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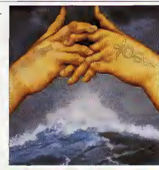

At the center of our universe, we traditionally envision the eternal human soul According to Francis Crick, that could change Cover art by Jim Zuckerman (Additional art and photo credits, page 82)

FEATURES

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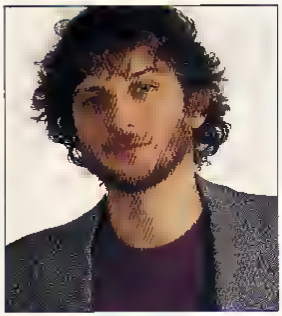
FIRST WORD

RACE MATTERS:
Analyzing the politics of patriotism

By Greg Meyerson



Meyerson is assistant professor of critical theory at the University of North Carolina at Greensboro.

The slave trade cost 50 million lives, says historian Howard Zinn. For most Black people, the Confederate flag symbolizes this holocaust. March 4, 1992 was Confederate Flag Day in North Carolina. The Confederate flag flies atop the Georgia Capitol and, until recently, the Alabama Capitol. A bumper sticker features the Confederate flag and the message, "Heritage Not Hate."

People need community and cultural identity, so some get their sense of belonging by honoring Robert E. Lee, others by honoring Harriet Tubman. I think we should honor Harriet Tubman, not the other guy. Instead, we get dueling nationalisms. "If Blacks can have an NAACP, then why can't Whites have an NAAWP," Klan members will say.

It is strange to equate Black and White nationalisms. The enormous power differences get lost in such equations. White people don't get Jim Crowed or lynched by the thousands or hit with job ceilings (except for women) and restrictive covenants. Whites are not besieged by noxious stereotypes. In a recent study, subjects were shown pictures of a White man holding a razor during an argument with a Black man. When the White subjects described the picture, they remembered the Black man holding the razor. Dominant stereotypes see Blacks as either criminals or as beneficiaries of reverse discrimination, yet Blacks face systematic discrimination in applying for mortgages or in job interviews. (The jobless rate of Black college graduates is 2.24 times that of Whites.) Sister Soulja says Blacks can't be racist because they don't have the power of White supremacy.

Nationalism carries an uncanny logic though. Louis Farrakhan has stood on the same podium with Arthur Butz (who argues in *The Hoax of the Twentieth Century* that the holocaust was an invention of Jews and commies) and White supremacist Tom Metzger. This is nothing new. In 1922, Marcus Garvey sought support from Edward Young Clark, the imperial wizard of the Klan; in 1924, he invited John Powell, head of the Anglo-Saxon clubs, to speak at the United Negro Improvement Association headquarters. Elijah Muhammed met with Klan officers in Atlanta to work out a treaty promising Elijah his Black nation within the United States as reward for supporting a right wing takeover. In Chicago several years ago, Steve Cokely, a Black Muslim follower of Farrakhan, made the news by insisting that there was a plot by Jewish doctors at Cook County Hospital to inject Black babies with the AIDS virus. Black and White united in their separateness and anti-Semitism. Jewish Nationalism is subject to similar paradoxes. Shlomo Ariel, in a 1983 letter published in *Ha aretz*, reported that in seminars set up for young Israeli conscripts, every group contained boys who argued for the physical elimination of Arabs. When Ariel drew parallels between the 1982 Sabra-Chatila massacres of Palestinian refugees and the Nazi extermination campaign, the boys "voiced their approval and declared their willingness to do the exterminating with their own hands" without guilt.

Racism and nationalism are not identical, but they feed on each other. Patriotism, the mother of all nationalisms, feeds them both. I regularly ask my students how many Southeast Asians were bombed and starved by the U.S. government during the Vietnam War. One hundred thousand is the usual answer. My students underestimate twentyfold Vietnam War deaths. Arthur Butz estimates that a million Jews died during World War II—most dead by diseases resulting from the transport of Jews to labor camps in the East. The Nazi apologist underestimates Holocaust victims only sixfold. Nearly 100 percent of Americans do not think the American flag is a symbol of imperialism. Most Americans think that imperialism is nothing but the rhetoric of Muslim fanatics blinded by their own patriotism.

Racial inequality is the vanguard of increasing class inequality. In the United States, the top 1 percent own more wealth than the bottom 90 percent. The richest 834,000's net worth is almost a trillion more than the poorest 84 million. The world's richest billion have 83 percent of the wealth; the poorest billion, 1.4 percent. Americans tend to see class status as a function of individual effort. Everyone can be a millionaire, or at least middle class. Class, though, is more like a curve, where 80 percent of the students get F's. Since class analysis is taboo in America, we get instead a rich mosaic of nationalism, racism, patriotism; the rich get richer—heritage, not hate. We could make a flag out of all of this if we didn't already have too many of them. ∞

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COMMUNICATIONS

READERS' WRITES:
Nuclear solutions to age-old disputes, glorious gums, and receiving signals from unknown origins

Fight Back

"Future War, Future Peace" by Ben Bova in your November 1993 issue was, on the whole, quite intriguing and very logical in its extrapolations on possible future events. The only point at which I think the narrative goes awry is the description of the nuclear exchange between Pakistan and India. It seems to me that should there be a nuclear attack against a Muslim nation, other radical fundamentalist Muslim nations would take the opportunity to strike with missiles of their own. Such an attack would provide the perfect opportunity for a justified jihad against the "infidels," carried out by nuclear means.

Michael LaBauve
Prineville, OR
AOL: Demon3

Chelation Frustration

Your article on chelation therapy [Medicine, November 1993] was sorely needed to help combat the prejudice against it on the part of the medical profession. I have witnessed the struggle to have Medicare pay for chelation treatments, whereas they will pay a large part of $35,000 for a heart bypass without comment—this, in spite of the fact that most bypass recipients require another operation in five years. I personally have struggled with periodontal problems for years. During my last visit with my dentist he remarked that the improvement in my gums has been extraordinary since my series of chelation therapy treatments.

Charles F. Warren
San Diego, CA

There have been numerous well-conducted scientific studies attempting to show that chelation therapy improves atherosclerotic narrowing of arteries, and none have shown any benefit. Despite the obvious appeal to have a medical "Drano," none has thus far been found, but many of my patients have spent thousands pursuing this remedy—none with long-term benefits.

Greg Skipper, M.D.
Newberg, OR

In Offense of Reason

Robert Killheffer implies in "The Consciousness Wars" [October 1993] that science has essentially shown that the soul is entirely the creation of the brain, which will die with the rest of the body. Whoa! If we're going to talk about the mind, let's at least keep an open one. Consider the analogy comparing the mind to a TV set. Just as a TV is tuned to a particular program that does not originate from within the TV, so might the brain act as an interpreter of the mind. If we tamper with the innards of a TV, the picture will distort and eventually disappear, but we have not damaged the source of the signal.

Steve Briggs
South Portland, ME

Regarding "In Defense of Reason" [Books, October 1993]: Since the moment scientists actually established ratio and the intellect as the absolute measure for truth, the humiliating process of cynically reducing the enormous spectrum of human experience to a 'scientifically measurable' and generally recognized minimum has taken place. One fact that has been successfully ignored all along is that what actually is measurable depends entirely upon the state of the technology you use to measure. A small look back to the time when radio waves or bacteria couldn't be measured or seen and were declared nonexistent should be enough to make science step back from its self-declared position of defender of absolute truth.

Claude Pauly
London, England

POLITICAL SCIENCE

RICHARD NIXON REBORN
Readme first

By Tom Dworetzky

To install. In a virtual world, it's strictly cut-and-paste reality. It's been there/done that, spliced together to make each of us whoever we dream to be. So look out, it might turn out that you are whoever you think.

Moment 1: Cable surfing the dark fiber one day/night, I spied pixel rot in the corner of the holo color pattern and moused to it. I found that broken edge, don't know how. An old clip-chip toehold maybe, forgotten, unerased. I slipped in.

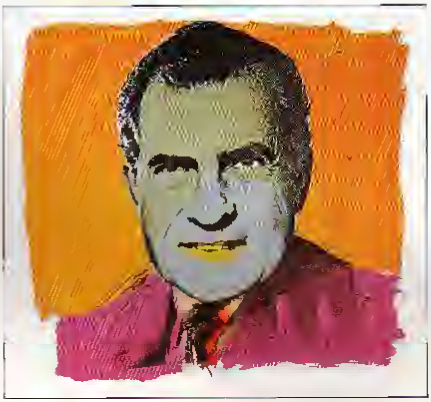
Moment 2: Holoscreens in my contacts showing too much, too soon. I don't want it, I want it too much. Further in. It's old inside, layers of the onion peeling, revealing ancient buried wizardry. "Those who hate you don't win unless you hate them. Then you destroy yourself."

Moment 3: Interlaced video waves still receding from deep space, reaching us here at the new galaxy. The imagery of the past finally catches up into the breech in the edge, smacks against the present visimagery.

Moment 4: Bright sunlight pinning me to a ledge against a flat wall of hot concrete, the whomp of copter blades. "I knew if I continued to look around it would be difficult for me to contain my own emotions. So I turned from the red eyes of the crowd and looked only at the red eye of the camera, talking to the nation." I flash the crowd the victory sign, my arms outstretched. "You're Dick! YOU'RE DICK! Rising over a valley, each point of light's a node of inspiration. Who had the key? What did it open?

Moment 5: The door latch is taped back so that it won't slam shut. Not a light on. The wave of ether pushes against my back, the pressure mounts. "And this is our beloved family dog."

Moment 6: Mommy, mommy, momney, monney, money. I'm back. Mommy." I made my misfakes, but in all my years of public life I have never profited, never profited from public service. . . I welcome this kind of



examination because people have got to know whether or not their president is a crook. Well, I am not a crook."

If you're going to be like that, I'm going to leave you. You won't have me to kick around anymore.

Moment 7: Man with a beard. Abe, the Great Emancipator, talking to me from a painting on the wall. "They came after me, too," he said. "Boy, my head hurts!" "When the president does it, that means it is not illegal."

A haze, churning from night into day, vaguely familiar faces: a crewcut, a bouffant, a headband with long, blond hair. Men grasp my biceps, hold me as we move from the shadows of a great house to a perfectly manicured lawn. Whomp, whomp, whomp. It's suddenly windy, loud, hundreds of people surround me in the burning sunlight, noise overcoming their shouts. The strong men help me up the stairs. I turn at the top, blinded by the light, and swing my arms stiffly to their extremes. Peace. I sign with my upturned fingers; that's what I want now. Then into the dark machine, and we're flying. Whee! Look at the little people down there.

Moment 8: I thought I knew who I was, that no one and nothing could shake me. There it is, coming right at my head. "I want you to stonewall it."

Epilogue: Medic Report 06753. Male in his twenties found in apartment after reported disturbance in the power grid near Swall and Wilshire. Appears to have gotten trapped in locked VR routine about 10:45 p.m. Was hallucinating and suffering massive info overdose but was stabilized and after therapy should recover most, if not all, functions. As required by law, this case was immediately reported to the Virtual Diseases (VD) tracking unit of the Centers for Disease Control. The epidemic of such VD cases, now a national crisis, requires that we isolate the individual in electronic quarantine to prevent his now altered psychoneuroimmunological system from further fragmentation and infection to surrounding infogrid virtual space. We have placed him in the ICU on Roosevelt Island where he will be provided full life support and long-term psychoreconstruction. At present, he is being fed IV and soothed with light rock. DD

Moving into the past, you take a chance of a lifetime. And like the tube of a sea wave, the database can collapse on you, but the imaginary present is built on the imaginary past.

ARTS

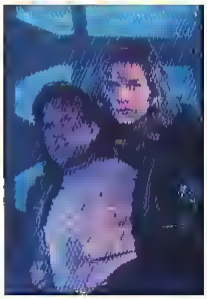
GETTING A LOT FOR A LITTLE
FGM's *Monolith* is a good film on a modest budget

By Robert K. J. Killheffer

John Eyres and Geoff Griffiths didn't set out to become movie moguls. As partners in the early 1980s, they had built up a fairly successful 11-store video-rental chain in South Wales and hardly thought of *making* movies themselves.

But then a British filmmaker, Richard Driscoll, approached Eyres and Griffiths looking for investment to complete his nearly finished film *The Comic*. The two bought in, and it didn't take much exposure to the movie business to convince them they wanted more. "We went on the set for two days," Eyres recalls, "and loved it. So we said, 'Hey, why don't *we* make a movie?' "

From owning a video-rental chain to forming EGM Film International, partners Eyres and Griffiths have found success making movies for less. Right: a scene from *Monolith*, EGM's latest release.



So they founded EGM Film International and in 1987 made their first movie, *Good Night, God-bless*, and a small profit. It wasn't until their fifth project, the science-fiction thriller *Project Shadowchaser*, that EGM had a real budget to work with. *Shadowchaser* scored a surprising success, released theatrically across Europe and in the Far East and racking up impressive video numbers here in the United States.

On the strength of that film's record, Eyres and Griffiths moved to Los Angeles, and this year they'll release their latest movie, *Monolith*, another science-fiction action thriller, starring Bill Paxton (*Trespass, Near Dark, Boxing Helena*), Lindsay Frost (*Dead Heat As the World Turns*), Louis Gossett, Jr. (*An Officer and a Gentleman, Enemy Mine, Diggstown*) and John Hurt (*The Elephant Man, Even Cowgirls Get the Blues*). Directed by Eyres and produced by Eyres and Griffiths, *Monolith* is the story of two cops (Paxton and Frost) who become unwilling partners in a search for the truth behind what they sense is a sinister cover-up of a bizarre murder. As it turns out, they have no idea just how sinister and bizarre the case will become.

Their search leads them quickly into trouble with a secret government agency (the "Department of Historical Research") headed by the power-hungry heavy Villano (Hurt) and into deadly conflict with the alien life force that Villano hopes to control—a being that can take over other bodies. There are shades of *Invasion of the Body Snatchers* and *The Thing*, but *Monolith* plays the old possession shtick for action rather than pure suspense (although there's plenty of that, too).

In an industry made infamous by its GNP-sized budgets, overpriced stars, and make-or-break 100-million-dollar risks, Eyres and Griffiths succeed by keeping their films well within reasonable costs. Their first movie was made on a budget of $120,000, and even *Monolith*, which hardly skimps on effects or explosions, cost a mere $8 million. "When I hear about sixty- or seventy-million-dollar budgets," says Griffiths, "I wonder, what are they doing with all that money?"

One of the secrets to staying under budget is to use the available technology. Eyres and Griffiths worked with Introvision, a special-effects studio, using a dual-projection system to obtain many of the exciting effects they were after, including a heart-stopping fight atop a high-rise under construction. (Introvision's system was also used in the train-wreck scene at the start of *The Fugitive*.)

The dual-projection system allows actors to step into an imagined set projected from detailed miniatures. Not only does it cost less than building monstrous life-sized sets or going on location, it makes breathtaking action sequences possible without danger to actors or crew. "You couldn't do the high-rise shot without it," says Griffiths. "Well, you *could*, but can you imagine what it would take to get a whole film crew up thirty stories?"

Another key to EGM's success, both creative and economic, is the activity and interest of its owners. With Eyres directing and coproducing with Griffiths, they aren't spending megabucks on a big-name director or shelling out hefty cuts to outside producers and their hordes of assistants. "John loves to be involved in the whole process," Griffiths says. "He's there from the start all the way into the editing room." That kind of involvement gives EGM very close control over both the budget and content of its movies.

Monolith will be available on videocassette in late February, but naturally Eyres and Griffiths are already at work on their next film, a sequel to *Project Shadowchaser*. They began shooting in October and at this point, plan to produce as many as four films a year. What are their ambitions? Besides continuing their record of financial success, they'd love to make a truly *great* film. But Griffiths feels there's nothing but fate that can guarantee that.

"John and I will always make good movies," he says. "I don't think we'll ever fail to do that. But a *great* film—that's in the hands of the gods." ∞

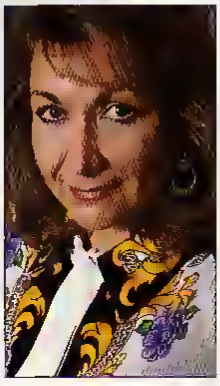
IBOGAINE II: DOWN MEMORY LANE

Does one trip equal 30 years on a therapist's couch?

By Nina L. Diamond

It's the closest thing anyone's seen to a bona fide cure for drug and alcohol addiction, yet, paradoxically, ibogaine's curative power seems to derive from its consciousness-altering properties. Despite the government's historic queasiness about sanctioning studies of mind-active drugs, ibogaine penetrated the bias and survived to become only the second psychoactive drug to get the green light on the long road to FDA approval (MDMA was the first). "The FDA has been very responsive on this one," says neuroscientist Deborah Mash of the University of Miami. Mash heads the team conducting the FDA human safety trials.

Treating drug addiction with a psychoactive drug is still considered ironic, says University of Miami neuroscientist Deborah Mash, who heads the team conducting FDA human safety trials on ibogaine.



Mash is the latest link in the ibogaine story, but one who will bridge the gap between anecdotal evidence and scientific proof needed for FDA approval. Ibogaine is derived from the roots of *Tabernanthe iboga*, a shrub native to equatorial Africa, where tribes have long used it in small doses to remain alert while hunting and in larger amounts during sacred rituals. In 1962, heroin addict Howard Lotsof took a trip on ibogaine and afterward found that he'd lost his desire for heroin and suffered no withdrawal symptoms [see Mind, July 1993 *Omni*]. Lotsof gave the substance to other addicts, and they, too, were unhooked from drugs that previously ruled their lives. "The International Coalition for Addict Self-Help ran underground trial testing on ibogaine," Mash says, "and it was found to cure addiction to heroin, cocaine, and other substances."

In 1986, Lotsof formed NDA International and secured a use patent on ibogaine for treating drug and alcohol addiction. Underground trials began in the Netherlands in 1990, with more than three dozen addicts since treated as test cases. Tests will soon begin in other European countries and in Israel. Mash was among the American investigators invited to Leiden to witness ibogaine in action. "I call it a chemical bar mitzvah," she quips. "It's a psychoactive drug, but not a hallucinogen like LSD. It puts you into a thirty-six-hour waking dream state. During this altered state of consciousness, you relive your childhood experiences, get to the root of your addictions."

"Ibogaine was used as a rite of passage in Africa," says Lee Hearn, laboratory director of the Metro-Dade Medical Examiner's Department and a member of Mash's team. "Now it may be used to reprogram an addict's life. Anecdotal reports indicate that while on ibogaine, he or she is detached from childhood recollection, but is reexamining, coming to grips with it, perhaps understanding it for the first time. All neuroses are potentially solvable this way. Drug addiction," he adds, "is an illness of the spirit. If you're going to cure it, you have to do so at that level."

Mash remembers Mark, an American in Holland for ibogaine treatment. "His brain was working overtime. He was viewing his past as a detached participant, observing where he went wrong, reintegrating it. He didn't want to speak or be interrupted. I spoke to him but didn't want to be intrusive." On ibogaine, one may confront experiences long ago swept under the emotional carpet. Scientists have been startled to see that ibogaine cures the anxiety of decoupling from a long-term habit, prevents withdrawal symptoms, and relieves—although not completely eliminates—cravings. "Mark went thirty days without craving, but then it started," Mash reports. "We don't understand craving, although it's tied to relapse. An addict will tell you it's triggered by certain cues. We think it's similar to classical conditioning [see Mind, November 1993 *Omni*]."

Mash is testing ibogaine's pharmacologically active metabolites. "If craving returns to some extent in some people, it may be because ibogaine's metabolites are washing out over time," she speculates. "Maybe we'll need something after ibogaine for maintenance." But so far no one has had a bad trip, and the only side effects reported are slight nausea and imbalance at the treatment's beginning. In monkey studies Mash found no brain toxicity. "Toxicity only showed up in a study at Johns Hopkins University, and it was only toxic in near-lethal high doses." Yet ibogaine's physiological mechanism remains a mystery. "It doesn't bind to any known brain receptor," says Mash, whose team includes a neurologist, a psychiatrist specializing in addiction, and a social worker expert in "inner child" work.

"A negative bias has evolved surrounding the use of psychoactive drugs," Hearn laments, "because of recreational uses of substances like LSD. It's a mistake to label them as bad because they're mind active. Maybe ibogaine will change some misperceptions and open the door to research with psychoactive drugs." Mash agrees. "Treating drug dependence with a *drug* is still considered ironic." Also ironic, she adds, is that the first trials are taking place in Miami, the premiere transit point for cocaine in this country.

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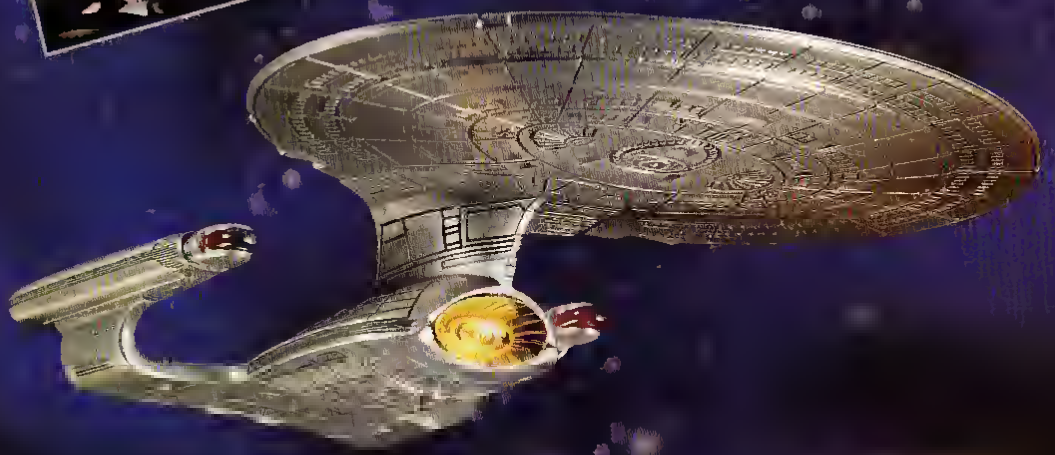

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SOUNDS

RAISING A RUCKUS ABOUT NOISE: It threatens your hearing and your health

By Robert Angus

Everybody knows that prolonged exposure to loud noise can damage your hearing. But did you know that noise may also cause or contribute to hypertension and sleeplessness in adults as well as learning impairment and unruly behavior in children?

More than 28 million Americans have significant hearing impairment, much of it permanent and untreatable. The Environmental Protection Agency estimates that nearly four times that number—about 40 percent of the total U.S. population—is exposed to enough noise to cause permanent hearing loss. Couple that with acoustician Alice Suter's conclusion that the noise level in America is increasing at a rate of 1 percent a year or better and you have the makings of a major health problem.

Estimated noise levels inside airplanes, according to some experts, can surpass the volume that the EPA deems safe.

