wilson somehow encounters her present husband as a young man years before she met him. Later in the episode she is terrified when told by the aliens that it is 1957—three years before she was born. Wilson also credits the aliens with saving her life she twice had alien premonitions of nearly being killed by lightning, and on August 7, 1989, Wilson put on a pair of rubber-soled shoes just moments before lightning shattered the courtyard wall

and nearly killed her.

I don't think Wilson is perpetrating a hoax. If she were, she certainly would have left out the journal entry dated August 4, 1992: "I'm with Senator Gore. Wilson wrote, 'and we are in a large room with many people. He is organizing something. Governor Clinton must be here, too—now I'm looking directly at President Bush. He really looks tired—beaten.' When Wilson tells Gore that she has never voted Republican, Bush looks at her 'with a look of disgust on his face.' Later she realizes that Gore and Clinton are preparing a feast, and she watches as it grows larger and larger.

Following this journal entry Wilson writes, "Although I did not remember seeing any alien beings associated with this encounter, it felt the same way all of my other visitations felt. It was extremely weird."

I asked Wilson if she had actually seen Bush, Gore and Clinton.

I hope not, she replied with just a touch of humor.

But that's a contradiction. I pointed out. You say your alien encounters are real and that this encounter with political figures was just as real as those you have with the aliens.

"Did I say that?" she said. "Well, I don't think it was Gore because he was very alien—his whole demeanor was some form of camouflage." Wilson regards this episode

as an alien-inspired vision of the Clinton and Gore win in November 1992.

Wilson also believes one of the beings actually helped her with the book, pointing out before the book went to press that she had transcribed five journal dates incorrectly.

Though some may think Wilson's account ridiculous, it is, in fact, typical of the sort of outré material that abductees consider part and parcel of their alien experiences. It's no wonder that investigators intent on proving the alien root of UFO abductions often leave such material out of their published stories. It clearly weakens their case.

What does Wilson think about her verbiage account, so potentially damaging to the alien hypothesis and contrary to UFOlogy's unwritten code?

"Some people suggested that I cut out some of this material," she told me. "but I thought there is a lot more going on, and even though we don't understand it, it doesn't mean that it shouldn't be reported. As far as I know, this has not been done before. The book was really put out there for other experiencers, because I know they are experiencing things that they cannot account for by reading Budd Hopkins' *Intruders* and David Jacobs' *Secret Life*."

Despite her candid attitude, Wilson's ultimate conclusion echoes that of the

abduction gurus: The aliens are probably collecting data," she opines, landing strictly within the standard-issue abduction scenario and sounding a lot like Budd Hopkins, who was the first to investigate her case back in 1988.

In fact, like Hopkins, who has penned the introduction for *The Alien Jigsaw*, Wilson tends to blame aliens for just about all the weirdness. "I know that penguins aren't eight feet tall, and they don't float in midair," she explains. "That was an instance of camouflage and screen memory. And I don't really think dead people are visiting me. I think that's a form of alien manipulation. I do believe that the time travel is real, but I think there have been a few occasions where they manipulated me into thinking that happened."

If you think about it, of course, the surrealistic scenes described by Wilson have the fantastical feel of dreams. Is she, in fact, recalling nocturnal images from the land of dreamy dreams— concocted by a trick of consciousness cooked in the fires of REM, and transformed in the morning to a cocktail dish of aliens, starbabies, and UFOs? When I ask Wilson for the temporal context of her encounters, her response is typically straight forward—and telling. "I would have to say that the last thing I remember prior to most of these experi-

**IN WILSON'S OUTRÉ ACCOUNT, UFO ABDUCTION INVOLVES TIME TRAVEL, DEAD RELATIVES, PREMONITIONS, POLITICAL SUPERSTARS LIKE BILL CLINTON, AND AN EIGHT-FOOT-TALL FLOATING PENGUIN—EVERYTHING YOU CAN IMAGINE AND A WHOLE LOT MORE.**



ences," she said, "is going to bed."

Isn't that sequence—going to bed, falling asleep, getting "abducted" and waking up—suggestive of the nightly journey we all take to the imagistic outback of the dream?

"That's a fair question," she replies. "But I happen to have dreams all the time and, even if I don't leave my bed, abductions and dreams just do not feel the same."

Whether Wilson is reporting from the land of Nod, the domain of aliens or some other realm yet unknown, we may never know. But whatever the truth of the matter, it's time to applaud her tell-all book and attitude. Her story is, in fact, far more typical of abduction cases than we have been led to believe. And the only way to learn the truth behind the UFO abduction phenomenon is to let it all hang out.

Wilson's candid tale may have already opened the floodgates. Some researchers new to the field have begun to balk at the pre-packaged version of the abduction phenomenon we have been spoon-fed by the experts, and other abductees are beginning to step forward with stories of their own. A 24-year-old businessman from Harrison County, West Virginia, for example, has come forth claiming that he has been abducted by aliens at least 1,500 times. **DO**



CONTINUED FROM PAGE 24

the next day they have their neighbor's story. I think a lot of that is going on."

In fact, an examination of the literature reveals that those reporting shared abduction experiences virtually always know one another beforehand, or contact one another before giving their stories to independent investigators. Because of this, researchers can never really prove there had been no collaboration, either consciously or unconsciously between the alleged abductees. The ideal case would involve two or more people who did not know each other but who gave corroborating details of the same abduction incident to independent investigators. There is no such case. Of course, if the reports of mass abductions were literally true, there should, in fact, be dozens, hundreds, even thousands of such cases in the files of UFO investigators.

David Jacobs tries to explain why there are none. "The secret aspect of the phenomenon," he says, "is remarkably efficient and extraordinarily effective. The way in which the alien program is instituted mistakes against having a

what has happened to them. They might know that an odd thing has happened here or there, but linking it to a UFO abduction is not something most of them would probably do. So of all the abductees out there we only hear from about .001 percent of them. But every once in a while we'll have a case where somebody who is an abductee will come up to another person and say, 'I know you. I've seen you before. And they will trace it back to an abduction event they have shared.'"

Jacobs does not look to such experiences for verification of the existence of the abduction phenomenon, however, having long ago moved beyond verification in search of answers to such questions as: Who are they?, Where do they come from?, and What do they want with us? "Yes, some people still want to be persuaded," admits Jacobs. "But it's not something that I spend a lot of time on, because for me that's a little bit of wheel spinning. I realize that for others this is extremely important, but I can't be too much bothered with that because it takes a lot of time and effort and it keeps me away from re-

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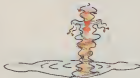
no reason for being there unless they really happened—that tells him this is real. 'Just last night,' he says, citing one example, 'I did a session with a guy who saw maybe 15 other people aboard. He was abducted with his wife and two kids. He remembers being in line with a group of people, and once they went into the waiting area they took their clothes off. He noted in front of him an older guy, heavy set, and bald with just a fringe of hair on his head. He told me in passing that there was a mole on his left shoulder.'"

A mole on his left shoulder. To Jacobs, that kind of detail just smacks of a real, rather than an imagined event. But such details will never be enough to convince the rest of the world that Catherine, Jack, Jim, Chuck, Mary, Bill, Joen, and millions of other humans have been abducted by aliens. Some thing more is needed, something more than what any abduction case, or mass abduction case, for that matter, has yet been able to provide: a shred of physical evidence. If there have been millions of abductions, it seems as if by now we'd have come up

# The Artist

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If, being as one  
with your work  
is the criterion  
of genius —



— immortality  
is within my  
grasp —





# CHROMO

Fiction By Ernie Cole and A. J. Gombie

**H**ard-sole boots pounded and echoed off the narrow street driving casual loungeurs and pedestrians into the nearest cover. Doorways, back alleys, any space away from that sound became suddenly crowded with terrified, scattering people.

The leader signaled and the pounding became a whisper of carefully placed foot in a softer, still determined pace.

The Sanitation Squad halted abruptly on the leader's hand signal. Frank Slater leaned against the black wall, his ISO suit scraping away rebel graffiti. Idiots, he thought; they know it comes off easily but they persist in painting and spraying their seditious nonsense.

He peered around the wall, cursing the ISO suit for jutting out before he could see. If the pissy little informant was right, there should be two men under that halo. On a foggy damp night like this the street light was aptly named, its cold bluish light surrounded by a misty saint's corona. And there he was, Brad Johnson's baby brother. Johnson himself would be on the scene in minutes, there having been a general police call.

There were actually four of them, but all the better. Rebels were rebels and he and his unit were empowered to eradicate where deemed necessary. Slater smiled; it usually was necessary.

Even at this distance, he could see the red eyes of the carrier. His brow furrowed. How could the scum rebels stand close to a man so clearly infected with CHROMO? No matter. It was time to get to work. The carrier must be the first target. There must be no chance of his getting away. Slater let his weapon hang from its sling and made a pattern of signals that his men, through long hours of training, understood immediately. The man in

the long gray topcoat was his. Slater's.

A petrol's hissing wail was the signal for Slater to spring into action. That vehicle could only be Brad Johnson responding. Slater jumped out, his weapon already fixed on Terry Johnson. The group of four, alerted by the siren, were crouching, ready to bolt. Two of them did and were cut down by Slater's men. One of them was the carrier. Their bodies, already lifeless when they smashed into and slid along the street, smoked with the crackling energy of the Sanitation Squad's weapons. Terry Johnson and the remaining rebel put their hands up. Slater laughed out loud, the metallic sound eerie in counterpoint to the hissing siren. He smoked the quaking rebel next to the Johnson брат. The body jumped and slid near the other two. Apart from briefly closing his eyes and compressing his lips, Terry Johnson said nothing and revealed nothing of his feelings or reaction. Slater smiled approvingly. The boy had balls no question. He was a traitor and a fool, from a family of fools, but he had balls.

Slater walked closer as the siren behind him stopped, the patrol car's wheels sliding on the wet ground. Doors were opening. Voices raised. Brad Johnson's booming above the others. "War, Slater—don't lose!" he pleaded. Now, thought Slater. Now. The boy blinked once, then attempted what Slater thought might be a sneer.

The charge blew away Terry Johnson's head, disintegrating each fragment with a lingering succession of crackling puffs of blue lights. They died away in tiny sparks bouncing along the street. Brad Johnson's mind below of fear and rage echoed once along the now quiet street. A smiling Slater turned to face him.

It was a recurring nightmare.

Brad Johnson's dream world has become

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CHROMO—something new in the world of science fiction, a bold new approach to storytelling.

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interactive CD-ROMs, motion pictures, the Internet, media not yet invented. CHROMO will spread across them all... taking you along.

For now, enjoy the preview of the world of CHROMO if you're brave enough.

Painting by Klaus Dietrick



a monochrome, monotone hell. In that inferno, a twelve-year-old boy, trapped in an ISO protective suit far too large for him, screamed soundlessly his breath misting the faceplate. As Brad clawed at the suit's controls, trying to open it to help the boy, a green mist began to rise in the suit like stagnant water, slowly gathering around the boy's chin, then lips, then

Every time he awoke from the dream, Brad's hands were still clawing hooked like talons, still trying to open the damned suit. He knew that boy. His face, so clear in the dream, blurred into something like a police mugshot sketch on waking; its features not really those of anyone, but he knew that boy.

Another drink, he was certain, would not help him at all to figure out exactly what it was he was up against. But it would ease things a bit. Make him feel he was up to it.

To what?

To going up against Dr. Maelstrom. There. That wasn't so hard, was it? No that special blended liquor didn't solve anything, but it sure made you breathe deeply. He'd eschewed the opt-cube. As it was, he'd been using it more than he thought safe. Psychoses was a real danger with the little old cube. He checked the time. A few minutes yet before he had to leave for the shareholders' meeting. Brad poured himself three more fingers in a wide glass.

After all, Richard Maelstrom had to pass like anybody else, didn't he? In fact, Brad remembered a time when he and the all-powerful head of Genex were side by side at the company dinners. The Captain of all Captains of Industry had cupped his penis so that it would be safe from Brad's possible gaze.

He took another sip of the amber bliss. Oh yes. Much better.

Brad concentrated on Raymond Masters. Dr. Maelstrom's dogbody for all his brilliance. Then, of course, there was Masters' wife, Sonia. What should he make of her?

Brad stopped over the ISO window and stared out at the city he'd once loved. He looked past his reflector, an athlete going to seed. His hair, though still full, was lank and lifeless. His slacks, not quite freshly pressed. The once trim waistline protruded above the loosened belt.

The city's pinpoint windows winked like stars on the impossibly high edifice. How he had once loved that city. He tried to remember how he'd felt, that very long time ago. It was no use. Too much had happened since. Too many killings in the name of protection. Protection from CHROMO, the disease that has inspired about: deathly fear in

all of us for how long now?

And to Brad and his men had fallen the awful task of protecting the general populace. Protecting their lives that is, by taking the lives of others. Of the afflicted.

Sonia Masters had sworn to him that she was close, very close, to finding the key. Not according to her husband, the celebrated discoverer of the lock to that key, the CHROMO molecular chain. Masters' brilliant research had culminated in the exposure of the elegant pattern now so familiar through constant wheezing bullens. Culminated.

And then stopped.

Somewhere Raymond Masters, su-perscientist, winner of every truly prestigious international prize, holder of some of the most complex and envid genetic patents, had come up against a solid wall. CHROMO yielded its outline, its mathematically elegant patterns, like a posturing feline, then halted all further advances. Stopped at the moment of intimacy, the moment of revelation. The moment of pleasure.

How then could Sonia Masters say she was fashioning the key? Was she deluded? She would not lie to Brad. Not now. But if neither he nor delusion—what? Not a real cure, surely.

Across the city he once loved, lay the Sprawl. In its labyrinthine alleys and hovels, the broken streets and bliny poverty, rebels without hope plotted. He pined them. The military man in him hated them for their inaptitude, their lack of discipline, of power.

He checked the time again. Now he was sure of what he would say at the meeting when called. It would be short and sweet and they wouldn't like it one bit. Brad Johnson rubbed at the stubble on his chin and decided that, if two drinks were this beneficial, why then two more.

Dr. Richard Maelstrom's passion was chess. Computers having long since become grandmaster players. Maelstrom and easily of crow play, however elegant the moves. Three dimensional chess was his game. He loved sucking in the computer programs, making seemingly random and illogical moves, and then listening to the low whirr as the idiot machine tried desperately to log in the strategy for future use. That machine reminded him of Masters. He chuckled as he thought of Raymond.

Masters had balked at first. Oh, he ranted a bit about his principles, his ethics, the morality of it all—God help us! In the end, it all came down to the matter. The matter. The stuff that cannot be held in the hand, or smelled, or felt. But for Richard Maelstrom it was as palpable as air and just as important. It

was power.

Project Habitat.

Maelstrom's computer reminded him of the time in soft, malleable tones. When Maelstrom grunted the machine, mistaking it for absentmindedness, said: The shareholders' meeting, sir? Maelstrom waved at it impatiently. "Yes, yes, I know. Bishop captures pawn. Queen check."

He smiled as the machine whined, trying to make sense of the move. It was simple, really. Take the pawn. The machine—for so Maelstrom thought of it, never giving it a name—would be forced to take the bishop with its king, thereby losing its casting privilege. It was a lost trade, Maelstrom felt.

He had explained the project to Masters in words of many syllables, that being Masters' mode of understanding and expression. Maelstrom could at most hear the whirring in the man's brain as he tried to log in the sense and store the strategy for future use.

Genex, the entity Maelstrom had fashioned as surely as it were clay in his hands, was embarking on the greatest, the most expansive industrial enterprise in the history of the planet. Nothing less. Its scope was no longer a measurable form. It was beyond wealth, beyond power. It was ultimate.

And Raymond Masters would be responsible.

Of course, Masters didn't know that. It was his speech at the shareholders' conference that would trigger the explosion. It would mushroom immediately and become The Project. And the Japanese, these double-dealing, genetically self-centered, would be world leaders would alone. Maelstrom liked that.

They would alone.

To have to explain it to Masters at any length was a measure of the man's essential smallness. But he was reachable. The carrot, looming impossibly large before his astonished eyes, enlivened him from the stick behind. He would, did submit. Con Amore.

He wife Sonia was another matter.

Masters' Maelstrom seemed to have to have only a tenuous control over her. Her constant probing into what she called the key to CHROMO's lock was—unsettling. She was not approachable through the same avenues of conviction as her husband. Nor was he used-up, hulk of an ex-commander, Brad Johnson. He was no longer a factor, excepting insofar as he could still be used, public hero that he still was. And Maelstrom knew just how to use him.

That was part of his genius.

"Shareholders' meeting in 22 minutes, 17 seconds." The computer reminded him. It would not do so again.

having been programmed against what his owner would consider nagging. Maelstrom called for the door and it whispered open. He turned and conceded the game.

The machine, insofar as any machine could be, was puzzled. "You concede, sir?" It whirred, then clicked then accepted. As a smiling Maelstrom left to go to the Genetex shareholders' meeting, the singular turning point of his remarkable life, he chuckled at the machine's inherent stupidity and its surprising malleability.

Spiral remembered his sixth birthday quite clearly. His father overheard him blurring out as fast as his baby syntax would allow, that square root of a seven figure number to his astonished uncle. He beat the boy until restrained by a horned family.

Father and son thereafter regarded each other only peripherally suspiciously, and as seldom as possible. After CHROMO failed most of his family, Spiral made his plans to leave. Only his mother kept him from fleeing their now uncrowded home. When the Squads killed her like an animal, her eyes blazing red with the disease, Spiral left. He felt a horrible guilt that her death was his freedom. But it was worth a lot to look over his shoulder on leaving and see his father staring after him, stunned and alone.

He made his way easily into the first ranks of the rebel cadres. They were cells, really. Five men to a cell. If captured, they could not tell what they did not know, however ingenious the persuasion. Their connections were cellular, easily and often changed, impossible to trace.

His ability to smoke his way through cyberspace was invaluable. Any degree of classified information was open to him. He checked the days' haul. A press to a conference on hole-solds and their artificial gestation—whatever that was about. Must be good for something. Some profit for him or the cause. He would bring it to Mr. Lightstone as he did with almost everything he brought back from the lipack.

Lightstone was the man. He made it all happen. Without him there was no rebel cause, he was it. A first-class VIP pass for the Genetex shareholders' meeting tonight. With it, anyone would gain instant entry. Unchallenged. That looked real good. Mr. Lightstone would know what to do with that. He was the man who was going to make things right. Though, in some vague way Spiral did not want things to be made right. He liked things the way they were, with infiltrators, spies, good guys,

bad guys. The Sprawl and the City, the black wall to be breached with combat-band guards to be bribed and above all what he alone could supply: info.

As he made his cautious way back to Lightstone—or where Lightstone might be—he glanced at a terminal way station with the usual longing. It was one of the new models, one he hadn't tried to tap into yet. No. Enough for the day. He sorted through the rest of the take and put it neatly into the little boxes. That was how he thought of the processes of his brain: little boxes, like egg crates, all stuffed with info and all instantly accessible.

Spiral knew he was important to the cause. Lightstone himself, his arm around Spiral's shoulder, would praise him to the others. Spiral regarded Mr. Lightstone with great love and something close to pity. For all his years, his courage and generosity, Mr. Lightstone was somewhat naïve. He seemed to be sure of the cause, winning, an end to the fighting. There was no end to the cause, the fight. Any more than there was an end to CHROMO. It was the disease that kept the struggle going. Spiral knew. While there was CHROMO, there would be the fight, the cause, the good guys and the bad guys.

Spiral was proud to be known by name to every Squad in and out of the Sprawl. His capture or death, he knew, would have instant recognition, promotion for every man on the team that brought him down.

He was twelve years old.

Maelstrom considered the enigmatic Lightstone, leader of the rebel resistance. His legend had grown beyond reasonable belief. His narrow escapes, retold and told again throughout the Sprawl and into the city, gave credence to the biggest part of his mythos: that Lightstone was part hole-pat machine, wholly unouchable. There would be time enough to deal with him and the rebels. They served a purpose, after all. Were it in Maelstrom's power to magically vaporize them all instantly, he would not.

Maelstrom watched the glittering lights of the city blurring past the limo window. The chauffeur occasionally glanced at the traffic-case screen as it computed the time it would take to reach the Genetex auditorium. Cruising the VIP lane made the trip easier though there was some traffic this evening.

Still, Lightstone was a bit beyond control. Too many recent casualties among the Sanitation Squads. Morale was slipping. As good as Frank Slater was, he was not the leader Brad Johnson used to be. Used to be, being the

operative term. Yet Slater had what Maelstrom most needed: an amoral ferocity that could be turned, like a white-hot torch, against whatever target it was directed. Slater seemed to hate everything outside of himself with a paranoid simplicity. The man was invaluable. A great tool. Like all tools, useful. Until the day they were no longer useful. Then.

Lightstone stared at the pass with disbelief.

The boy, Spiral, had outdone himself. Lightstone doubted the cause could contrive in its present escalation of harrying the Maelstrom structure without the gifted boy. The Genetex shareholders' meeting tonight was no more been counting profit and loss after. Though some members might have expected it to be just a self-congratulatory gathering, the atmosphere, the feel of the thing, told him otherwise. Something was up. Something big. Everyone who was anyone would be there tonight. Including Lightstone, mused some previously unwitting guests courtesy of our gifted young Spiral.

Frank Slater's dream would come true.

Brad Johnson would fall into his hands, along with the Masters bitch. There is justice after all. Slater chuckled, winking at one of his men. The man nodded uneasily. The others did their best to ignore the weird, metallic chuckles emanating from Frank Slater's ISO suit.

Brad Johnson's brother sent out to kill Lightstone—a prime assignment given to baby brother and better handled by himself—had been turned instead into a traitor by that freakish entity. What infernal incantations the evil Lightstone had breathed into that little man's ear, no one could tell, and Slater could not guess at. What a pleasure—what a delight—it had been to waste the little beastard. Then to see big brother boo-hoing over the corpse—ah, that had been even better. It had taken three men to hold the raging Brad back from Slater. Or at least thought Slater, that was how it appeared. Had their positions been reversed, Slater knew it would take more than three men to stop him from whatever damage he wished to inflict. When Johnson had calmed down sufficiently and the men had released him, staying close by at the ready, Johnson had threatened legal action. Slater almost spit into his faceplate in utter disgust.

The whole damned family was like to be self-righteous posers, ineffectual as quiches. Johnson's appointment, for example, to the theater of war where he had "distinguished" himself

THE NEW YORK TIMES  
"A Brilliant and Inspiring Book" —*THE NEW YORK TIMES*

"Behold! Human beings living in an underground den . . . Like ourselves, they see only their own shadows, or the shadows of one another, which the fire

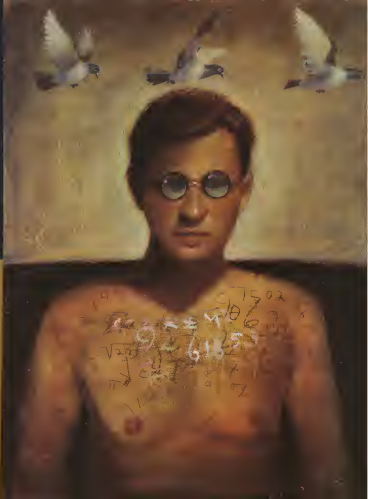
throws on the opposite wall of the cave."—Plato, *The Republic*

I rose from the bed, leaving Diane sprawled across the rumpled sheets, smiling.

# FEIGENBAUM NUMBER

Feigenbaum's  
numbers are the  
most important  
in the world. They  
are the key to  
the future of  
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In the mirror I saw her eyes narrow, her mouth tighten. The other women turned from the window laughing, one slim graceful arm pushing back a kind of chestnut hair.

Diane skinned her brown hair back from her face. "Is it too much to ask, Jack, honey, that just once after we make love you don't go rushing off like there's a three-alarm fire? Just once?"

I didn't answer.

to be treated like—"

I clutched the edge of the dresser, which was both a scratched pressed-board "reproduction" and a polished cherrywood lowboy. Two perfume bottles floated in front of me: yellow plastic spraybottle and clean-lined blown glass. I squeezed my eyes shut. The ghostly Diane disappeared in the act of sauntering, slim and assured, toward the bathroom.

asphalt parking lot, and I blended its three floors harmoniously with a low hillside whose wooded lines were repeated in horizontal stretches of brick and wood. The paper-cluttered lobby was full of humed students trying to see named advisors, and it was a marble atrium where scholars talked eagerly about the mind of man. I walked down the corridor toward my cubicle, one

This is the latest batch of phase-space diagrams. Fran said, "The computer just finished them—I haven't even printed them yet."

I crouched beside her to peer at the terminal.

"Don't look any more disorganized to me than the last bunch."

"Nor to me, either, unfortunately. Same old, same old. She laughed in chaos theory: there is no same old, same old. The phase-space diagrams were infinitely complex, never repeating, without control.

But not completely. The control was there, not readily visible, a key we just didn't recognize with the mathematics we had. Yet.

An ideal no one had seen. "I keep thinking that your young mind will pick up something I've missed." Fran said, "I'll make you a copy of these. Plus Pyotr Solerak: has published some new work in Berlin that I think you should take a look at. I downloaded it from the net and e-mailed you."

I nodded, but didn't answer. For the first time today, calm flowed through me, soothing me.

Calm.  
Rightness.  
Numbers.

Fran had done good, if undistinguished, work in pure mathematics all her life. For the last few years after—and I, as her graduate student—had worked in the precise and austere world of iterated function theory, where the result of a given equation is recycled as the starting value of the next repetition of the same equation. If you do that, the results are predictable: the sequences will converge on a given set of numbers. No matter what initial value you plug into the equation, with enough iterations you end up at the same figures called attractors. Every



Fran was the only person I'd seen who came close to matching what she should have been.

I mean, how do you think that makes me feel? Slam, bam, thank-you, ma'am. We have an actual relationship here, we've been going out for three months. It doesn't seem a lot to ask that after we make love you don't just—"

I didn't interrupt. I couldn't. The dizziness was strong this time, soon the nausea would follow. Sex did that. The intensity Diane ranted, jerking herself to a kneeling position on the bed, framed by lumpy maroon window curtains opened a crack to a neighbor's peeling frame house and weedy garden. Across the room the other Diane stood framed by crimson silk draperies opened a crack to a mellowed-wood cottage rotting with climbing roses. She blew me a slight-hearted kiss. Her eyes glowed with understanding.

The nausea came.

"—can't seem to understand how it makes me feel to, can't.

—don't even really look at me, not when we make love or—

Eyes shut, I groped for the bedroom door. "Jack!"

I slammed the doors, both of them and left the apartment before Diane could follow. With her sloppy anger, her overweight nakedness, her completely justified weeping.

Outside was better. I drove my Escort to campus. The other car, the perfectly engineered driving machine with the sleek and balanced lines, shimmered in and out around me, but the vertigo didn't return. I'd never gotten very intense about cars, and over the years I'd learned to handle the double stroke of anything that wasn't too intense. The rest I avoided. Mostly.

The Aaron Felding Faculty Office Building jutted back like three stones from the

of a row allotted to teaching assistants and post docs.

But Dr. Frances Schneider's door was open and I couldn't resist.

She sat at her terminal, working, and when I knocked on the doorjamb (scarred metal, ghostly graceful molding) she looked up and smiled. "Jack! Come look at this!"

I came in, with so much relief my eyes prickled. The material Fran's long, age-spotted fingers were held poised over her keyboard, and the ideal Fran's long, age-spotted fingers echoed them. The ideal Fran's white hair was fuller, but no whiter, and both were cut in simple short caps. The material Fran wore glasses, but both Fran's bright blue eyes, a little sunken, shone with the same alert tranquility.

She was the only person I'd ever seen who came close to matching what she should have been.

equation can generate a set of attractors which iterations converge on like homing pigeons flying back to their nests.

Until you raise the valve plugged into the equation past a point called the Feigenbaum number. Then the sequences produced lose all regularity. You can no longer find any pattern. Attractors disappear. The behavior of even fairly simple equations becomes chaotic. The pigeons fly randomly, blind and lost.

Or do they?

Fran—like dozens of other pure mathematicians around the world—looked at all that chaos and sorted through it, and thought she glimpsed an order to the pigeons' flight. A chaotic order, a controlled randomness. We'd been looking at nonlinear differential equations, and at their attractors, which cause iterated values not to converge but to diverge. States which start out only infinitesimally separated go on to diverge more and more and more—and more, moving toward some hidden values called, aptly enough, strange attractors. Pigeons from the same nest are drawn, through seeming chaos, to points we can identify but not prove the existence of.

Fran and I had a tentative set of equations for these idealized points.

Only tentative. Something wasn't right. We'd overlooked something, something neither of us could see. It was there—I knew it—but we couldn't see it. When we did, we'd have proof that any physical system showing an ultradependence on initial conditions must have a strange attractor buried somewhere in its structure. The implications would be profound—for chaos mathematics, for fluid mechanics, for weather control.

For me.

I loved looking for that equation. Sometimes I thought I could glimpse it behind the work we were doing, almost visible to me. But not often. And the truth I hadn't told Fran: couldn't tell her was that I didn't need to find it, not in the way she did. She was driven by the innermost kind of intellectual hunger, a true scientist.

I just wanted the peace and calm of looking. The same calm I'd found over the years in simple addition in algebra, in calculus, in Boolean logic. In numbers, which were not double-sided but just themselves, no other set of integers or constants or fractions lying behind these ones, better and fuller and more fulfilled. Mathematics had its own arbitrary assumptions—but no shadows on the cave wall.

So I spent as long with Fran in front

of the terminal as I could, and printed out the last batch of phase-space diagrams and spent time with those, and went over our work yet again, and read Pyotr Solov'ev's work, and then I could no longer put off returning to the material world.

As soon as I walked into Introduction to Set Theory my mouse returned.

Mid-October. Two more months of teaching this class, twice a week, 90 minutes a session, to keep my fellowship. I didn't know if I could do it. But without the fellowship, I couldn't work with Fran.

Thirty-two faces bobbed in front of me, with 32 shimmering ghosts behind them. Different. So different. Jim Mulcahy, a sullen slouching 18-year-old with a lined face and resentful eyes, frowning out—and behind him, the quiet, assured Jim, unhampered by whatever had caused that terrible resentment, whatever kept him from listening to me or studying the text. Jessica Harris, straight A's, thin face pinched by anx-

iously for students to wait for faculty or each other, or enlightenment. One chair blocked fully a third of my door way, apparently shifted there by the girl who sat head down, drawing in a notebook. My headache was the awful kind that clouds vision. I banged my knee into a corner of the chair (graffiti on varnish on cheap pine, clean hand-stained hardwood). My vision cleared but my knee throbbed painfully.

"Do you mind not blocking the doorway, Miss?"

"Sorry." She didn't look up, or stop drawing.

"Please move the damned chair."

She hitched it sideways, never raising her eyes from the paper. The chair banged along the hall floor, clanging onto my throbbing brain. Beside her, the other girl shrugged humorously in charming self-deprecation.

I forced myself. "Are you waiting for me? To see about the class?"

"No." Still she didn't look up, rude even for a student. I pushed past her, and my eyes fell on her drawing paper.

## Attractors disappear. The behavior of even fairly simple equations becomes chaotic. The pigeons fly randomly, blind and lost. Or do they?

ety, thrown into panic whenever she didn't instantly comprehend some point—and behind her, the confident Jessica who could wait a minute, study the logic, take pleasure in her eventual mastery of it. Sixty-four faces, and 64 pieces of furniture in two rooms, and sometimes when I turned away to the two blackboards (my writing firm on the pristine surface, and quavery over dust-filled scratches), even turning away wasn't enough to clear my head.

The students complain you don't look at them when you talk. "my department chair had said. "And you don't make yourself available after class to deal with their problems."

He'd shimmered behind himself, a wise leader and an overworked bureaucrat.

Nobody had any questions. Nobody stayed after class. Nobody in the first 32 students had any comments on mine sets, and the second 32 I couldn't hear, couldn't reach.

I left the classroom with a raging headache, and almost tripped over a student in the hall.

Chairs lined the corridor walls (water-stained plaster, lively-textured

It was full of numbers, a table for binomial distribution of coin-tossing probabilities, with  $x$  as the probability of throwing  $n$  heads, divided by the probability of throwing an equal number of heads and tails. The columns were neatly labeled. She was filling in the numbers as rapidly as her pen could write, to seven decimal places. From memory or mental calculator?

I blurted. Most people don't do that.

"Is that an observation, an insult, or a compliment?"

All I could see of both girls were the bent tops of their heads, lank dirty blonde, bushy golden waves.

She said. "Because if it's an observation, then consider that I said I already know that."

The vertigo started to take me. "It's an insult, then," I said. "I'm not most people."

I put out one hand to steady myself against the wall.

And if it's a compliment. I said, "Thanks, I guess."

The hallway pulsed. Students surged toward me. 64 of them, except that I was only supposed to teach 32.

and they weren't the ones who really wanted to learn, they were warped and deformed versions of what they should have been and I couldn't teach them because I hated them too much. For not being what they could have been. For throwing off my inner balance, the delicate metaphysical ear that coordinates reality with ideal with acceptance. For careening past the Fegenstein number, into versions of themselves where attraction was replaced by turbulent chaos. I fell heavily against the wall, gulping air.

"Hey!" The girl looked up. She had a scowling bony face with a too-wide mouth, and a delicate fine-boned face with rosy generous lips. But mostly I saw her eyes. They looked at me with conventional concern and then at the wall behind me, and then back at me and shook ran over me like gasoline fire. The girl reached out an arm to steady me, but her gaze had already gone again past me, as mine did everywhere but in the mirror inseparably drawn to what I had never seen: the

So what? Just don't give in to it."

I think it's a little more complicated than—

"It's not. In fact, it's real simple. Just do what you want, anyway. And don't whine."

"I'm not—"

"You are. Just don't let the double vision stop you from trying anything you want to, I don't." She glared beligerently. Behind her, the other Mia radiated determination tempered by acceptance.

"Mia, I do try to do the things I want. Math. My dissertation. Teaching." Not that I wanted to be doing that.

"Good," she snapped, and looked over my shoulder. "Double vision doesn't have to defeat us if we don't let it."

I said, "Have you ever found any others like us?" What did my ideal self look like? What strengths could she see on his face?

No, you're the only one. I thought I was alone.

"Me, too. But if there's two of us,

precious. The ideal Fran, too, looked different from the day before. Her skin glowed from within, almost too strongly as if a flashlight burned behind its pale fine-grained surface.

"That was metaphorical, Jack. I know what the system was before it diverged—the equations are there on the desk. But this one looks different! See. Here."

She pointed and explained. Nonlinear systems with points that start out very close together tend to diverge from each other, into chaos. But there was something odd about these particular diagrams: they were chaotic, as always around a strange attractor, but in nonpatterns I hadn't seen before. I couldn't quite grasp the difference. Almost, but not quite.

I said, "Where are those original equations?"

"There. On that paper—no, that one."

"You're using Amfeller's Constant? Why?"

"Look at the equations again."

I did, and this time I recognized them, even though subatomic particle physics is not my field. James Amfeller had won the Nobel two years ago for his work on the behavior of electron/positron pairs during the first 30 seconds of the universe's life. Fran was mucking around with the chaos of creation.

I looked at the phase space diagrams again.

She said, "You can almost see it, can't you? Almost. See."

"Fran!"

She had her hand to her midriff. "It's nothing, Jack. Just indigestion on top of muscle tension on top of sleeplessness. I was up all night on those equations."

"Sit down."

"No, I'm fine. Really I am." She smiled at me, and the skin around her eyes, a mass of fine wrinkles, stretched tauter. And behind her, the other Fran didn't smile at all. She looked at me, and I had the insane idea that somehow, for the first time, she saw me.

It was the first time I'd ever seen them diverge.

"Fran, I want you to see a doctor."

"You're good to be so concerned. But I'm fine. Look, Jack, here on the diagram."

Both Frans lit up with the precise pleasure of numbers. And I—out of cowardice, out of relief—let them.

"I can't understand a thing in the fucking course."

The voice was low, male, the words distinct but the speaker not identifiable.

## She sat across from me, and the other Mia sat behind her, green eyes hopeful in her lovely face. Hopeful that she was no longer alone.

other Jack shimmering behind me, the ideal self I was not.

"It affects you differently than me," Mia said over coffee in the student cafeteria. I'd agreed to go there only because it was nearly empty. I don't get nauseated or light-headed. I just get mad. It's such a fucking waste."

She sat across from me, and the other Mia sat behind her, green eyes hopeful in her lovely face. Hopeful that we could share this, that she was no longer alone, that I might be able to end her loneliness. The physical Mia didn't look hopeful. She looked just as furious as she said she was.

"Nine times out of ten, Jack, people could become their ideal selves, or at least a whole lot fucking closer, if they just tried. They're just too lazy or screwed up to put some backbone into it."

I looked away from her. "For me." I said hesitantly. I guess it's mostly the unlikelihood of it that's such a burden. Seeing the ideal has interfered with every single thing I've ever wanted to do with my life. Except mathematics.

She squinted at me. "Unlikelihood?"

there could be more. Maybe we should—"

"Damn it, Jack, at least look at me when you're talking to me!"

Slowly my gaze moved back to her face. Her physical face. Her mouth gaped in anger; her eyes had narrowed to ugly slits. My gaze moved back.

"Stop it, you asshole! Stop it!"

"Don't call me names! Mia."

"Don't tell me what to do! You have no right to tell me what to do! You're no different from—"

I said, "Why would I look at you if I could look at her?"

She stood up so abruptly that her chair fell over. Then she was gone.

I put my hands over my eyes, blotting out all sight. Of everything.

"What was this system before it started to diverge?" Fran said.

She held in her hands a phase space diagram I hadn't seen before. Her eyes sparkled. Even so, there was something heavy around her mouth, something that wasn't in the Fran behind her, and for a minute I was so startled I couldn't concentrate on the



I turned from writing equations on the board. Thirty *seventy-four* faces swam in front of me. "Did one of you say something?"

Silence. A few girls looked down at their notebooks. The rest of the students stared back at me, stony. I turned back to the board and wrote another half equation.

Fucking moron who couldn't teach a dog to pass? A different voice. My hand, holding the chalk, shook. I went on writing.

Shouldn't be allowed in front of a classroom. This time, a girl. I turned around again. My stomach churned. The students stared back at me. They were all in on this, or at least tacitly complicit.

I heard my voice shake. "If you have any complaints about how this course is being taught, you are advised to take them up with the department chair, or to express them on the course evaluation form distributed at the end of the semester. Meanwhile, we have additional work to cover." I turned back to the board.

Fucking prick who can't make anything clear.

My chalk stopped, in the middle of writing an integer. I couldn't make it move again. No matter how hard I concentrated, the chalk wouldn't complete the number.

Trying to make us flunk so he looks bigger?

Slowly I turned to face the class.

They sat in front of me, slumping or smoking or grinning inanely. Empty faces. Stupid faces. A few embarrassed faces. Fourth-rate minds, interested only in getting by, ugly gaping maws into which we were supposed to stuff the brilliance of Maxwell and Boltzmann and von Neumann and Russell and Aristotle. So they could mis-cast it and spit it on the floor.

And behind them, behind them.

Get out, I said.

One hundred twenty-eight eyes opened wide.

"You heard me? I heard myself screaming, 'Get out of my classroom! Get out of this university! You don't belong here, it's criminal that you're here, none of you are worth the time to sit you on feet! Get out!' You've deviated too far from what you... what you..."