The dangers of noise are, unfortunately, not as clear-cut as those from most other health hazards. First of all, one person's noise may be another's music. And noise measurements taken in the same location at different times produce differing results. Finally, noise can fool the human ear. An increase in sound of three decibels (the measurement unit used by acousticians)—believed to be the smallest increment detectable by humans—actually represents a *doubling* of sound energy. In fact, what sounds like a doubling of loudness to us is actually a tenfold increase, 10 dB, in sound energy.

Daytime sound levels in a quiet suburban neighborhood generally register about 52 dB, while city noise scores closer to 80 dB. While airlines typically plead ignorance about the noise levels inside their passenger cabins, acoustical experts put the level at 78 dB to 83 dB, depending on the type of plane, the exact location of the measuring device, and whether the plane is climbing or cruising. A Los Angeles apartment immediately adjacent to a busy freeway may have a noise level as high as 88 dB. While sound actually becomes physically painful at 132 dB, the EPA has decreed 55 dB as the average safe level for noise.

While the threats of noise to hearing are well known, scientists are only now discovering that it can trigger different sorts of health risks. For example, studies on animals indicate that prolonged exposure to noise raises blood pressure, which then remains elevated long after the noise has disappeared.

Traditionally, acousticians have tried to reduce noise levels by using sound-damping materials such as draperies, carpeting and acoustic tiles. Unfortunately, there's a rather modest limit to how much sound these materials can absorb. The modern approach, by contrast, relies on active electronic noise cancellation rather than simple isolation. The German audio firm Sennheiser used this principle in the headphones it developed for a major European airline. The lightweight, open-air headphones contain a tiny microphone built into the ear cup that picks up outside noise and feeds it to a processor, also in the ear cup, that determines both the volume and its frequency distribution. The processor then generates a signal that's equal to but out of phase with the noise, and it mixes the new signal with any program material—air-traffic instructions, perhaps, or an in-flight movie soundtrack—and sends it out to the wearer. The listener hears all of the program information and only about half of the noise that would be audible without the headphones. For safety reasons, this technique doesn't perform noise cancellation on higher frequencies normally associated with voice warnings and high-pitched alarms. Recently, two additional manufacturers—Koss Corporation and Noise Cancellation Technologies—introduced noise cancellation headphones of their own.

For those of us without access to such technology, simple acoustic earplugs of the type recommended by the Occupational Safety and Health Administration for use in noisy workplaces also reduce perceived noise by about 50 percent. These earplugs are most effective in blocking high-frequency sound, while active noise cancellation best screens out low-frequency noise, the kind that interferes most with speech intelligibility.

Auto makers Nissan and Ford and several aerospace research facilities in Great Britain are trying to apply active noise cancellation to entire cars and jetliners. The technology they've come up with so far, alas, falls short of the individual headsets produced by Sennheiser and others. DO

WHEELS

FUEL-CELL FEVER
Power source for a future generation of cars

By Jeffrey Zygmont

Fuel cells run on hydrogen, which has suffered an image problem ever since the *Hindenburg*—the prize German blimp that was buoyed by the explosive gas—went down in flames in Lakehurst, New Jersey, in 1937. But fuel-cell advocates point out that the gasoline that today powers our precious automobiles is also an incendiary substance. And the fact that we handle so much of it so safely proves. If nothing else, that it's possible to safeguard ourselves against hazards inherent in fuels.

Besides, fuel cells hold enormous promise as a power source for a future generation of automobiles. Electric cars driven by fuel cells instead of batteries could provide the long driving range and rapid refueling we're accustomed to without spewing pollutants. And hydrogen is as plentiful as sea water. What better replacement for finite, nonrenewable gasoline?

The drive to develop fuel cells for transportation enjoys support not just from Earth-firsters and hydrogen heads, but from government and business people as well.

Today, General Motors, Allied Signal, Dow and Lockheed have fuel-cell programs. The technology boasts its own lobbying organization, the Ad Hoc Coalition on Fuel Cells for Transportation. And last year, Senator Harry Reid of Nevada hosted a hearing to promote the gas before a subcommittee of the Environment Committee.

"This is a high-risk, high-payoff field. It deserves a lot of government support," says Paul MacCready, founder and chairman of AeroVironment, the engineering firm that helped GM design its Impact electric car. Its latest project, the solar-powered Eternal Airplane, will use regenerative fuel cells for the night power needed to keep it aloft forever.

Like batteries, fuel cells generate electricity by chemical reaction. But batteries require recharging—basically using electricity to drive the reaction in reverse, returning the battery to its original, charged state. With current technology, it may take up to several hours to recharge electric car batteries, even after a mere 100 miles or so of driving.

In a fuel cell, the reaction generally moves in one direction. After giving up electrons at the anode, hydrogen migrates through an electrolyte to combine with oxygen at the cathode, creating water as a byproduct and feeding a flow of electrons—electricity, that is—between the terminals. The cell requires no recharging, though it must be refueled.

Given a widespread distribution system, refilling a car with hydrogen and (absent a fix for cell contamination by plain air) pure oxygen could conceivably be as simple as topping up with gasoline at the corner garage. Of course, hydrogen filling stations won't appear before there are cars to patronize them. And since few consumers are likely to buy hydrogen-powered cars without a ready fuel source, the fuel-cell initiative aims to start by populating fleets, which can keep hydrogen supplies at their terminals. In fact, electric buses with fuel-cell power are already appearing. One built by Canada's Ballard Power Systems is circling test tracks, a U.S. Department of Energy program aims to complete three by next year and begin urban fleet testing in 1995.

Tackling transit buses first allows fuel-cell builders to gain operational experience while working to develop cells small enough for automobiles and affordable for the motoring public. "Passenger cars are particularly challenging due to the tight size constraints and cost restrictions," says Peter Teagan, vice president charged with technology assessment for market-research company Arthur D. Little.

Some developers say they're close. The R&D company Energy Partners is trying innovative manufacturing methods—replacing expensively machined parts with molded ones, for example. "The ultimate goal is to use mass-production techniques in the manufacture of fuel cells as a replacement for internal-combustion engines," says Rhett Ross, Energy Partners' sales manager.

Still other hurdles remain before fuel cells become suitable for private cars. Hydrogen itself is relatively expensive. Also, on-car tanks for gaseous hydrogen remain troublesome. One proposal would equip autos with reformers, devices that convert methanol or natural gas to hydrogen. The DOE-sponsored buses reform methanol on board. But skeptics say that an automobile is just too confined for that.

Robert Rose scoffs at skeptics. "What we're talking about is engineering, and engineering yields to money," says the coordinator of the lobbying group. He expects that once fuel-cell feasibility is apparent, private-sector R&D will really take off. "I am confident that people will find ways to make money selling fuel-cell-powered vehicles," he says. ∞

STARS

MEASURING STARQUAKES:
Asteroseismology could answer ancient questions about the universe

By Bill Lawren

An intriguing new field called asteroseismology has sprung up within the larger discipline of astronomy. While its name might make it seem a bit arcane and overspecialized, the data gathered by its practitioners is anything but. Asteroseismology could unravel some of the cosmos's knottiest mysteries—even the birth date of the universe itself.

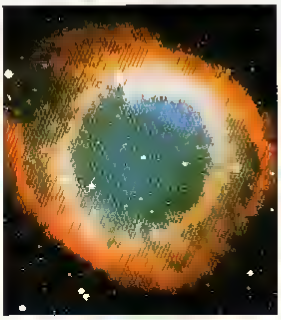
Asteroseismology, explains Iowa State University astronomer Steven Kawaler, works very much like the terrestrial variety. Seismologists watch the acoustic compression waves generated when an earthquake takes place. As those waves radiate through the inner earth, they bounce off any region where the composition or density of material suddenly changes, which gives the scientists a sort of CAT-scan profile of the inner earth and its distinct layers.

Asteroseismology is similar, except, as University of Texas astronomer Edward Nather says, "We don't have to wait for an earthquake." The stars that asteroseismologists study are constantly vibrating, sending compression waves ricocheting through their interiors to the surface, where they manifest as changes in the stars' brightness. Asteroseismologists have learned to measure these changes using global telescope networks such as the Whole Earth Telescope.

Most recently, the scientists have trained the networks on a particular white-dwarf star that goes by the uninteresting name of PG-1159-035. But the observations reported by Nather and his University of Texas colleague Donald Winget are nothing short of fascinating. They indicate that as PG-1159-035 changes brightness, it can display at least 125 different light frequencies, with display periods ranging anywhere from 385 to 1,000 seconds.

The white dwarf's dazzling show reveals a wealth of information to asteroseismologists. Until recently, Nather explains, astronomers had assumed that the insides of white dwarfs were uniform, composed of the same material from the surface down to the core—"just big bowls of jelly," as Nather puts it. But the complexity of PG 1159-035's variations suggests that their insides contain layers.

Asteroseismology also provides fascinating clues to the star's history. In particular, the new data is helping to resolve



The largest known planetary nebula, the Helix Nebula, consists of a cloud of gas surrounding the remains of a red giant. Astronomers have theorized that when the gaseous nebula drifts away, the central star becomes a white dwarf.

what Nather calls "one of the great mysteries in astronomy"—how red-giant stars come to end their lives as white dwarfs.

Astronomers agree that red giants eventually run out of thermonuclear fuel and then collapse into ultradense white dwarfs. But they don't know the detailed story of that collapse. Some theorize that as red giants collapse, they eject their outer atmospheres, which become clouds of gas—or nebulae—at the center of which is a very hot, contracting object that will eventually become a white dwarf.

If that scenario is correct, Nather says, then white dwarfs should be constantly cooling off. But the observations that he and Winget compiled indicate that PG-1159-035 is actually heating up. "That was a shocker," Nather says. "It tells me that we don't have the story right yet."

Getting the story right is important. White dwarfs, Nather explains, represent "the end products of stellar evolution. So written in the white dwarfs is the history of the way stars have behaved since day zero."

To piece together this history, asteroseismologists take "temperature censuses" of white dwarfs in the disc of the Milky Way. If theory holds, the coldest of these stars should be the oldest, and calculating the distribution of the hotter white dwarfs indicates the rate at which they've cooled. A little math yields a figure for the galaxy's age: about 10 to 11 billion years, according to Nather.

But Nather readily admits that "the whole business of the age of the universe is up in the air." Measurements of the oldest stars in the halo of the Milky Way—which many experts think formed before the galactic disc—produce an estimated age for the universe of 15 to 16 billion years.

In an effort to resolve the conflicting estimates, Nather and his colleagues began last spring to examine white dwarfs in the galactic halo. If the temperature range of those stars corresponds to that of the disc's white dwarfs, then the universe may indeed be as "young" as Nather proposes. But if they turn out to be older (that is, cooler), then the 15-to-16-billion-year estimate may be closer to the truth.

"That's the issue we're trying to resolve. What was the timetable for the construction of the universe?" Kawaler says. "It's a very exciting time for us." ◻

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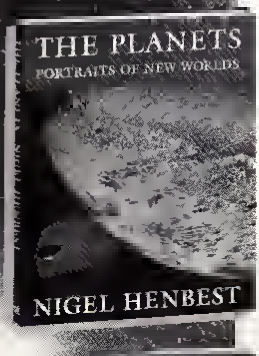

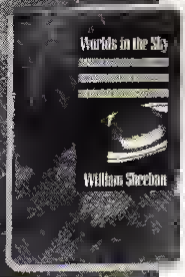

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ELECTRONIC UNIVERSE

DEBBIE DOES SILICON VALLEY
In search of sophisticated electronic entertainment

By Gregg Keizer

Mix sex with science fiction and you've got a potent—and provocative—combination. Old tales of outer-space orgasms and weightless love making may have been shoved aside by all-too-realistic scenarios of plague or mind-numbing teledildonics, but sex still plays a big part in telling the stories of the future. As it should. For what kind of fun would it be getting to the future if sex weren't along for the ride?

Too bad digital science fiction doesn't agree. Sure, there's an oblique reference in a game here, an adolescent hormone run amok in a game there. But if you want an adult diversion on your personal computer—and that's about the only place you'll find it since the major videogame makers keep their publishers on a tight censorship leash—you'll have to look outside of science fiction. At least for now.

The models pose, the shutter clicks, and you're the one calling the shots. Penthouse Interactive's *Virtual Photo Shoot* puts the user behind the erotic *Penthouse* lens.

It may not be everyone's ideal entry into the adult arena, but Penthouse International's *Virtual Photo Shoot* is the slickest, most professionally produced piece of bawdy binary to date. In this compact disc—available for the Macintosh and Windows—you play the part of a magazine photographer, snapping pics in a virtual photo studio. And with the Penthouse name, it doesn't take a rocket scientist to figure out who the subjects are. The three digitized women on the disc are as beautiful, sensual, and bereft of clothing as the ones in its namesake.

Putting the vast storage capabilities of CD-ROM to good use, *Virtual Photo Shoot* includes 90 minutes of QuickTime video on the Mac version (and a similar amount of Video for Windows footage on the PC version), an audio CD-quality background beat, and plenty of digitized speech. All play a part in helping you suspend disbelief as you enter the imaginary studio, virtual Nikons around your neck.

During the photo shoots, you go interactive by literally calling the shots. Like a real photographer, you tell the models how to pose, then as their video clips comply, you click the shutter shut. The frames you've snapped are noted and later displayed on a contact sheet of thumbnails. The easily navigated interface lets you back up, recall the last shots, or even change your mind when you're in the darkroom, where you can replace one frame with another. When it's all over, *Penthouse* publisher Bob Guccione appears onscreen to critique your work.

Virtual Photo Shoot is intriguing not only for what it does, but for the techniques and technology it applies. Unlike many other CD-ROM titles that promise interactivity and then only let you choose which way to turn at the end of some dungeon corridor, *Virtual Photo Shoot* lets you make the same choices that a *Penthouse* photographer has at his or her disposal. That's the essence of a virtual experience. And the key to believing in the experience—and in the end, buying the idea that you're *not* just in front of your computer—is the video, which was shot specifically for the disc. Multiple camera angles, closeups, and fluid motion all contribute to the feeling that you are in charge, not just playing a passive observer.

Digital science fiction would be smart to pick up a pointer or two from *Photo Shoot*. Though science-fiction action games are cool, they ain't the only game in town (no matter what the publishers think). Exotic, or erotic, science fiction based on adult characters, not just a charging plot line, *is* possible electronically.

Hope beyond PCs is on the horizon. The new Panasonic FZ-1 Real 3DO Interactive Multiplayer system, a multimedia game machine designed by 3DO (the California startup led by Trip Hawkins), hit the shelves last fall. The Panasonic 3DO box uses a built-in CD-ROM drive, video-compression software, and special graphics processors to provide full-screen, full-motion video, high-quality sound, digitized speech, and flicker-free animation to its titles. As important for science fiction and its adult audience, though, is the censor-free, hands-off approach 3DO takes with its software developers. Unlike Nintendo and Sega, 3DO won't restrict its licensees to kiddy games, demand a ratings system, or excise content. It's as much a bow to the manufacturing process as anything, for although Nintendo and Sega control the making of the cartridges that go into their machines, 3DO won't have that luxury. Anyone can press a CD.

Science fiction, at least the kind published in binary form on disk or disc, needs to grow up. Software like *Virtual Photo Shoot* and systems like 3DO provide the example and the means. All SF has to do now is catch up with the future—and the future *does* have sex. I promise. ∞

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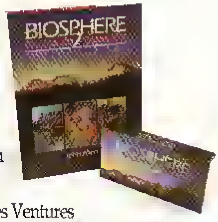

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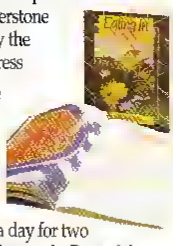

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MEDICINE

THE BIOLOGICAL ROLLER COASTER
Chronobiologists study the body's natural rhythms

By Hunter Whitney

Ben sits in bed, intently tapping the buttons on a white box that looks like a mutant Gameboy, but he's not playing. The box is the Psycho-Log 24, and it's testing the 25-year-old's reaction time, mental arithmetic performance, and a host of other variables. Used by NASA scientists and other researchers, the Psycho-Log 24 is one of the newest developments in compact physiological and psychological rhythm monitors—instruments that could transform the way we live.

From blood pressure to short-term memory, even affecting the potency

of aspirin and other drugs, your body's natural rhythms may be the key to good health.

All living things, from amoebae to Aunt Sally, possess internal clocks and calendars directing a variety of biological cycles. Everyone's hormone levels rise and fall in reliable patterns throughout the day, week, month, and year. The same is true for body temperature and several other factors. The mind has its ups and downs as well. Short-term memory, for example, has daily peaks in the morning, while the senses sharpen in the early evening.

In the past, charting these human "time structures" has been difficult. However, Franz Halberg, M.D., director of the chronobiology laboratories at the University of Minnesota, believes advanced technology can unlock the secrets of what he calls the "chronome." He is currently spearheading a drive for the Human Chronome Initiative, a proposed international effort to map physiological rhythms.

To Halberg, the standard annual physical exam is "like looking at a snapshot of someone on a roller coaster." Halberg and colleague Germaine Cornelissen, Ph.D., director of biometry at the chronobiology labs, are creating a reference databank of blood pressure, enzyme activity, and other chronomes. Cornélissen envisions a time when everyone will have a personal chronome profile of key body rhythms. She says research has already found important applications for these chronomes. For example, the potency and toxicity of many drugs (including narcotics, asthma medications, and aspirin, as well as antihypertension and anticancer agents) depend upon when they are taken. "People can take lower doses and get better results by taking blood-pressure medications about two hours before the peak in their circadian [roughly 24-hour] blood-pressure rhythm," says Cornélissen.

Erhard Haus, M.D., a professor in the department of laboratory medicine and pathology at the University of Minnesota, points out that the link between rhythms and health reaches at least 6,000 years into our past. Physicians in ancient Egypt, says Haus, had a system of "seven-day magic" in which the processes of life, including disease symptoms, were thought to revolve around seven-day cycles. "They had no data," Haus reflects, "but retrospectively, it seems as though they may have been onto something." Modern medicine is rediscovering the importance of a roughly seven-day (circaseptan) rhythm. According to Haus, for example, transplant patients tend to have more rejection episodes 7, 14, 21, and 28 days after surgery. "In the past," he notes, "we thought societal customs were responsible for circaseptan cycles, but unicellular organisms and rodents also display seven-day rhythms, and they don't care about our weekends."

At the Hermann Center for Chronobiology and Chronotherapeutics in Houston, Texas, clinicians work with a patient's time structure in diagnosis and treatment, using a host of compact monitoring devices, including wrist actigraphs and actillumes that look like digital watches but actually track and record patients' biological rhythms. "We had a patient who was extremely depressed and had trouble sleeping," recalls Dr. Michael Smolensky, director of the Hermann Center. "Using the wrist monitor, we found that the patient had a rare, nearly twenty-six-hour sleep/wake circadian rhythm instead of the usual roughly twenty-four-hour cycle." As a result of the abnormal body rhythms, the man was becoming socially isolated. "We recommended a dramatic change in treatment," says Smolensky, "including bright-light therapy and other techniques to synchronize him to the societal norm of twenty-four hours."

Smolensky believes "the time has come for chronobiology, and the idea of the Chronome Initiative makes sense." Widespread recognition of the importance of body rhythms would not only provide new or improved treatments for various ailments, it could reshape the basic approach of modern medicine, moving it away from the outdated view of an unchanging body. "It's a big job," says Smolensky, "but at least we've begun." OMNI

SPACE

SELLING AMERICA ON ORBITING ADS
Madison Avenue commercializes space in its distinctive fashion

By Devera Pine

If space, as the *Star Trek* credo goes, is the final frontier, then consider it tamed (part of it, anyway). And who did the taming? NASA, perhaps? Or the Soviet/Russian space program? Nope—Arnold Schwarzenegger.

Last summer, millions of Americans saw a Conestoga rocket sitting on its launch pad waiting to blast off into space with its precious cargo, the Commercial Experiment Transporter (COMET). They also saw four words emblazoned on the side of the rocket: *Schwarzenegger* and *Last Action Hero*. The rocket carrying the first private commercial space mission also carried the first advertisement ever in space, making local space safe for sales pitches and sparking a vigorous debate over whether advertisements belong in space at all.

Officially, the *Last Action Hero* ad wasn't the first advertisement in space. In an effort to raise foreign currency, for the past four years the Russians have sold space on their Soyuz rockets to hawk merchandise ranging from Sony electronics to Unicharm feminine hygiene products. However, the *Last Action Hero* ad was the first to be done American style: in other words, with lots of hype.

In fact, the $500,000 ad resulted in about $20 million worth of publicity for Columbia Pictures, largely due to the novelty of the event, says Mike Lawson, president and chief executive officer of Space Marketing, the ad-sales representative for the COMET. It didn't do much for the film's performance, however; *Last Action Hero* got trampled in the summer box-office battle by the dinosaurs of *Jurassic Park*. Regardless of the ad's effect, we'll probably see billboards on rockets about every three years, Lawson predicts. "It depends on the hook—if it's viable," he says.

Other forms of space advertising may be a little slower to follow. Tentative plans for a logo-bearing, mile-wide mylar satellite operated by several organizations have been scrapped. Space Marketing, however, does plan to continue selling ads on commercial rockets and even plans to film a commercial in space, according to Lawson.

Officially, NASA remains neutral. "One of our goals was to encourage space commercialization," says Charles Redmond, a NASA spokesperson. "We had not anticipated it in this area."

Redmond acknowledges that on some level, ads in space make NASA uncomfortable. But he adds, "In the current climate, the impact on the economy is more important than it has been in the past. There is a slowly awakening awareness of current realities and their impact on NASA."

Those realities include a changing NASA budget and a private-sector space-industry program that won't get off the ground. Are ad dollars the key to funding private-sector space missions? "We're going to have to go after commercial dollars to help pay for scientific research," says Lawson. "Absolutely no doubt."

This space for rent: To acquire hard currency, the Russians sell advertising space on their Soyuz rockets to firms like Sony.

And the price we'll have to pay may be orbiting commercials. "When you give the private sector the opportunity to conduct operations in space, you get what the private sector does, which is figure out how to make money," says John Logsdon, director of the Space Policy Institute at George Washington University. "It's along the lines of advertising under the ice and along the boards at hockey games. Aesthetically it may be displeasing, but you either have to prohibit it or compensate people for money they could have made."

Eventually, Logsdon says, rules governing space-based ads will have to be made so that ads don't interfere with other uses of space. "To the degree that you have some big reflecting sign up there that makes it difficult for astronomers on the ground to see—you probably want to prohibit that," he says. "But putting something on the side of a rocket that's going to operate for two or three minutes and then be gone forever—so what?"

John Pike, director of space policy at the Federation of American Scientists, agrees—as long as the rocket belongs to the private sector, not the U.S. government. "I would be concerned if the shuttle were all covered with decals like an Indy racer, with a big Pennzoil decal on the rudder."

As for more permanent forms of space advertising, Pike hopes that we don't one day have the equivalent of the Goodyear blimp in orbit. "I think space is about the proposition that man does not live by bread alone—that there are values in life other than commercial values." ◻

CONTINUUM

UNTIL JUSTICE ROLLS DOWN LIKE WATERS: A memorial for a battle that goes on Plus, laughter really *is* the best medicine, and sneakers ahoy!