A few boys in the front row sauntered out. A girl in the back started to cry. Then some of them were yelling at me, shaking, only the shaking wasn't in my classroom. It was in the hall, down the hall. It was doors and bells and outside the window an emergency

medical van, and they were carrying Fran out on a stretcher, her long-fingered hand dangling limply over the side, and nobody would listen to me explain that the terrible thing was not that she wasn't moving but that lying on the stretcher as quietly were not two Frans, as there should have been, but only one. Only one.

I didn't go to the funeral.

I took Fran's last set of diagrams, and copied her files off her hard drive and packed a bag. Before I checked into the Morningdale Motel on Route 66, I left messages on Dana's answering machine and the department chair's and my landlady's.

"...don't want to see you again. It's not your fault, but I mean it. I'm sorry."

"I resign my teaching fellowship and my status as a post-doc at this university."

"My rent is paid through the end of the month. I will not be returning. Please pack my things and send them to my sister CDD at this address. Thank you."

I locked the motel door, unwrapped two bottles of Jack Daniels, and raised my glass to the mirror.

But no toast came. To him? Who would not have been doing the stupid

melodramatic thing? Who would have seen Fran's death as the random event it was, and grieved it with courage and grace? Who would have figured out the best way to cope with his problems from a healthy sense of balance undisturbed by knowing exactly what he could never ever ever measure up to? I'd be damned if I'd drink to him.

To Fran? I said, and downed it straight and went on downing it straight until I couldn't see the other, better room lurking behind this one.

Even drunk, you dream.

I didn't know that I'd expected the hangovers, and the throwing up, and the terrible, blessed backlogs I'd expected the crying jag. And the emotional pain, like a dull drill. But I'd never been drunk for four days before. I'd thought that when I slept the pain would go away, into oblivion. I didn't know I'd dream.

I dreamed about numbers.

They swam in front of me, pounded the inside of my eyelids, chased me through dark and indistinct landscapes. They hunted me with knives and guns and fire. They hurt. I didn't wake screaming, or disoriented, but I did wake sweating, and in the middle of the night I hung over the toilet, puk-



ing, while numbers swam around me on the wavering, double floor. The numbers wouldn't go away. And neither would the thing I was trying to drink myself out of. No matter how drunk I got, the double vision stayed. Except for the equations, and they hurt just as much as the polished floor I couldn't touch, the cool sheets I couldn't feel, the competent Jack I couldn't be. Maybe the equations hurt more. They were Frank's.

Take Amlester's Constant. Plug it into a set of equations describing a nonlinear system.

Phase space diagrams: Diverging, diverging, gone. A small difference in initial states and you get widely differing states, you get chaos.

Take Amlester's Constant. Use it as a Let's equal!

A small difference in initial states. A Fran who diverged only a small amount, a Jack who

Take Amlester's equation.

I almost saw it. But not quite.

I wasn't good enough to see it. Only

meant, "How the fuck did you get in here?"

"Well, didn't you see how I got in here? Weren't you even conscious?" She walked closer and went on staring at me, in soiled underwear, the empty bottle on the floor. Something moved behind her eyes.

"How did you find me?" It hurt to speak.

"Hacked your Web account. You put this dump on it."

"Go away, Mia."

When I'm good and ready, Jesus, look at you."

"So don't."

I tried to roll over but couldn't, so I closed my eyes.

Mia said, "I didn't think you had it in you. No, I really didn't." Her tone was so stupid—such a mix of ignorance and some sort of stupid feminine idealization of macho asshole behavior—that I opened my eyes again. She was smiling.

"Get Out Now."

"Not till you tell me what this is all

away. Drawing every fiber of my body into it, I hauled myself off the bed and toward the bathroom. My stomach churned and the rooms wavered. It took two hands to grope along the wall to the shower.

The water hit me, hard and cold and stinging. I stood under it until I was shivering, and it took that long to realize I still had my bras on. Bending over to strip them off was torture. My toothbrush scraped raw the inside of my mouth, and the nerves in my brain I didn't even care that when I staggered naked into the bedroom, Mia was still there.

She said, "Your body is closer to his than your face."

"Get out, Mia."

"I told you when I'm ready, Jack, there aren't any more of us. At least not that I know of. Or that you do. We can't fight like this."

I groped in my overnight bag, untouched for four days for fresh underwear. Mia seemed different than she had in the cafeteria, gentler, less abrasive, although she looked the same. I didn't care which—or who—she was.

"We need each other," Mia said, and now there was a touch of desperation in her voice. I didn't turn around.

"Jack—listen to me, at least. See me!"

"I see you," I said. "And I don't want to. Not you, not anybody. Get out, Mia."

"No."

"Have it your way."

I pulled on my clothes, gritted my teeth to get on my shoes, left them untied. I braced myself to push past her.

She stood in the exact center of the room, her hands dangling helplessly at her sides. Behind her the other Mia stood gracefully, her drooping body full of sorrow. But the physical Mia, face twisted in an ugly grimace, was the only one looking at me.

I stopped dead.

They always both looked at me. At the same time. Everybody's both, Mia, Diane. From the department chair, my students. Where one looked, the other looked. Always.

Mia said, more subdued than I had ever heard her. "Please don't leave me alone with this Jack. I need you."

The other Mia looked across the room, not over my shoulder. Not at him. At... what?

From a small difference in initial states you get widely differing states with repeated iterations. Diverging, diverging, chaos... and somewhere in there, the strange attractor. The means to make sense of it.

And just like that, I saw the pattern in the phase space diagrams. I saw

## The knock on the door woke me, sounding like a battering ram. Someone was picking the lock. I lay on the bed and watched, my anger mounting.

he was

I poured another whiskey.

The knock on the door woke me. It sounded like a battering ram.

"Get out. I paid at the desk this morning. I don't want room service!"

The shouting transferred the battering ram to my head, but the knocking ceased.

Someone started picking the lock.

I lay on the bed and watched, my anger mounting. The chain was on the door. But when the lock was picked the door opened the length of the chain, and a hand inserted a pair of wirecutters. Two pairs of wirecutters, physical and ideal. Four hands. I didn't even move. If the motel owner wanted me, he could have me. Or the cops. I had reached some sort of final dismal place—I simply didn't care.

The chain, cheap lightweight links, gave way and the door opened. Mia walked in.

"Christ, Jack. Look at you."

I lay sprawled across the bed, and both Mias wrinkled their noses at the smell.

I said, even though it wasn't what I

about. Is it Dr. Schrader? They told me you two were pals."

Fran. The pain started again. And the numbers.

"That's it, isn't it, Jack? She was your friend, not just your adviser. I'm sorry."

I said, "She was the only person I ever met who was what she was supposed to be."

"Yeah? Well, then, I'm really sorry I'm not what I'm supposed to be... I know. And you sure the hell aren't. Although you know, you look closer to him this morning than you ever did on campus. More... real."

I couldn't shove her out the door, and I couldn't stop her talking, and I couldn't roll over without vomiting. So I brought my arm up and placed it across my eyes.

"Don't cry, Jack. Please don't cry."

"I'm not—"

"On second thought, do cry. Why the fuck not? Your friend is dead. Go ahead and cry if you want to!" And she knelt beside me, despite what I must smell like and look like, and put her arms around me while, hating every second of it, I cried.

When I was done, I pushed her

the equations:

"Jack? Jack?"

"Just let me write them down."

But there wasn't any chance I'd forget them. They were there, so clear and obvious and perfect, exactly what Fran and I had been searching for.

Mia cried, "You can't just leave! We're the only two people like this!"

I finished scribbling the equations and straightened. My head ached, my stomach wanted to puke, my intestines prokled and squirmed. My eyes were so puffy I could barely see out of them. But I saw her looking at me with her scared bravado, and I saw the other one not looking at me at all. Diverging. She was right—we were the only two people like this, linked in our own chaotic system. And the states I could see were diverging.

"No, I got out just before I had to go back into the bathroom. 'There aren't two. Soon, only one of you.'"

She stared at me like I was crazy at the time I was puking. And the other Jack was doing God knows what.

I didn't really care.

I haven't published the equations yet.

I will, of course. They're too important not to publish: proof that any phys-

ical system showing an ultradependence on initial conditions must have a strange attractor buried somewhere in its structure. The implications for understanding chaos are profound. But it's not easy to publish this kind of innovation when you no longer have even a post-doc position at a decent university. Even though Fran's name will go first on the article.

I may just put it out on the Internet. Without prior peer review, without copyright protection, without comment. Out onto the unstructured, shifting realities of the net. After all, I don't really need formal attention. I don't really want it.

I have what I wanted: relief. The other faces—other rooms, other buildings, other gardens—are receding from me now. I catch only glimpses of them out of the corner of my eye, diminished in size by the distance between us, and getting smaller all the time. Diverging toward their own strange attractors.

It's not the same for Mia. When she said at the Morningside Motel that I looked more like the ideal Jack than ever before, it wasn't a compliment to my unshaven howness. For her, the phase space diagrams are converging. She can barely discern the ideal separate from the physical now, the

states are that close.

She smiles at everyone. People are drawn to her as to a magnet; she treats them as if their real selves are their ideal ones.

For now.

The crucial characteristic about chaotic systems is that they change unpredictably. Not as unpredictably as before the Schroeder Equations, but still unpredictably. Once you fall into the area past the Feigenbaum number, states converge or diverge chaotically. Tomorrow Mia could see something else. Or I could.

I have no idea what this ideal Mia was looking at when she gazed across the motel room, away from both me and him. When you are not the shadow on the cave wall but the genuine ideal, what is the next state?

I don't want to know. But it doesn't matter whether or not I want it. If that state of life comes into being, then it does, and all we can do is chase it through the chaos of dens and labyrinths and underground caves, trying to pin it momentarily with numbers. All our states diverge from what we know toward something I cannot even imagine, and don't want to.

Although, of course, that too may change. **OO**

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Do you have one so simple even a parent could beat it?



# WHITFIELD DIFFIE

**A (SEMI) PRIVATE CONVERSATION WITH  
THE HEADMAN OF  
THE CYPHERPUNK REVOLUTION**

**D**epressed for weeks, worried his career was going nowhere, he mulled over a set of apparently unsolvable problems. Otherwise unemployed, Whitfield Diffie was a househusband about to cook dinner for his wife when he sat down in the living room of their borrowed quarters to ponder once more the ideas that had

plagued him for a decade. Diffie cared about hidden writing—codes, ciphers, cryptograms—because he had a passionate interest in keeping people's private lives private. A Sixties radical with blond hair flowing down his back, he saw cryptography was the only way for citizens to protect themselves from government snooping. He

PHOTOGRAPHS BY CHRISTOPHER SPRINGMANN

Bill knew even in the early Seventies that cryptography was vital to home shopping, digital money, automated offices, and other business-related activity planned for the information highway. Society could never stop doing business face to face and move into computerized negotiations without the invention of digital signatures—electronic “handwriting” as unique as that produced by pen and ink. And on that spring day in 1975, Diffie suddenly saw how to do it. The solution flitted across his mind, left momentarily, then came back in a real adrenaline rush of excitement. In a brilliant stroke he solved two of the biggest problems in modern cryptography and, as a bonus, realized for the first time they were related.

In classical cryptography, one secret key is used both to encrypt and decrypt messages. Diffie saw that this key could be split. Half would be public knowledge; half would be kept secret. This idea of separate but mathematically related keys allowed “two magical things” to happen. People

mathematics and always a poor student. Diffie graduated from MIT with a math degree in 1965. To avoid the Vietnam War, he took draft-deferred jobs as a computer programmer at MIT and then Stanford Artificial Intelligence Laboratory. Diffie's early interest in cryptography was rekindled when his boss, AI pioneer John McCarthy, was asked in 1972 to look into security on the ARPAnet, the military communications network that later grew into the Internet.

Diffie eventually quit his job to become the world's first public cryptographer. This began with bar fires back and forth across the continent, with stops to buttonhole any scientist willing to talk about cryptography. One conversation led back to Stanford and Martin Hellman, a young professor of electrical engineering. From 1975 to 1978, Diffie and Hellman co-authored a series of now-classic papers on public key cryptography. In 1992, the Swiss Federal Institute of Technology awarded Diffie an honorary doctorate in recognition of his creation: public key cryptography.

#### **JOB:**

Distinguished Engineer, Sun Microsystems

#### **AMBITION:**

To secure all the telephones in North America

#### **WHY WE NEED DIGITAL SIGNATURES:**

The most important thing security of love is to recognize people, hold private conversations, sign our signature—a transferable form of recognition. These securities go much deeper than locking one's doors at night. As we move into digital media, we have to replace face-to-face recognition or our lives will be less secure.



#### **INVENTION:**

Public Key Cryptography

#### **WHY CRYPTOGRAPHY IS A TOOL FOR DEMOCRACY:**

If you're the target of sophisticated opponents today, you must take extraordinary precautions to have a private conversation. The president tweets with a mobile secure conference room, the “security” of which depends on hundreds of people who design, build, and deploy it. Privacy is no longer a function of our individual abilities. Cryptography is a parcel return to something we used to take for granted that has since been compromised.

can send you messages encrypted with your public key that can be read only with your private key. Or conversely, you can send out cryptograms that can be read by anybody, but recognizable as only coming from you. The first realization solves the problem of making cryptography available to everyone. The second allows for digital signatures. Split-key or public key cryptography has been adopted by companies ranging from AT&T to Apple. And Diffie's cryptographic protocols underlie the security measures incorporated into all modern computer networks.

Diffie met his wife at the door that evening with a sober look on his face. “I’ve just discovered a very important idea,” he said. “I don’t think our lives will ever be the same again.”

Diffie, who describes his life as “a mosaic of how not to get things done at the night time,” was born to Campbellite Southern Baptist parents in 1944. But he grew up in a mainly Jewish section of Queens, New York, where his father taught Spanish and Latin American history at City College and his mother worked as an independent scholar on the French woman of letters Madame de Sevigne. Largely self-taught in

Secret writing dates back to Egyptian hieroglyphics. Codes and ciphers have always been jealously guarded secrets of state until Diffie and fellow cryptocommandos, who call themselves cypherpunks, began developing expertise on their own. A field traditionally reserved for spies, soldiers, and diplomats is now a hot topic on the Internet, with public access to cryptography being the latest battle cry in the information revolution. “For the past few years I’ve made my living out of politics,” says Diffie, who writes position papers and testifies before congressional committees. His latest cause is the Clipper chip, an attempt by the U.S. government to embed cryptographic hardware into the nation's telecommunications channels. These chips will contain back doors allowing the government to eavesdrop on telephone calls and computer messages. Diffie argues that Americans must oppose this effort to put the cryptographic genie back in the bottle.

Our talks began in Diffie's office at Sun Microsystems's campus in San Mateo and ended at his second office in downtown Palo Alto. At dinner Diffie's wife, Egyptologist Mary Fischer, recounted with tears in her eyes the scene of

coming home to hear of her husband's great discovery. "He was right. Our lives were not the same after that."

—Thomas Bass

**Omni:** How do you secure all the phones in North America?

**Diffe:** I'd mulled this problem over in my mind for two years, and when I got to Stanford in 1969, I began thinking about a seemingly unrelated problem. How do you conduct business using home computer terminals? I didn't see how to create a paperless office without having what we now call "digital signatures" on your electronic documents.

**Omni:** How did you solve this problem of digital signatures?

**Diffe:** I was aware of two sorts of authentication mechanisms. The first, now used to protect the password table in the UNIX time-sharing system, employs "one-way functions." These are easy to compute in one direction, but hard in the other. The second is called challenge and response. Military fire-control radars send out a randomly selected challenge and only friendly aircraft know how to encrypt the challenge correctly and return it to the radar for verification.

One of these protects you against somebody studying the lock and figuring out how to make a key; the other against eavesdroppers on the channel watching the process and knowing how to repeat it. I was trying to combine both systems in one package when I saw that it was possible to design a mechanism that could verify a response to a challenge, even though it could not have figured out the response. This is what we now call a digital signature. I wrote the idea down in my journal and forgot about it. It got added to a list called "Problems for an Ambitious Theory of Cryptography."

About two weeks later I had another breakthrough. In between cleaning and cooking, I suddenly realized the problem could be turned around to solve the question bothering me since 1965: How do you initiate secure communication with somebody you've never met? I'd already seen that by means of an asymmetric pair of transformations that are the inverses of each other, a crypto system could either sign or verify a signature. Then I realized if I did the verification (the nonsecret part) first, I could encrypt messages by means of one-way functions—in such a way that only one person could get them back.

**Omni:** Did you shout, Eureka!

**Diffe:** I walked downstairs to get a Coke, and almost forgot about the idea. I remembered I'd been thinking about something interesting, but couldn't

quite recall what it was. Then it came back, and I was acutely aware, for the first time in my work on cryptography, that I'd discovered something really valuable. After dinner I walked down to Marty Hellman's house. We'd yet to develop the term "digital signature," so we talked instead about things like "one-way authentication." It took me an hour but finally Marty understood and got interested as I was.

**Omni:** How does public key cryptography work?

**Diffe:** In classical cryptography, the cryptographic variable or key controls how plaintext is transformed into ciphertext. Every key does it differently. The critical thing in classical systems is their symmetry. Knowing how to encrypt messages tells you how to decrypt them. My big realization was understanding how to build a cryptographic system in which each communication was controlled by not one, but two keys. The two keys are related, so anything you encrypted with one can be decrypted with the other. But they

along with communications intelligence, is one of two major functions of the National Security Agency COMSEC moves tons of keys around the world every day to cryptographic devices, mostly military, using a range of systems: key tape, paper tape, cards, disks. When a ship comes into port, the cryptostations go ashore with their loaded briefcases and pick up tons of pounds of material for keying their machines. Prior to Aldrich Ames, the two most famous spy scandals in a generation involved the sale of cryptographic keys to the Russians—who read our traffic.

With conventional symmetric cryptography, you can talk securely only to people to whom keys have been distributed. This just won't do for securing a telephone system. There's no physical way to do it. Distributing cryptographic keys to the entire population would be the equivalent of sending everyone a registered letter when you retailed your phone, just in case you ever wanted to talk to them. The best

I was acutely aware, for the first time in my work on cryptography, that I'd discovered something valuable. I walked downstairs to get a Coke.

also have the property that if you're told only one key, you can't figure the other one out. We subsequently called these the public key and the private key.

**Omni:** What do you gain by splitting the two keys?

**Diffe:** Imagine you want to send me a secure message. You look up my public key in your phone book, plug it into your machine, and encrypt a message for me in such a way that it can be read only with my private key. I generate the key pair and disseminate my public key as widely as possible, but keep the private key to myself. Whenever a message encrypted with my public key comes in, I can read it. Since my private key is required to read it, nobody else can. This was the invention's first more mysterious application. It got us over the fundamental problem in all previous systems—the only way for you and me to talk cryptographically is if we first have an "out of band communication," as they say in the jargon, in which we exchange keys.

Key distribution is a major part of classical cryptography. In the U.S. government, it's handled by the COMSEC or materials control system which

you can do is have "key distribution centers" that share keys among subscribers and make introductions.

**Omni:** What's wrong with that?

**Diffe:** The key distribution center must set up every call, and worse, it can read all the traffic. But public key cryptography reduces key storage requirements to the point where there is only one secret for every person in the net work, and that secret never has to move. The key gets manufactured in your own cryptographic device, and stays there. The public key is the movable part. In practice, I got my name and public key signed by a sort of notary public, so you can recognize it as belonging to me. Then my secure phone calls yours and hands you my credentials. "Whitefield Diffie is calling and his public key is such and such." Some central authority is still involved in introducing us, but I can no longer read the traffic.

**Omni:** How did you design keys that are both public and private?

**Diffe:** It's not obvious to you because it isn't obvious. It wasn't obvious to me, and I did not discover a solution to the problem as I originally posed it. Marty

Helman and I discovered another approach—Diffie-Hellman—that solves many problems better. But three mathematicians at MIT, Ronald Rivest, Adi Shamir, and Leonard Adleman [RSA], actually solved the original problem.

**Ques:** How does this approach, the RSA system, work?

**Diffie:** Start with the notion of a one-way function. If you took algebra in high school, you probably remember how much easier it is to raise numbers to powers than it is to take roots. If I ask you for the fifth power of the number 2, it takes a few seconds of multiplying to discover that  $2^5 = 2 \times 2 \times 2 \times 2 \times 2 = 32$ . But if I ask you what's the fifth root of 32, it takes longer to figure out. If I give you a number as big as ten billion, it'd take you a very long time to calculate its fifth root. So raising numbers to powers is a one-way function with respect to the inverse operation of extracting roots.

Another example is multiplying versus factoring. If I give you two numbers—31 and 87, which are both prime—you can easily multiply them:  $3007$ . But if I give you the product,  $3007$ , then finding out that 31 and 87 are its factors is much harder. The fact that multiplying prime numbers is easier than factoring them has been a fundamental problem

in mathematics since the Greeks.

RSA, which to date is the most successful public key cryptographic system, combines these two phenomena. Raising numbers to powers is a one-way function in relation to extracting roots. Multiplying prime numbers is a one-way function relative to factoring. If the product is big enough, and you alone know its factors, this constitutes a trapdoor that lets you and only you decrypt messages.

**Ques:** How does it work?

**Diffie:** Your cryptographic equipment manufactures two large primes, each of which is 300 digits long, and multiplies them together to get a product 600 digits long. These numbers are big; they utterly dwarf any that describe phenomena in the physical world. The number of particles in the universe, for example, is estimated to be less than 100 digits long.

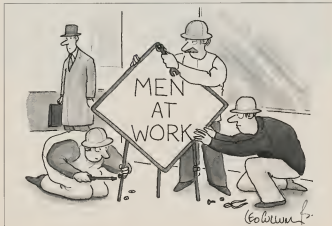
The 600-digit number, the product, is made public. It's immeasurably difficult for anybody but you to factor this number. The largest number of this type that's been factored—last year—was "RSA Challenge Number 129." A 129-digit number is a long way from a 600-digit number. First proposed in the Seventies, the Challenge was only solved by hundreds of computers

working together for years.

**Ques:** What did you do as a kid?

**Diffie:** The same thing I do as an adult. I mostly remember staring off into space. From time to time I did well in mathematics. I read [Robert] Heinlein's *The Rolling Stones* about a family who takes up an old spaceship and travels from the moon to the other planets. The family believes mathematics is the key to understanding the world. One summer I went off to Europe carrying the *Chemical Rubber Company Handbook of Mathematical Tables*. It had no text, just tables of formulas and integrals. The next summer I studied G. H. Hardy's *Course of Pure Mathematics*. This was a better choice, but probably not as good as taking Courant's calculus. Still, by the time I entered MIT, I probably knew half as much mathematics as I know now.

As a kid I was passionately interested in military things, but being an intellectual snob, I thought cryptography was vulgar. Everybody liked spying and cryptography, but few people were interested in camouflage, chemical warfare, or the influence of the Crusades on military architecture in thirteenth-century Europe. In junior high I lived the "fat period" life, going to dance parties where I acted like a cross be-



tween Elva and Archie. But I changed completely in high school and the discussion groups of the Ethics Culture Society became the social and intellectual foundation of my life. I became a peacenik, method for nuclear disarmament, sang folk songs in Washington Square Park. Wild parties became places where you sat around discussing the meaning of life. At MIT I regarded myself as a pure mathematician, particularly interested in analysis. Curiously, the things I did best are not particularly useful in cryptography. **Q**ues: Were you into sex, drugs and rock and roll?

**Offit:** I would not wish to speak ill of any of those things.

**Q**ues: I presume you partook of the Sixties revolution.

**Offit:** Oh yeah. I'm a Sixties man all the way down.

**Q**ues: What did you do after college?

**Offit:** To dodge the draft in 1965, I took a job at the Mine Corporation, which worked on command and control systems for the military. I worked as a computer programmer on Multics, an interactive tool for symbolic mathematics that eventually became the Macsyma system. *Software is the greatest development in manufacturing technology in our lifetime, maybe in the millennium.* I became seriously interested in proving software correctness.

**Q**ues: When does cryptography come back into his picture?

**Offit:** Security was a large part of the Multics time-sharing computer system going on at MIT and I began thinking more and more about personal privacy. Multics had elaborate file protection systems, but all required trusting the programmers. Whoever password I had on them, system programmers could always get at my files, and somebody could always get at the system programmers, who wouldn't be interested in going to jail to protect my files. We're verging from a free society into tyranny when the government can go behind my back and subpoena files from system programmers, which is what they do now in bank investigations. I saw that the only way to control my files would be to encrypt them.

**Q**ues: Did you go to Stanford to study cryptography?

**Offit:** No, I went to work with John McCarthy at the AI lab on the proof of correctness of programs. He was the only other person I knew at the time who understood how important the problem was. Proof of correctness appears to mathematically prove that the programs you write will always do what you want them to do. Many programs work on an effectively infinite number of

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inputs, so there are too many possibilities for fast.

But in 1972 I got interlocked when Larry Roberts, head of information processing at AFPA—the Advanced Research Projects Agency at the Pentagon—approached the NSA for help with ARPAnet's security. But as the boss of a mere \$100-million-a-year military research project, poor Larry wasn't entitled to NSA's help. They told him to go stuff it. So Roberts asked McCarthy to think about network security. McCarthy did cook up a cryptographic program. All time-sharing systems since the Sixties had commands that said "encrypt file," but nobody used them because they were so cumbersome and slow. I thought a serious cryptographic program should be able to encrypt a file as fast as you could copy it, and McCarthy's program came nowhere close to that.

**Q**ues: So really, the NSA got you working on cryptography?

**Offit:** Yes, I was officially working for AFPA, but only because they were using NSA's money and doing them a favor. Proof of correctness of programs has since grown into a big security-related industry. By spring 1973, I was working on nothing else but cryptography. This did not please McCarthy, who

wanted me back on proof of correctness. But I was old enough then not to worry about the draft, so I took an indefinite leave of absence.

On one of many cross-country trips I stopped at the IBM lab in Yorktown Heights [New York] to visit Alan Titter, one of the first generation of telephone hackers. Titter called himself "the biggest man in computer science"—he weighed 400 pounds. He introduced me to Alan Konheim, who directed IBM's cryptographic research group—probably the only significant American research group then in cryptography outside the NSA. Konheim was very secretive. He only told me one thing, and probably wishes he'd never said that. "When you get back to Stanford, look up my friend Mary Hellman," he said.

When I returned to California in 1974, I called Hellman. We immediately found each other the best informed people we'd ever encountered. Marty and I worked together for four years and became a great pair in Konheim's bush. Our first political fight started in 1975, when the government adopted as the data encryption standard [DES] a system developed by IBM. We thought it was too small. I made my living for several years on



gung against DES, and now I'm making a living arguing against a new government standard, the Encrypted Encryption Standard.

The government is trying to push on everybody a new cryptographic standard. Its secret and will be available only in tamper-resistant hardware—the Clipper chip. The government will control the products you buy. Worse yet, those products will contain a trapdoor allowing the government to read the traffic when it feels it needs to.

**Omni:** Why is the Clipper chip so devoutly to be opposed?

**Diffe:** If the only telecommunications products available allow the government to spy on your conversations, then there'll be no privacy left for anybody except fat cats who can fly around to visit one another in person. This tremendous centralization of the government's power will create a basic vulnerability in American communications. Power so centralized in an entity can be captured, whether by foreign invader or coup d'état. By creating a

pair of government agencies

**Omni:** How will the fight end?

**Diffe:** It's hard to believe the government will get what it wants, but that doesn't mean freedom won't suffer in the process. They are swimming upstream against the flow of technology. People dedicated to protecting their communications will get better systems as time goes on, but that doesn't mean honest citizens will have that freedom. The administration has insisted it will not make private use of cryptographic systems illegal, but FBI director Louis Freeh recently admitted at a meeting in Washington that if encrowded encryption got in the way of wiretaps, he'd push for a law against it. Freeh keeps telling Congress electronic surveillance is necessary for law enforcement, even though there were fewer than 1,000 court-ordered wiretaps last year out of nearly 250,000 federal cases. NSA's former chief lawyer likes to cite the case of a pedophile in Sacramento who encrypted his computer files. I think the pedophile has already been

Many of us regard that period as a golden age in American political culture.

**Omni:** How secure is the government's proposed escrow system?

**Diffe:** Building trapdoors into security equipment inherently reduces its security. For intelligence reasons, the government is demanding the system only use 80-bit keys. This tells you the upper bound on the amount of work needed to cryptanalyze messages: 2<sup>80</sup> objects. This is a million million million computations. It would have to be an incredibly interesting phone call for anybody to do 2<sup>80</sup> computations to read it. On the other hand, given the way the system is organized, it takes only a few times that much work to read all the traffic ever passed through an individual telephone. In 2005 or 2010, when things much more computing power or new cryptanalytic techniques, somebody who's been recording this traffic might read it with relative ease. And make no mistake about it, people are recording lots of traffic right now.

**Omni:** Now that I can get cryptographic programs on the Internet, hasn't the public outsmarted the spies?

**Diffe:** In no way has the battle for the availability of cryptography been won. Since the end of World War II, people have been saying the end of the spy-masters was nigh. But if you drive through Cheltenham or Fort Meade, you notice a lot of money being spent on fancy new buildings. Communications intelligence is still eating high on the hog, because the rate traffic migrates into potentially vulnerable telecommunications channels exceeds the rate traffic can be protected. The Internet itself doubles in size every 14 months.

Will more of this traffic be encrypted in the future? Undoubtedly. Will cryptosystems become and stay popular for years, even though they have flaws or trapdoors somebody knows how to exploit? Very possibly.

**Omni:** So, then, the only way to break secret codes is for a lot of people to attack them?

**Diffe:** Not necessarily a lot of people, just the right people.

**Omni:** This seems to argue for making cryptographic algorithms public.

**Diffe:** It certainly does. If you publish your algorithm you're more likely to hear if somebody breaks it. Thinking you can keep cryptographic algorithms secret from your major opponents is folly. It takes strong opponents to break a good algorithm, but the strongest—best funded—also have the capacity to acquire the algorithm against any reasonable commercial attempt to keep it

## Tremendous centralization of the government's power creates a vulnerability in communications. Power so centralized can be captured.

system that can be turned against the American people, we are making the country vulnerable in a way that could become very important in the future.

**Omni:** Why's the government pushing it?

**Diffe:** I imagine there's a hidden intelligence agenda here. The government is obviously terrified about the proliferation of products over which it has no control. Widespread deployment of cryptographic systems too difficult for NSA to routinely break might degrade their performance and result in their budget being cut.

**Omni:** Didn't Vice President Gore announce that the government was backing down on the Clipper chip? It will go into our telephones, but not into our computers.

**Diffe:** I don't think he backed down on anything. His statement was merely misleading. The Clipper chip has always been intended for telephones, and we have no idea what he's cooking up for computers. He merely reiterated the demand for a key escrow system. This is a mechanism built into cryptographic systems allowing the government to read the traffic. The keys for bypassing the encryption will be held in escrow at

convicted, but they want to get hold of his files and put him away for another ten years. The notion of pedophiles "seducing" people over the Internet hardly seems a major threat to society.

Banning cryptography is not like gun control. We don't have drive-by shootings on the Internet. This approach to crime control is a lot of nonsense. They say they want to prevent a security-minded criminal from going down to Radio Shack and buying off-the-shelf communications equipment that will defeat law enforcement. This means government-approved equipment has to be the only product available.

**Omni:** Will I be able to go to Radio Shack and buy a crypto machine nobody can crack?

**Diffe:** I'm inclined to think so. In the 1790s, when the Bill of Rights was ratified, any two people could have a private conversation—with a certainty no one in the world enjoys today—by walking a few meters down the road and joining to see no one was hiding in the bushes. There were no recording devices, parabolic microphones, or laser interferometers bouncing off their eyeballs. You will note civilization survived

secret. The reason to keep crypto systems secret is most people working in the business are spies. The NSA is the supplier of algorithms for the U.S. communications security but something between three quarters and 90% of their budget goes to spying, so they have a vested interest in keeping cryptographic equipment out of their opponents' hands.

**Omni:** Are you a spy?

**Diffe:** I don't work for anybody but Sun Microsystems, and I don't enoop for anyone but myself.

**Omni:** Do you get offers?

**Diffe:** Only from NSA, if that counts and never good enough.

**Omni:** The field of cryptography historically has lent itself to amateurs.

**Diffe:** We amateurs like to think so. Thomas Jefferson invented a cryptographic system rediscovered among his papers in 1922 and was later adopted by the Navy. If he'd used his own system when he was Secretary of State instead of one infinitely easier to solve, U.S. traffic might have been secure into the twentieth century. Instead, it was porous well into the Forties.

**Omni:** In 1960 you predicted all computers and telephones would be encrypted by now.

**Diffe:** I was vastly wrong about the degree to which people would be concerned with the problem. But the vast majority of the world's communications is still unencrypted. Interception costs are dropping, meaning the need to protect telecommunication channels is rising, and at some point the situation will spark a vast tangle of products. But so far people still don't see the damage being done to them by insecure communications, so they keep postponing the decision to do something about it.

**Omni:** How can you tell when eavesdropping is happening?

**Diffe:** It's hard for anyone other than an intelligence organization to know it's being spied on. You may see "manifestations." Five times in one year you lose contracts by narrow margins to the same competitor who seems to know in advance what your bids are going to be. But it's expensive and difficult to figure out if this is due to a communications security failure. During the Cold War, spies changed sides relatively infrequently, but in industry people change sides every day. Many people in Silicon Valley constantly move. So security problems in industry may be more difficult than in the military. The military knows people are spending lots of money attacking its communications, whereas industry is usually in the dark about it.

**Omni:** What types of problems are

you working on now?

**Diffe:** Certification of cryptographic systems is the core problem. The difficulty of finding hidden functions in computer programs is unboundedly high. How can you certify there aren't trapdoors in systems, particularly if manufacturers are working with trade-secret designs? I don't know how ordinary people can be supplied with something they trust, because the reward for undermining widely-used systems is very high.

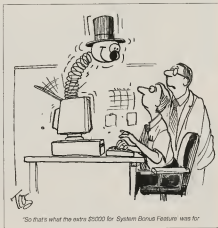
Intelligence agencies are not in business to play fair. They don't want to break traffic that they can arrange to get some easier way. So they're building visible trapdoors into things through the key escrow program. There's no reason to believe they aren't also building trapdoors into things that are hidden. For instance, I've been told the diagnostic computers in cars now record information about your driving style that potentially affects your warranty. If your mechanic can determine the highest speed you achieved in the last several thousand miles, then your car is spying on you.

**Omni:** Sun Microsystems's largest customer is the U.S. government. Has anyone in the company suggested you tone down your criticism?

**Diffe:** I see no sign the government regards my activities as objectionable or that my activities hinder it in any way. Having people testify before Congress and carry on public debate creates the illusion of democracy. Why should they object to that? I give apparent legitimacy to these behind-the-scenes processes. I don't seem to have any real effect on what happens.

**Omni:** In his story "The Gold Bug," Edgar Allan Poe says there is no such thing as a cipher that can't be broken. Do you agree?

**Diffe:** That's a tricky question. Now, coming to the problem are inclined to say it's easy to make an unbreakable system. If you start designing a secure communications product today by the time it goes into service in 2000, your system is good for 20 or 30 years. But on the last day it's in use, somebody encrypts a sensitive message so important it's still interesting to an opponent 50 years later. This means you're designing today against an opponent who sits down to attack you a century from now. He holds in his pocket calculator more computing power than we now have in the entire world, and he knows a bunch of mathematics as yet unimagined. Do you see why it's a hard problem? **DD**



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FICTION BY MICHAEL SWANWICK  
ILLUSTRATION BY ERIC DINYER

# RADIO WAVES

*I was walking the telephone wires upside-down, the sky underfoot cold and flat with a few hard bright stars sparsely scattered about it, when I thought how it would take only an instant's weakness to step off to the side and fall up forever into the night. A kind of wildness entered me then and I began to run.*



# *I made the wires sing. They leapt and bulged above me as I raced past Ricky's Luncheonette and up the hill. Past the old chocolate factory and the IDI Advertising Display plant. Past the body shops, past A. J. LaCourse*

Electric Motors-Controls-Parts. Then where the slope steepened along the curving skein of rowhouses that went the full quarter mile up to the Ridge. Twice I overlook pedestrians hunched and burdened heads doggedly down out on incomprehensible errands. They didn't notice me of course. They never do. The antenna farm was visible from here. I could see the Seven Sisters spangled with red lights, dependent on the earth like satellites. "Where are you running to, little one?" one tower whispered in a crackling, staticky voice. I think it was Hegemone.

"Fuck off," I said without slackening my pace, and they all chuckled.

Cars mumbled by. This was ravine country, however built up, and the far side of the road, too steep and rocky for development, was given over to trees and garbage. Hamburger wrappings and white plastic trash bags rustled in their wake. I was running full out now.

About a block or so from the Ridge I stumbled and almost fell. I slapped an arm against a telephone pole and just managed to catch myself in time. Aghast at my own carelessness, I hung there, dizzy and alarmed. The ground overhead was black as black, an iron roof, yet somehow was as anxious as a hound to leap upon me, crush me flat, smear me to nothingness. I stared up at it horrified. Somebody screamed my name.

I turned. A faint blue figure clung to a television antenna atop a small, stuccoed

In a panic, I scrambled up and ran toward the Ridge and safety. I had a squelch in the old Roxy and once I was through the wall, the Corpsgrinder would not follow. Why this should be so, I did not know. But you learn the rules if you want to survive.

I ran. In the back of my head I could hear the Seven Sisters clucking and gossiping to each other, radiating television and radio over a few dozen frequencies. Indifferent to my plight.

The Corpsgrinder churned up the wires on a hundred needle-sharp legs. I could feel the ion surge it kicked up pushing against me as I reached the intersection of Ridge and Levenington. Cars were pulling up to the pumps at the Atlantic station. Teenagers stood in front of the A-Plus Mini Market, licking half-smoked cigarettes into the street, stamping their feet like colts, and waiting for something to happen. I couldn't help feeling a great longing disdain for them. Every last one worried about grades and drugs and zits, and all the while snugly barricaded within hulking fortresses of flesh.

I was scant yards from home. The Roxy was a big old movie palace fallen into disrepair and semiconverted to a skateboarding rink which had gone out of business almost immediately. But it had been a wonderful place once, and the terra-cotta trim was still there, ribbons and river-gods, great puffing faces with periwigs, guitars, flowers

I grabbed at a rusty flange on the side of the Roxy.

Too late! Pain exploded within me, a sheet of white nausea. All in an instant I lost the name of my second daughter, an April morning when the world was new and I was five, a smoky string of all-nighters in Rensselaer Polytech, the jowly grin of Old Whatasface the German who lived on LaFountain Street, the fresh pain of a sprained ankle cut back at a Banana Republic warehouse fishing off a yellow rubber raft with my old man on Lake Champlain. All gone these and a thousand things more sucked away, crushed to nothing, beyond retrieval.

Eurus as any wounded animal, I fought back. Foul bits of substance splattered under my fist. The Corpsgrinder reared up to smash me down and I scrambled desperately away. Something tore and gave.

Then I was through the wall and safe and among the bats and gloom.

"Cobb!" the Corpsgrinder shouted. It lashed wildly back and forth, scouring the brick walls with limbs and teeth as restless as a March wind, as unpredictable as ball lightning.

For the moment I was safe. But it had seized a part of me, tortured it, and made it a part of itself. I could no longer delude myself into thinking it was simply going to go away. "Cahwahwahwb!" It broke my name down to a chord of overlapping tones. It had an ugly,

brick duplex, Charlie's Widow. She pointed an arm that flickered with silver fire down Ripka Street. It seemed about to see what was coming after me.