Standing on the top step of the Southern Poverty Law Center in Montgomery Alabama I can see the fragments of a history in danger of slipping into national memory as, 'That was the past " I can see the Dexter Avenue Baptist Church where Martin Luther King preached nonviolent resistance, the street where weary marchers from Selma filed toward the Capitol steps, the same steps where Jefferson Davis swore to fight for slavery, a Capitol building that until 1993 flew the Confederate flag

Just beneath me, however, is a memorial intended not only to commemorate the past but to speak in soft flowing water how the past is ever with us Carved along the border of a round table that sits atop a pedestal low enough for the curious reach of children are the names of 13 major events of the civil rights movement and the names of 40 individuals who lost their lives in the struggle for equality Gently looming behind, a nine-foot curved wall bears a single inscription " — until justice rolls down like waters and righteousness like a mighty stream.' The Civil Rights Memorial, like the Center that commissioned it, is more than a testament to the past It stands also as a warning that so long as our society is content with abusing the poor alienating minorities and protecting the privileged, it will be blood and not water that flows in our streets

Architect Maya Lin knows the power of words and water.

Oddly named, the Center is about more than the South, or poverty, or the law Founded in 1971 as a nonprofit legal and educational resource the Center sought to protect the civil rights of minorities and the poor During the 1970s, the Center was busy teaching lawyers how to try capital-punishment cases; setting up Klanwatch, an investigative team that tracks hate-group activities and trying law suits involving civil-rights abuses However, it was the landmark case *Donald v United Klans of America (UKA)* that catapulted the Center and its executive director and chief trial counsel Morris Dees into legal legend

In 1981, the body of Michael Donald a Black student at a local college, was found swinging from a camphor tree A few miles away, the charred remains of a cross were found on the front lawn of the county courthouse Two local Klan members were convicted for the lynching Here the story might have ended had not the Center seen an opportunity to teach the Klan a lesson in responsibility Claiming that Tiger Knowles and Henry Hays were acting on behalf of the Klan when they murdered Donald, Dees argued that the UKA was responsible for the actions of its members In a civil suit, the first of its kind Dees won a $7 million verdict in punitive damages

More recently, the Center won a similar verdict for $12.5 million against Tom and John Metzger and other members of a neo-Nazi skinhead group These verdicts are designed to bankrupt hate groups and thus limit the resources needed to spread the gospel of hate and fear and the myth of White supremacy As important as the legal victories are however they are only one aspect of the real work of the Center As Dees puts it, 'We've been in the education business for years " And so the Center has taken the fight against hate from the courtroom to the classroom

Teaching Tolerance is the Center's latest project and one that will hopefully have long-range influence in fighting the root causes of inequality Designed to give teachers of grades K–12 a resource for teaching interracial understanding *Teaching Tolerance* is a magazine and video packet distributed free to schools around the nation 'We don't have all the answers,' Dees explains, 'and we can't just sit kids down and say be tolerant What we are doing with *Teaching Tolerance* is providing teachers with a forum to share ideas " a way to explore how fear and ignorance beget hate and violence

Standing in front of the memorial I read an issue of the Klanwatch newsletter I am shocked by the extremity of offenses such as bars of Jewish human soap for sale in Florida, or a woman supporting gay rights in Colorado who is maced and held down while crosses are cut into her hands But perhaps more horrifying still are the dozens and dozens of more ordinary hate crimes the daily casual assaults in the form of threatening letters, painted swastikas and tire slashings As I read over the 11 accounts of cross burnings representing six different states, I realize just how close our past is to the present Behind me, I hear the faint sound of water pouring over the top of the wall flowing over the names of those who have fallen It is a deafening reminder of all that must yet be done until justice rolls like water and righteousness a mighty stream.

—*ANNA COPELAND*

CONTINUUM

A FISH STORY

Nature programs kokanee salmon to spawn at age 4 and then deteriorate grotesquely and die. What if, Colorado Division of Wildlife biologists speculated, the salmon couldn't spawn? Perhaps they would live longer, growing into trophy-sized giants.

So in 1988, the biologists fed the steroid methyl testosterone to 169,000 newly hatched fry. (The FDA had approved the treatment, but it had never been put to use.)

Instead of becoming sterile, the fish grew gonads, and although the absence of females prevented spawning, at age 4, the kokanee—which by nature turn horribly ugly in their old age, developing humped backs and hooked jaws and losing their fins and scales—still began to die. The steroids made them bigger and stronger, enabling them to live a few months longer, but eventually "nature prevailed," says fisheries biologist Mike Japhet.

The wildlife division heard from some animal-rights activists, upset that it had artificially altered a natural life cycle. "It's a fair criticism. We were, in a way, playing God," Japhet says.

But the division heard from even more fishermen who wanted to know when it would stock more of the big fish. The answer: It won't. "Any further work is best done as a full-blown study," Japhet says.

—Teresa Tsalaky

SPACE BIKERS

Astronauts can't get away from exercise even in space. Working out in zero gravity prevents bones from leaching calcium and slows muscle loss. But whenever a shuttle astronaut jogs on the orbiter's treadmill, the rest of the ship starts to rock and roll from the vibrations. All that bouncing around doesn't do much for delicate science experiments on board.

To help, NASA recently tested three stationary-bicycle systems, all designed to reduce vibrations astronauts tested the bikes on STS-50 last summer. One design, the Ergometer Vibration Isolation System (EVIS), used a system of motors to counterbalance the movements of a biking astronaut.

A second vibration-killing design called for the astronauts to ride a stationary bike suspended in midair via a spider-web pattern of eight bungee cords. "It was an interesting ride—pretty stable actually," says Rick Connell, an engineer for Krug Life Sciences, the NASA contractor that developed the bikes. Connell rode the bike on a special airplane used to test experiments before they're run in space.

> THE LARGEST VOLCANO KNOWN IS ON MARS. OLYMPUS MONS, 370 MILES WIDE AND 79,000 FEET HIGH, IS ALMOST THREE TIMES HIGHER THAN MOUNT EVEREST

Finally, the astronauts test-rode a stationary bike bolted to the shuttle's deck.

The results are in on the first two designs. They each produced 10 times less vibration than the treadmill. In fact, sensors couldn't discern a difference between the vibrations produced by the bikes and by normal levels of shuttle activity.

At press time, NASA planned to test a new bike combining the best features of EVIS and the bungee bike, on STS-60, scheduled for a November 1993 launch.

—Devera Pine

Kokanee salmon spawn and then die young and ugly. Science can prevent them from spawning but not from dying on schedule.

WATCH SOME MONTY PYTHON AND CALL ME IN THE MORNING

How does a guy like George Burns get away with smoking cigars and chasing women when he's almost 100 years old? Probably by laughing about it. While laughter has long been known to reduce tension and help lift spirits, recent studies suggest that humor may play a key role in keeping the body feeling good as well.

In his latest study of immune-system responses, William Fry of Stanford University inserted catheters into the veins of medical students, drawing blood every few minutes while showing a videotape of the comedian Gallagher. *Gallagher?* "Some people find him very amusing," says Fry, a leading gelotologist—from the Greek *gelos*, meaning laughter. Those who did find Gallagher funny showed an increase in white-blood cell activity, which is crucial in fighting off bacteria, says Fry, who conducted his research with Lee Berk at the Loma Linda University Medical School.

"Laughter has a profound and extensive physiological effect," Fry maintains. Yukking it up, he says, increases heart rate and circulation, stimulates the immune system, and even improves muscle tone. "Laughter is really enormous exercise, involving your face, abdomen, and legs."

Fry claims that laughing heartily 100 times a day equals ten minutes on a rowing machine. It's also less dangerous. "We've had very few reports over the years of people having heart attacks while laughing," Fry says.—Peter Callahan

AN ELECTRONIC WAY TO SPRAY

Awareness of substances that can contribute to ozone depletion has led most countries to ban chlorofluorocarbons (CFCs) from spray cans, in which they served as propellants. While that's good news for the environment, it's bad news for those partial to aerosol products. Gas propellants replaced CFCs in most aerosols, but they're highly flammable and lose their propulsion when held sideways or upside down. Now Yves Privas, a French physical and chemical engineer who worked for NASA on the lunar module's refrigeration system, has found a possible solution to the aerosol dilemma—an electronically controlled, nonpropellant spray device.

Privas's device employs a fast-action pump, activated by a solenoid, that emits the spray. A microprocessor programs the solenoid differently for each type of product being sprayed. The same sprey device can dispense products as varied as hair spray, paint, and perfume by simply replacing the polyethylene container in which the product is housed. Rechargeable batteries supply the power source.

The device's performance is superior to that of current spray products and less expensive in the long run, as the device only needs to be purchased once, and the products contained in the polyethylene containers cost less," Privas contends. A major household-products and cosmetics company has tested Privas's invention and plans to manufacture it in the near future.—Bruce Gain

> PANAMA HATS ARE ACTUALLY MADE IN ECUADOR

X MARKS THE (ARTIFICIAL) SPOT

The past 20 years have seen the development of an astonishing variety of artificial body parts, from plastic hips to Gore-Tex ligaments to Jarvik hearts. Now scientists in England have taken an important step toward developing what may be the most fundamental manmade organ of them all: an artificial chromosome.

Geneticist Peter N. Goodfellow of Cambridge University and his colleagues have moved a telomere—the structure at a chromosome's tip that keeps it from unraveling—from the end of the long arm of an X chromosome toward the center of the arm. Shifting the telomere in this manner creates a structure that has only a middle part, called a centromere, and a telomere, with no genes in between. The next step, currently under way, is to perform the same operation on the short arm of the chromosome. The resulting artificial chromosome will be a sort of genetic blank cassette, ready—in theory, at least—for researchers to insert and manipulate human genes.

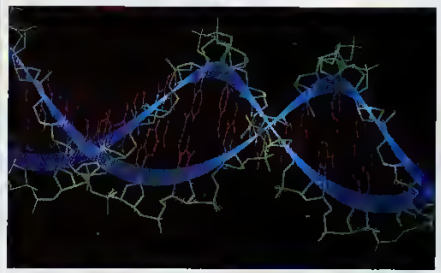
Goodfellow cautions that it could be a long way from theory to reality. "In effect," he says, "we already have the artificial chromosome. But the important thing is to be able to put the DNA we want in the chromosome and then find a way to move the chromosome from cell to cell." Goodfellow and his team are currently experimenting with a number of ways to accomplish that feat and expect to know within a year or two whether their approaches will succeed.

In the long term, Goodfellow thinks, doctors could use artificial chromosomes as a sort of "delivery vehicle" for gene therapy, transporting healthy genes from cell to cell to correct disease-causing deficiencies.

—Bill Lawren

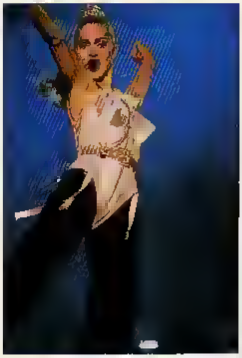
"Men tire themselves in pursuit of rest."

—Lawrence Sterne



Researchers hope to one day be able to insert specialized DNA like the computer-generated strand above, into artificial chromosomes.

CONTINUUM



Madonna: a soothing addition to the gynecologist's office?

CALLING DR. MTV

How do you keep a young woman relaxed during an unpleasant physical exam? Just turn on MTV.

Psychologist Vaughn Rickert of the Arkansas Children's Hospital in Little Rock tried the technique on 30 females aged 13 to 20 who were undergoing a colposcopy, in which a doctor looks into the vagina and cervix through a magnifying instrument. Understandably, this exam makes a lot of women anxious and fidgety, which only prolongs the exam. So Rickert taped a two-hour slice of MTV, showed it to patients during the examination, and carefully charted their reactions. Those who got their MTV he found fidgeted less and needed less reassurance from their doctors than those who were examined without the videos.

"Vanessa Williams had the most soothing effect," Rickert notes, "and Madonna was good, too."

What if the patients are over 30 and MTV just makes them *more* nervous? "Try Crosby, Stills, and Nash," Rickert suggests, "or if they're my grandmother's age, try Lawrence Welk."

—Bill Lawren

A LENS FOR YOUR EARS

A San Francisco company has developed a new hearing device perfect for those reluctant to wear a conventional hearing aid.

ReSound's Earlens consists of three parts. A tiny

THERE ARE 43 ANT SPECIES IN GREAT BRITAIN, THE SAME NUMBER OF ANT SPECIES CAN BE FOUND ON A SINGLE TREE IN PERU.

transducer, about half the size of a contact lens, attaches to the eardrum with a drop of oil. A small microphone clips to the wearer's clothes, and a battery-powered coil converts the signal from the microphone to a magnetic field, which makes the transducer and the eardrum vibrate. Frog Design of Palo Alto, California, devised a loop for the Earlens, worn around the neck and shoulders, that incorporates the coil and battery. It's so well designed, says ReSound vice president of marketing Jack Giroux, that "you forget you have it on."

ReSound has begun formal tests with 22 moderately hearing-impaired patients and hopes to gain Food and Drug Administration approval for the Earlens sometime in 1995. Earlier, the company conducted informal tests with six hearing-impaired patients already wearing the best hearing aid ReSound made. The consensus? "They all commented on how pleasant it was to hear normal sounds without having to feel something in their ears," Giroux says.

—Bill Lawren

SEABORNE SNEAKER SEARCH

Curtis Ebbesmeyer's tennis shoes will help predict global warming. Call them Nostradamus Nikes.

When Seattle resident Ebbesmeyer, who calls himself an "opportunistic oceanographer," heard that a shoe shipment had gone overboard in May 1990, southeast of the Alaska Peninsula, he asked beachcombers on the Pacific Coast to pinpoint landing sites and dates of the 62,000 drifting shoes. He then contacted James Ingraham Jr. of the National Oceanic and Atmospheric Administration, who modeled the spilled sneakers' paths, verifying a computer simulation of prevailing ocean currents.

"We know extraordinarily little about how the ocean moves, yet currents are a major factor in understanding global warming and predicting the weather," says Ebbesmeyer, who now wears a pair of hightops that soaked in seawater for a year.

Never before have scientists been able to follow the trajectories of so many floating objects over such a large area of the Pacific, according to Ingraham. A planned drift experiment of that magnitude would have cost hundreds of thousands of dollars.

It took six months for the Nikes to hit the Pacific Coast. Last spotted in northern Hawaii, the shoes still adrift should eventually wash ashore in Japan.

—Teresa Tsalaky

These sneakers performed valuable oceanographic research.

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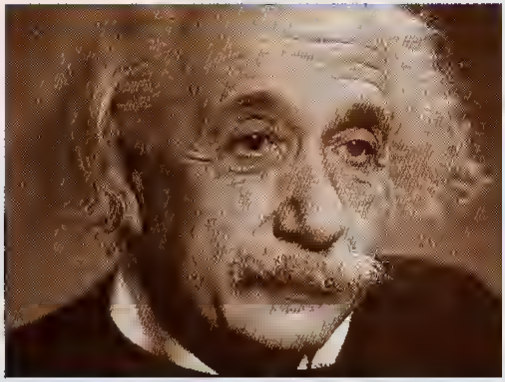


Good news for scientists A study indicates that people with intellectual jobs face less risk of senility

USE IT OR LOSE IT

In the first study of its kind French researchers have concluded that if you don't want to lose your marbles, you'd better use them The scientists found that people in nonintellectual occupations—particularly farm workers—face a much greater risk of senility and other forms of cognitive impairment in old age than do those who hold intellectually demanding jobs

As part of a larger European research project to study the risk factors for dementia neuroepidemiologist Jean-François Darfigues of the University of Bordeaux and his colleagues correlated the level of intellectual functioning in 3 700 people over the age of 65 with their primary occupations

INDIA INK ACTUALLY COMES FROM CHINA

Dartigues's group found that after adjusting for age, sex, and education level, former farm workers are 6 1 times more likely to be mentally impaired than those in intellectual occupations—teachers, managers lecturers executives, and professionals The risk is 2 9 times greater for farm managers, 2 8 times for domestic-service employees, and 2 5 times for blue collar workers

The study results held yet another surprise for Dartigues He discovered that the subjects who performed the best on the mental tests were not those with the most education but rather "those people with little education but with an intellectual occupation"

Dartigues and his coworkers first thought that nonintellectual workers might have performed more poorly in the study because many of them had undergone long-term exposure to various chemical solvents in their jobs But upon further analysis, Dartigues says, "We could not find a relationship between solvent exposure and cognitive impairment"

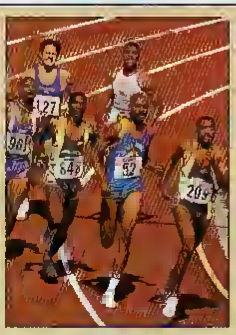
—Paul McCarthy

A LITTLE SOMETHING FOR THE NERVES

Is biotechnology about to render Gatorade obsolete?

Interneuron a biotech company based in Lexington Massachusetts, has developed a drink that it claims combats muscle fatigue The beverage contains choline a natural substance crucial to the synthesis of acetylcholine a chemical released by nerve cells that signals muscle cells to contract In a recent study, ten long-distance runners who drank this lemon-flavored potion before running shaved five minutes, on average, off their time on a 20-mile course. "Other sports drinks attempt to replace electrolytes and sugars depleted as a result of exercise," says Interneuron vice president Bobby Sandage "This drink is different because it's specifically designed to replenish choline

More than ten years ago, investigators at Johns Hopkins Medical School showed that the firing of nerves that cause muscles to contract depends upon the amount of choline available to those nerves Interneuron researchers have shown that the choline levels in an athlete's blood drop



after strenuous exercise They have also shown that blood choline levels rise after an athlete drinks their beverage However the company has yet to demonstrate that muscle fatigue is actually caused by a choline or acetylcholine deficit. "We really can't measure acetylcholine levels in the synapse—the gap between nerve and muscle cells," Sandage explains

Gary Wenk, a neuroscientist at the University of Arizona suspects that the phenomenon of exhaustion involves more than just choline "They've picked out choline as *the* chemical system to look at But what about all the other things—nutrients and amino acids that become depleted during exercise—that they're not looking at?"

—Steve Nadis

ARTICLE BY LINDA MARSA

Last December, Scripps Research Institute, the nation's largest private biomedical laboratory, inked a ten-year $300 million deal granting Sandoz, the giant Swiss pharmaceutical, the right to commercialize breakthroughs made by Scripps scientists. But when Bernadine Healy, then director of the National Institutes of Health (NIH), heard the news, she went ballistic.

UNHEALTHY ALLIANCES

This is "against the spirit of science and possibly against the law," Dr. Healy fumed at a Congressional hearing convened by Representative Ron Wyden to examine this questionable alliance. This will transform Scripps, which receives $100 million annually from the NIH, into a "subsidiary of a foreign drug company." Since the contract covers a ten-year period, it grants Sandoz what amounts to a leveraged buyout of a $1 billion research effort—and the exclusive rights to breakthrough drugs formulated with American taxpayer dollars.

These agreements are "nothing unique," countered Scripps officials, who refused to furnish copies of their contract, which they said was confidential. They insisted there was nothing wrong with selling the rights to more than a billion dollars of taxpayer-supported research to a European company for a fraction of their cost. Scripps became conciliatory and altered its arrangement with Sandoz only when Healy threatened to cut off their grants.

Unfortunately, the Scripps people are right: The lucrative liaison between one of America's premier research facilities and the behemoth pharmaceutical isn't unusual. Since 1980, Congress has enacted several laws that give drug companies unprecedented access to exclusive patent rights to medical therapies invented by government or government-sponsored researchers. Congress hoped to hasten the transfer of technology from the public to the private sector and so speed the development of promising treatments. Lawmakers also sought to ensure America's continued global supremacy in pharmaceuticals—one of the few bright spots on the nation's economic landscape ten years ago.

The legislation not only sparked a sharp increase in the patents of inventions developed with federal support, it also midwifed the birth of the $2 billion biotech industry. But these laws, coupled with the probusiness, antiregulatory stance of the Reagan-Bush era, completely changed the way biomedical research is conducted and spawned unwholesome relationships between academia, government, and industry.

The alliances distorted the research agenda in favor of a shadowy amalgam of monied special interests and promoted the emergence of an entirely new breed: the scientist-entrepreneurs, who straddle both worlds. And more than a few scientists have become millionaires many times over through their links with biotechs or pharma-

ILLUSTRATION BY ANITA KUNZ

ceuticals. "Medicine isn't what it was," says Michael Wilkes, a professor of medicine at UCLA. "In the past, people did research and had high ethical standards. Today, everybody is hoping to make big money."

An elite class of science superstars now possess unprecedented power. Their presence on a faculty can propel a second-tier institution to the front ranks—and enable the university to lure megabucks benefactors. It's no longer unusual for supernovas such as geneticist Leroy Hood to negotiate a $12 million package over dinner with Seattle-based billionaire software magnate William Gates III to relocate his laboratory from Caltech to the University of Washington, like a Heisman Trophy winner dickering over salary and perks.

At the same time that researchers were forming partnerships with big business, government oversight agencies like the Food and Drug Administration (FDA) and the NIH have been gutted and politicized after 12 years of not-so-benign neglect. They have been lax in cracking down on shady scientists, hobbled by a lack of resources, and outflanked by the vastly superior forces of the multibillion-dollar drug industry they're entrusted to police.

"It's getting harder and harder to find a government agency that stands for anything," says George J. Annas, director of the Law, Medicine, and Ethics program at the Boston University Schools of Medicine and Public Health. A three-year inquiry conducted by the late Ted Weiss, a New York congressman, charged that public health was "endangered" because the NIH did too little to keep conflicts of interest and fraud from infecting the research it funds. Yet the Bush White House, under pressure from the drug industry, squelched a package of conflict-of-interest regulations designed to discourage misuse of federal grants.

Today, biomedical research has become an entirely too incestuous process. "The iron triangle of government, industry, and academia constitutes a mutually reinforcing system of self-interest that brings to a close an important period of independence for basic research," says Sheldon Krimsky, chair of the department of urban and environmental policy at Tufts University in Medford, Massachusetts.

Rarely do the interests of the public enter into this cozy equation. "The labs and the drug companies are romancing one another, cutting sweetheart agreements and jilting the taxpayer," said Representative Ron Wyden. But it is taxpayers who pick up the tab and often pay twice: by bankrolling federally funded research and by paying exorbitant prices for therapies formulated at taxpayer expense.

In fact, the federal government is the mainstay of the nation's giant biomedical research establishment and pumped more than $12 billion into health-related R&D in 1993. About $3 billion of this money is spent in government labs. But the vast majority of federal monies is doled out to universities and private, nonprofit laboratories like Scripps, according to a report by Congress's Office of Technology Assessment (OTA). These funds not only support scientists, but they also pay for much of the infrastructure of the laboratories at American universities.

The pharmaceutical industry spends about $12 billion each year on research, but a recent Senate probe revealed that it spends far more on promotion than on devising new therapies. Of the $67 billion consumers shelled out for prescription drugs in 1990, 35 percent was pumped into marketing and profits while only 16 percent went to drug development.