It was the Corpsgrinder.

When it saw that I'd spotted it, it put out several more legs, extended a quilled head, and raised a howl that bounced off the Heavenside layer. My nonexistent blood chilled.

98 OMN

wyverns. I crossed the Ridge on a dead telephone wire, spider-web delicate but still usable.

Almost there.

Then the creature was upon me, with a howl of electromagnetic rage that silenced even the Sisters for an instant. It slammed into my side, a storm of razors and diamond-edged fury, hooks and claws extended.

muddy voice. I felt dirtied just listening to it. "Caw— A pause —aabb!"

In a homed daze I stumbled up the Roxy's curving, patterned-in roof until I found a section free of bats. Exhausted and dispirited, I slumped down. "Caw aw aw aabbuh buh!"

How had the thing found me? I'd thought I'd left it behind in Manhattan. Had my flight across the high-tension

lines left a trail of some kind? Maybe. Then again, it might have some special connection with me. To follow me here at must have passed by easier prey. Which implied it had a grudge against me. Maybe I'd known the Corps grinder back when it was human. We could once have been important to each other. We might have been lovers. It was possible. The world is a stranger place than I used to believe.

The horror of my existence overtook me then: an acute awareness of the squalor in which I dwelt, the danger which surrounded me, and the dark mystery informing my universe. I wept for all that I had lost.

Eventually the sun rose up like God's own Peterbilt and with a triumphant blast of chromed trumpets, gently sent all of us creatures of the night to sleep.

When you die, the first thing that happens is that the world turns upside-down. You feel an overwhelming disorientation and a strange sensation that's not quite pain as the last strands connecting you to your body part, and then you slip out of physical being and fall from the planet.

As you fall, you alternate. Your substance expands and thins, glowing more and more faintly as you pick up speed. So far as can be told, it's a process that doesn't ever stop. Fainter, thinner, colder... until you've merged into the substance of everyone else who's ever died, spread perfectly uniformly through the universal vacuum forever moving toward but never arriving at absolute zero. Look hard, and the sky is full of the Dead.

Not everyone falls away. Some few are fast-thinking or lucky enough to maintain a tenuous hold on earthly existence. I was one of the lucky ones. I was working late one night on a proposal when I had my heart attack. The office was empty. The ceiling had a wee mesh within the plaster and that's what saved me.

The first response to death is denial. This can't be happening, I thought. I gaped up at the floor where my body had fallen and would be undiscovered until morning. My own corpse, pale and bloodless, wearing a corporate tie and sleeveless gray Angora sweater. Gold Rolex. Sharper image dark accessories, and of course I also thought, I died for this? By which of course I meant my entire life.

So it was in a state of personal and ontological crisis that I wandered across the ceiling to the location of an old pneumatic message tube, removed and plastered over some 50 years be-

fore. I fell from the seventeenth to the twenty-fifth floor and I learned a lot in the process. Shaken, startled and already beginning to assume the wariness that the afterlife requires, I went to a window to get a glimpse of the outer world. When I tried to touch the glass, my hand went right through. I jerked back. Cautiously I leaned forward so that my head stuck out into the night.

What a wonderful experience! Times Square is when you're dead! There is ten times the light, a living being sees. All metal things vibrate with inner life. Electric wires are then scratches in the air. Neon sings. The world is filled with strange sights and cries. Everything shifts from beauty to beauty.

Something that looked like a cross between a dragon and a wrap of smoke was leaping in the Square. But it was lost among so many wonders that I gave it no particular thought.

Night again. I awoke with Led Zeppelin playing in the back of my head. Starway to Heaven. Again. It can be a long

briefest instant then careening gleefully into oblivion. In the instant of restoration following the bolt, the walls were transparent and all the world made of glass. Its secrets available to be scooped out. But before comprehension was possible, the walls opaque again and the lightning's indecently affronted faced like a madman's smile in the night.

Through it all the Seven Sisters were laughing and singing, screaming with joy whenever a lightning bolt flashed and making up nonsense poems from howls, whistles, and static. During a momentary lull, the flat hum of a carner wave filled my head. Phenoma, by the feel of her. But instead of her voice, I heard only the sound of fearful soba.

"Whee?" I said. "Is that you?"

"She can't hear you," Phenoma purred. "You're lucky I'm here to bring you up to speed. A lightning bolt hit the transformer outside her house. It was bound to happen sooner or later. Your Nemesis—the one you call the Corpsgrinder, such a cute nickname

When it saw that I'd spotted it, it put out several more legs, extended a quilled head, and raised a howl. My nonexistent blood chilled.

wait between Dead Millionaire

"Waky-waky, little man," crooned one of the Sisters. It was funny how sometimes they took a close personal interest in our doings, and other times ignored us completely. This is Euphrosyne with the red-eye weather report. The outlook is moody with a chance of existential despair. You won't be going outside tonight if you know what's good for you. There'll be lightning within the hour."

"It's too late in the year for lightning," I said.

"Oh dear. Should I inform the weather?"

By now I was beginning to realize that what I had taken on as weakness to be the Corpsgrinder's dark aura was actually the high pressure front of an approaching storm. The first drops of rain pattered on the roof. Wind stirred and the rain grew stronger. Thunder growled in the distance. "Why don't you just go fuck your—"

A light laugh that drifted up into the supernatural, and she was gone.

I was listening to the rain underneath when a lightning bolt screamed into existence, turning me inside out for the

by the way—has her trapped."

This was making no sense at all. "Why would the Corpsgrinder be after her?"

"Why? Why? Why?" Phenoma sang a snatch of some pop belted or other.

"You didn't get answers when you were alive, what makes you think you'd get any now?" The spinning went on and on. "She can't sit it out," I said. "The Corpsgrinder can't—hey wait. Didn't they just war her house for cable? I'm trying to picture it. Phone lines on one side, electric on the other, cable. She can slip out on his blind side."

The static intensified and then rose in a most un-Widowlike wall of despair.

Typical. Phenoma said, "You haven't the slightest notion of what you're talking about. The lightning stroke has altered your little owl. Go out and see for yourself. My hackles rose. You know damned good and well that I can't—"

Phenoma's attention shifted and the carner beam died. The Seven Sisters are fickle that way. The time, though it was just as well. No way was I going out there to face that monstrosity. I couldn't. And I was grateful not to have

to admit it.

For a long while I sat thinking about the Corpsegrinder. Even here, protected by the strong walls of the Roxy, the mere thought of it was paralyzing. I tried to imagine what Charles Widow was going through: suspended from this monster by only a thin curtain of brick and stucco, feeling the hand radiation of its malice and need. It was beyond my powers of visualization. Eventually I gave up and thought instead about my first meeting with the Widow.

She was coming down the hill from Westborough with her arms out, the inverted image of a child playing a tight-rope walker. Placing one foot ahead of the other with deliberate concentration, scanning the wire before her so cautiously that she was less than a block away when she saw me.

She screamed.

Then she was running straight at me. My back was to the transformer station—there was no place to flee. I shrank away as she stumbled to a halt.

"It's you!" she cried. "Oh God, Char-

women would have been a sigh. "You'd think that I—well, never mind. She offered her hand and when I would not take it, she said, "This way."

I followed her down Main Street, through the shallow canyon of the business district to a diner at the edge of town. It was across from Hubcap Heaven and an automotive junkyard bordered it on two sides. The diner was closed. We settled down on the ceiling.

"That's where the car ended up after I died," she said, gesturing toward the junkyard. "It was right after I got the call about Charlie. I stayed up drinking and after a while it occurred to me that maybe they were wrong; they'd made some sort of horrible mistake and he wasn't really dead, you know?"

Like maybe he was in a coma or something, some horrible kind of misdiagnosis; they'd gotten him confused with somebody else, who knows? Terrible things happen in hospitals. They make mistakes.

"I decided I had to go and straighten things out. There wasn't time to make

didn't know when. The two of us sat each other off, laughing louder and louder, our merriment heterodyning until it filled every television screen for a mile around with snow.

My defenses were down. She reached out and took my hand.

Memory flooded me. It was her last date with Charlie. He was an electrician. Her next-door neighbor was having the place rehabbed. She'd been working in the back yard and he struck up a conversation. Then he asked her out. They went to a disco in the Adams Mark over on City Line Avenue.

She wasn't eager to get involved with somebody just then. She was still recovering from a hellish affair with a married man who'd thought that since he wasn't available for anything permanent, that made her his property. But when Charlie suggested they go out to the car for some coke—it was the Seventies—she'd said sure. He was going to put the moves on her sooner or later. Might as well get it settled early so they'd have more time for dancing.

But after they'd done up the lines, Charlie had shocked her by taking her hands in his and kissing them. She worked for a Bucks County pottery in those days and her hands were rough and red. She was very sensitive about them.

"Beautiful hands," he murmured. "Such beautiful, beautiful hands."

"You're making fun of me," she protested, hurt.

Not! These are hands that do things, and they've been shaped by the things they've done. The way stones in a stream are shaped by the water that passes over them. The way tools are shaped by their work. A hammer is beautiful, it is a good hammer and your hands are, too."

He could have been scamming her. But something in his voice, his manner said no. He really meant it. She squeezed his hands and saw that they were beautiful, too. Suddenly she was glad she hadn't gone off the pill when she broke up with Daniel. She started to cry. Her date looked alarmed and baffled. But she couldn't stop. All the tears she hadn't cried in the past two years came pouring out of her, unstoppable.

Charlie-boy, she thought, you just got lucky.

All this in an instant. I snatched my hands away, breaking contact. "Don't do that!" I cried. "Don't you ever touch me again?"

With that decision the Widow said, "It wasn't pleasant for me either. But I had to see how much of your life you remember."

It was mine of me, but I was shocked

## I was fresh off the high-tension lines, still vibrating with energy and fear. I could remember almost nothing of my post-death existence.

lie. I knew you'd come back for me. I waited so long but I never doubted you, never, we can—" She lunged forward as if to hug me. Our eyes met.

All the joy in her died.

"Oh," she said. "It's not you."

I was fresh off the high-tension lines, still vibrating with energy and fear. My mind was a blaze of contradictions. I could remember almost nothing of my post-death existence. Fragments, bits of advice from the old dead, a homely confrontation with something, some creature or phenomenon that had driven me to flee Manhattan. Whether it was this event or the tear-some voltage of that radiant highway that had scoured me of experience. I did not know. "It me," I protested.

"No, it's not. Her gaze was unfathomably frank. "You're not Charlie and you never were. You're—just the sad remnant of what once was a man, and not a very good one at that. She turned away. She was leaving me! In my confusion, I felt such a despair as I had never known before.

"Please," I said.

She stopped.

A long silence. Then what in a living

coffee so I went to the medicine cabinet and gulped down a bunch of pills at random, figuring something among them would keep me awake. Then I jumped into the car and started off for Colorado."

"My God."

"I have no idea how fast I was going—everything was a blur when I crashed. At least I didn't take anybody with me, thank the Lord. There was this one horrible moment of confusion and pain and rage and then I found myself lying on the floor of the car with my corpse just inches beneath me on the underside of the roof. She was silent for a moment. My first impulse was to crawl out the window. Lucky for me I didn't. Another pause. "It took me most of a night to work my way out of the yard. I had to go from wreck to wreck. There were these gaps to jump. It was a nightmare."

"I'm amazed you had the presence of mind to stay in the car."

"Dying sobers you up fast."

I laughed. I couldn't help it. And without the slightest hesitation, she joined right in with me. It was a fine warm moment, the first I'd had since I

to realize that the passage of memories had gone both ways. But before I could voice my outrage, she said: "There's not much left of you. You're only a fragment of a man: shreds and tatters, hardly anything. No wonder you're so frightened. You've got what Charlie calls a low signal-to-noise ratio. What happened in New York City almost destroyed you."

"That doesn't give you the right to—" "Oh be still. You need to know this. Living is simple. You just keep going. But death is complex. It's so hard to hang on and so easy to let go. The temptation is always there. Believe me, I know. There used to be five of us in Roxborough, and where are the others now? Two came through Mianayunk last spring and camped out under the E for a season and they're gone, too. Holding it together is hard work. One day the stars start singing to you, and the next you begin to listen to them. A week later they start to make sense. You're just reaching to events—that's not good enough. If you mean to hold on, you've got to know why you're doing it."

"So why are you?"

"I'm waiting for Charlie," she said simply.

It occurred to me to wonder exactly how many years she had been waiting. Three? Fifteen? Just how long was it possible to hold on? Even in my confused and emotional state, though, I knew better than to ask. Deep inside she must've known as well as I did that Charlie wasn't coming. "My name's Cobb," I said. "What's yours?"

She hesitated and then, with an odd sidelong look, said, "I'm Charlie's widow. That's all that matters." It was all the name she ever gave, and Charlie's Widow she was to me from then onward.

I rolled onto my back on the tin ceiling and spread out my arms and legs, a phantom starfish among the bats. A fragment she had called me: shreds and tatters. No wonder you're so frightened in all the months since I'd been washed into this backwater of the power grid: she'd never treated me with anything but a condescension bordering on contempt.

So I went out into the storm after all.

The rain was nothing. It passed right through me. But there were ion-heavy gusts of wind that threatened to knock me off the line, and the transformer outside the Widows' house was burning a fierce atomic blue. It was a gusher of energy: a flare star brought to earth, dazzling. A bolt of lightning unzipped me, turned me inside out and restored me before I had a chance to react.

The Corpsegriender was visible from the Roxy, but between the burning transformer and the creature's metamorphosis, I was within a block of the monster before I understood exactly what it was I was seeing.

It was feeding off the dying transformer, sucking in energy so greedily that it pulsed like a mosquito engorged with blood. Enormous plasma wings warped to either side, hot blue and transparent. They curved entirely around the Widows' house in an unbroken and circular wall. At the resonance points they extruded less detailed versions of the Corpsegriender itself, like sentinels, all facing the Widow.

Surrounding her with a prickly ring of electricity and malice.

I retreated a block, though the transformer fire apparently hid me from the Corpsegriender for it stayed where it was, eyeslily staring inward. Three times I circled the house from a distance, looking for a way in. An unguarded cable, a wrought-iron fence, any unbroken stretch of metal too high or too low for the Corpsegriender to reach.

Nothing.

Finally, because there was no alternative, I entered the house across the street from the Widows: the one that was best shielded from the spouting

and stuttering transformer. A power line took me into the attic crawl-space. From there I located the electrical system down through the second and first floors and so to the basement. I had a brief glimpse of a man asleep on a couch before the television. The set was off but it still held a residual charge; it sat quiescent, smug, bloated with stolen energies. If the poor bastard on the couch could have seen what I saw, he'd've never turned on the TV again. In the basement, I hand-over-handed myself from the washing machine to the main water inlet. Straddling the pipe, I summoned all my courage and plunged my head underground.

It was black as pitch. I inched forward on the pipe in a kind of panic. I could see nothing, hear nothing, smell nothing, taste nothing. All I could feel was the iron pipe beneath my hands. Just beyond the wall the pipe ended in a T-joint where it hooked into a branch line under the drive. I followed it to the street.

It was awful like suffocation infinitely prolonged. Like being wrapped in black cloth. Like being drowned in ink. Like strangling noselessly in the void between the stars. To distract myself, I thought about my old man.

When my father was young, he navigated between cities by radio. Driving



clerk and usually empty highways: he'd beat the dial back and forth, back and forth, until he'd hit a station. Then he'd withdraw his hand and wait for the station ID. That would give him his rough location—that he was somewhere outside of Albany, say. A sudden signal coming in strong and then abruptly dissolving in groans and eerie whistles was a fluke of the ionosphere, impossibly distant and easily disregarded. One that faded in and immediately cut meant he had grazed the edge of a station's range. But then a signal would grow and strengthen as he penetrated its field, crepusculo fade, and collapse into static and silence. That left him north of Troy, let's say, and making good time. He would begin the search for the next station.

You could drive across the continent in this way, passed from hand to hand by local radio, and tuned in to the geography of the night.

I went over that memory these times, polishing and refining it, before the branch line abruptly ended. One hand

puffy man stood with his sleeves rolled up, elbow deep in the sink, angrily washing dishes by candlelight. A woman who was surely his wife expressly smoked a cigarette at his staff back, drawing in the smoke with bitter intensity and exhaling it in puffs of hatred. On the second floor a preadolescent girl clutched a tortoise-shell cat so tightly it struggled to escape, and cried into its fur. In the next room a younger boy sat on his bed in earphones, Walkman on his lap, staring sightlessly out the window at the burning transformer. No Widow on either floor.

How I wondered, could she have endured this entropic oven of a blue collar farmhouse, forever the voyeur at the banquet, watching the living squander what she had already spent? Her traces were everywhere: her presence elusive. I was beginning to think she'd disappeared and given herself up to the sky when I found her in the attic, clutching the wire that led to the antenna. She looked up, amazed by my unexpected appearance.

## It was feeding off the dying transformer, sucking in energy so greedily that it pulsed like an enormous mosquito engorged with blood.

groped forward and closed upon nothing.

I had reached the main conduit. For a panicked moment I had feared that it would be concrete or brick or even one of the older pipes the city laid down in the nineteenth century, remnants of which still linger here and there beneath the pavement. But by sheer blind luck, the system had been installed during that narrow window of time when the pipes were cast iron. I crawled along its underside first one way and then the other, searching for the branch line for the Widows. There was a lot of crap under the street. Several times I was blocked by gas lines or by the high-pressure pipes for the fire hydrants and had to awkwardly clamber around them. At last, I found the line and began the painful journey out from the street again.

When I emerged in the Widow's basement, I was a nervous wreck. It came to me then that I could no longer remember my father's name. A thing of rage and shade indeed! I worked my way up the electrical system, searching every room and unintentionally spying on the family who had bought the house after her death. In the kitchen a

"Come on," I said. "I know a way out."

Returning, however, I couldn't retrace the route I'd taken in. It wasn't so much the difficulty of navigating the twisting maze of pipes under the street, though that was bad enough, as the fact that the Widow wouldn't hazard the passage unless I led her by the hand.

You don't know how difficult this is for me," I said.

It's the only way I'd dare. A nervous, humorless laugh. "I have such a lousy sense of direction."

So, steeling myself, I seized her hand and plunged through the wall.

It took all my concentration to keep from sliding off the water pipes. I was so distracted by the violence of her thoughts. We crawled through a hundred memories, all of her married lives all alike. Her's one.

Daniel snapped on the car radio. Sad music—something classical—flooded the car. "That's bullshit, babe. You know how much I have invested in you?" He jabbed a blunt finger at her dress. "I could buy two good whores for what that thing cost."

Then why don't you, she thought.

Get back on your Metroliner and go home to New York City and your wife and your money and your two good whores. About reasonably she said, "It's over, Danny, can't you see that?"

"Look, babe. Let's not argue here, okay? Not in the parking lot, with people walking by and everybody listening. Drive us to your place. We can sit down and talk it over like civilized human beings." She clutched the wheel, staring straight ahead. "No. We're going to settle this here and now."

"Christ." One-handed, Daniel wrangled a pack of Kents from a jacket pocket and knocked out a cigarette. Took the end and in his lips and drew it out. Funched the lighter. So talk.

A wash of hopelessness swept over her. Married men were supposed to be easy to get rid of. That was the whole point. "Let me go, Danny," she pleaded. Then, lying, "We can still be friends."

He made a disgusted noise.

"I've tried, Danny. I really have. You don't know how hard I've tried. But it's just not working."

"All right. I've listened. Now let's go." Reaching over her, Daniel threw the gearshift into reverse. He stopped on her foot, mashing it into the accelerator.

The car leaped backward. She shrieked and in a fury of panic swung the wheel about and slammed on the brakes with her two feet.

With a jolt and a crunch, the car stopped. There was the tink of broken plastic. They'd hit a lime-green Hyundai.