> "ALL WE RECEIVE IN RETURN FOR THE EXTRAVAGANT TAX BREAKS WE GIVE TO THE DRUG INDUSTRY," CHARGED SENATOR DAVID PRYOR, "IS THE HIGHEST MEDICATION PRICES IN THE INDUSTRIALIZED WORLD."

And very little that's innovative emerges from our corporate labs. Most pharmaceutical research is geared toward formulating "me too" or copycat products to compete with rivals rather than genuinely new drugs that advance medical treatment. Of the 348 drugs introduced by the 25 largest pharmaceuticals between 1981 and 1988, only 12—or 3 percent—were deemed important therapeutic advances by the FDA, according to a 1989 report by the Senate Aging Committee staff. Another 44, or 13 percent, had "modest" potential for gains. The vast majority—84 percent—were seen as having little or no potential for advances in treatment.

In stark contrast, 70 percent of the drugs that have a substantial therapeutic gain are produced with government involvement, and up to half of the most promising AIDS and cancer drugs are concocted in government or university labs. "We hear a lot about the industry's unsurpassed innovation and global competitiveness," says Peter Arno, a health economist at Albert Einstein College of Medicine and the Montefiore Medical Center in New York and coauthor of *Against the Odds*, about AIDS drug development. "The facts beyond the rhetoric are very different. It is not competitive brilliance but government-granted monopolies that accounts for much of the industry's profitability."

Even more disturbing is a 1990 GAO report which found that 51 percent of FDA-approved drugs have serious postapproval risks and could cause adverse reactions that lead to severe or permanent disability or death. Yet drug prices escalated at four times the inflation rate in 1992. Americans are paying top dollar for treatments whose effects are negligible or even harmful.

These alarming trends have sparked Congressional inquiries and raised troubling questions about the future of U.S. biomedical research. "All we receive in return for the extravagant tax breaks we give to the drug industry," charged Senator David Pryor, who is calling for a cap on drug prices, "is the highest medication prices in the industrialized world."

The innovation and boldness of vision that made American biomedical research second to none seems to have been lost. What went wrong? The problem started, say critics, at the beginning of the drug-development pipeline. The once pristine scientific laboratory, where scientists deciphered the root causes of disease, has become a hotbed of commerce.

The seminal event that ushered in this new era was the 1980 Bayh-Dole Act, which was augmented by later legislation. This bill gave universities the rights to the patents on federally funded research conducted on their campuses, which enabled schools to attract corporate dollars in exchange for exclusive licensing agreements on all discoveries made under a company's sponsorship. A 1986 law permitted government researchers to cut similar deals, known as CRADAs (Cooperative Research and Development Agreements).

Congress also gave corporations tax credits for investing in university research as an incentive to boost R&D spending, plus a 50-percent tax credit for expenses related to formulating so-called "orphan drugs" for diseases af-

TAXOL: THE ANATOMY OF A DEAL

In the late 1950s, National Cancer Institute (NCI) researchers scoured the globe hunting for substances in nature's pharmacopoeia that curbed the wild cell growth of cancer. Taxol, derived from the

bark of Pacific yew trees, was one of thousands of compounds tested on animals in government labs. It didn't seem to halt cancer, so it remained a laboratory curiosity until 1979 when scientists detected the unique way taxol kills cells.

Another decade would pass, however, before researchers found a way to dispense taxol, which is composed of an almost insoluble molecule. Then, in 1989, a Johns Hopkins team, in a test of women with advanced ovarian cancer, made a startling discovery that electrified biomedicine. In 30 percent of the patients, all of whom had only months to live, taxol shrank their tumors by more than half. Subsequent studies revealed the compound was equally promising in combating advanced breast and lung cancer.

Scientists were ecstatic, hailing taxol as the most significant new cancer drug in 15 years. Wall Street analysts predicted the potential worldwide market could top $800 million annually. The NCI, which has spent $32 million so far bringing the blockbuster drug from the test tube through much of the FDA approval process, immediately solicited proposals from drug makers to participate in a Cooperative Research and Development Agreement (CRADA) for the commercial marketing of taxol.

Applicants were given just 45 days to respond. Of the four companies that made the deadline, the NCI selected Bristol-Myers Squibb (BMS). BMS was awarded exclusive rights to harvest Pacific yews on federal forest land, then the only source of taxol, and monopoly control over the data from federally funded research, including about 30 trials on different types of cancer.

BMS pays no royalties on taxol sales and a pittance for the rights to the yew tree bark. In exchange, the company agreed to a fair-pricing clause. Yet once taxol won FDA approval, BMS set the drug's wholesale prices at $1,000 per treatment—roughly eight times what it cost NCI researchers to synthesize taxol. BMS claimed the cost was based on its "huge" $114 million investment in the development of taxol.

But when Congressional investigators pressed for an accounting of where all this money was spent, the company threatened to avoid future collaborations. Ron Wyden (D-Ohio), who headed this probe, was outraged. "American consumers who have funded drug development through the gift of corporate tax credits and federal lab research should not be bludgeoned by price gouging," he lectured BMS executives.

NCI officials blame their failure to control taxol's price on BMS's refusal to furnish its development costs. But James P. Love, director of the Taxpayer Assets Project of the Center for Study of Responsive Law, a consumer group founded by Ralph Nader, thinks the "taxol giveaway" is a case study in bureaucratic negligence. "While NCI is not run by rocket scientists," says Love, "a child with a fourth-grade education and a pencil and paper could have easily estimated BMS's development and manufacturing costs from a review of publicly available documents from Security and Exchange Commission filings."

Love also contends that such short notice for the submission of proposals for the taxol CRADA virtually guaranteed that BMS, "the NCI's favorite partner in drug development," would be the winner. Government officials stoutly deny any improprieties, however.

But it's no secret BMS enjoys a cozy relationship with the NCI. In fact, the company has built a multibillion-dollar oncology empire marketing ten other anticancer drugs invented through taxpayer-funded research, including cisplatin, carboplatin, carmustine, and lomustine. "This has produced desirable results," says Steve Jennings, an aide to Wyden, "but it also creates a close, symbiotic, codependent relationship like the one between the military and defense contractors."

flicting less than 200,000 patients. According to a 1993 OTA report, drug companies claimed $1.4 billion in credits against their federal income taxes in 1987 (the most recent year for which figures were available). The rationale behind these laws was to ensure that breakthroughs resulting from academic research would be quickly translated into marketable products.

Collaborations between academia and industry are not new," says Kenneth Kaitin, associate director of the Center for the Study of Drug Development at Tufts University in Boston. The academic science community has always been part of a commercial network. But these new laws accelerated the process. In the early Eighties, drug makers and venture capitalists swarmed over campuses dangling money and stock options like baseball scouts cruising the minors for talent.

Technology transfer, however, turned into a free lunch for private corporations. "The Bayh-Dole Act was a watershed disaster . . . which eroded the public's ownership or control over important technology," charged Ralph Nader in testimony before Congress. "This Act . . . increased the private monopoly power of companies who sell these resources back to the citizens who paid

for them in the first place."

The agreements, like the deal between Scripps and Sandoz, allow drug makers to skim the cream off the top of university research without paying scientists' salaries and other overhead costs like buildings, support staff, and libraries. "Essentially this privatized the whole research enterprise," says David Noble, a professor of history at York University in Toronto and a founder of the National Coalition for Universities in the Public Interest. "And to add insult to injury, all deals made under Bayh-Dole are secret. The public is denied even knowledge of it, much less scrutiny or oversight."

As the Scripps-Sandoz contract was originally conceptualized, academic scientists would have become "indentured scholars to a single corporate entity," says Tufts professor Krimsky. A 1992 study revealed that of about 800 biotechnology faculty members, 47 percent consulted with industry; the average moonlighter earns about $5,000 annually, but superstars can net $25,000 a year for a few hours' work. Nearly 25 percent of these academicians received industry-supported grants or contracts, and 8 percent owned equity in a company whose products were related to their research. Most notable among these are Harvard AIDS researchers William Haseltine and Max Essex, both of whom own a hefty slice of Cambridge BioScience, a Boston-based biotech that makes, among other things, an AIDS antibody test.

These alliances have a chilling effect on research, which often gets skewed toward the interest of the corporate patrons. "There's been an increase in mission-oriented research—applied as opposed to basic studies—because companies rarely encourage fishing expeditions. 'The whole culture is now geared toward investing in research that has a quick payoff rather than learning something new that might yield rewards in the long term,' says Boston University's Annas.

But some of the greatest breakthroughs, like penicillin, are serendipitous. A 1976 study of the origins of ten important clinical advances in the previous 30 years revealed that key discoveries were uncovered almost twice as often through basic research than through goal-directed research.

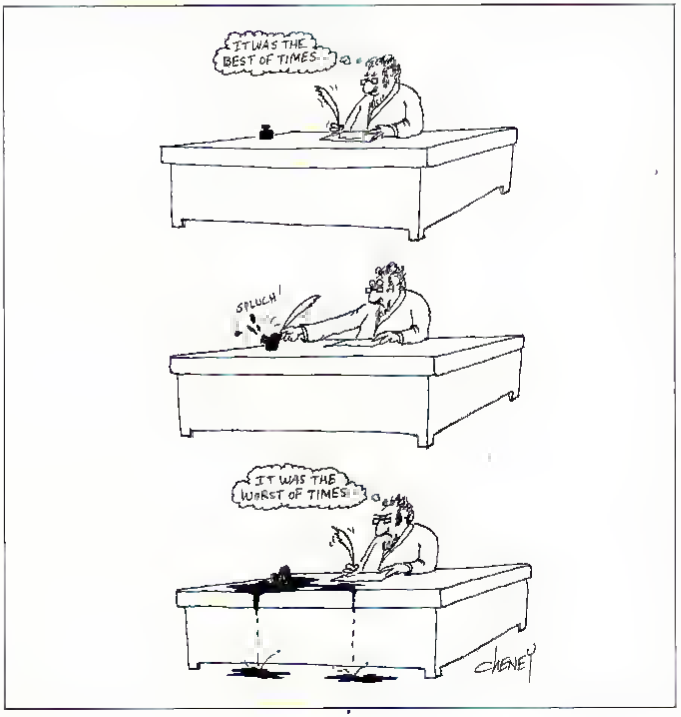
Scientists bound by corporate contracts are also expected to safeguard trade secrets, with data dispensed to colleagues on a "need to know" basis. But this stanches the free exchange of information that is the lifeblood of the scientific process and creates artificial divisions between faculty. Indeed, relations have soured between professors who have joined the gold rush and those who haven't. Friends have become enemies. Experiments and lab refrigerators are now routinely locked up to protect proprietary secrets. As one scientist cynically speculated in *Nature*, the science journal, perhaps the single greatest danger to mankind from biotechnology is the escape of the "venality gene" on campus.

The cross-pollination between government and industry has also triggered a serious brain drain at the NIH. So many top scientists have either entered into cooperative agreements, or CRADAs, or simply left to launch their own companies that the future of basic research—and by definition biomedicine itself—could be in grave jeopardy.

The first of these CRADA partnerships was signed in April of 1988 between Genetic Therapy (GTI), a tiny start-up in Gaithersburg, Maryland, and the NIH's W. French Anderson, the gene-therapy pioneer. In exchange for a quick infusion of $2.5 million, which fortuitously enabled Anderson to double the size of his lab at a critical juncture in his research, GTI got exclusive rights to license anything developed during the collaboration. That means the marketing rights to the astonishing gene-therapy techniques Anderson has since devised belong to GTI—not to the taxpayers who paid Anderson's salary and provided him with a laboratory for more than 25 years.

Since then, the NIH has entered into approximately 250 of these arrangements, and dozens more are in the works. Yet the NIH's track record of protecting the public's interest when cutting technology-transfer deals with companies is abysmal. Many breakthrough therapeutics invented at the public's expense are sold to drug companies—which are often granted monopolies as an incentive to market these drugs—for nothing or at bargain-basement prices.

How AZT, first formulated in the 1960s by researchers on grants from the National Cancer Institute (NCI), one of the institutes that comprise the NIH, was transformed from a useless chemotherapy into a billion-dollar AIDS wonder drug is a good example. When scientists at Burroughs Wellcome, a British pharmaceutical, discovered that AZT thwarted the AIDS-causing HIV virus in the test tube, Samuel Broder, then associate director of the NCI, used the substantial resources of his agency to speed the FDA approval of this potentially life-saving drug.



Once AZT passed regulatory muster in January of 1987, however, the key role played by NCI scientists who may have naively assumed credit would be shared was forgotten. Burroughs Wellcome has since made $1.4 billion from AZT but the American public has never received a dime in royalties. When the drug maker initially slapped a $10,000 annual price tag per patient on the potentially life-saving drug, AIDS activists were enraged.

Over at the National Cancer Institute, the scientists who helped develop AZT as an anti-AIDS drug felt betrayed. "The position of the Burroughs Wellcome Company would appear to be that AZT was developed within the company with little substantive contribution by others," wrote Samuel Broder in a 1987 letter to Burroughs Wellcome. "Your position saddens me and my colleagues at the National Cancer Institute . . . and I was (and remain) extremely disappointed by this turn of events."

The entangled financial web between government, industry and academia also fosters conflicts of interest. This is particularly problematic when companies are testing the safety and efficacy of treatments in preparation for getting FDA approval to commercially market a compound. Typically, drug makers have their own network of principal investigators (PIs)—scientists and doctors at leading medical schools around the country who conduct the clinical trials. PIs are compensated for their work, and their academic institutions receive a stipend to cover overhead costs for the trials.

But scientists' objectivity is called into question, says health economist Arno, "when they have a financial interest in the outcome." One of the most flagrant examples of this was Retin-A, the acne medication touted by Ortho, a subsidiary of Johnson & Johnson, as a wonder drug that could erase wrinkles. After an article appeared in the January 1988 issue of the *Journal of the American Medical Association*, demand for the antiaging elixir skyrocketed—nearly 1 million tubes were sold in February of 1988 alone. However, government scientists never duplicated the results of the original study. In the interim, the Raritan, New Jersey–based Ortho, made millions.

Of course, scientists bristle at the suggestion that their corporate ties may influence their findings. "It certainly raises flags," says Tufts's Kenneth Kaitin, "but you can receive industry funding and not have it bias your results. But when a company pays 10 to 20 percent of researchers' incomes, along with sizable honorariums to their universities for the use of their facilities, it's tempting to put a positive spin on raw data which are often ambiguous."

"The drug industry is more likely to continue pumping money to those whose results show that a compound is safe and effective than those who don't," says Dr. Sidney Wolfe, head of Public Citizen's Health Research Group, a consumer-research organization. "Hundreds of people have been killed and thousands injured because data have been falsified or withheld."

The FDA, the final checkpoint in the drug-development pipeline, still operates on the honor system and assumes companies act ethically in collecting and reporting test results. But the honor system is a relic of a bygone era when staggering sums weren't riding on the results. In 1990 dollars, according to the OTA, it cost $194 million to make a drug from scratch and shepherd it through the FDA approval process in the 1980s; in 1969, the cost was $65 million. The fact that it's in a company's interest for its products to be safe and effective is the built-in failsafe. A bad drug could trigger more than just a costly public-relations disaster; people's health—even their lives—might be at stake.

But if a company intentionally deceives the FDA, it is virtually impossible to ferret out the truth unless a whistle blower comes forward with the smoking gun—which is how the serious health problems caused by silicone-gel breast implants finally came to light after more than a decade of cover-ups. With 150,000 women getting implants each year at anywhere from $1,000 to $5,000 for each operation, breast implants generated $450 million a year for the nation's plastic surgeons—and nobody wanted to jeopardize this lucrative cash cow. In 1992, however, FDA commissioner David Kessler, in the face of intense pressure by lobbying groups, was able to declare a moratorium on the unrestricted sale of silicone-gel breast implants. (Since implants had been on the market for more than 30 years, they escaped federal scrutiny under new rules enacted in 1976 regarding medical devices.)

Then, confidential corporate memos, some dating back to the mid-1970s, surfaced during product-liability suits. The documents revealed Dow Corning, a Michigan-based company who made some of the implants, failed to disclose its own scientists' concerns that the implants leaked and ruptured. "I have proposed again and again that we must begin in-depth study of our gel envelope

and bleed phenomenon," wrote researcher A. H. Rathjen in 1976. Seven years later, William Boley, another Dow scientist, warned about the lack of "valid long-term data to substantiate the safety of gels for long-term implant use."

The ensuing scandal underscored the fact that the FDA, which does not have the power to subpoena company records, has no legal clout and is too short-handed to catch all but the most flagrant abuses. "Staffing deteriorated during the 1980s and appropriations were frozen," says Mike Kubic, an FDA spokesperson. "Yet during the same time, Congress passed more than a dozen laws that increased the FDA's mandated workload. So we were getting less money to do more work."

But changes are on the horizon. Congress recently permitted the FDA to levy users' fees and require drug companies to ante up $75 million a year, which will allow the agency to hire 620 new drug reviewers over the next 5 years. In exchange, the agency has pledged to cut drug-approval time from more than two years to 12 months—which will save the pharmaceutical industry millions. The FDA is performing more intensive audits of drug tests. To make it easier for manufacturers and health professionals to report problems, the FDA also launched Medwatch, a postapproval surveillance program.

Commissioner Kessler is also requesting that Congress give the FDA more enforcement powers, enabling the agency to seize corporate documents or pull drugs from the market and to replace the honor system with a network of federally supported drug testers who have no ties to drug companies. "The control of testing should not be in the hands of industry," says Wolfe. "It is an impossible conflict of interest that has been abused so many times."

The more prestigious medical publications, like the *Journal of the American Medical Association* and the *New England Journal of Medicine*, now detail researchers' financial ties in order to alert readers to any possible bias. Many universities have adopted strict guidelines requiring scientists to disclose all financial arrangements, including stock holdings and sources of outside income. FDA and NIH officials are pressing for the adoption of similar federal regulations.

In the wake of the Scripps-Sandoz contract, the NIH has convened a task force to formulate more stringent rules for these collaborative agreements. Lawmakers like Representative Ron Wyden and Senator David Pryor are also probing drug profiteering and the alliances between academia and industry. "What really astounded us was that Scripps could make deals without the consent of its principal funder, the NIH," says Steve Jennings, staff director of the Congressional subcommittee Ron Wyden chairs. "We're pushing for more disclosure. A little sunshine can be a great disinfectant."

But perhaps the best hope for the future rests with the vast majority of scientists who haven't forgotten that the goal of biomedical research is to heal the sick and prevent disease—not line their own pockets. Like Manuel Patarroyo, the Colombian immunologist who formulated a malaria vaccine. Last May, rather than getting entangled in lengthy licensing negotiations that could delay distribution of this life-saving vaccine, Patarroyo donated the patent rights—which could be worth millions—to the United Nations World Health Organization. His gesture, he said, was "a gift to mankind from the Colombian people." Not everyone however appreciated his gesture. Since announcing his intention to give away the vaccine, Patarroyo has received death threats. Unabashed, he continues to work on a vaccine for tuberculosis which he hopes will be available this year. ∞

SOUL SEARCHING WITH FRANCIS CRICK

Article by Daniel Voll • Photograph by Alan Weisskopf

The Nobel laureate who 40 years ago codiscovered the double-helix structure of DNA—the master molecule that contains the genetic code—is in his office overlooking the Pacific Ocean at the Salk Institute in La Jolla California Francis Crick is studying a postcard reproduction of William Blake's famous etching of Isaac Newton in which the great scientist is depicted naked, sitting in a cleft of rock Newton is bent with his compass in hand, trying—rationally—to decipher the mysteries of our universe

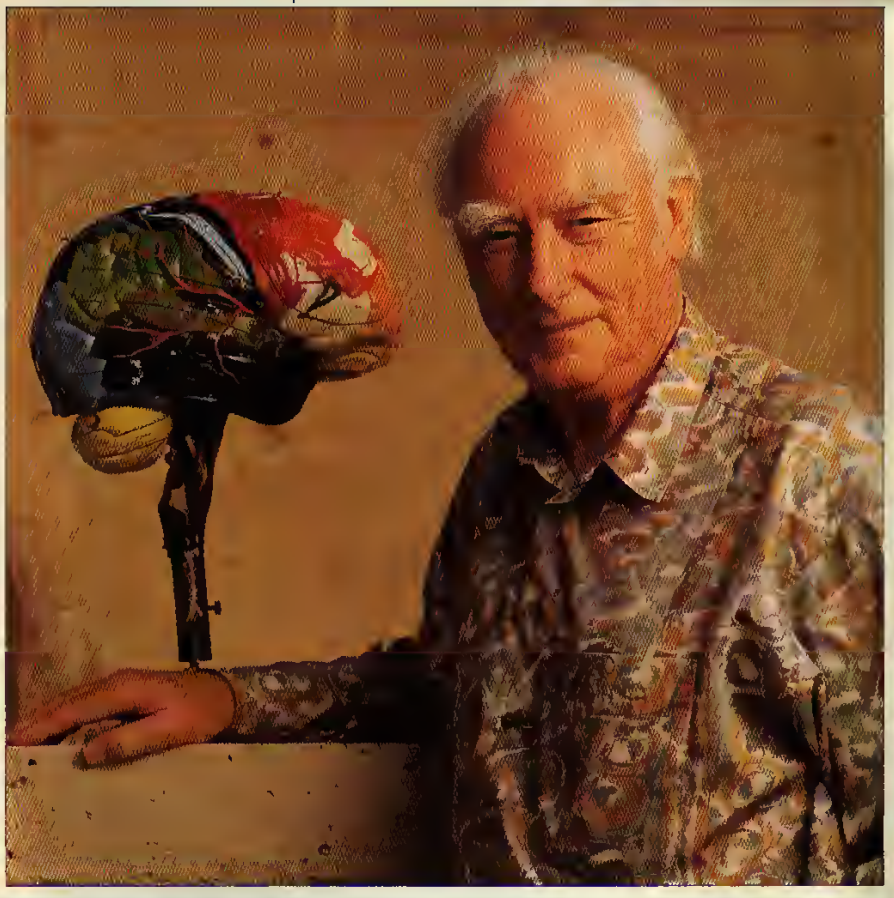
It was Blake the eighteenth-century poet and artist who warned that scientists in trying to decipher that which should remain indecipherable would "turn that which is Soul & Life into a Mill or Machine "

If Blake were alive today it seems a fair bet that Crick, and his new book *The Astonishing Hypothesis The Scientific Search for the Soul*, would surely provoke his ire In the book, Crick now 77 baldly sets out to discover whether what we commonly regard as soul or consciousness *is* actually a machine a neural machine And he implores the scientific community to tackle "the experimental study of consciousness and its relationship, if any, to the hypothetical immortal soul "

Crick's "astonishing hypothesis" declares that all of our interior states joys and sorrows, our memories and ambitions, even our personal identity and the cherished notion of free will are "no more than the behavior of a vast assembly of nerve cells " And with an audacity that Blake would have found heretical, Crick also claims to have located the seat of free will *inside* the brain

The desire to map what we call consciousness—what Crick also calls awareness—is not new But with the publication of his book Crick one of the fiercest reductionists in science has joined one of the hottest scientific debates of the decade. And his views he admits are a "head-on contradiction to the religious beliefs of billions of human beings alive today "

Crick comes to the consciousness wars armed of course with impressive



ALL OF OUR INTERIOR STATES—OUR FEELINGS OF JOY AND SOR ROW—ARE NO MORE THAN A VAST ASSEMBLY OF NERVE CELLS.

credentials However at the age of 31, when Crick, having spent the war years designing mines to blow up German merchant ships, took stock of his scientific credentials he found himself with a not-very good degree, redeemed somewhat by his achievements at the Admiralty 'No published papers at all,' he says

Determined to get work in England s postwar science boom he applied his "gossip test' to his own life Crick's gossip test says that the things you are talking and thinking about, you should go to work on The two subjects which he settled on in 1947 for his life s work touched on problems which in many circles seemed beyond the power of science to explain. "What attracted me to them was that each contained a major mystery—the mystery of life and the mystery of consciousness I wanted to know what in scientific terms those mysteries were ' Six years later he and James Watson had discovered the structure of DNA widely regarded as the most important biological discovery of the twentieth century earning them both a share of the prestigious Nobel Prize in medicine Fifteen years ago after arriving at the Salk Institute Crick turned his attention to the study of the second subject which he had chosen to investigate in 1947 the mystery of consciousness

What is the neural basis of consciousness?' he asks "That s the problem Obviously it's very mysterious " But people have forgotten, Crick reminds us, how mysterious the nature of genes appeared as late as 1943 Molecular biology at the time was considered a sloppy field The phrase Watson uses is intellectual chaos That is exactly the state of our ideas of the brain—intellectual chaos Lots of ideas rumbling around but nothing very clear People arguing about things that will probably turn out to be pretty fatuous eventually—it's just chaotic '

To Crick the key to understanding the mystery we call the soul does not lie in religion philosophy, or psychology, but in *neurons* Most current ideas about the brain he argues will not survive a detailed understanding of how it works the idea of a soul or mind separate from the brain and not penetrable by our known scientific laws is probably an outdated myth he says Looked at in the perspective of human history, he argues the main object of scientific research on the brain is not merely to understand and cure what may afflict us but "to grasp the nature of the human soul " Whether this term is metaphorical or literal is exactly what Crick is trying to discover

Unlike dualists such as neuroscientist Sir John Eccles who believe in the 'ghost in the machine,' Crick doubts whether there is any need for a spiritual concept of a soul to explain behavior Religion he claims is based on evidence which by scientific standards is so flimsy that only an act of blind faith makes it acceptable In fact, he suggests raising his white, prominent eyebrows that give him a devilish air "If the members of a church really believe in a life after death why do they not conduct sound experiments to establish it?"