"Oh, that's just perfect!" Daniel said. The lighter popped out. He lit his cigarette and then swung open the door. "I'll check the damage." Over her shoulder, she saw Daniel hug at his trousers' knees as he crouched to examine the Hyundai. She had a sudden impulse to slow the car around and escape. Step on the gas and never look back. Watch his face, dismayed and dreading, in the rear-view mirror. Eyes flooded with tears, she began quietly to laugh.

Then Daniel was back. "It's all right, left's good."

"I heard something break."

"It was just a tail-light, okay?" He gave her a funny look. "What the hell are you laughing about?"

She shook her head helplessly unable to sort out the tears from the laughter. Then somehow they were on the Expressway, the car humming down the indistinct and warping road. She was driving but Daniel was still in control.

We were completely lost now and had been for some time. I had taken what I was certain had to be a branch line and it had led nowhere. We'd been



tracing its twisty passage for blocks. I stopped and pulled my hand away. I couldn't concentrate. Not with the claudes and persons of the Widow's past churning through me. "Listen," I said. "We've got to get something straight between us."

Her voice came out of nowhere, small and wary. "What?"

How to say it? The honor of those memories lay not in their brutality but in their particularity. They nestled into empty spaces where memories of my own should have been. They were as familiar as old shoes. They fit.

"If I could remember any of this crap," I said. "I'd apologize. Hell, I can't blame you for how you feel. Of course you're angry. But it's gone, can't you see that, it's over. You've got to let go. You can't hold me accountable for things I can't even remember, okay? All that shit happened decades ago. I was young. I've changed. The absurdity of the thing swept over me. I'd have laughed if I'd been able. I'm dead, for pity's sake."

A long silence. Then "So you've figured it out."

"You've known all along," I said bitterly. "Ever since I came off the high-tension lines in Manayunk."

She didn't deny it. "I suppose I should be flattered that when you were in trouble you came to me," she said in a way that indicated she was not.

"Why didn't you tell me then? Why drag it out?"

Danny—

"Don't call me that!"

"By your name. Daniel. Daniel Cobb."

All the emotions I'd been holding back by sheer force of denial closed about me. I lunged myself down and clutched the pipe tight, crushing myself against its unforgiving surface. Trapped in the friendless wastes of night, I weighed my fear of letting go against my fear of holding on.

"Cobb?"

I said nothing. The Widow's voice took on an edgy quality. "Cobb, we can't stay here. You've got to lead me out. I don't have the slightest idea which way to go. I'm lost without your help."

I still could not speak.

"Cobb! She was close to panic. 'I put my own feelings aside. Back in Manayunk, you needed help and I did what I could. Now it's your turn.'"

Slightly inebriated, I shook my head. "God damn you, Danny," she said loudly. "I won't let you do this to me again! So you're unhappy with what a jerk you were—that's not my problem. You can't redeem your malice on me any more. I am not your fucking salvation. I am not some kind of cosmic

last chance and it's not my job to talk you down from the ledge."

That stung. "I wasn't asking you to," I mumbled.

"So you're still there! Take my hand and lead us out."

I pulled myself together. "You'll have to follow my voice, babe. Your memories are too intense for me."

We resumed our slow progress. I was sick of crawling, sick of the dark, sick of this lightless, formid existence, disgusted to the pit of my soul with who and what I was. Was there no end to this labyrinth of pipes?

"Wait," I'd brushed by something. Something metal buried in the earth.

"What is it?"

"I think it's—" I groped about, trying to get a sense of the thing's shape. "I think it's a cast-iron gatepost. Here. Wait. Let me climb up and take a look."

Relinquishing my grip on the pipe, I seized hold of the object and stuck my head out of the ground. I emerged at the gate of an iron fence framing the minuscule front yard of a house on Ripka Street. I could see again! It felt so good to feel the clear breath of the world once more that I closed my eyes briefly to savor the sensation.

"How ironic," Euphrosyne said.

"After being so heroic," Thalia said.

"Overcoming his fears," Agias said.

Rescuing the fat man from hunger and disease like—"I said said."

"Realizing at last who he is, Prometheus."

"Beginning that long and difficult road to recovery by finally getting in touch with his innermost feelings," Aulo said. Hegemone giggled.

"What?" I opened my eyes.

That was when the Corpsesgrinder struck. It leaped upon me with stunning force, driving spear-long talons through my head and body. The talons were barbed so that they couldn't be pulled free and they burned like molten metal. "Ahhhh, Cobb," the Corpsesgrinder crooned. "Now this is sweet."

I screamed and if I drank in those screams so that only silence escaped into the outside world, I struggled and it made those struggles its own, leaving me to kick myself deeper and deeper into the drowning pools of its identity. With all my will I resisted. It was not enough. I experienced the languorous pleasure of surrender as that very will and resistance were sucked down into my attacker's substance. The distinction between me and it weakened, stunted, dissolved. I was transformed.

I was the Corpsesgrinder now. Manhattan is a virtual school for the dead. Enough people die there every

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day to keep any number of monsters fed. From the store of memories the Corpsegriinder had stolen from me, I recalled a quiet moment sitting cross-legged on the tin ceiling of a sleaze joint while table dancers entertained Japanese tourists on the floor above and a kobold instructed me on the finer points of survival. The worst thing you can be turned by," he said, "is yourself."

"Very aphoristic."  
"Fuck you. I used to be human too."  
"Sorry."

"Apology accepted. Look, I told you about Salamanders. That's a shitty way to go, but at least it's final. When they're done with you, nothing remains. But a Corpsegriinder is a parasite. It has no true identity of its own, so it constructs one from bits and pieces of everything that's unpleasant within you. Your basic greeds and lusts. It gives you a particularly nasty sort of immortality. Remember that old cartoon? That hellacious toad saying, 'Kiss me and live forever—you'll be a load, but you'll live forever!'—he grinned. 'If you get the choice, go

Festa outside of 30th Street Station. The engine was going and the heater and the windshield wiper, too, so I snapped on the radio to mask their noise. Beethoven filled the car, the Moonlight Sonata.

"That's bullshit, babe." I said. "You know how much I have invested in you? I could buy two good whores for what that dress cost." She refused to meet my eyes. In a while that set my teeth on edge, she said, "Damn, can't you see that it's over between us?"

"Look, babe, let's not argue in the parking lot, okay?" I was trying hard to be reasonable. "Not with people walking by and listening. We'll go some place private where we can talk this over calmly like two civilized human beings." She shifted slightly in the seat and adjusted her alert with a little tug. Drawing attention to her long legs and fine ass. Making it hard for me to think straight. The bitch really knew how to twist the knife. Even now, crying and begging, she was aware of how it turned me on. And even though I hated

wanted the Widow, wanted her so bad there were no words for it, I wanted to clutch her to me so tightly her ribs would splinter and for just this once shed know it was real. I wanted to own her. To possess her. To put an end to all her little games. To know her every thought and secret, down to the very bottom of her being.

No more lies, babe. I thought; no more evasions. You're mine now.

So perfectly in syno was I with the Corpsegriinder, that she shifted its primary consciousness back into the liquid sphere of memory where it hung smug and lazy, watching a voyeur with a willing agent. I was in control of the autonomous functions now. I reshaped the tentacles, merging and discombining them into two strong arms. The claws and talons that clutched the fence I made legs again. The exterior of the Corpsegriinder I morphed into human semblance, save for that great mass of memories sprouting from her back like a bloated spider-sack. Last of all I made the head.

I gave it my own face.  
"Surprised to see me again, babe?" I leered. Her expression was not so much fearful as disappointed. "No," she said wearily. "Deep down, I guess I always knew you'd be back."

As I drew the Widow closer, I distantly knew that all that held me to the Corpsegriinder in that instant was our common store of memories and my determination not to lose them again. That was enough, though. I pushed my face into hers, forcing open her mouth. Energies flowed between us like a feast of tongues.

I prepared to drink her in.  
There were no barriers between us. The was an experience as intense as when making love, you lose all track of which body is your own and thought dissolves into the animal moment. For a giddy instant I was no less her than I was myself. I was the Widow staring fascinated into the filthy depths of my psyche. She was myself witnessing her astonishment as she realized exactly how little I had ever known her. We both saw her freeze still to the core with horror. Horror not of what I was doing.

But of what I was.  
I can't take any credit for what happened then. It was only an impulse, a spasm of the emotions, a sudden and unexpected clarity of vision. Can a single flash of decency redeem a life like mine? I don't believe it. I refuse to believe it. Had there been time for second thoughts, things might well have gone differently. But there was no time to think. There was only time enough to feel an upsetting of revulsion, a visceral desire to be anybody or anything

## The horror of my existence overtook me then, an acute awareness of the squalor in which I dwelt, the dark mystery informing my universe.

with the Salamander."

"So what's this business about hunting my life?"

"Sometimes a Corpsegriinder will rip you in two and let half escape. For a while."

"Why?"

"I dunno. Maybe it likes to play with its food. Ever watch a cat torture a mouse? Maybe it thinks it's fun."

From a million miles away, I thought. So now I know what's happened to me. I'd made quite a run of it, but now it was over. It didn't matter. All that mattered was the hoard of memories, glorious memories into which I'd been dumped. I wallowed in them, picking out here a winter sunset and there the pain of a jellyfish sting when I was nine. So what if I was already beginning to dissolve? I was intoxicated, drunk stoned with the raw stuff of experience. I was high on life.

Then the Widow climbed up the gatepost looking for me. "Cub?"

The Corpsegriinder had moved up the fence to a more comfortable spot in which to digest me. When it saw the Widow, it reflexively parked me in a memory of a gray drizzly day in a Ford

being aroused by her little act. I was. The sex was always best after an argument. It made her slush.

I clenched my anger in one hand and fisted my pocket with it. Thinking how much I'd like to up and give her a shot. She was begging for it. Secretly, maybe, it was what she wanted. I'd often suspected she'd enjoy being hit. It was too late to act on the impulse, though. The memory was playing out like a tape, immutable, unstoppable.

All the while, like a hallucination or the screen of a television set receiving conflicting signals, I could see the Widow frozen with fear half in and half out of the ground. She quivered like an acetylene flame. In the memory she was saying something, but with the shift in my emotions came a corresponding warping-away of perception. The train station car, the windshield wipers and music all faded to a murmur in my consciousness.

Tentacles whipped around the Widow. She was caught. She struggled helplessly, deliciously. The Corpsegriinder's emotions pulsed through me and to my remote horror I found that they were identical with my own. I

but my own bathhouse self, a profound and total yearning to be out of the burden of such memories as were mine. An aching need to just once do the moral thing.

I let go.

Bobbing gently, the swollen corpus of my past floated up and away, carrying with it the pathetic Conspirender. Everything I had spent all my life accumulating fell from me. It went up like a balloon, spinning, dwindling, gone. Leaving me only what few last memories I have narrated here.

I screamed.

And then I cried.

I don't know how long I clung to the fence, mourning my loss. But when I gathered myself together, the Widow was still there.

"Denny," the Widow said. She didn't touch me. "Denny, I'm sorry."

I'd almost rather that she had abandoned me. How do you apologize for one you can no longer remember? For having been someone who, however abhorrent, is gone forever? How can you expect forgiveness from somebody you have forgotten so completely you don't even know her name? I felt twisted with shame and misery. "Look," I said. "I know I've behaved badly. More than badly. But there ought to be some way to make it up to you. For, you know, everything. Somehow. I mean—"

"What do you say to somebody who's seen to the bottom of your watched and inadequate soul?"

"I want to apologize," I said.

With something very close to compassion the Widow said, "It's too late for that. Denny. It's over. Everything's over. You and I only ever had the one trait in common. We neither of us could ever let go of anything. Small wonder we're back together again. But don't you see, it doesn't matter what you want or don't want—you're not going to get it. Not now. You had your chance. It's too late to make things right." Then she stopped, agitated at what she had just said. But we both knew she had spoken the truth.

"Widow," I said as gently as I could, "I'm sure Charlie—"

"Shut up."

I shut up.

The Widow closed her eyes and swayed, as if in a wind. A ripple ran through her and when it was gone her features were simpler, more schematic, less recognizably human. She was already beginning to surrender to the anthropomorphic.

I hid again. "Widow—" Reaching out my guilty hand to her.

She stiffened but did not draw away. Our fingers touched, tensed, melted.

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"Elizabeth," she said. "My name is Elizabeth Connelly."

We huddled together on the ceiling of the Roxy through the dawn and the bleak horror that is day. When sunset brought us conscious again, we talked through half the night before making the one decision we knew all along that we'd have to make.

It took us almost an hour to reach the Seven Sisters and climb down to the highest point of Thela.

We stood holding hands at the top of the mist. Radio waves were pushing out from under us like a great wind. It was all we could do to keep from being blown away.

Underfoot, Thela was happily chatting with her sisters. Typically, at that moment of greatest resolve, they gave not the slightest indication of interest. But they were all listening to us. Don't ask me how I knew.

"Cobby?" Elizabeth said. "I'm afraid."

"Yeah, me too." A long silence. Then she said, "Let me go first. If you go first, I won't have the nerve."

"Okay."

She took a deep breath—funny, it you think about it—and then she let go, and fell into the sky.

First she was like a kite, and then a

strip of paper, and at the very last she was a rapidly tumbling speck. I stood for a long time watching her falling, dwindling, until she was lost in the background flicker of the universe. Just one more spark instantly.

She was gone and I couldn't help wondering if she had ever really been there at all. Had the Widow truly been Elizabeth Connelly? Or was she just another fragment of my shattered self, a bundle of related memories that I had to come to terms with before I could bring myself to let go? A vast emptiness seemed to spread itself through all of existence. I clutched the mist spasmodically, then, and thought, *Jesus!*

But the moment passed. I've got a lot of questions, and there aren't any answers here. In just another instant, I'll let go and follow Elizabeth (if Elizabeth she was) into the night. I will fall forever and I will be converted to background radiation, smeared over thinner and cooler across the universe, a smooth uniform, and universal message that has only one decode. Let Thela carry my story to whoever dares to listen. I won't be here for it.

It's time to go now. Time and then some to leave. I'm frightened, and I'm going.

Now GG

## INTERVIEW



**P**erides, a Dark Piece by James Turrell, appears to be a pitch-black theater without a movie. Gropedown a light-trapping corridor in the Mattress Factory, a Pittsburgh museum, and wait. Forlorn staring conjures a milky galaxy, which might not be there, but is the bright image generated by the viewer's neural networks. When the eyelids close, the galaxy flickers on,

PHOTOGRAPH BY WILLIAM COUPON

**A light-and-space artist  
serves a celestial observatory from a  
voiceless's cove. Inside,  
starlight older than the Milky Way will  
be "present to touch."**

# JAMES TURRELL

like lights in a dream. Twenty minutes later, the galaxy may glow blue, a peripheral glance turns its edges red. Under the balcony are two low-wattage red lights that impatient viewers may fail to witness. "Although the light hardly exists," comments Turrell, "it possesses great intensity. We see light as light."

This movie minus frames is by no means the limit of the Turrell light-and-space

an experience found in museums around the United States and Europe. Ghost Wedge slices the dark with an oblique wall of cream-on-tomato-soup colored light in Trace Elements tungsten and fluorescent lamps transform a depthless aperture swirling with foggy, ambient light into a flat glowing rectangle. Heavy Water, in Poitiers, France, invited swimmers to dive into pools of liquefied light. In Halls, England, white-coated attendants pushed willing victims into the Gasworks, a metal sphere where strobes accelerated sublime color fields into what one freaked reviewer described as a kaleidoscope of Islamic tile designs injected straight into the eyeball.

The apotheosis of Turrell's art, however, is Rodin Crater, located in the Painted Desert, 45 miles from Flagstaff, Arizona. Turrell's monumental earthwork includes carving a celestial observatory out of an extinct volcanic cinder cone. As tall as the Chrysler Building, the 600,000-year-old formation will utilize "geologic knowledge" to delineate events in the sky, including rare planetary alignments. Bunkhouse chambers, oriented toward the four cardinal directions, will frame light-fields empowered by celestial bodies by occluding all but their light. One sky space, a light-filled bathing pool, will function as a radio telescope, transmitting sounds of distant galaxies to visitors. In the reshaped crater bowl, visitors will encounter the phenomenon of "celestial vaulting," the ballooning of the sky into a vast dome.

Rodin Crater is the logical culmination of the career of an artist who, from the



start, refused to traffic in traditional materials.

After studying mathematics and perceptual psychology at Pomona College, Turrell knew he wanted to sculpt with light. But how would he form it? His early works employed flames, but their heat and gases inspired him to seek a less noxious version of his medium. For his first exhibition at the Pasadena Art Museum in 1967, he projected veiled light cubes at corners, they not only altered the spatial dynamics of the room, but appeared from a distance to be solid, hovering objects.

In 1968 he joined Robert Rauschenberg, an artist who dematerialized paintings, and Edward Worth, a physiological psychologist investigating perceptual problems likely to trouble Apollo astronauts. The three experimented with states of consciousness derived by sensory deprivation, investigated Ganzfelds, or homogeneous fields of shadowless light, and light- and soundless, anechoic chambers. A year later, the California-born artist retreated to his Ocean Park studio. Knocking down walls in the old Mendota Hotel, erecting partitions, and controlling the amount of light entering windows, he experimented with the aesthetic power of ambient and atmospheric light.

The son of an aeronautical engineer, Turrell initially supported his work by restoring vintage aircraft and flying supplies to remote mines and highway projects. His inspirations, he's said, often come from airborne perceptions of light and weather fronts. As he

**"This art is about your seeing, not mine." Spec: works from the Turrell exhibitlines: A Frestal Passage (fluorescent light), above; Amba (fluorescent and ultraviolet light), below; Kana (argon and helium light), top right; Blue Walk, right; aerial view of the Rodin Crater, bottom right.**

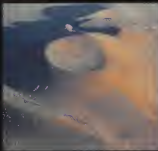


considered liberating his work from indoor spaces, the *Mendota* was sold and he was kicked out. A lively Guggenheim grant enabled him to fly an old Hello-Courier plane from Canada to Mexico, in search of the appropriate land formation for his largest work. The *Rodas*, the ideally shaped crater, was not for sale at first. But by 1977, with the help of the Dia Foundation involved in large environ-



mental art projects, he purchased the 1,100-acre site for about \$6 an acre.

While he has reshaped the crater rim, enhanced his plane, and raised \$6.6 million for the earthwork, his art has spawned more than 100 solo exhibitions, and in 1984 he was awarded a MacArthur Foundation fellowship. Critics praise his work as otherworldly superlatives: "Visions of the Absolute . . . rigged to a dimmer switch." But the average museum-goer needs no art history to revel in it. Curators report enthusiastic visitors leap into the piece,



presumably to join their terrestrial bodies to the sublime luminance within. In Germany, one spaced couple was found procreating in a glowing Turrell. For some, light-and-space art proved disorienting; both the museum and artist were sued by visitors who leaned on light walls and fell in the Whitney's 1981 retrospective.

Interviewer Vicki Lindner met Turrell at his hangar studio at the Flagstaff airport as he returned from designing a stage set for a Gertrude Stein opera in Europe. Lindner and Turrell, whose hobbies include gliding and freetdaling, chased fleet pronghorns up gulled two-tracks in her rented Bronco that was not insured for off-road travel. The 52-year-old artist seemed more interested in discussing the black grama grass he'd planted to restore pastures on his Turkey Tanks ranch than the nuances of light-and-space art. But when the huge red and black crater pulsed out of a storm front's screen of wind-whipped pink dust, before a streaming cloud formation called Jacob's Ladder, he exclaimed, "If this were a painting would you believe it? Now you see where the work comes from!"