The only way to understand what we regard as the soul Crick argues is to understand how nerve cells in the brain behave and interact But with 100,000 neurons beneath every square millimeter of the brain s cortical sheet and with the human cortex containing some tens of billions of neurons—comparable to all the stars in our galaxy—how does Crick suggest scientists go about this?

> "IN 1943, MOLECULAR BIOLOGY WAS CONSIDERED A SLOPPY FIELD THE PHRASE WATSON USES IS 'INTELLECTUAL CHAOS.' THAT IS EXACTLY THE STATE OF BRAIN RESEARCH—LOTS OF IDEAS RUMBLING ABOUT BUT NOTHING VERY CLEAR "

Experimentation on the living human brain is limited by ethical considerations 'Most people do not object to an experimenter fixing electrodes to their scalp in order to study their brain waves " Crick says but they do object to having a portion of their skull removed even temporarily, so that electrodes can be stuck directly into living brain tissue " Crick suggests an alternative strategy which seems at first glance deceptively simple If you want to learn how consciousness works concentrate your research on the visual system—on how we see That our eyes are the windows to our soul is not just an aphorism to Crick

Visual awareness is an example of consciousness," Crick says, and as if to underscore his point a yellow-and-blue hang glider drifts into view outside his office window, swooping and diving above the Pacific He leans forward • 'We have a very vivid picture of the world. The question is how that is produced in the brain

Visual perception combines attention with short-term memory, but by standards of exact sciences Crick points out we don t know how our brains produce the visual awareness that we take so much for granted We can glimpse fragments of the processes involved—the way the eye responds to light—but we lack both the detailed information and the ideas to answer the most simple questions How do we see color? What is happening when we recall the image of a familiar face?

Although the main function of the visual system is to perceive objects and events around us the information available to our eyes ' is not sufficient by itself to provide the brain with its unique interpretation of the visual world In a recent special issue of *Scientific American* devoted to the mind and brain Crick and his collaborator for the past several years Christof Koch a computation and neural-systems specialist from the California Institute of Technology speculated on how the brain uses past experience—"either its own or that of our distant ancestors which is embedded in our genes"—to help interpret the information coming into our eyes . Your eyes—or we will say—your brain ' they wrote, "must find the best interpretation of visual symbols in the light of its past experience Thus, what the brain has to build up is a many-level interpretation of the visual scene, usually in terms of objects and events and their meaning to us.'

Crick suspects that visual awareness—and perhaps consciousness itself—involves the cortex and also the thalamus, which he calls the "organ of attention All senses (except smell) have to pass through the thalamus the gateway to the cortex Consciousness, Crick says depends crucially on thalamic connections with the cortex

The cortex consists of two separate sheets of nerve cells, one on each side of the head These cortical sheets are in Crick s words, "about the size of a man s handkerchief" and are folded so as to fit on either side of the skull Often referred to as gray matter the cortex consists mainly of neurons or nerve cells which are electrical and chemical signalers

The job of a neuron is to receive information, usually in the form of electrical pulses from other neurons Some of these connections are local—they only go a fraction of a millimeter or at

Astonishing Hypothesis: 'Let's face it, at this point my hypothesis is just that—a hypothesis. But then so is religion. I don't know the answer. It may turn out that the point of view I take will be shown to be wrong. That's one of the risks. Your idea may be wrong. Whatever is discovered about the brain in the future, however, won't be very supportive of people's religious beliefs.'

Society: 'We are an evolving society, and science is the catalyst for better or worse, and we have to constantly adapt. How are people going to relate to all this new knowledge? It's difficult enough for doctors to keep up with the advances in medicine. The nature of whatever we are trained to do is going to change in our lifetime—whether you're a mechanic or a doctor.'

Theory: "Keep your ideas as fluid as you can, concentrate on key questions. Otherwise, it gets too chaotic. It's no use going into an area with a fixed set of ideas. You have to keep a constant state of vigilance. It's part of your stock in trade not only to have ideas, but to have a continual assessment of how much you think each one is worth. It's like investing. You have to adjust your portfolio, and you can't expect all your investments to pay off.'

Dogma: "Obviously a disbelief in religious dogma was a very deep part of my nature. I had always appreciated that the scientific way of life, like the religious one, needed a high degree of dedication and that one could not be dedicated to anything unless one believes in it passionately."

The Prize Discovery, 1953: 'Talk is mainly what Watson and I did. You might say we didn't do anything but talk. Oh, we did a little model building toward the end, but mainly it was discussing how you go about the problem. Certainly in crystallography we learned from others, but often we taught ourselves, not always correctly, of course. Had Jim Watson been killed by a tennis ball, I'm not sure I would have discovered DNA alone. When I was younger, I was indefatigable. I remember people like Watson telling me to shut up.'

Christmas: 'I was tired of Christmas trees, so my son Michael made a giraffe about six feet high, with chicken wire and papier-mâché, and then we painted it. Instead of Christmas, I think our culture should celebrate Newton's birthday, which is also the twenty-fifth of December. If we're going to celebrate the winter solstice—which is what Christmas is—we might just as well tie it to somebody modern rather than somebody. Not everybody enjoys these myths.'

Brain: "There is one fact about the brain that is so obvious, it is seldom mentioned. It is attached to the rest of the body and communicates with it."

Postmodern World: "When I go to visit my grandchildren, I cannot understand what they are saying. My son produces computer games, and one of the titles is *Dudes with Attitude*. I had no idea what that meant! There used to be suffragettes; now there are feminists. I feel rather like one of those English judges who asks questions for clarification—you know, 'What's a dude?'"

Fundamentalism: 'The age of the earth is now established beyond any reasonable doubt as very great, yet in the United States millions of people still stoutly defend the naive view that it is relatively short, an opinion deduced from reading the Bible too literally. They usually deny that animals and plants have evolved and changed radically over long periods, though this is equally well established. This gives me little confidence that what they have to say about the process of natural selection is likely to be unbiased, since their views are predetermined by a slavish adherence to religious dogma.'

The Neurobiologist: "I don't think there was a general expectation that I would achieve very much in neurobiology. I think the general reaction was, 'Who is this old guy coming into our field?'"

Scientists: "In our culture, the scientist is hero and villain. People don't say, 'Literary people say "To be or not to be."' But they do say, 'Scientists say....' Scientists are all clumped together. We are not all cold, emotionless people in lab coats—that's the stereotypical view, and I'm astonished how much it persists."

Einstein: "Theory is as much art as science. Think of Einstein as an adolescent asking himself whether a light wave would seem stationary if one ran abreast of it. From that innocent question arose, years later, his theory of relativity."

Psychologists: 'One might have expected that the major effort of psychologists and neuroscientists would be directed toward understanding consciousness. This is far from the case. The majority of modern psychologists omit any mention of the problem, although much of what they study enters into consciousness. Most modern neuroscientists ignore it.'

The War Analogy: "In science, thinking in terms of military operations is quite useful—though people don't like to do this. The confusion of the scientific search is like the confusion of a battle. A country suddenly collapses and the whole arrangement changes. That's very much how the development of scientific research goes. Like science, everyone is supposed to cooperate, but rivalries surface. Then you get the temperaments of generals—many of them are prima donnas, like a lot of leading scientists. And, of course, there are the ethical questions: 'Why are we fighting this war?'"

Responsibility: "Scientists are a lot more socially responsible than most people. For example, when the issue of

CONTINUED ON PAGE 82

CRICK TAKES

"HAD JAMES WATSON BEEN KILLED BY A TENNIS BALL, I'M NOT CERTAIN I WOULD HAVE DISCOVERED DNA ALONE."

best, a few millimeters—but others leave the cortical sheet and travel some distance before entering another part of the sheet or going elsewhere, for example to the thalamus or the spinal cord. These longer connections are often covered by a fatty sheath, which enables the signal to travel faster and which gives this tissue a somewhat white, glistening appearance. Forty percent of our brain is made of this "white matter," and this is crucial to Crick's notion of just how much communication there is within the brain.

This communication system handles both explicit and implicit representations of the visual world. The explicit representation is symbolized without further extensive processing. An implicit one contains information but needs further processing to make it explicit. Crick hypothesizes that our brain must produce an explicit multilevel symbolic interpretation of the visual scene in order for us to "see" it.

Some people, Crick says, may find it difficult to accept that what we see is only a symbolic interpretation of the world—it all seems so like the "real thing." Unlike, for example, the Hindu belief that what we see is "maya"—or illusion, and that nothing we see actually exists, Crick argues that the world does exist but that "we have no direct knowledge of objects in the world."

And though Crick believes that visual consciousness is, in part at least, about the very route information takes through the brain, and most importantly, where it gets to and which neurons are firing, he confesses: "I myself find it difficult at times to avoid the idea of the homunculus—a little man in our head directing it all. One slips into it so easily." And if all this sounds a bit complex, Crick sums it up neatly, grinning: "As Lewis Carroll's Alice might have phrased it, 'You're nothing but a pack of neurons!'"

Some of Crick's colleagues at the Salk Institute may have wondered if Crick himself had gone through the looking glass last year when he bounded into an afternoon faculty tea announcing that he'd located the seat of free will in the human brain. Crick describes free will as the "feeling that one is free to make personal choices."

What prompted this announcement was an account he'd read by his colleague Antonio Damasio, a well-known neurologist, of a woman who, prior to recovery from brain damage, had suffered a loss of will. The importance of studying cases of brain damage, Crick says, is that they show which parts of the brain are necessary for functions such as consciousness or free will. For a month, the woman appeared unresponsive, lying in bed but with an alert expression. She could follow people with her eyes but did not speak spontaneously. She gave no verbal reply to any questions put to her, though she appeared to understand, because of the way she nodded in reply. When the woman recovered, she said she had not been upset by her inability to communicate even though she'd been able to follow conversations; she hadn't talked because she had had "nothing to say." Her mind had been "empty."

Crick was intrigued. "I immediately thought she'd lost her will and wondered where the damage was." The damage turned out to be in or near the anterior cingulate sulcus, a region Crick was delighted to learn receives many inputs from higher sensory regions and, as he had guessed, is at or near the higher levels of the motor system where movements are planned. "Take the complex act of swimming," he says. "How does the brain plan it all?" According to Crick, one of the functions of visual awareness is to plan movements. "What is the connection between seeing something and the part of the brain that plans and exe-

cutes movements? he asks. "Clearly it's about neurons firing."

Reading more case histories, Crick stumbled upon the "alien hand" syndrome, a kind of brain damage in which one of the patient's hands makes simple movements, which the patient denies he or she willed. A patient's left hand, for example, might spontaneously grasp some object put near it, though the patient denies that he or she is responsible for the movement. In some cases, the patient is unable to get the hand to let go and has to use the right hand to detach the left hand from the object. One patient found that he couldn't make his "alien" hand let go by his own willpower, but he could make it release its grasp by saying "Let go!" in a loud voice. These cases fascinated Crick, especially when he learned that the damage was again in or near the anterior cingulate sulcus, substantiating his theory that this is the seat of free will.

Some scientists have speculated that the seat of consciousness is located in the hippocampus, a small, seahorse-shaped part of the brain that stores for a few weeks or more the codes for new long-term episodic memories before the information is conveyed to the neocortex. Crick disagrees, citing the case of a patient who had his hippocampus system on both sides knocked out after an injury. While the patient couldn't remember anything that happened more than a minute before, he could see and talk perfectly well, which convinced Crick to rule out the hippocampal system as the seat of consciousness.

The trouble with speculation about consciousness, Crick admits, is that the damage is rather crude. If we could make nicely controlled brain damage on people, we could find out how the brain works, but we're not allowed to do that—quite rightly."

A plastic model of the human brain is on a shelf nearby. When I asked Crick to show me the location of free will, he cautioned, back-pedaling a bit, "Now, this is still highly speculative." From the walls of his office, portraits of Einstein and Darwin stare down at us. He cradles the brain in his hands and says, rubbing the anterior cingulate sulcus with his forefinger, "Free will is most likely located here, but we think there probably is a frontal component as well. It certainly isn't at the back of the brain." He lays his thumb against the primary motor area. "Yes, it's definitely near here, but it may depend on interactions with this frontal region."

When reminded of the widespread belief in the existence of the soul separate from the body, he pauses, looks up from the model, and says flatly, with perfect timing, "Surely, if almost everyone believed it, that is in itself prima facie evidence for it. But then, some 4,000 years ago, almost everyone believed the earth was flat."

Smiling now, Crick reminds me that his friend Leslie Orgel has teasingly suggested that there may be a religious peptide in the brain. Seeing that this speculation is going on the record, he settles back in his chair. "Oh, I don't think there is quite a religious peptide, but there is probably something in people's brains that makes some of them more susceptible to religion than others. Whether it's inherited or not, or whether it's something produced by early training, is like the question about homosexuality. There's no reason why all that shouldn't be found out."

Eight paintings of nude women line Crick's office at his quiet, airy home in La Jolla. They were painted by his wife, Odile, whose studio adjoins his office. It was Odile's drawing of a double helix that accompanied the now-legendary 700-word article in *Nature*, the British science magazine, announc-

CONTINUED ON PAGE 80

THEY HAD LEFT THE CREATURE ALONE FOR FIFTY YEARS. THERE IN ITS VAST SHIP OUTSIDE THE TRADE LANES ITS ENGINES WERE STILL.

ASSASSIN

PAINTING BY H.R. GIGER

"A man is not a woman. . ."

—Apache saying

They knew I did not want to be the one to kill it. They knew how difficult it would be for me to do it, and yet I was the one they sent, persuading me as only the Gongaware Council of the First Worlds could have.

"You understand it better than anyone," Prihoda Delp, Council Chair, insisted in chambers. "So much of what the creature is, is in you as well, Rau Goni. You know this and we know this and the creature knows it too. We should never have let matters develop this far, but we did, and now you—more than any engineered mercenary or conscripted soldier or machine we might send—have the best chance to end it."

They knew I could not refuse. They did not bother to offer money or starships or livable moons. These I *could* have refused. They offered instead a question: Is it Light or Darkness you believe in, Rau Goni? Which is your destiny—to end it, or at least try—or, by refusing to go, to keep the Darkness alive?

They knew about my family. They knew about my father, but then who did not? They knew about me—even the time, long ago, when I nearly died on the planet we call The Hand. They knew about my mother's death and my sister's, and the day my father left our world to become what he would become. A council like the Gongaware always learns what it needs to learn to do what it must do.

They did not ask my brothers to go and I know why.

They had left the creature alone for fifty years. There in its vast ship outside the trade lanes of the First Worlds it had kept its engines still—communicating with no one—

FICTION BY BRUCE McALLISTER

and so they had left it alone After all, it had not been a creature at first, it had been a *man*—a man intent on changing himself, but a man nevertheless A man with the wealth to purchase such a ship and to outfit it and the status to demand that he be left alone He was after all Giman Goni—Master Mapper of Hamusek, the genius who had made Change itself possible who had fathered, by his theoretical models and technological applications the unique human designs of ten billion citizens on over three hundred worlds who had become wealthy in the process, and who had, in the end known tragedy

The creature rarely stirred in the bowels of the ship and there had been times when the Council wondered if it were even alive Yet bioscanners had showed that it was and now those scanners, passing as close to the ship's hull as they dared, were reporting how the creature was moving again—moving through the endless corridors of the ship At this point in time given what the creature had become its sanity could not be trusted I knew this and the Council knew I knew

Like all humans today, I could change my body if I wished Yet I do not I am in the minority Even Prihoda Delp has been Changed—a little taller she confides eyes both stronger and more compassionate than before lungs now able to breathe successfully the atmospheres of the five worlds which she must in her official duties visit most frequently

Perhaps I have chosen to remain the way I am because I am Hamusek because the Hamusek way of thinking values pride, the dignity of acceptance and a willingness to work with what one has been given by birth without complaint—though that same way of thinking I know produced my father his Maps and Change itself But it was a vision of a human *community* vast as a galaxy that led him to these things This is what I tell myself

I have told the Council that after I have finished—if I succeed—I wish to return to The Hand to the graves of my mother and sister That I wish to live on that odd planet for a year and that I wish only to have my expenses paid for I do not wish any legacy from him

They have agreed Sometimes I think they may even understand "Why did he bury them *there* Rau Goni?" Prihoda Delp has asked me more than once Why did he bury them there, she means, by the dry seas with their endless sand, on a world where the fish must glide through the air to find water, where mud and molten rock seep through the thin crust and earthquakes make new mountain ranges even in one's lifetime My mother had never visited that world Why *there* instead of Hamusek?

I am only seventy years old, while a Council member is two or three times that I know what I wish, though I do not have the wisdom yet to know why I wish it So I do what I do, trusting that there is wisdom

The clearest image they have—twenty years old a lucky bioscan through the thinnest section of the hull—shows a creature with two heads, each facing the other each with what we imagine is the ability to speak One face is dark—like space itself The other, white as a moon The hair that grows from both skulls turns, at the waist, into scales—the long scales of a serpent from our oldest, deepest dreams The blue-black hair is dark enough that we imagine it shines, as it does on so many Hamusek The long tail whose purpose eludes all who have studied it is as thick around as the creature's trunk, and living things that can only be the creature's children (each no larger than my hand) cling to its tail their legs limp their hairy heads buried in the pores of its chitinous hide, perhaps feeding, perhaps asleep

The long, articulated fingers on the creature's two hands end in talons made of metal—the same metal that shines on the two foreheads and leads by wires, to the walls

The image is grainy but experts have studied its shadows for years Attempts to obtain other images have failed The creature has not ventured so near the hull again, remaining instead deep within the ship, making the ship hum in ways only a living thing could and now at last, starting to move again through the endless corridors

No creature is simply an image *There is another light*, as our father used to say *The light* within—*without which no living thing has meaning*

Or the darkness *within*, I would say to him now

EGYPTIAN

ART TRANSCENDING TIME.

♦

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The image is motionless on the Council's screen. None of the council members speak. I close my eyes and see a darkness. In the darkness I see a light moving like a moth in moonlight at Hanabata's Pond when I was a child, my father's voice beside me sometimes speaking sometimes singing, sometimes silent. The light moves fitfully through the darkness on a path only it understands as it seeks a greater light and failing accepts the darkness.

"No living thing," my father says to me in the night—the northern winds quiet, his eyes on me as I stare toward the mountain ranges where even now few people live—"can look for the light forever, not find it, and not be changed, Rau."

I keep my eyes closed. I see the moth begin to transform. I see its abdomen lengthen, become a tail snaking into the night—dark as night—and the head split slowly in two until the two faces turn to gaze at each other (because after all, there is nothing in the darkness to see except ourselves).

I open my eyes, but still see it. The moth gives birth to children who will never leave it, who will stay forever, sucking blood from its tail . . . because after all, in the darkness there is nothing for us to eat except ourselves. And my father says:

"If we look long enough and do not find it, it does not exist—or that is what we believe, and by believing it, make it so."

He had made his discoveries by then, built his "changeable maps" of human genes and found his Light. My mother and sister were still alive and yet this was how he talked to me that night, as if he knew what might happen.

I was thirteen. He was fifty. I did not have the words to argue with him, though I knew I should.

The ship the creature inhabits—the ship now so much a part of it—is a third-generation 300-kiloton lodeship, the kind used in the era of raw-ore mining five centuries ago when such ships needed armament and the starlock system did not exist. My father bought it in "deadspace mothballs," as they say, just outside the orbit of The Singing, fifth planet of the star called Hallock. There he kept it, orbiting the red giant and soon forgotten by the human children of that system. But the Council did not forget. They knew what a man like Gon—that brain, that vision—might be capable of . . . especially if he were insane. They knew, too, what a ship like that would be capable of—if he kept it operable or somehow managed to improve it.

The ship is three times its original size now and no longer looks like a ship. Like its lone inhabitant, it has been changing itself, adding to its mass, reconceiving its shape—all at the creature's whim, all with metal it had obtained in the first decade by purchasing other mothballed ships and in later years by mining with its motile machines the thin belt of asteroids just inside Hallock's sixth world. The purchase of dead ships was easier for it, I am sure, but the corporations and private owners, at the request of the Council, stopped selling at last, and mining one's own metal on free territory does offer privacy. Do the citizens of The Singing and The Dancing . . . I sometimes wonder . . . have any idea what that man has become?

Two-kilometer-long alloy extrusions that make no sense to those who have studied them point toward Hallock itself, while a third extrusion, not unlike a tail, points toward the darkness of space—the space between stars—as if to say: *Do not be fooled, even a star is nothing.*

"THE SHIP . . . NO LONGER LOOKS LIKE A SHIP. LIKE ITS LONE INHABITANT, IT HAS BEEN CHANGING ITSELF, ADDING TO ITS MASS, RECONCEIVING ITS SHAPE . . . ALL AT THE CREATURE'S WHIM."

I remember him saying more than once:

The things we make, Rau . . . we become.

The ship's engines were simple at first. Sub-lock sequential tokomaks. But they too have changed. Those hired by the Council to study the sounds at a safe distance do not understand what they hear at the heart of the ship, and even now, in Council chambers, I can hear them argue. Is the creature *itself* now the engine? Is the creature's organic heart now the heart of the ship, the rhythms we hear the rhythms any ship would make if it had such a heart? Has the creature built an organic analog for the ship—for its body and its brain? Has he been laughing at everyone, making of himself—and the ship—but a terrible joke? Is this the greatest *art* any human being has ever made? Or is this metal-and-flesh thing he has spent half a century shaping simply what he believes *he* is in the eyes of God?

Even the weapons are different. The standard beams that a lodeship might need in more lawless times to defend itself are gone. In their place, on the hull that is no longer a hull—that glitters with a moving mosaic of alloy plates not unlike scales—there are photon weapons that appear powerful enough to annihilate entire ships, though the energy to do it would drain even a ship like this. There are weapons that appear to be neutron-casters only—weapons made to kill living things without destroying precious ships and cities. There are even weapons pointed inward, at the heart of the ship itself, unmovable. "What are these for?" the Council asks me and I do not answer. Do I tell them what I have dreamed—that the weapons are connected, that if one is fired, all will fire?

"I do not think they are weapons," I say at last. I do not say, "I believe they are voices waiting to scream." I do not say, "They are a simple equation between life and death. To kill is to be killed."

Only a Hamusek—and one who has seen a light extinguished in the night—would know what I mean.

When he would sing to me, it would be the oldest songs on Hamusek, the ones our people brought with them to our world five hundred years ago, the ones we have sung even as we have changed to fit our world, even as we have remained the same, true to ourselves. We are, after all, tall and dark-skinned, with blue-black hair—descendants of the families of a small corporation called "New India," whose employees specialized in exploratory support for Terra-type or Terraformed worlds—in other words, scouts, trackers, surveyors, clearers, outposters, and "wilderness sensitives." Whether we came from the dark-skinned Caucasian people of the Terran state of India or from the Asiatic "Indians" of Terra's North America, we could not be sure. There were legends—the kind my father loved—but legends hide the truth. We could, of course—in the strange ways of history—have come from both.

My father *knew*. In the end, after the tragedy, my father's Maps certainly showed him. But in the daily lives of Hamusek's children, the genetic truth has never mattered. We have characteristics of both peoples. They have sensed us well. The legends live on, and we sing the songs.

Like all young children in the towns and cities, I had grown up hearing their melodies their feelings without understanding their strange words As I got older I began to ask what the words meant, and as I learned, I explained them to my younger brothers Toth and Gram Our father would sing the song first in the old language the way he would for my mother who loved his voice and then he would sing it again, in words *we* could understand

He would sing to us on the banks of Hanabata's Pond in the cool night, on the streets of Seventh City, in his office at the polytechnic university when we visited him He would sing of things that did not feel like Hamusek, because indeed they had once belonged to another world

The song I remember best was his favorite He would begin by saying solemnly This is a song about a love that even death could not extinguish In this song a woman's lover drowns and comes back to her as a ghost When she sees him she says to him—

And he would sing

Assunuth bi hoddentin ashi inzayu?
Bi hoddentin ashi tahay-o?
Bi hoddentin ashi ik'a-eshkin chiaona ay
Yandustan benanoyett chi na?

And then he would sing it in words we understood

Oh where is your soft bed of skins, my love?
Where is your soft warrior's sheet?
And where is the fair one who watches over you
As you lie in your long dreamless sleep?

He would stop and say Her lover looks at her, as pale as death, and answers " And then he would sing

The sea is my soft bed of skins, my love
The sand is my soft warrior's sheet
And the long hungry worms they do feed off of me
As I lie every night in the deep

He had a good, strong voice (as our mother always said) but he would not share it at festivals or town meetings In this way he was not Hamusek at all He was alone, and he chose to be The songs I know now were for him—so that he could perhaps, feel the feelings lost to him as he made his Maps and dreamt of a Truth so bright that it blinded him The songs were for us only as they revealed him to us We did not sing them with him He never taught us

And even they—these songs—were not enough to put a moon in the sky for him to save him with their light

The ship that carries me to the creature is small and unassuming I am its one inhabitant *Who I am*—my name, my biography in a variety of languages, my body as twelve different scans have rendered it, and my own genetic Map—has been broadcast for thirty interdays in the direction of the creature's ship in the broadest arc possible, on the chance that the creature (or its ship) might be listening and that my identity might somehow matter

If it hears the transmission, it does not act it does not fire at my craft

It lets me come to it as a father would

I do not know what atmosphere it breathes If it breathes anymore with lungs I mean—gasses in its blood I carry my own—two days' worth—in lightweight tanks on my back, praying that the creature's ship will ask no more of me than one or two gravities and that it still breathes what I breathe I carry two weapons of my own choice a small, worn laser-aimed projectile-rifle of the kind every Hamusek father gives his son at thirteen and a long blade of volcanic glass from The Hand, seventh planet of our star a blade I made myself on that world half a century ago The Council did not understand these choices *Why not a cyclic-grenader? An energy suit? An arm launched missile? You would have so much less to fear, would you not Rau Goni?* They meant well—when has the Council not meant well?—but intentions are not understanding

I chose my weapons to show him I understood

I do not wear an armored suit of the kind soldiers wear I do not wear an explorers atmosphere suit I wear the clothes I wore on Hamusek patterned shirt (in the "married tartans" of our family) and the plain durable pants we wore to school each day and still wore when my father returned home from the university eyes distant as we pleaded with him to tell us about his work, about the Maps what it might mean Women who looked like cats and were ferocious Men who looked like serpents and were kind Children who could jump across rivers with boulders in their arms! Eyes that could see living creatures at the heart of a star!

In the end he would indeed tell us—his three sons and his daughter on the floor before him—what it meant how human beings would with the right machines be able to alter themselves at any point in their lives and as they did know the *consequences* of every change they made in themselves Would lungs that let you breathe the air of ten worlds shorten your life in the end or lengthen it? Would growing talons keep you from seeing in the night? Would eyes as pretty as the rainbow fish of Dajonica make the grain crops of Hamusek poisonous to you? The Maps would be able to tell you

"There have never been *maps* like these" he would say

It was like a legend—a Hamusek tall tale—and we would listen to the story with wide eyes How simple the idea of the Maps was how the idea had come to him one day while he was singing—*singing* how he wouldn't have been able to make them—in their exquisite detail—without the great computers on Tar and Rasi and the Council's vast station in orbit around the twin stars of Goatcher How he had spoken with those computers through satellites and relays and starlock communiques for five Hamusek years, had come to know them like friends even felt affection for them Sometimes he would even dream at night of meeting them, of meeting those machines and finding human beings not machines at all

How he had given these computers his model—the 'flowing paradigm,' the "open finity'—for the entire Map series and had asked them to generate the first Map using the vast genetic, environmental and social data of their memories to give flesh to his 'paradigmatic paradox

How they had done what he asked and made the second Map, too and the third and how, even now, as he spoke to us that evening, they were helping him design the *machines* he would

"WOULD LUNGS THAT LET YOU BREATHE THE AIR OF TEN WORLDS SHORTEN YOUR LIFE IN THE END OR LENGTHEN IT? WOULD GROWING TALONS KEEP YOU FROM SEEING IN THE NIGHT?"

need to use the Maps to let the Changing begin at last

We listened even when we did not understand for it was a story about *hope* and that part was always clear Our mother would listen too and in the end to say good night, we would touch our foreheads to his to hers—as sons and daughters of Hamusek always did—and would go to bed happy to have had him to ourselves for a time

Everything was the Light in those days though none of us could see because of it

I have with me two small, convenient "devices" to detect biomass and motion-in-darkness The Council offered and I accepted They believe they know how difficult my journey to him will be, how fraught with danger they imagine a monster that wishes to consume me, and yet if that is what awaits me, it is not my father I go to meet Or a battle between a man who has lost all sanity and his son—flesh against flesh bone against bone but if that is the struggle to come, it is not my father I am going to meet I take the small, convenient devices simply because they may help me find him I may not need them We Hamusek see well in the dark, given the long nights of our planet, our breeding for five centuries, the genetic inclinations of those humans who first came to our world

I take the devices I take as well a small container—one that holds *nothing*

The spacecraft that brought me to the great ship leaves and I stand in the silence of the lock listening I cannot hear the little ship moving away I cannot feel its vibrations through the throbbing of this massive ship but I know it will station itself just beyond the range of the ship's odd weapons and wait for a signal from me If the signal comes it will return to this same lock and accept one human being Rau Goni If, after seventy-two ship hours the signal has not come the little craft will report to the Council and the Council will send what armament it feels is necessary to end it

I pray that I do not stumble, that I do not fall unconscious I pray that my tanks will work I pray that there will not be an accident to set the end in motion

According to those who sent me there are four thousand kilometers of corridors in this ship That does not matter Whatever direction I move I will know whether I am moving closer to him or farther away A son—or daughter—of Hamusek always knows It is in the Maps in the genes of one 'India' or another As psychologists have shown since the Changing began, the first bonds of mother and child, or father and child do not disappear even when the bodies Change

There is I remember a legend on Hamusek about a father who dies and leaves his body but calls to his seven sons until the sons unable to bear it any longer forsake their flesh to be with him It was that very legend—told to me by my father—which took me to The Hand fifty years ago to my mother's and sister's grave there, to death itself

I have always wondered what the stories of a people—their legends tall tales and songs—do to them That is, what power these stories have to shape human lives by *their* image, and the people's own

My father has wondered, too I am sure

The corridors are dark I remove my tanks slowly, take a tentative breath It is *air*—the air of Hamusek stale but familiar dusty yet full of trees

In this darkness I become what I was as a child in the forests there what all Hamusek are—in their wilderness My nostrils flare I smell a hundred different things The blood in my skull roars

CONTINUED ON PAGE 84

the record cold continues unabated

TOM SEVER

THE MAN WITH EYES IN THE SKY: A NASA ARCHAEOLOGIST USES SATELLITES TO DISCOVER THE LOST HISTORIES OF ANCIENT CULTURES

PHOTOGRAPHS BY DAVID MICHAEL KENNEDY

As a teenager at boarding school, he began sneaking outdoors after lights out. "I fell in love with the sky," recalls Tom Sever, now NASA's archaeologist and a remote-sensing expert at the John C. Stennis Space Center in southwest Mississippi, "and I started inventing my own constellations." Two of his night-sky creations—a 1957 Chevy convertible, his first favorite car, and a San Francisco boxcar, like those that passed on a nearby railroad track. "I know the Greek constellations, and I've taught them," says the 45-year-old, "but even today, the most vivid ones in the sky are the ones I first created."

Sever's gift for envisioning new or subtle patterns has served him well. Pursuing his doctorate in anthropology/archaeology at the University of Colorado in the mid Seventies, he studied prehistoric architecture, astronomy, and calender systems. In two summers with project scientists in the Southwest studying Anasazi astronomy, he still

searched for patterns. The work included taking measurements of kiva orientations and other Pueblo building structures and hunting for the solstice and equinox positions that the ancient Anasazi used in their ceremonies.

In a 1977 field trip into the Andes, he worked with Earthwatch Foundation archaeologists to investigate the Quechuan Inca's astronomical ceque lines and architectural alignments outside the town of Cuzco. A system of 41 lines emanates from the Temple of Gold, and along each line are eight shrines called Wakas, which could be, among other things, caves with human bones. After a day's trek at an altitude near 9,000 feet, Sever sat on a mountainside at dusk watching the sun fall behind the Andean high peaks and imagined a satellite flying overhead, its sensors collecting data from the vast mountainous region below.

In the last 15 years, Sever has realized his epiphany in the Andes by developing and refining remote-sensing technology. This includes optical light-gathering sensors that discriminate and identify surface objects by analyzing reflected light, and microwave/radar imaging sensors that can pierce clouds, jungle canopy, sand and soils. Mounted on satellites, space shuttles, airplanes, blimps, tethered balloons, and even truck-drawn sleds, these remote sensors "see" far beyond the narrow range of visible light (the band waves between ultraviolet and infrared frequencies) in the energy spectrum to which the human eye is limited. And Sever plays a central role in choosing just what remote sensors will focus on and what their computer backup will analyze.

FAVORITE CONSTELLATION:
Classical Leo, personal '57 Chevy (a.k.a. Orion)

MOST CHALLENGING JUNGLE:
Peruvian Andes

MOST ADMIRED AUTHOR:
Loren Eisley

RECOMMENDED READING:
Interstellar Migration and the Human Experience by Ben Finney and Eric Jones

MOST REWARDING DISCOVERY TO DATE:
The footpaths of the Arenal, Costa Rica

MOST SUCCESSFUL BANDWIDTH RANGE FOR ARCHAEOLOGY TO DATE:
Thermal infrared

FAVORITE POEM:
Ulysses by Tennyson

QUOTE:
"Remote-sensing technology will prove more important to archaeology and anthropology than carbon-14 dating."

As we spoke in Sever's office at Stennis, NASA's premier rocket test site for 30 years, at one point a steady roar built lasting several minutes. It was another static test firing of the space shuttle main engine, part of the program that surpassed 500,000 seconds of test time in one year alone. Around the rocket-test stand, a variety of remote sensors collected and measured data streams generated from the engine's components, all to produce better and safer rocket engines. This same space-age sensor technology is helping archaeologists detect and record micro amounts of energy, whose pixels they sift and enhance to make the invisible visible, the hidden found. Tom Sever's work is allowing thousands of scientists and researchers to see for the first time.—Neil McAleer

Omni: What were your thoughts about the future of archaeology during that 1977 summer in the Andes?

Sever. After tracking the ancient Inca lines through the mountains for three months, we'd completed only two and a half of 41 lines. I became aware of just how tedious and expensive most field work can be, especially when you're working in demanding environments such as roadless mountain regions. Sitting on that hill, I thought that even if I were to receive my research funding for years to come, I'd never know the answers, because there were 28 *other* sets of 41 lines throughout South America. At that rate, it would take over 100 years to complete the survey. That meant with our current technology, I'd never understand how this ancient Inca calendar system worked. It bothered me a lot—not knowing, and perhaps never knowing. Then it dawned on me that my plight was that of all archaeologists, no matter where they worked. That's when I thought, Could NASA satellite technology be applied successfully to archaeology?

Omni: Once at Stennis, you quickly saw the advantage of airborne sensors?

Sever. The high quality of airborne-sensor data and superior resolution made it the best way to test the application of remote sensing to archaeology and anthropology. Aircraft at this time flew much closer to the ground than satellites, so for sensors mounted on aircraft, the resolution was 5 and 10 meters, versus 80 for satellites. At first there was no funding for archaeology, but I began to win over people working in agriculture, forestry, soil science, wetlands—all of which are relevant to archaeology. They'd then use the instrumentation to solve problems—often the same as archaeologists face.

Much archaeology research focused on site-specific information. Putting information on known, excavated sites into a database, researchers can develop a site profile. Such characteristics as elevation, distance from water, distances between sites or cities, corridors, and transportation routes

can help predict potential archaeological sites

As I began to explore the application of remote sensing, some scientists expressed doubt. Many were skeptical because earlier airborne sensors were similar to a low-powered telescope unable to detect details on Mars or Jupiter. And a satellite sensor's 80-meter resolution would let you see a prehistoric road or wall ruin in the data. Because it hadn't worked earlier, it was hard to convince these scientists it would work this time.

Omni: Where was your first opportunity to prove them wrong?

Sever: Chaco Canyon in northwestern New Mexico, near the Four Corners region. At first I thought about going to more exotic places like Stonehenge or the Pyramids in Egypt, but in the end it was the lab's modest funding that determined our choice. The Chaco Canyon Research Center had done aerial photography and ground survey and had begun a database. If our sensors found prehistoric roads, this would be proof that the technology could work for archaeology. And if we didn't find any roads, that would be an answer too.

We flew the Thermal Infrared Multispectral Scanner [TIMS] for the first time over Chaco in the spring of 1982. It could resolve the ground down to a five-meter square. The TIMS also detects temperature differences to a tenth of a degree centigrade on or near the ground. This enabled it to detect prehistoric roads of Chaco Canyon that date to 900 or 1000 A.D. Later when I stood in Chaco Canyon and looked across the north mesa, holding computer-enhanced images in my hands, I could not see any features with my eyes that were there in the images. That's when the promise of this technology really hit me—how powerful it was, and what it could mean to me and archaeologists everywhere. I walked out and studied the site because I simply could not believe how good this sensor already was.

Omni: Besides the importance of the thermal sensor, what else did you learn in New Mexico?

Sever: In three more flights over Chaco later in the Eighties, we found some 200 miles of a prehistoric roadway system extending south to Navajo Springs, Arizona, and into southeast Utah. Just how much farther this roadway system extends remains unknown. At one time, people believed Chaco Canyon was a center for redistribution. But the extent of the road system puts that theory in doubt. I see Chaco Canyon as a social and religious center. People were coming in, exchanging ideas, practicing ritualistic activity, then returning to whence they came. It explains why we've found so few bodies in Chaco. They'd take their dead home to their respective pueblos.

We discovered parallel road segments, sometimes dual sets, making four roadways that would continue for a while and then merge into a single roadway. The myths chronicle the Pueblo's merging as one people, then separating, then merging again in the future.

Omni: What other sites have you used to develop these sensors?

Sever: We've flown all our sensors over Poverty Point, Louisiana, one of the earliest and most sophisticated archaeological sites in North America. We've built a wonderful database using different types of sensors, optical and radar, from the site, which dates back from 1200 to 1000 B.C. to it's abandonment about 600 B.C. Actively studied and excavated in the Fifties, it has a central plaza surrounded by six concentric ridges, their purpose unknown.

> "WHEN PAYSON SAW THAT ONE OF THE LINES RAN OUT OF A CEMETERY HE WAS EXCAVATING AND LED TO OTHER EXCAVATION SITES, HE WAS CONVINCED I HAD SOMETHING MORE THAN AN ACTIVE IMAGINATION."

In the early Eighties, we used TIMS to detect a linear feature invisible from the ground that ran from the central plaza out across these ridges. It turned out to be a causeway or rampway coming into the site. Lying outside and due east of the plaza is a large bird-effigy mound that was once 110 feet high. These earthworks date about 1000 B.C. That a lot of trade material was found there—copper from Michigan, flint material from the Ohio and Tennessee regions—indicates a large trade network existed, perhaps using the river system.

Omni: The project around Arenal Volcano, Costa Rica, provided the most dramatic proof of remote sensing's potential. How did it get started?

Sever: Jim Wiseman, chairman of archaeology at Boston University, recognized the importance of the technology and helped organize a conference that eventually brought 24 top people in various disciplines to Mississippi. An outshoot of the conference was choosing an area and site to demonstrate the technology. That's when I met with Payson Sheets, an archaeologist from the University of Colorado, who had a grant to excavate prehistoric villages in Costa Rica. Devastated by ten volcanic eruptions over the past 4,000 years, these villages were preserved to some extent under layers of ash.

After Sheets's team first surveyed this tropical rain forest region in 1984, NASA initiated two series of overflights using a specially equipped Learjet that flew about 1,000 miles high. When the second series of flights was completed in spring of 1985, our remote-sensing database included color and false-color infrared photographs, thermal data from the TIMS, two bands of synthetic aperture radar data, and light-detection and ranging data. Later seven spectral bands from the Landsat satellite's thematic-mapper [TM] instrument were also added, making this one of the most extensive remote-sensing databases constructed for archaeology.

Early in 1985, Payson and I were at the site, which is on the Continental Divide, 90 miles from San Jose, Costa Rica, studying the landscape by foot. I saw a linear feature running through it and pointed it out to him. But he, lacking my computer experience, couldn't see it. As many remote sensors do, I was seeing from a different perspective—one that merges the aerial and ground information. Later on, Payson confessed that he was beginning to wonder who NASA had sent him—this guy who thought he was seeing things everywhere.

Then I suggested we go back and look at the color-infrared photography to see if these features showed up there. Our field lab was a wooden shack in the little village of Tilaran, rented for 87 cents a day. We studied the images; lines appeared where I saw the features. Payson also saw them in the images and became a believer.

Omni: What did you think the linear features were?

Sever: I first thought they were roadways, because they seemed to be several feet wide at the surface. Then we began digging trenches at the base of the cemetery where one of the linear features diverged. As the workers dug the first trench, Payson and I studied the volcanic layers of ash deposited over 4,000 years. As we excavated through the layers, a V pattern emerged, indi-

cating erosion. When we finally got through the ash layers, Payson studied the base, which was only one or two feet wide and said, 'This isn't a road way. It's a footpath.' We were seeing prehistoric footpaths, literally walking in the footsteps of the ancients. In discovering the world's oldest known footpaths, we'd proven to the skeptics that remote sensing was important to the future of archaeology and anthropology.

Over the next few years we put in 40 to 50 trenches, and with dating techniques, distinguished two different time frames for the footpaths. The earliest network, dated to about 500 B.C., was not as extensive as the later one. There were more footpaths connected to more sites, leading from villages to the cemetery on a high ridge of the Divide, where the people would commune with the departed spirits of loved ones. We can now know the daily movements of people more than 2,000 years ago.

Omni: Besides the infrared, what other remote sensors proved useful?

Sever: The faint lines indicating footpaths on infrared photography could be seen only in open pasture lands. Later, however, we used the TIMS to discriminate footpaths beneath thick forest. Landsat's mapper imagery also helped us find out if the Arenal area was a dryer forest environment during earlier time periods and if the present-day tropical forest grew over it. Satellite data on the Continental Divide shows one side, the dry Pacific, as red and the other, the lush wet Atlantic, as green. As we excavated villages we found the soils there were oxidized, meaning they were receiving sunlight. But the footpath areas were not, meaning they were under a deep forest canopy. Prehistoric peoples were moving through the tropical forest and living in an environment similar to what we see today—even after all the volcanic eruptions over the centuries.

Omni: How important is remote-sensing technology to our well being?

Sever: More than most people realize. The stereotype has archaeologists just digging up spearheads and pottery and anthropologists just writing down the words of primitive tribes. But we're examining how people adapted to their environment throughout time, how they experienced environmental shift, why cultures come and go. Soils associated with artifacts are as important as the artifacts themselves—probably more relevant than the actual objects. Now more than ever, archaeological research is interdisciplinary: botany, forestry, soil science, hydrology—all contribute to a more complete understanding of the earth, climatic shifts, and how people adapt to large regions. This understanding is critical to decision making affecting the planet.