**Ques:** What's the difference between a Turrell and a traditional work of art?

**Turrell:** This art is about your seeing, not mine. Light is my material, but I use it to reflect the medium of direct perception. In Monet's *Haystack*—really a record of someone else's seeing—the haystack is not as important as the light on it. Rather than stand you in front of a painting of a haystack, I'd just stand you

in front of the haystack so that you wouldn't miss what there was to see then I'd remove the object of perception, the haystack. There'd be no confusions about what you'd be looking at. You'd be looking at your seeing. This is direct experience, as opposed to interpreted experience.

**Omer:** So light as perceived as a thing in your art discovered by the viewer?

**Turrell:** We generally see light as the bearer of the revelation, something we use to illuminate spaces and surfaces, as opposed to according it any thingness itself. Think about the lenticular cloud, a smooth, saucer-shaped cloud formed downstream from an obstruction like a mountain range and standing still in a high wind. Here comes the moisture particle, pushed up just enough that the rise precipitates the water out of the solution and it becomes visible. What we see, however, is light passing through it at 195,000 miles per second. You're seeing something that's not there, but we call it a "cloud." We've given cloud thingness

**Turrell:** A sensing space catches, or senses, light—just like the eye or camera, which we made to approximate our vision. In these spaces the light differs from ordinary light. In dreams we've seen light like this. We dream in color. In a lucid dream the colors are as rich as, if not richer than, when your eyes are open, and the resolution of clarity as good as a beautiful, high-altitude, sunlit morning. People may be surprised to see this kind of light in a conscious awake state.

**Omer:** How do you create this color?

**Turrell:** Normally we make a space and turn on the light above. This light empties the space of any atmosphere and makes it quite blank—the light doesn't pervade it like something physical. We light architectural spaces with daylight. In daylight the iris is completely closed. A rich darkness in color only happens at a low-level light when the iris is open. So you can take your nice little color wheel and sail it like a Frisbee, because it's meaningless in additive light.

I take seeing down to the light level

**Turrell:** He did? He shouldn't have done that! How do I know he got it set back exactly right?

**Omer:** It seems, then, that you use ordinary lighting in sophisticated ways.

**Turrell:** We don't have the instruments of light I'd like. I have in my collection an Edison light bulb over 100 years old; you can put electricity to it and it will light. The light bulbs of today won't last 100 years, and they're still a filament in an evacuated glass envelope. We've had great progress in changing the architecture of fixtures and design aspects of what holds the light, but I can't get a light I can dial from infrared up through ultraviolet. My work is going to be seen as primitive art not too long from now. But I create the instrument of seeing out of what's available.

**Omer:** Gearing into the aperture in *Trace Elements*, I felt as if I were in a blizzard white-out and could hear the wind.

**Turrell:** In sensory synesthesia, one sense influences sensing in another. Sensing is really discontinuous. In a *Divided Space* piece you feel the air in the aperture is thickened, and you're almost breathing this colored fog that occupies and inflects space. Color occupies space in a similar way to sound. Singing in the shower, you can find one or two notes that make your voice resonate in that cavity and sound incredible. Light will do the same thing.

In the kind of space I'm making, I use a combination of complex frequencies, a bit like a painter does. Only one color will occupy that volume appropriately so you search until you find that color. When you do, it literally fogs up—it looks like light hangs in space. If you try to see the wall you have to look through this thing, light. It occupies the space; it is not an illusion.

**Omer:** You don't like the word "illusion"?

**Turrell:** I strenuously object to the idea that this work is an illusion. The phrase *percept* (or *feel*) is used for an image you believe to be there that is really not there. I'm conjuring up a situation to make you understand what really is. These works allude to what they really are—a space occupied by a different kind of light.

**Omer:** Viewers have sometimes become disoriented in your pieces. In *City of Anshin*, a work in Amsterdam and New York, people fell and had to crawl out on their hands and knees.

**Turrell:** There were four rooms in a row. As you left the first, pale green room you retained a pink afterimage. The next room was red, and you came to it with this pink. People felt someone was turning the lights up and down. You walked through the rooms to a door. The door had no color and looked flat.

## I have pieces you enter only with vision, others that are all around you, and some works that you pull over your head like a T-shirt.

Much of my work investigates this idea of thingness. I've removed a lot of the thingness of objects, but substituted the thing of perception and light. I've given it materiality, whereas we don't normally accord materiality to light.

**Omer:** Isn't light a powerful physiological substance?

**Turrell:** Absolutely. We drink light as vitamin D. They've put it in milk for children. Of course, they've forgotten to put it in whiskey to help adults stay away from depression. Light strongly affects the endocrine system, and now it's used to treat certain forms of cancer.

**Omer:** Ultraviolet light causes cancer, too.

**Turrell:** Light is radiation. I've had melanoma, so I know. And psychologically staring into the campane, we have the same relationship to light as a deer hesitating in the headlights of a car. This glazed-eye vision is a kind of abstract thinking without the symbolism of words, a theta state. That power of light is what I seek to use. I don't use light as a camera of content, as a movie does.

**Omer:** You call the aperture filled with foggy light in your *Divided Space* pieces a "sensing space." What do you mean by that?

where the iris opens. The eyes feel, like touch, like when you look into the eyes of a lover and experience that intensity of touch with the eyes. The intimacy of being invaded with that kind of look can be frightening.

**Omer:** How do you construct this sensuous atmosphere?

**Turrell:** I use regular light bulbs, but I need to work with them—tape them sometimes they get wrapped. I need little light out of them, so I use shutters—like strips of black tape on a plastic tube that you dial to determine how much light you let out. I control the amount of light that way or with dimmers or a combination of both. The big thing is to reduce the light to where the eyes open and the feeling is there. In the Denver Art Museum piece (*Trace Elements*), the wattage is less than one candlepower. If you strike a match the piece is gone. But it seems light-filled.

**Omer:** Michael Olenyok, curator of the Mattress Factory, turned up the fluorescent tubes on the aperture in *Classics* and instantly the piece, which from a distance seemed a flat glowing leveler plane, turned into a hole in the wall with lights recessed around it.

So people felt the doors were closed, they looked solid, but we know they're not. And then to try to lean against one of them? I was startled that people would actually believe it so much they couldn't see if any other way.

**Q**mm: You sound a bit leasy.  
**Turrell:** Well, in 1982 and 1983 I was sued for \$1.5 million by a person whose husband was a Supreme Court justice in Oregon. They had big law stuff lined up against me, and it cost me a lot of money to get out of it. Three people fell at the Whitney Museum in New York. They all sued. I wasn't acquitted until the case went to federal court. The justices who broke her went. He sued me for lack of conjugal privileges. I said "Hey, she just broke her wrist. It must have been a hell of a hard job." I got \$500 in contempt of court for that comment.

Because photos could make the work look transparent or so you couldn't see through it, they wanted me to build the piece again. I said "Give me the face, and I'll be happy to do it anywhere you want." This is benign work. Sculpture like Mark Di Suvero's—swinging steel, big pieces of wood, a great deal of mass—you can get hit by that thing, hit your head, or get squeezed underneath it. One guy lost a leg and another was killed. In my art someone looks at this and there's nothing there—so it's the effect of the art. Yes, I was a little leasy.

**Q**mm: Yesterday when we saw Roden Crater surrounded by a haze of dust-infused pink light, you said that vision could offer an idea for a piece. What thinking processes occur between the vision and the completed work?

**Turrell:** Looking at the Jacobs Ladder the veil it formed, the Veil, or rain that evaporates before it hits the ground, I'd ask myself: How where, do you see this? Is it something you see way out there, or in here? Something you can go through, or enter? Can it be worked in the near space, or between you and me, so that I can't see it even though we're in the same physical space? I play with the idea of the picture plane. I have pieces you enter only with vision: others you enter that are all around you, and some you pull over your head like a T-shirt so the inside seeing behind the eyes is affected.

**Q**mm: Is it true you became interested in light as a primary material when you discovered you preferred projected slides of paintings in art history classes to the paintings themselves?

**Turrell:** I wanted to work with light before that, but it's true. A painting like the Mona Lisa is photographed to fill the frame—and so is a Barnett Newman,

whose works are 20 to 30 feet long. When projected, they're both the same size, although different in actual scale. More important, the slide is projected with light so the luminous quality comes off the screen. So seeing the original works was a disappointment. Once you've been a pilot for 30 years—over sea light you couldn't explain?

**Turrell:** Many pilots have had interesting experiences, but they know better than to talk about them too much. People in airline transport have to be "stable." Remember the Japan Airlines pilot who had a sighting while flying a cargo plane out of Anchorage? Somehow it was made public and now he's a taxi driver in Tokyo. I don't disbelieve in UFOs. When I see a light I don't question whether it's of this world or otherworldly. My first thought at looking at any light is, Okay, how do I work with that? I'm also interested in the styles of observed UFO craft; they've changed to follow our own design sensibility. I used to collect UFO models. There's the Adamsky disc with the

That was true, yeah. I even have a hard time rationalizing it today. I was trying to be reasonable, but it wasn't a reasonable thing to do. At the time I was having difficulty wanting what I did to be recognized as art as much as painting or sculpture. I don't want to be limited to something you can put into an elevator. I've been able to fly planes because I realize them and sell them, so they pass through me, just as the art does. As long as it keeps passing through, when you start to need to hold onto it, it becomes troublesome. Whose art is this? Who owns it?

**Q**mm: Who owns Roden Crater?  
**Turrell:** The Baystone Foundation. And it, in fact, owns me. Owning a piece of the surface of the earth is an interesting delusion we've created in a capitalist society. We all think this piece is mine. Isn't it ludicrous? Basically objects are imbued with power of consciousness continually being injected into them. When consciousness leaves, these things begin their journey to dust. That's what happens with the house, the

I'm interested in the styles of observed  
UFOs. In the 1920s, they had  
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cupole on top and the Buck Rogers style in the Twenties. UFO craft were often described as having rivets, with the idea of modernism, they became sleek, like Ferraris.

**Q**mm: What did the Apollo moon missions mean to you?

**Turrell:** They expanded the sense of territory we inhabit with consciousness. To see that blue planet rising over the surface of the moon was pivotal. Martha Graham or Merce Cunningham should have choreographed the landings. Instead, we sent up astronauts to drive a golf ball and put a flag up, which was all stiff, like a ponie implant. We rationalize we went to the moon for the technological spin-offs—we got Teflon and Teflon. Sorry, we didn't. We took this amazing journey. It should have been celebrated by humans, not just a nation.

**Q**mm: Early in your career you rejected the notion art could be bought and sold. Didn't you once take back a piece you'd sold to a collector and, in its place, leave the collector a restored vintage Cadillac?

**Turrell:** These are interesting stories—they could be true as well

relationship when thought leaves it.

**Q**mm: Well, recently you've done collectible prints and drawings that raise money for building the crater.

**Turrell:** Now I make aquatints, wax emulsion drawings, and double-image photographs you view through stereoscopic glasses. I made a hologram of the crater from the air. Bruce Nauman works with holograms, too, but they're of his face or termites, and lack the impression of science.

**Q**mm: What led you to create Roden Crater as art?

**Turrell:** I always wanted to do a monumental earthwork. It's about taking the cultural artifact we call "art" into the natural surrounding. We have a tradition of bringing painting and photography of nature involved with light into the museum—like the Hudson River School and Ansel Adams. If you take art into nature it can easily be overpowered. For me to take art into natural surroundings was not so much to take nature on. Instead of competing with the sunset, I wanted to use it, as light, and create a situation where perceptions were heightened more than they would be without art there.



**Omni:** Why this particular volcanic crater?

**Turrell:** Roden's a beautiful cinder cone, and had the shaping on top I needed. Flying for seven months, back and forth, just looking at landscape and thinking "was one of the most special times of my life. I considered a volcano at the bottom of Craters of the Moon [National Monument] in Idaho, and one in a pretty little volcanic field near Baker, California. Roden was my favorite."

**Omni:** How did you reshape the crater?

**Turrell:** I moved 400,000 cubic yards of cinder from high to low spots on the rim to give it a uniform height. It's not all done, but the crater now actually shapes the sky. It's such a relief. We were about 200,000 yards into it and celestial vaulting hadn't happened. Now, you'll come to the top of the crater wall through a tunnel into an oval, rootless chamber, and the sky that seemed so flat, even opaque, suddenly will become dome-like. At night, the stars will seem to form the huge vault of space. You'll get this sense of closure although nothing physical is there.

## I got caught up in, dazzled, or fascinated by light. It was like Andy Warhol stepping into a supermarket and being astounded by it.

**Omni:** How will the chamber work?

**Turrell:** Take a small amount of light into an underground chamber that occludes light you don't want, and light you do want will be very strong. Take a sunset, in a landscape it can be strong, but if you take the light from it into a place that's occluding all other ambient light, you make it even more intense.

I'll make precise bunklike slots so that light from the horizon up streams into them. This gives ambient light from an area a spatial quality; it will have one aspect of night and another at day. It will change with the season. The ambient light creates a background "noise," or setting. When there's an event in light, it will come through and destroy this sense of atmosphere with its magic. These events last sometimes less than 14 minutes.

**Omni:** What celestial events will the chamber intensify?

**Turrell:** The spaces look at different portions of sky. Small changes in light-source location will make huge changes in what you'll see. Four cardinal spaces take in general light, east and west spaces are specifically for rich floral, sunset colorations. The north

space alters the sensations of the earth moving by removing the horizon. Each space will have something for morning and night. The only stable point to look at is the stars, so you'll select them as your reference. After a time that stable reference point will move, and you'll physically feel as if you're leaning. It's not an illusion. Some portions of sky have more old light—light coming from farther away. With the Milky Way, you're seeing light from our galaxy. The sun's light is newer, like pouring Beaulieu into space. To have light from stars older than the Milky Way means selecting those areas of sky to align with a space. Then you have relatively old light present to touch.

**Omni:** How else will visitors encounter the "music of the spheres?"

**Turrell:** You will have to swim into several spaces. In one space in the Upper Fumarole, the crater's secondary vent, you can sit in a nice, warm bath that also acts like an apochromatic lens to focus the three major colors in the same place. The pool will be a sensing place

everyone could stand around dressed in black and watch the event. The object of perception would be the same, but the experience different.

**Omni:** Were you thinking of the crater's context when you decided to become a cowboy?

**Turrell:** Please, I'm not a cowboy. I'm a rancher! There are different job descriptions here. To begin with the beauty of the place attracted me, so I noticed some diminution of it because of some overgrazing. The land around the crater is setting and context, is important. So not dealing with the landscape is terribly arrogant. By practicing holistic range management, we plan to bring back 135 square miles of grassland. This area has been traditionally grazed since the 1880s—if I didn't guess it someone else would. When we first applied for grazing rights they were denied because we weren't ranchers, so we had to become ranchers. To take ranching into the twenty-first century, you have to respond to environmental issues. It's been an interesting process, learning about the relationship of grasses to grazing animals.

**Omni:** How will visitors get out here?

**Turrell:** We'll do eight to ten tours a day. I'll have a staff to take people out. There will be a ramp for the handicapped; there aren't too many volcanic craters where you can go all the way to the top in a wheelchair. There'll be as many events during the night as during the day, so people can stay overnight. Beds will be carried toward openings, so visitors will be awakened by an image of the sun overhead.

**Omni:** How will the celestial events change over time?

**Turrell:** I can go to the planetarium, model the crater's spaces with cardboard, and actually see what's going to happen in the future. The continent is moving about an inch a year to the north. Celestial events are made to be seen over the next 26,000-year cycle of Polaris; the events will be seen in the center of the spaces about 2,000 years from now. In 4,000 years they'll be where they are now, but on the opposite side of the space. After that they'll begin to go out of the spaces. In the year 26,800 what you see will be located where it was in 1900, while in the meantime the cinder cone will be eroding. In some way this is the making of a pre-ruin.

**Omni:** What will you do when you finish Roden Crater?

**Turrell:** I have other outdoor projects in mind. The next I want to do is on Mars. You have to have goals! You don't know if you're getting there if you don't have goals! **OO**

# CHROMO

(CONTINUED FROM PAGE 77)

was what actors called actor-proof. It had been like shooting fish in a barrel. Hardly any resistance. They could have sent Bo-Bo the chimp and he would have garnered every ribbon and medal given to Johnson. That hopewash about rescuing his men from an encirclement. A leader took care of his men, that was that. That appointment should have been mine. Slater often whispered through gritted teeth:

For Frank Slater, the killing had become pleasurable early on. Dumb shit Brad Johnson with his professional couples. He'd have let that diseased kid get away that day. Ten-year-old kid, his eyes already a deep red with CHROMO, his movements erratic. The little dwarf would've infected half the damned Sprawl. One shot brought him down. Little guy. He remembered Johnson's look. Made Slater happy for a week.

Taking Brad Johnson's place would be only logical. Should have come sooner but... what the hell. Commanding the Squads was what Slater was born for. And hey—it was for the public weal, wasn't it? He was the bulwark between CHROMO and the gutless populace hiding up in the great citadel in their mile-high condos, away from the Sprawl. Away from the poverty, the stink, the CHROMO—the action.

He was a hunter by disposition, by nature. Though hunting CHROMO victims was not entirely satisfying; they had no means with which to fight back, not much defense. On occasion an armed ragtag inflicted a casualty or two among his men, or the rare armed rebel appearing out of nowhere "wid-eyed" making a suicide attack.

These skirmishes kept the politicians generous and on their toes. Funding was never a worry; the fat asses gave him more than he asked. Invitations to their fancy homes too. The manfolk uneasy with him, the women fascinated. He found the women disgustingly easy and eventually of no interest to him at all.

Slater looked forward to no more than the hunt, may it last forever. That and the final showdown with Brad Johnson. Big fucking hero Johnson has been drunk, his eyeballs rolling with opticube use. Christ, how he hated that son of a bitch! Killing his brother had been most satisfying. Now Frank Slater looked forward to killing Brad Johnson.

Slowly would be good.

Killing Lightstone—the Lightstone—would then be the capstone of his career. He was bound to be persona most grata and—in the highest circles. Mean-

strom himself—the site of supremacy—would place the circle of blue ribbon around his neck. On national TV. The nation's highest award. Nothing closer to him, nothing held back. On the swards would still regard him with what they thought was condescension. But it was weak, like the light wave from an exhausted weapon; its power source used up. It was he, Slater, who had the high ground, from which he regarded them all. Only Maelstrom loomed above and that same Slater granted to him readily, gladly.

Maelstrom after all was Maelstrom.

Sonia Masters leaned closer to one of the screens. Her lithe body twisted slightly as she strove to force a result with body English. Raymond Masters watched her while he pretended to read his news printout of the day. He needn't bother to pretend, he knew. She was so absorbed she would not have noticed him dancing a hump.

It would be impossible, he knew, to make her understand the project. She only saw her own efforts at finding the key. Her world was in that multicolored workstation, staring at the dimmed CHROMO configuration. He watched her edge the substructure closer to the CHROMO papercluster. CHROMO shied away as it always did, oozing, with seeping vulnerability. Raymond's lips formed a sneer. CHROMO was about as vulnerable as laminated rocket skin. His sneer turned into a genuine smile as he saw CHROMO gather itself, certain now of its foe's essential weakness, it straightened. The curving stopped. Like a taking fighter, it came off the ropes, suddenly not tired or weak. Accepted. Quickly, easily.

Sonia shook her head, her lustrous hair spilling over her shoulders, then bent to the task again. Masters checked the time. Soon he would be speaking at the shareholders' meeting. Maelstrom had insisted that he. Masters speak first. The first words on the road to Project Habitat. Raymond felt the beads of sweat on his upper lip. He patted it gently with a flesh, stiff linen handkerchief.

It would be a dead end, this substructure. Promising that nothing CHROMO was too good. Too adaptive. He remembered reading about the old ebola strain, late twentieth century. The victims took it to the grave. Outbreaks were sporadic and limited. CHROMO on the other hand... weakened and maddened its victims, but they survived far longer. The vector, an incubator of swarming, multiplying billions of bacteria, staggered on to infect others. CHROMO was smart.

Sonia leaned closer again to the screens. Her concentration, Raymond marveled, was total. It really was time they were going.