In Costa Rica, the culture survived repeated volcanic explosions. Other cultures, like the advanced Maya societies, did not survive or recover from similar eruptions. Did it have to do with the size and violence of the eruption, the way they farmed their land over time, or territorial and political struggle?

Omni: Where did you fly next?

Sever: Guatemala has many unexplored areas in what was the old Maya Empire, including the Piedras Negras region and Usumacinta River Valley on the border of Mexico and Guatemala. Their inaccessibility and distance from any population center, plus leftist guerrilla activity, has also discouraged expeditions into this area. We joined forces with the National Geographic Society and a small research company in Mississippi. It began as a salvage project because of many rumors about a dam that would have flooded the Usumacinta River Valley, destroyed archaeological sites, caused tremendous environmental destruction, and uprooted the surviving Lacandon Maya.

Omni: Did you hope to change this dam-construction policy?

Sever: That was never the focus of our efforts. We just wanted to understand what was going on in the region so good decisions for preservation could be made in the future. In 1988, we produced a thematic-mapper image from Landsat [using several sensors to look at larger areas of terrain] of the Piedras Negras region, using three out of its seven bands for processing. To our surprise, it showed all the land on the Mexican side had been deforested, while in Guatemala, the forest thrived. These TM images were distributed in Guatemala, a copy was brought to the attention of Guatemala's President, Vinicio Cerezo, who immediately summoned the Mexican ambassador. Remotely sensed images of their borders was a factor eventually leading to the presidents of Guatemala and Mexico shaking hands for the first time in 150 years. As a result, the plans to build the dam were halted. A few years later, all seven presidents of Central America signed an agreement to work together on the environment.

Omni: What happens archaeologically when the land is burned?

Sever: The limestone used to build Mayan temples and other structures is also burned. Fire and rain can destroy them, and they can erode away in a few years. There's a constant race between preservation and looting.

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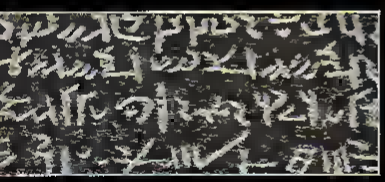
ANTIMATTER

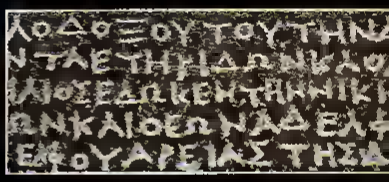
UFO UPDATE:

Throughout history, dozens of writing systems have been attributed to gods, spirits, or E.T.'s. Are any of them real?

Have aliens visited our planet, leaving messages of hope or despair imprinted in the mind of man? Mario Pazzaglini, a Newark, Delaware–based clinical psychologist aims to find out. His controversial evidence: More than a hundred samples of "alien writing," including symbols reportedly seen on alien craft, scripts read by abductees in so-called alien books, and material said to be psychically transmitted directly into human brains.

According to Pazzaglini, author of the new book, *Symbolic Messages: An Introduction to the Study of Alien Writing*, the concept of alien writing is hardly new. Throughout history, he says, whole systems of writing have been attributed to gods, angels, spirits, and, most recently, extraterrestrial beings. The god Thoth supposedly gave Egyptians the gift of writing. And Quetzelcoatl, the feathered serpent, is said to have handed some Mexican cultures their symbol systems.





The incredible number of "alien" scripts are only the latest part of the pattern. "Certainly, something is happening at psychological, sociological, and perhaps even physical levels," Pazzaglini says. "Either we're desperately trying to tell ourselves something, or someone is trying to get through to us."

Despite this insight, Pazzaglini brushes aside the possibility that the many alien scripts he describes are actually different species trying to communicate with us. "They cannot all be real or of true alien origin," he says.

One problem is hoaxing. "There's a lot of it," Pazzaglini explains. "One person tried to pass off an exact copy of a page from the *Book of Mormon*. Other alien scripts are simply too mundane; it's unlikely, for example, that an alien writing system would contain exactly the same letters as our own alphabet unless they were writing specifically for us in English."

After eliminating obviously forged scripts as well as those without enough symbols for true evaluation, Pazzaglini was left with five samples to put to the test. "These five scripts are promising," he says, "because each displays a limited number of symbols in patterns suggestive of grammar." Three of the five even seem to share some symbols and may be part of a single writing system. But Pazzaglini won't commit himself on that point. "It's like comparing your handwriting and my handwriting and someone else's printing," he says. "If you were totally unfamiliar with a language, and that language was more complex than ours, it would be pretty hard for you to tell if those three represented the same system or different ones."

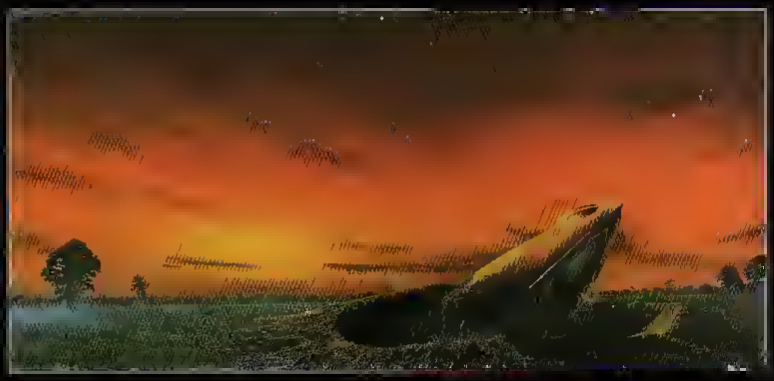
While researchers are normally hush-hush when it comes to alien scripts for fear that dissemination may contaminate future responses, Pazzaglini will reveal this. One of his favorite candidates looks like Gregg shorthand. But unlike shorthand, the structure appears to be syllabic, somewhat like Sanskrit.

Despite all the theories, Pazzaglini is unwilling to rule out psychological interpretations for the "alien" writing he has seen. "The psyche may be capable of some incredible unconscious maneuvers," he explains, "including devising symbol-sound systems with inherent syntax and grammar. We could be neurologically wired to do this." Still, he can't help but wonder if those few promising scripts might not be evidence that "something truly unknown is at hand."

—PATRICK HUYGHE

ANTIMATTER

CALLING ALL ALIENS



While NASA uses radio telescopes to scan the skies for E.T.'s, a group from Kenosha, Wisconsin, has a more aggressive approach. The so-called "Moderns" are building "UFO magnets" out of crystals, electronic equipment, and spare parts, hoping to lure aliens down from outer space.

Built by Modern member Otto Maddix, the new technology was mounted at the Kenosha Veterans Memorial fountain, where some 25 people watched the gizmo spin madly for about 45 minutes before it fell apart. "We hope the crystals inside put out some kind of signal," Maddix says.

But the technology, which Maddix and the Mods claim can send signals faster than the speed of light, has come under fire. "There were lots of questions about technical details," notes local bar owner Jon E. Mod (a.k.a. Jon Madison), who initiated the work. "People questioned whether it actually functioned as a magnet at all."

To quiet the critics, Maddix, the technician of the group, has now completed work on his second-generation mag-

HOPI CURSE

It was back in 1978 when Jimmy Lee Hinton dreamed he was surrounded by dancing kachinas—Hopi masked gods. Terrified, he awoke at 2:00 a.m. to the sound of wind chimes. Then the phone rang. It was Randall Morris, Hinton's partner in the theft of four ancient idols from Hopi land near Shungopavi, Arizona, two weeks earlier. Morris had just experienced an identical nightmare.

Hinton believes that marked the beginning of a Hopi curse that for 15 years has followed everyone connected with the theft of the 4,000-year-old three-foot-long carved cottonwood figurines. A motorcycle accident partially paralyzed Morris, Hinton suffered inexplicable liver and kidney failure, and two men who helped try to sell the idols died in separate car accidents. Yet another man involved in the theft had a heart attack.

Hinton claims he would never have stolen the artifacts if he'd known what they were. The most sacred objects of the Hopi religion, representing the Corn Maiden and her family as well as the Dawn Woman, were unknown to the White man until Hinton and Morris found them in a cave. Since these objects were needed to initiate young men into Hopi adulthood, the manhood ritual was simply abandoned for 15 years.

According to Hopi Police Chief Ivan Sidney, the ancient ceremony was recently reinstated using the Corn Maiden's daughter, recovered because the thieves accidentally left it behind in some bushes. The other figurines were supposedly burned by an artifacts collector who is said to have feared the law was closing in on him.

Both Sidney, now with the Native American Program at Northern Arizona University, and Hinton—who has confessed to the theft, asked forgiveness of the Hopi, and joined the Native American church—doubt that the priceless idols were really destroyed. Both believe they are out there somewhere. "I hope someone reading *Omni* will have information about them," Sidney says, "and help us get them back."

—Sherry Baker

net. This time, he has worked to create a laser-light display that projects graphics appealing to the alien sense of art. "The device also incorporates an E.T. detector that can distinguish between humans and aliens," he adds. "That will be convenient, because if someone shows up and claims to be an alien, we'll have a way to find out."

—Steve Nadis

NIGHT VISIONS

Are people most psychic in the middle of the night? British parapsychologist Serena Roney-Dougal believes they may be. "A lot of folklore claims that psychic events happen at night," she says. "All that folklore makes sense given the fact that the neurohormone melatonin is made at night in the pineal gland." Roney-Dougal believes that chemical compounds called beta-carbolines might be produced from melatonin and points to chemically similar plant compounds used by Amazon tribes.

"All the shamans use the ayahuasca vine to produce psychic experiences from healing to precognition," she says. "Analysis of the vine reveals substances chemically close to the beta-carbolines."

Commenting on this theory, neuroscientist Francis Schmitt of MIT says, "The idea that naturally occurring substances like melatonin produce different effects at one phase of the circadian rhythm versus another is completely reasonable. The psychic part of it I know nothing about."—Keith Harary

REVENGE OF THE APEMAN

You would think the director of zoos and parks for the Interior State of Mexico could tell a real gorilla from a fake. But when Victor Bernal and several coworkers arrived in Miami last year and allegedly attempted to buy a black-market gorilla to replace a great ape that had recently died at the Toluca Zoo, they offered $92,500 for a man in a monkey suit.

The Mexicans' trouble began when they contacted a Miami primate dealer in search of a gorilla. Black-market purchase of a gorilla is "highly illegal," stated U.S. Fish and Wildlife Agent Jorge Picon, who was tipped off by the animal dealer. "Gorillas are endangered, and their legal purchase and exportation require so much red tape, it is almost impossible."

Picon quickly arranged a sting operation to catch the would-be monkey owners. Miami's Metro Zoo cooperated, arranging for Picon to enter after hours with the Mexicans. Posing as a black-market primate dealer, Picon brought the Mexicans to see a large live gorilla owned by the zoo, which was said to be in on his shady dealings.

According to federal agents, the Mexicans agreed to buy the ape and arranged for the gorilla to be flown back home. But when Picon met the Mexicans at the Opa-Locka Airport, the creature inside the cage marked "live animal" wasn't the zoo's gorilla—it was a monkey-suited federal agent. For the sake of realism, the cage was filled with hay and two weeks' worth of gorilla manure. The would-be buyers fell for the phony ape and when Bernal moved closer to the beast, Picon arrested him.

DID THE MEXICANS BUY A LIVE GORILLA OR A MAN IN A MONKEY SUIT?

Bernal, along with four cohorts, will stand trial in Miami next summer. "We hope they will be convicted," says Picon. "But attorneys have already argued that the Mexicans didn't buy an endangered species, they bought an agent in a monkey suit."

—Sherry Baker

CRICK

CONTINUED FROM PAGE 55

ing the 1953 discovery of the molecular structure of DNA.

The Cricks have been married 44 years. Odile with bright hazel eyes and a quick laugh, says of their courtship, which began when she was translating captured German documents in London, "I'd never been with a scientist. It took some getting used to. When we went on our first picnic, one very romantic afternoon, Francis gave me a lecture on gravity. They are both laughing now. I simply asked, 'Cricks says,' if she knew how far up gravity went."

On Crick's desk is a home computer—nothing fancy, a simple workstation. Mostly he uses it for accounting and domestic functions. He finds computers, he says, 'a bit obsessional' and prefers to work out his scientific theories in longhand. When the discussion turns to the comparison of the brain to a computer, Crick cautions that this parallel, if carried too far, leads to unrealistic theories. In the first place, he explains, a computer works much more quickly than the human brain. And while the operations in a computer are largely serial—one after another—the arrangements in the brain 'are usually massively parallel. For example, about a million axons go from each eye to the brain, all working simultaneously.'

> "THINK ABOUT THE SIZE OF THE UNIVERSE. IN SHAKESPEARE'S TIME, THEY HAD NO IDEA HOW BIG IT WAS. DOES OUR KNOWLEDGE TODAY REMOVE THE MYSTERY OF IT? IT SEEMS TO ME WHAT YOU LOSE IN MYSTERY YOU GAIN IN AWE."

The loss of a few neurons is unlikely to alter the brain's behavior appreciably. "In technical jargon," Crick says, "the brain is said to 'degrade gracefully.' A computer degrades catastrophically—even small damage may cause havoc." A typical neuron in the brain can have anywhere from a few hundred to many tens of thousands of inputs, but a transistor—a basic unit in a computer—has only a few inputs and outputs. Yes, Crick argues, computers can be programmed for extensive number crunching, rigid logic and playing chess, but when faced with tasks that ordinary humans can do in a rapid and effortless way, such as seeing objects and understanding their significance, even the most modern computers fail. And yet in the storage and retrieval of information, the computer is much more precise, and it's clear that memory is stored in a computer in a different way. But for Crick, the fundamental difference is that while a computer has been deliberately designed by engineers, the brain has evolved over many generations of animals under the pressures of natural selection.'

The mysterious aspects of consciousness might disappear if we could build machines that had the "astonishing characteristics of the brain and if we could follow exactly how they worked," Crick says, but he does not hold much hope that in the near future such a machine will be built. Perhaps they will be more like the brain of a frog or even that of a humble fruit fly. Until we understand what makes us conscious, we are not likely to be able to design the right sort of artificial machine nor to arrive at firm conclusions about consciousness in lower animals.

The problem of consciousness, Crick believes, will be far more difficult to solve than DNA. "But you have to remember," he says, "that we didn't know how simple DNA was. For all we know, there may be a simple answer to this one, but it doesn't seem likely. The brain is a more complex system. DNA was much earlier in evolution—the answer had to be simpler or it wouldn't have got started. DNA has been here for three and a half billion years. Consciousness is relatively late. Don't forget, modern man has been here for only a hundred thousand years or so."

For Crick, the image of the brain as an impenetrable black box is outdated and self-defeating. "Most of the mysteries of life are not seeable—all of science depends on roundabout methods. If it were straightforward, it would be done straightaway." Our secret weapon in brain research, Crick suggests, may not be theorists and computation experts, but people who are using computers to solve practical problems. "In the workplace, 'people have to produce gadgets that work, which is what evolution has to do." For example, the post office had to produce a machine that can read handwritten zip codes. Gadgets like this 'probably will give us ideas of what happens in the brain, because evolution tends to produce gadgets as well. In that sense, evolution knows nothing about theory; it only knows how to build gadgets.

From San Diego, it's two hours over the mountains to the house Francis and Odile Crick have recently built in the Anza Borego desert. Driving down Montezuma's Grade toward the desert floor, the steep, boulder-strewn descent is reminiscent of the barren, atavistic landscape at the start of *2001: A Space Odyssey*. In the distance is the dying Salton Sea, which historian Bill deBuys calls a "place where consequences collect."

This is where Crick goes to get away, his hermitage. And like his work in neurobiology, which he turned to after decades of pioneering work in molecular and developmental biology, he is slowly mapping the territory out here as well, walking trails each twilight through the desert with his wife, learning the names of wildlife and vegetation: creosote bush, ocotillo, elephant tree. It is to this desert in blistering afternoon sun that we have come to talk about the culture that Crick foresees if indeed scientists find that the soul is simply a machine.

He says he will be very surprised if developments in science 'don't make radical changes in the way educated people think of themselves." And still, he knows, like the debate over evolution, 'vast numbers won't be influenced— usually for religious reasons.'

In Crick's culture, psychology will be a hard science, and philosophy departments will house researchers who also have degrees in biology or neurobiology. And words like *conscious* and *unconscious* he suggests, may be replaced by *processing unit* or *awareness unit*. (Already, Patricia Churchland, one of the few philosophers in the world with a detailed knowledge of neurons and the brain and also of neural networks, has at Crick's urging, an adjunct appointment at the Salk Institute.)

'Many people think all things can't be explained by chemistry and physics, that it's explainable only as something outside science—a life force. That was also the view about our genetic inheritance before we knew about DNA. Most scientists believe there isn't anything else." But he admits, "that's still a hypothesis." He knows at this point, based on the scientific data, that he couldn't convince a skeptic. "They would just say, 'That is just your prejudice.'" He adds with a chuckle, 'Which is not to say that your prejudice may not turn out to be right.'

He admits that some people will be

disturbed by the religious implications of the book especially those who believe there is life after death The implication that it might not be true and that we might be able to show it scientifically will be disturbing.' The others who will be disturbed, he says, are those "who don't actually believe in life after death but who haven't faced up to the implications of it yet.' Though beliefs change slowly the church in Crick's culture will increasingly have to reckon with science Scientifically we know if you are out in a thunderstorm the chances are increased that you may be struck by lightning We no longer think that it's because we didn't sacrifice an ox recently to Jove Look at the beliefs people had in the past Do you really think it was sensible to look at the entrails of a chicken to predict what was going to happen in the future?"

He predicts that while scientists are basically tolerant of religion, that may not last There eventually will be conflict. We might even see religious science wars One would hope that could be avoided People outside the scientific culture Crick says, "are naturally beginning to feel threatened by scientists And they are wise to feel that They will be threatened."

I venture to ask if Blake was right to warn of scientists turning that which is soul into machine? Are there some things that should remain undeciphered? Crick is smiling now—a mischievous ironic smile You know," he says, "Blake used to sit outside naked in the garden with his wife and talk to angels Now I've got nothing against sitting naked in the garden but talking to angels—don't you find that a bit odd?"

The desert sun has begun to sink behind the Santa Ysidro Mountains, its nearly autumnal colors settling over Crick's face softening his angular features I wonder if, in his scientific view, there is room for mystery Well, what do you mean by mystery?" he asks "It's a mystery how the darn thing behaves whether it's in the activities of neurons or not" And as if he implicitly understands what the next question must be, for it is the universal question of an anxious and God-yearning people—If soul is only a metaphor, a story we tell to comfort ourselves and if there is no ghost in the machine, then what does that leave us with?—Crick leans forward, his face reflecting the last light of this fading day and says, 'Think about the size of the universe In Shakespeare's time they had no idea how big the universe was Does our knowledge today remove the mystery of it? It seems to me what you lose in mystery you gain in awe.

CRICK TAKES

CONTINUED FROM PAGE 52

recombinant DNA arose the scientists themselves imposed a moratorium for six months In the Human Genome Project, a percentage of the budget was set aside to study the social impact and ethical questions—at the suggestion of the scientists."

By the People "Sooner or later, people have to realize that where we are going is partly their responsibility, and they have to judge the issues and make collective decisions as to where they want to go."

Consciousness "It is better to avoid a precise definition of consciousness because of the dangers of premature definition Until the problem is understood much better any attempt at a formal definition is likely to be either misleading or overly restrictive, or both."

Experimentation "In our culture you're allowed to volunteer for the Peace Corps or the armed forces, run the risk of being killed or coming down with infectious diseases and maybe not returning alive These things are thought to be praiseworthy, but volunteering to help knowledge, to help further scientific discovery that's not part of our culture I would, however be very unhappy if experiments were conducted on people without their informed consent That would be wrong."

Superstition "Only scientific certainty—with all its limitations—can in the long run rid us of the superstitions of our ancestors."

DNA "Ethical questions regarding DNA and RNA are beginning to enter into the consciousness of our society These are very troubling questions that are going to be raised in churches and synagogues They will raise the issue of individual responsibility Social attitudes change—about every five years One time, everyone was worried about recombinant DNA and how dangerous it was but you hardly hear that nowadays You hear little things like 'Chefs (there's an organization called Chefs Against DNA) don't like recombinant food.' Bizarre."

Abortion "It's a matter of viewpoint. If you view the fetus as an immortal soul, it makes a difference But remember, that's only a hypothesis."

The Emperor's New Mind, by Roger Penrose (Oxford University Press, 1989) "I talked to him recently at a garden party in Oxford His argument is that quantum gravity is mysterious and consciousness is mysterious and wouldn't it be wonderful if one explained the other It will be remarkable if his main idea turns out to be true."

The Self and Its Brain, by Karl Popper and John Eccles (Springer-Verlag, 1985) "Both of them are dualists—they believe in the ghost in the machine I have little sympathy for either of their points of view They would probably say the same of mine."

Consciousness Explained, by Daniel Dennett (Little Brown, 1991) "A rather premature title, don't you think? Dennett is a philosopher who knows some psychology and also a little about the brain and neuroscience. He has interesting ideas but appears overpersuaded by his own eloquence Dennett does suggest in a half hearted way, a few experiments that might be done to support his ideas. Characteristically, they are all psychological; one would never gather from his book that experimental confirmation, by the methods of neuroscience, is essential."

On His Own Book "Crick has many interesting ideas and speculations but no single concrete, plausible proposal."

Francis Crick's new book, The Astonishing Hypothesis: The Scientific Search for the Soul, *is published by Charles Scribner's Sons (January 1994)*

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ASSASSIN

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and I hear what I would never hear were these corridors in the light blinding all other senses.

I sense the first child near a turn in the corridor and realize that the walls here are not metal at all, but *skin*—scales, blood, pores. Did I already *know*? Did I know this even as I stepped into the ship, smelling the molecules of secretions, hearing the blood rushing, seeping, and just not wanting to believe? As his son, I should have known; shouldn't I?

My feet, in simple boots, whisper through dust, through a tinkle like glass, a crackling. I reach down to touch it and it is what I imagined. Years of scales sloughed off from the walls, years of skin, brittle and turning to dust. My feet have stirred up a cloud and my lungs hurt. I cough, cough again and walk carefully, so as not to stir up the years.

When I reach the sound—what I know must be the *child*—I hold up the motion-imager and play it across the wall. In the odd green light of the display I see the moving outline of it, head riveted to the wall, body jerking as it struggles to feed. There is an immense pore—a shadow on the display—and it is at this pore that the child suckles. The pore reeks of blood. It is blood that the child needs.

I understand these things, as I should.

As the small green image moves on the display, I *hear* the child's hugeness—its scaled tail sliding on the floor, atrophied arms grasping, at the *wallskin*, heavy jaws pulling at the leather of the great pore.

The tail slides across the floor toward me and I step back. When it doesn't move again, I step over it, hold my breath against the dust and hurry on. I *know* which corridors to take. I know where he is, because it is dark, because in the dark I am a son of Hamusek, descendent of "New Indians," and I am *his* son. The smells grow worse. Excrement. Old blood flaking away, turning to dust like rusted metal in your mouth. *New* blood oozing from the walls like tears.