The greater scheme, the enormous enterprise, would be beyond her. The project did not lend itself to easy description, and besides, she would never understand or condone Raymond's sacrifices in the cause of the greatest industrial. It was no use, he thought, looking at his wife's intent face. He would never tell her either of the sacrifices he had made in the name of the enterprise, would go on making as it matured into reality. What was it Jeremy Bentham said—"greatest good for the greatest number?" Bentham would have understood. Sonia never would.

And CHROMO was the key. Sonia searched for the key to CHROMO, not knowing the disease was itself the main element in the great enterprise. Without it, there was no enterprise, no Maelstrom, in fact. The entire structure would collapse without its basic underpinning. That was the great secret.

Masters marveled at the paradox. CHROMO needed us and, in its struggle for primacy, killed us. And we, for our own purposes, needed the deadliest plague we had ever known. CHROMO.

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## BATTELLE

CONTINUED FROM PAGE 47

and data communication with data processing. I'll be on the road and access my computer back at the office, access all databases of the Internet or any online service, receive and transmit data, and process it on the spot."

Snedaker adds, "Instead of a central processor cars may have 20 computers on-board—little guys, all networked together. That's done by microchips."

"Miniaturization will play a key role in developing intelligent transportation systems," says Milot. "In 10 years, we won't have self-driving cars, but we'll pack much more functional communications into them—on-board navigation, mapping, traffic and weather reports, calling police or tow truck with information about where the car is."

Snedaker squints his eyes and measures with his fingers. "At Battelle, we've built a wee little heat pump the size of a dime. By itself, that's just an exercise in miniaturization. But think of covering a wall with them. Suddenly, you can have a wall that's hot on one side and cool on the other. That takes you away from central heating and cooling. Miniaturizing creates enormous opportunities to put things precisely where they're needed."

"Within five years," he expounds, "forerunners of nanotechnology will involve medical devices—things put unobtrusively into your body to do something without hooking you up to a machine—something going via a needle up into a vein or a tiny implant sampling your blood or measuring pH and wirelessly transmitting the results. Baby boomers are reaching an age where their parts are starting to wear out."

The integration of power, sensors, and controls is the sixth influential technology on the list. Snedaker explains why. "Our ability to model atoms and molecules has been paced with our ability to model systems. Better understanding systems enables us to develop increasingly sophisticated sensors that sharpen our control over systems. The more precise control the less energy a system consumes. In the near future, automobiles and other machines will be very carefully and elegantly controlled. Honda recently unveiled an engine that reputedly meets California's 1997 clean-air requirements. A central feature of the engine is an extremely light electronic fluid-management system."

Milot offers another example. "In many factories engineers do computer-based product design that then must

be downloaded and translated manually into controls for machines on the factory floor. As more sensors and feedback loops are introduced on the assembly line, these 'smart systems' could come to control manufacturing from design input to product output."

Omni interviewer Bennett Davies takes the process another step. "It would be great if you could walk into an auto showroom, step into something like a virtual-reality booth, and custom design your own car. You wouldn't yet choose your own technical specifications or alloys, but you might have a choice of chassis, two or three engines, and almost unlimited choices of accessories. Your car would be delivered in three weeks!"

But what about the human body? Battelle chose antiaging technologies as the seventh on the list. According to Hassler, "With proper skin care a typical human can live to about 120, based on the number of errors that gradually creep into our DNA replications until we have a critical failure somewhere in the system. The more in-volunt attempts to combat aging have gotten the most attention because they affect outward appearance. But antiaging technologies are moving in much more significant directions."

Dr. Joyce Durnford, microbiologist, joins the discussion. "Retin A, for wrinkles and alpha hydroxy acids to encourage hair growth are among the few appearance-related things that work to some degree. True antiaging technologies address diseases and deterioration that come with aging, like heart attacks and arthritis. We expect to see dramatic advances made against chronic diseases, particularly as we develop immunotherapies to tweak the body into helping itself."

"We think a runaway inflammatory response promotes some heart attacks and some arthritis," Durnford continues. "Pharmaceutical houses are developing drugs to control the early stages of these responses."

"Cells at an infection or injury site produce on their surfaces cell-adhesion molecules (CAMs) that signal blood cells to stop what they're doing and attack the problem. We're targeting various structurally identical substances that could do the same job and be produced synthetically," says Durnford. "In conditions provoked by a runaway immune response, a CAM might stop an early step in the condition's development. Some CAM therapies should be in common use in 10 years."

In this context, "antiaging" means things that extend productive life. "Entire classes of tissue replacements are

being developed," says Durnford. "Synthetic skin and collagen could be used for replacement in several ways. Polymers affiliated with particular human growth factors will be injected at an implant site, stimulating the body's tissue to adhere to the implant quicker and better."

Medical science has provided lots of spare parts for people," adds Millet, "but so far they tend to come from the junkyard. More of these parts will require tailored materials, sophisticated miniaturized control circuits, a lot of embedded computer capability. This molecular design and miniaturization technology is lying around in our labs and in many products, but instead of being in my coffee pot, 10 years from now it might be in my neighbor's."

From bioreplacements, the discussion moves to number eight on the list: precisely targeted medical treatments. Durnford first compares this to a more commonly understood process of radiation treatment. Techniques of attaching radiation to antibodies to identify tumors is well established in treating several types of metastatic cancers. If you isolate and synthesize an antibody specific to colon cancer tissue and bind a radioactive molecule to it, you can give the antibody intravenously and it will travel throughout the body and attach itself to the tumor. Putting the patient in an imaging camera, basically a Geiger counter, you see where the malignant tissue is. Now, a new hand-held device lets the surgeon scan for radioactivity during surgery to be sure all malignancy is gone. Using the antibody to carry a drug instead of radioactivity, is promising, but although antibodies deliver the drug to the tumor surface, they usually fail to penetrate inside. People are working on that.

You can broaden the idea of targeted therapy," Durnford theorizes. Hormones, growth factors, a variety of proteins have specific docking sites on specific cells. Any one of them could be used to deliver a drug to a specific organ that needs it. We can expand targeted therapeutics to putting drugs not only where but also when they're needed."

The discussion turns to the ninth technology: hybrid fuel systems for vehicles. "We don't see a single-source solution to the vehicle fuel problem," begins Millet. "A strategic technology at a systems level is a vehicle that can carry multiple fuels and switch back and forth among them under control of a smart system. An internal combustion engine, a bit bigger than a lawnmower engine that gets 80 miles per gallon, accelerates the vehicle. Then at a preset cruising speed, it switches

over to compressed natural gas (CNG), electricity or some other fuel by sensing pressure changes on the accelerator pedal."

Fuel is political as hell," posits Sneider. "From a technical standpoint, everything is in place to do something significantly different. If the entire Middle East was suddenly cut off, we could burn natural gas, alcohol, coal or manure. We have an expectation everyone has an inalienable right to own a car. Everyone assumes those cars will be fueled by stored energy carried on board as a liquid and distributed nationally. To create economic pressure powerful enough to change the social expectations would take either a national emergency or very gradual, long-term shift. Right now, there's no social or environmental pull on new fuel technologies. No market pull."

Millet predicts that it will be at least 50 years before the U.S. national vehicle fleet runs predominantly on fuels that are not derived from petroleum. In 20 years, however, Sneider believes

merit. People can make decisions see consequences immediately, then see how other decisions alter those consequences. When people can do that, they gain insight into what works and what doesn't. Ten years from now, simulation games could replace TV shows as a major form of entertainment."

Once all 10 of these technologies have been accomplished, what technologies will exist on this list in 2008? Millet muses. Information storage and retrieval should make the top 10 in 2008. Somewhere on that list will be high-quality products custom-designed and affordably manufactured to an individual's explicit orders—clothes, appliances, luggage, all manner of things. Quite possibly hydrogen energy will be releasing the huge amount of energy locked in water. Management of water resources will make the top 10, driven by demand for resources in the oceans, growing crops, extracting minerals, and so forth.

Many believe we're on the verge of new worldwide epidemics," Millet con-

## A few years ago, scientists at Ohio State used deep-fry oil in place of diesel fuel and it worked. The bus exhaust smelled like McDonald's.

that "icy highways will probably permit no vehicles weighing more than 1,500 pounds. These cars will have little ceramic engines with exquisite controls that get extremely high gas mileage and won't be able to go faster than 60 miles an hour. You'll own a little car and rent the behemoth to take you over highways on long trips. Two of my neighbors do that now."

Finally, the tenth technology is education, which may be construed as an application of technology rather than a technology in itself. As Millet explains, "Learning from books is medieval. It's just not the most efficient way for people to learn. Vision is the most powerful sense for most people, so information certainly will become more visual. Ultimately it may become three-dimensional. A major area of development will be computerized simulation. People can choose a situation—the battle of Gettysburg, corporate management, their marriage—and test their ideas, see what happens, and rerun scenarios to see how different strategies affect the outcome. Business is already involved in simulation as a tool to develop judg-

ments. Identifying, preventing, and responding to them might well be on the list in 2008. Technological responses to the demand for personal safety of other kinds will be there, too. Several states have legislation pending allowing people to carry concealed weapons. Demand for personal sensors to detect harmful objects, like guns in our vicinity, will rise. A jogger might carry a little sensor alerting him or her when another person comes within 10 feet. Home and car security systems could be improved by better sensors, more accurate information, and immediate communication with police or emergency units. Consumer demand for foods high in nutrition and fiber, low in fat, and all natural will be strong. Work in plant genetics is progressing slower than some predicted, but shows promise in engineering food.

Bennett Davies poses his final question to the scientist of the future and the leader of this esteemed group. Which technologies surprised you by not making this year's list?"

Millet's response: "A cure for the common cold didn't even come up in conversation. ☐"

# GAMES

2 x 2 x 2.

A pair of square, wooden puzzles goes plastic

By Scot Morris

The best mechanical puzzles appear simple but turn out to be disarmingly difficult, until you know the secret. It's rare for a new secret to come along that is so simple it could have been discovered centuries ago but wasn't, but it has happened recently with two new ideas invented by woodworking hobbyists: they've earned the ultimate commercial accolade. They are now available in plastic.

Bill Cutler of Palatine, Illinois, built puzzles with blocks of varying sizes that had to be inserted in a certain order to fill a box exactly. His father-in-law found the box-filling puzzles too difficult even to try, so Cutler wanted to make him a joke gift, a puzzle that would appear absurdly simple but would turn out to be extremely difficult. The simplest configuration was four cubes that appeared identical but, once removed from the box, would turn out not to be perfect cubes at all—and to be maddeningly difficult to get back in.

"I tried designing varied pieces with all sorts of concealed angles, but it would be a woodworker's nightmare," Cutler told me. "Late one night, the final design came to me in a flash: all four pieces could be exactly alike!"

Cutler calls the final handish construction Blockhead and it's shown in oak above (spiked on the nails) and on the opposite page in one of the many incorrect configurations that prevent the four pieces from fitting in the box. Martin Gardner called



Two wooden puzzles: Bill Cutler's Blockhead—in oak, on the nails above—and Ken Walker's jigsaw puzzle, become so popular that they're available in plastic (plastic jigsaw shown below)

the Blockhead puzzle

"one of the best mechanical puzzles to come along this century." You can easily fit three pieces back into the box, but the fourth just won't go. How many wrong ways are there to put four blocks in a box? You'd be surprised.

Cutler's wood originals sold at \$40 apiece, a price that made them attractive only to serious collectors. Now, due in part to those collectors' rave reviews, the Blockhead puzzle has been pressed into a multi-colored plastic version, shown

both assembled and disassembled on the opposite page (upper right). Marketed by Wits End of San Jose, California, it's called Stark Raving Cubes and sells for about \$12.

In 1992 Ken Walker of Livermore, California, came up with an unusual way of cutting jigsaw pieces out of wood. Setting the platform of his scroll saw a couple of degrees off horizontal, he found that by varying the tilt of the cut he could produce a four-piece puzzle in which each piece can slide completely

off either adjacent piece, but not both at the same time. In the upper right corner of the opposite page (under the plastic Stark Raving Cubes puzzle) is a sample cut from wood. On this page, at left, is a plastic version that demonstrates one of the puzzle's most interesting properties: Held by one piece, the others disengage by about half their widths, but the assembly stays whole. The top piece is completely free from the bottom.

Once you know the geometric secret, you can separate the pieces in a couple of seconds. You'd have no difficulty putting two or three of them together again, but the fourth just won't fit.

Jerry Slovic, puzzle historian and owner of the world's largest puzzle collection, called Walker's idea "elegant, ingenious, and diabolical." When you look at it, you think it is too simple when you try it, you would swear it's impossible. Yet it does come apart. It's a brand-new idea, a brilliant puzzle that will become a classic.

Walker went so far as to apply for a patent, because he saw his new way of engaging and disengaging parts making possible new kinds of fasteners for clothes, handbags, and other items. Deeming Walker's idea new and useful, the U.S. Patent Office gave him Patent Number 5,439,227 last April.

Wood puzzles individually cut are expensive, but the plastic version now available, marketed by Binary Arts,

sells in toy stores for about \$5.95

#### PUZZLE POTPOURRI

The linkage puzzle (left) unanswered in the fall issue, has a simple solution. The pencil will trace the shape of an infinity sign, the logo of *Omni* magazine.

Here are some more puzzles to stretch your brain cells:

1. Name two parts of the body that, to change from the singular to the plural, require changing all the vowels.

2. Name two common English words that are spelled one way when applied to females

and another way when applied to males.

3. Usually, adding the letter "al" to the end of a word changes the number of the word (that is, singular to plural) but not the gender of the word. Dave 1000089@aol.com asks: "What word is it that, when the single letter 's' is added to the end changes both its number and gender?"

4. These words have one very unusual property in common: *rice*, *job*, *herb*, *tanger*, *swell*. What is it?

5. The words in question 4 were the only English words I knew with this strange property until I discovered another while drinking beer at a bar in Seattle. What is it?

6. Insatiable chessy pictures: These three words can each be transposed into one and

only one other English word by shifting their letters. What are the "other words" for each of the three?

7. I saw an unusual pair of sunglasses that had the regular large lenses and a second set of small lenses, embedded in the frame, for close-up viewing. They were in a specialty sporting-goods store. What kind of store was it?

8. Neil Stover tells me he knows of a specialized set of glasses for people whose occupation requires them to see far, at arm's length, and close up. Who are these specialized trifocals for?

9. I have heard of another set of custom glasses—trifocals with the separations vertical rather than horizontal, so that the wearer might have far vision to the left and near vision to the right, for example. Who might want such specialty glasses?

10. How can you draw a perfect oval with one turn of a compass?

11. Three thieves—Manny, Moe, and Mack—steal a number of identical gold coins and start to divide them up. It occurs to Manny that it will be unfair if the coins cannot be divided evenly by three. Mack comes up with a solution to divide the coins fairly before counting them, and

so that there can be no disputes over possible imbalances. What was Mack's solution?

12. Paddling his canoe in a river, Hans uncorks champagne and throws the cork into the river. He rows upstream 10 minutes and then has a crisis of conscience. Realizing he shouldn't litter, he instantly paddles downstream in search of the cork. He picks it up exactly one mile from the place where he dropped it. How fast is the current?

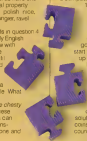
#### ANSWERS

1. Foot/feet and tooth/teeth.  
2. "Blondes" and "brunettes" are always female, males with such hair color are "blond" and "brunet." 3. Pinetrees/pineless. Note the odd change in number, from plural to singular.  
4. All the words change their pronunciations when capitalized.  
5. The word is "ranier" (for example, it's rainer today than yesterday). Capitalized it becomes Ranier—the mountain, ale, or prince of Monaco.  
6. Banalities, scythe, piecrust.  
7. A fishing store. Anglers need to shift their gaze from far to near for tying flies, baiting hooks, and so on.  
8. A concert musician.  
9. A portrait painter.  
10. First wrap the paper

around a cylinder. The shape a compass draws will be an oval.

11. The three agree before counting the coins that they will split them evenly down to the remainder. If there is no remainder, all is well. If there is one coin remaining, Manny gets it. If there are two coins remaining, Moe and Mack each get one.

In this way, each thief has exactly one-third chance of getting an extra coin from the "remainders." In other words, in all cases in which there is a deuce, 50 percent of the time Manny will get one extra and the other 50 percent of the time Moe and Mack will each get one extra.  
12. Three miles per hour. In the closed system of the flowing stream, the distance between cork and boat doesn't depend on the stream's current. Hans has been separated from the cork for 20 minutes, and in that time, the cork has gone one mile. It will drift three miles in an hour, so the speed of the current is three miles per hour. **OO**



# LAST WORD

## SCIENTIFIC OUTLAWS

Seeing the laws of physics in relative terms

By Christopher Kelley

**I**t is never too late to learn. Then again, it's never too early either. Take physics for example. I always thought Newton was just some guy who made great fig cookies. I was astonished to learn that he had also discovered a complex system of laws that govern the universe. Knowing these laws as a kid, I could have gotten much better grades in science class. I also could have pointed out to my older brother, Paulie, how totally unscientifically he behaved.

Newton's first law states, "An object at rest or in a state of uniform motion," such as my napping brother Paulie, "tends to remain in that state" unless his little brother is bored and stupid enough to try out law number two. Law two says, "When an object is accelerated by force" such as being woken up by a punch in the arm, "the amount of acceleration is equal to the force divided by the mass of the object."

However, it was always law number three that gave me the most trouble. Law three says, "For every action there is an equal and opposite reaction." By sneaking up and hitting Paulie in the arm, I would not produce an equal and opposite reaction but a reaction 30 times as violent as the punch I delivered. At first, I thought this was unfair. But later, as I learned more about science, I found out that this phenomenon was explained by Einstein's Theory of Relativity, which says if you punch a relative, especially one older and bigger

than you, you'll have to learn to eat your meals through a straw for the next two weeks.

Newton's incomplete version of his "laws of motion" can be explained by the "law of probability," a complex statistical equation which suggests Newton "probably" had no older siblings.

Einstein, in all likelihood, was the **youngest in his family**. As a child, he would have learned the harsh reality of teasing gone bad.

This would account for such a gross mathematical error in Newton's theory—little siblings just don't pack the same punch as bigger siblings after being rudely awakened ("the law of diminishing returns").

Another set of laws I wish I had known of earlier were the first two laws of thermodynamics. The first law states that energy can be neither created nor destroyed but only changed. If I had known that, I wouldn't have been so worried when Paulie smashed the energy forming my nose. He changed it into something resembling a flattened strawberry. Since flattened strawberries are rather tough to breathe through, I mistakenly thought my nose was destroyed. I immediately sought the medical attention of my mother by rolling around on the floor and moaning loudly. My mother, who wasn't

familiar with the first law of thermodynamics either, didn't realize that the energy that was once my nose was still alive and well—albeit unrecognizable. After

taking me to the hospital, she told my father what had happened and the second law of thermodynamics kicked in.

Law two states "a spontaneous tendency of energy toward the highest degree of randomness." Paulie, not willing to donate any body parts to sci-

ence, did everything he could to avoid my dad. He holed up off walls, furniture, and appliances. By the time my dad finally caught Paulie, everything was pretty random. Debts was everywhere and the house was a shambles.

Once I learned these laws of physics, they seemed almost too obvious. But if I weren't for great thinkers like Newton and Einstein, who originally identified phenomena and codified them into succinct, understandable scientific rules, I would still be living in ignorance.

It was rumored that after Einstein became famous for his theories, he decided to cash in on his growing popularity and, like Newton, start his own cookie business. It's said that he created a fortune cookie modeled after Newton's fig variety. Enclosed in the gooey middle of each cookie was a little piece of paper and written on it was a science fact like  $E=mc^2$ . Needless to say, Fig Einsteins failed. ☐

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Learning the Theory of Relativity and Newton's laws of a young one may prevent broken noses and bruised arms.