A child like that will never leave you, I say to him. *Even death cannot take such a child from you, can it, Father?*

Prihoda Delp and her Council were worried that I would not have enough food and water that the ship would be too large, that I would collapse from thirst and hunger before I would find him. How could I tell them—that I would *know* where he was?

I trip. I fall to my knees. I sniff, smelling dryness, skin without flesh. I move my hands blindly on the floor until I find it. I am afraid—my arms and legs are shaking—but I move my hands and find what I imagined. A bundle of dry bones. The twisted skin of a *child* dead for decades, injured by another perhaps, or lost between pores—its body mummified by an atmosphere that allows the bacteria of rot only if *he* wishes it . . . which of course he does not. *You want skin and bones to remember them by, don't you, Father.*

My right boot has separated a bone from its bundle. I reach down and pull. When I have freed it, I rise and take it with me, the ribbons of dry sinew and skin whispering against my skin.

So this is what you want—what you would like us all to be?

In the end I find him by the smell and by the sheer number of children, living and dead, that fill the corridors, the ones leading to the room at the heart of the ship. I find him by *his* smell and *his* sounds—the shifting of flesh against a metal that barely contains him, the rasp of scales wider than my face

against the alloy, the whisper of nutrients moving through kilometers of tubes from distant hydroponic tanks to the buccal orifices of his body, and the whisper of waste through other tubing.

He is exactly where I imagined he would be—in the room that houses the ship's great brain, which is his only companion now. Like a wife who will not leave him.

The dry, mummified bodies of his dead children (how many generations?) litter the entrance. I climb over them on hands and knees, my boots tearing through the skin and scales and brittler bones, then holding. I hear him shift only meters away—scales against metal, talons against themselves, the great lungs inhaling the stale air of a room whose ceiling towers in the dark. The whole room sighs.

It has not left this room in years, I know. The scanners were wrong. They saw his children, his immense children, and thought they were the father. It *cannot* leave the room. It fills it so completely that the electronic interfaces it once built between itself and the ship are embedded in its flesh now, have become its very neural wiring. The walls but another skin, the ship's body inseparable from its own. I smell its breath, which reeks of ancient air, ancient tubing, nutrients that would kill me if I drank them, blood that has been changed by fifty years of Mapping into something no longer blood.

I do not use the devices. I do not need to. I see him clearly, a reptile with the jaws of a *demeer*, that small, snarling demon of Hamusek no longer than a man's arm, that nightmare of children scared of the dark. *Don't let the demeer night-bite!* But this one is huge, a *demeer*-God, teeding on the Darkness.

Father? I say. I say it silently, eyes closed, my legs deep in the bones and skin of his children. He can hear me. I can feel his thoughts pass across my own, pass again, curious.

Who?

You know me, Father.

He has taken our "sensitivity"—our "wilderness gifts"—and with the Maps made of them something greater, as I knew he would. *I will talk to him,* I told the Council. *How?* they said, incredulous. *He is no longer human.*

He was the Master of Maps, I told them. *I am his son. That is enough.*

The body shifts. The floors creak. The secretions at the pores dry for an instant. The walls sigh.

It has, it realizes now, wanted this moment for years, though it has not known why. It has wanted *one* of us to come—one of *the man's three sons*—to come, to see what the *man* has made, to behold what he believes he is and by believing, has made of himself.

Father, I say.

It does not answer.

You are not, I tell him, *what you imagine.* I show it—what it imagines.

A spark darker than any night burning in a body so inhuman that the gods who made it weep, turn away, deny their creation.

A father who lets his children feed on his blood, only to consume them himself, in his hunger and hatred.

A reptile who imagines itself a moth, imagining a moon that just isn't there.

Then I show it something else. I show it—

Three sons and a daughter asleep on their cots in a quiet house, the four lights of their souls, their father in another room, unaware. I show the mother and the daughter dying, the two lights fading—while the three other lights live on. I show him the father again—in another room, larger and darker—unaware of these lights. I show it a man who imagines himself to be a reptile—to be the darkness made by the two lights that have gone out, because he has forgotten his own, and the living three.

No! the creature says and the room, the ship, the bones under me shake. I know that if I go on showing it what it *must* not see, it will kill me.

I show it a pond. I let it hear a singing—*a father's*—

The floor buckles, metal pops, the hideous tail moves swiftly through a cloud of bones and scales toward me—

Is this what you really *want?* I ask it.

I hold up the bone I have brought so that it may see it. It sees what I see in the eye of my mind.

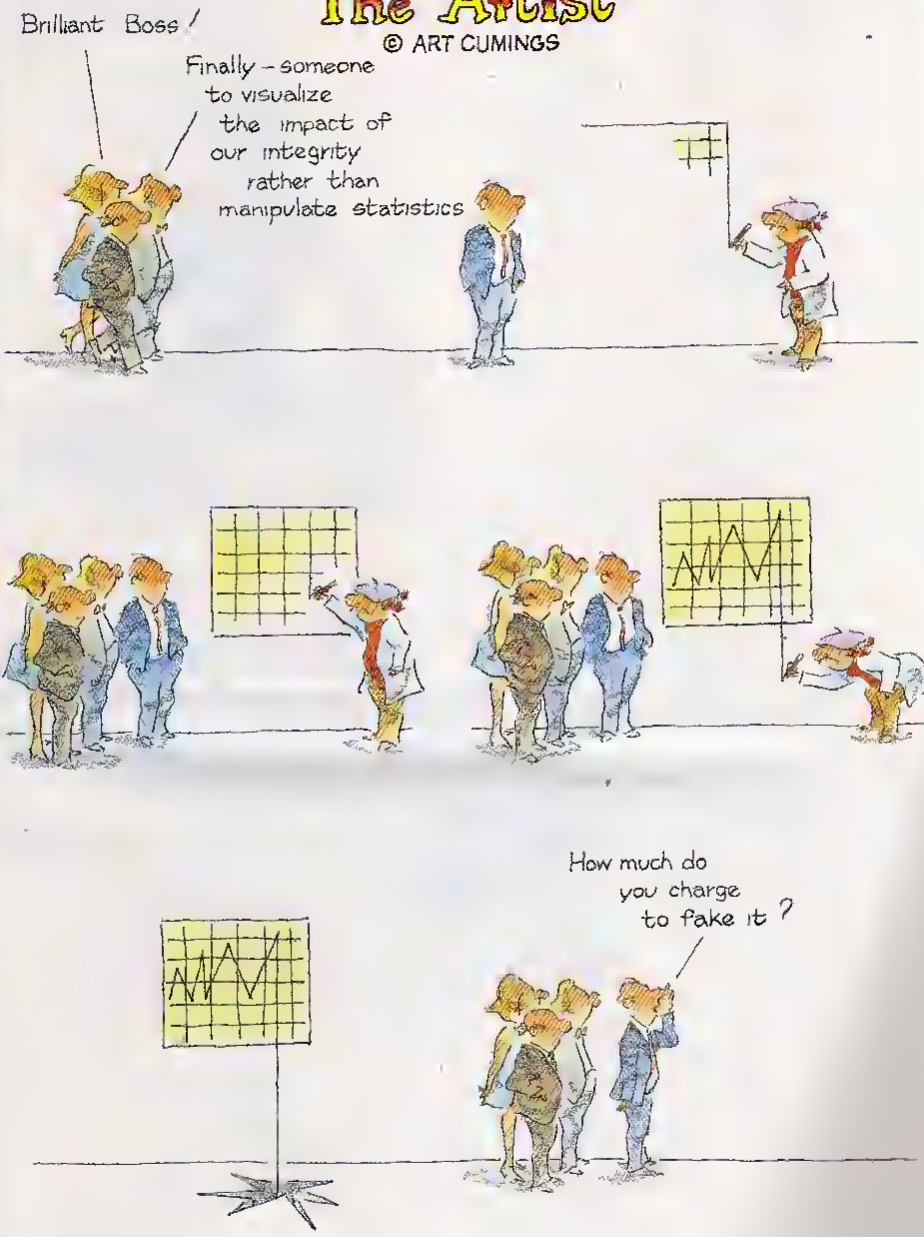
Bones explode before me in the darkness, the great tail thrashing as it tries to reach me. Splinters rain on my face. Dust fills my lungs. I cry out, dropping the bone, protecting eyes with hands as light explodes inside my skull, goes dark, black bones taking their place, pulling me toward them, toward darkness.

I am down on my knees in the bones, skin, and scales of his children. I show it a picture of *the man's daughter*—

And the jaws—those two reptile yet human heads—scream at me. The tail rushes and I fall again among the bones, hug them to me, feel myself lifted in the air, dropped. I lie coughing in the dust, and in wetter things.

Tubing has pulled from the walls. The

The Artist



air stinks of nutrients. I hear trickling—down walls, across floors. I am afraid I will touch it—the fluid—that it will burn.

I cannot breathe. I hold my sleeve to my nose and try, but I cannot.

I take the container I have brought with me and unscrew the lid. *Do you know—do you know what I have brought with me?*

It knows—because it sees what I see now—and before the great tail can reach me, to keep me from doing what I must do, I pour the ashes from the container into my hands, raise my hand, and blow them.

The ashes move as slow as a dream toward the creature—in the darkness here. The ashes mix with the dust.

I bring you your daughter and your wife. I would bring us all to you as dust if I could—

The jaws scream again, in harmony. The tail moves through the air—

Our mother and sister lay in the antiseptic plastic bubbles of their hospital room while the computers of the capitol's Medical Center—linked by subspace lightcom to the great computers orbiting Tar and Rasi—ran the Changing machines, splicing genes with lasers, accelerating the growth of cells. It took four days, and when the asymptotic malignancies began to appear—when the computers began to scream in alarm—it was too late. The cells were cycling on. Growth without direction.

I did not see them, but I heard. Organs invading other organs, destroying all boundaries of function. Mapless bodies that could not be reclaimed because they were no longer human, no longer Mappable. Flesh as dark as night. Bone curling within the flesh like pale vines. Noses where there should be none. Tongues where eyes should be. Stomachs that had swallowed hearts. Intestines snaking from every orifice.

He had wanted to believe that we Hamusek were a perfect marriage of the genetic codons of Caucasian India and Asiatic North America. He had so loved the wilderness legends he had learned as a child *and* the euphony of our Dravidian names, that this is what he wanted.

For a year he had shown our mother and sister the faces and bodies they might have, calling them up on the screen of his university computer. He had asked them again and again. "What would you like? That proud nose, Ladah? Those high cheekbones to go with your blue black hair? That smooth forehead, those rounded cheeks, Premila? The epicanthic eyes of one people and the narrow waist, wide hips of the other? *Which?*" He asked them so often that in the end he convinced them that it was indeed what they wanted. To be Changed. To be the first. Because they were our women. "Because," as he said, "it is *women* that men love."

Our mother would say, "What would you like us to be?"

And our sister would say only, "I want to look like Mother. Father."

In the end he had chosen for them, without asking what we—his sons—might want.

In the investigation—which found no criminal negligence, because of course there had been none—our *true* history as a people appeared. In a cabinet of wood-pulp records so old that they had been forgotten, that they had been lost long before Hamusek's capitol ever knew its first computer, we found what we were. In the extreme northeast corner of the nation of India, on the continent of Asia, on Earth, there had been a region called Arunchal Pradesh—in the language of its people, "the land of the rising sun." A world of endless forests, rivers, and mountains, it had been the home of a people of Asiatic stock who believed in the power of animal souls, in nature both Dark and Light. When a neighboring nation took this land, making it Pakistani, the people of Arunchal Pradesh could not abide by it. Their land had been their "India," and now it was not. After a decade, selling the resources of their wilderness—its oil, coal and wa-

ter—to clandestine brokers who cared nothing for national boundaries, the people of Arunchal Pradesh had their money, their corporation, and could leave to find their 'new India.'

They had been the first in Hamusek, yessir, the sons and daughters of Asiatic North America, hearing of a wilderness world like Hamusek, had come too—with their legends. Later, the disaffected of a Terran India in constant turmoil had come, too, bringing their legends as well. Legend had been added to legend. At first the descendants of Arunchal Pradesh had not intermarried. As time passed, they had.

The genetic paradigm of Hamusek had not been a perfect marriage. It had been a Sino-Tibetan Map layered over time with the genes of two continents. It had been *one* face, slowly becoming *two*.

Like *him*. A single creature. Each face regarding the other.

A people's legends, I understand now, are the stories they tell themselves in the darkness to make sense of a universe they do not understand. These stories may be a Light—

But they are never the true history of their flesh and bone.

He buried them both on the planet we call The Hand, because that way, he knew there would at least be *bones*—clear white relics of death, of his shame, his self-hatred. He would be able to think of them lying there in the ground for years, and by thinking, feed the darkness.

I knew this. I knew this when I went there and dug the bones up.

When I found the grave outside Clay and dug them up, I was crying, but when I burned them to ash in a kiln in the nearest village, I was not—for I knew it needed to be done.

The tail strikes the floor near me. Bones leap, striking my face, my chest. I step aside. I blow into my palm once more. The room shakes. I blow and hear a cry.

The sound becomes something else. Rhythmic, a breathing that cannot find air, a muscle contracting in pain, a human heart on fire.

The tail rises again, moves, hits me—

—and I die.

When I wake, I am not dead, but my left arm is broken, and my left leg too, perhaps. For a moment I do not know where I am. It is the ship, and yet it is not. I hear the massive breathing, and yet the room is quiet. I hear fluid trickle down walls, yet the tail does not move. A light is growing somewhere in the room, and this makes no sense. I think, *Fire?* I think, *Delirium?*

The room fades. The light grows brighter, and I know this is what the creature wants—that we remember it together.

He is sitting on the porch at home, overlooking the pond. He is crying, and I have never seen him this way. But I have been crying, too. It is noon. The sun is bright. My mother and my sister have died, and it is the next day. *I didn't mean to,* he is saying. *I didn't know, Rau. I thought—*

I am sixteen, but I know what I know now. I want to say to him. *You were impatient, Father. You wanted to Change them, to make them the very first to give them "gifts" everyone could see—as if they were Maps, Father, not human beings, and you the Great Mapmaker. You were so sure. You were so certain that "North American Indian"*

> "THE WALLSKINS AROUND ME DRIP WITH SOMETHING THAT SMELLS HIDEOUS. THE CHILDREN IN THE DARKNESS BEHIND ME DO NOT LIKE IT EITHER, AND COMPLAIN, MAKING HOARSE CRIES."

was the genetic source, because you wanted it to be. You wanted those legends, and because you did, you didn't wait . . . You wanted the universe to be what you wanted it to be, Father.

Impatience. I want to tell him. *has never been a Hamusek trait. Nor was it one of* their *traits either, Father.*

But I do not tell him these things. He is my father. I am his son.

I must leave, he says suddenly.

I do not understand, I say. I am frightened.

I cannot live here anymore. As he says it, I know what he expects: that because I am the eldest, I will tell the others. *I must go, Rau. I must bury your mother* and sister where they should *be buried, and then . . . and then I—*

Who will we stay with, Father? I can barely say it. My voice shakes too.

Your aunt and your cousins. His voice is distant, like a death. *You will all be fine, Rau.*

I want to go with you, I say. *Please.*

No, he says quietly. Then I think, he whispers. *I am going where no one else can go, Rau.*

I think I hear him say. *Stay right here, Rau . . . in the light.*

I do. I sit on the porch—in the midday sun—because he has told me to. I sit there long after he has left.

I will go with you, Father, I tell him in the darkness in this room. *I will go with you now, if you want me to.*

He says nothing, and then he says: *Why?*

To show you that you are wrong.

The man on the porch looks up, tears covering his face like blood, fluids seeping from walls.

He is trying to understand.

You know what I mean, Father, I tell him. *It is time for this to end. You've been waiting. You've known it would come to this. I am your son.*

The man is shaking. The ship is shaking. I must kneel because I cannot stand. One of the children moves listlessly in the bones beside me, whimpering.

You would do this for me? he asks at last. The words are barely human, even skull to skull, like this. I barely recognize the voice, the face that has begun to change in the night on this porch, by this pond.

Why? the jaws ask, opening and closing.

To show you a Light, Father.

The wallskins around me drip with something that smells hideous. The children in the darkness behind me do not like it either, and complain, making hoarse, little cries with vestigial throats. They want something else—something to fill their stomachs and end their hunger, not something like this.

There is no Light, the jaws say.

There is always, I tell it.

Not in Darkness.

There is no Darkness without Light to know it by—

You would die *for me?* the man asks suddenly. *You would—despite what I am, what I have done—die for me?*

Yes, Father.

It is the porch. The man I know as my father is singing. He is singing the entire song, the one he loved. Mother and Premila are in the house, and it is the four men—father and three sons—on the porch, looking out at the woods. The father's eyes twinkle, teasing us, as he sings the end of the song, how the woman whose dead lover has returned to her for a night but now must go, stops him.

Oh when shall I see you again, my love?
When shall I see you again?

And the ghost of her dead lover answers

When little fish they fly and the seas they do run dry
And the hard rocks do melt in the sun
When little fish they fly and the seas they do run dry
And the hard rocks do melt in the sun

He is telling me why. He is telling me at last why he buried them there—on the planet we call The Hand—with its dead seas, its flying fish, its searing stone . . . so far from Hamusek, so far from *home*. He is telling me how songs, like legends, may make us do what we do.

I nod. His eyes twinkle. We get up to go inside—

I get up on one leg, wondering how much blood I have lost, whether I will be able to walk. I pull up the sleeve of my broken arm. I unbutton my shirt, which is wet. I want him to *see* my wrist, my neck. I want him to see the scars, so that he will understand, if he does not already, why the Council sent me instead of my brothers.

There is one scar at my wrist. There is another at my throat. Both are deep and both were made with a blade of volcanic glass on a planet we call The Hand, a year after my father left. Both were made in the hope that Darkness would take me from the Light.

Fever, dehydration, and delirium lasted, I'm told, a week, and when the rescue team found me in the cave overlooking the dry lava beds and endless sand, I was, in the opinion of doctors, half a day from death. I had traveled so far in my dreams, and yet had never left the cave. I had discovered—on my long journey—that Darkness is not a single color, nor the absence of light, nor a *true* hunger for death, but only a desire for the end of pain.

It was a week later that I dug up their bones and burnt them to ash.

The Council knew all of this, and so I was the one they sent.

You understand don't you? it says at last.

Yes. I do.

It is a remarkable thing when a ship and its flesh-and-bone body die. The tubes stop their pulsing. The hydroponics tanks shut down, leaving nothing for the tubes to carry. The body that has been engineered for this very day—by its own deepest knowing, deeper than a Map, as deep as light itself—begins to dry out. The bones protrude from the skin. The odors change from a living death to a true death, to a darkness that calls itself by its real name, and by doing so, becomes light. Children who should never have been born—because they were made in the image of a lie—begin to scream in the thin, shrill way they know, and then begin to die.

You do not know how long it all takes. You lie in your own blood, your protruding bone, seeing a porch and a man and a snarling reptile no longer than your arm. Then you are up and walking. You pass scaly children in endless corridors, you trip, you fall, they pass over you, crawling, looking for walls that can feed them one last time. They are thirsty. They are scared. They can hear their brothers and sisters dying, and you feel suddenly what it must be like for them. *To be abandoned by the one you love—by the one who loves you.*

The engines are dying, too. The wallskins no longer smell. The silence is broken by the twitch of a tail, a claw, a child jerking once beside you.

You get up again. It is difficult, but you do. You reach behind you with your good arm to find the transmitter. You push the button the Council has made large enough for you to find it easily in the dark.

The transmission is something you can almost see.

A spark heading out into the darkness . . . where someone is waiting to come for you. ∞

INTERVIEW

CONTINUED FROM PAGE 75

Field work is extremely slow and painful. One hour on foot, one hour on a mule, hacking through the thick vegetation. So you must decide what will be the greatest return for the investment of field activity. On five field trips into the central Peten area since 1988, we've seen an incredible amount of looting and destruction—people usually in groups of four and five, robbing tombs and stealing artifacts. Remote sensing gives us another way to beat the looters into the field, though generally they have beaten us. Looting can be even more dangerous than leftist guerrillas. *Omni*: Have you had any close calls? Sever: Our group has never had a problem with looters, but we had a run-in with leftist guerrillas during our second field season. Even though we took many precautions, including passing along our intentions to the villagers so the word would spread, some people weren't too happy that we were there. One morning, about 30 minutes into the field, we were ambushed and captured by leftists. At first there was a lot of yelling. Then they rounded us up and kept us covered with their AK-47s.

We knew we were in trouble when they frisked us but let us keep our big machete and bowie knives. The knives were no threat to them. They took us through the woods to a clearing and surrounded us. That's when I thought it was really over and said to myself, "I guess this is it." But then our group had a chance to sit in a circle and talk for 15 minutes. We told each other things, like how we should avoid eye contact with our captors, not show any emotion, don't look mad. We were making it up as we went along.

The first question, in Spanish, was "Who here works for NASA?" We have jokes about this. I claim they all pointed at me! They claim there was an incredible silence as we looked around at them. They held up the Global Positioning System [GPS] receiver. Even though I thought I had inspected it well and cleaned everything, they found a little NASA decal on it. A colleague, Jim Nations, told them none of us could speak Spanish, and they took him away. That was scary. We didn't know if we'd ever see him again.

After 45 minutes, they brought him back and said things would be all right. Their lieutenant was a man of honor. Then they interrogated each of us individually for about ten hours. All this time, they kept their guns on us. Finally, the lieutenant said that they repre-

sented the people of the Petén, that their concern was for the poor people and that we were there without permission. He wanted the Americans to know this. Then he said we were free to go.

Omni: Would you go back again?

Sever: I'll do whatever has to be done without undue risk, to further the work. Exciting history, like the still-mysterious collapse of the Maya culture, waits to be discovered in the Peten. We did see some unrecorded temple ruins during other field trips there. A combination of moisture and vegetation bandwidths in the near-infrared range of Landsat's thematic mapper are revealing these pyramids. Because of the way vegetation grows around the Maya ruins, and because they are elevated features in a jungle area notorious for being flat, they stand out in the imagery. Sensors can see variation and help pinpoint the ruins. You can't see them from the air when you fly over, and if you're in the field, most likely you'll have to chop your way through the jungle to reach a specific site.

Stone monuments from the remote Piedras Negras area spotted on the black market may lead to other unrecorded sites. Glyphs on these monuments indicate that a great Maya center like Dos Pilas or Tikal, designated Site Q, once existed. Eight other cities mention it in their histories. Each city has its own emblem glyph. The Maya glyph, carved in stone, is not fully translated, but the epigraphers are continuing to help us decipher it.

Omni: Tell us about your work in Israel.

Sever: We're searching for an ancient fire-signal-tower system mentioned several times in the Bible that we believe extended from Jerusalem out into the Israelite Kingdom. We took GPS readings of 25 of the probable signal-tower sites and added these measurements to our geographic-information-system [GIS] database of the region. By digitizing the contour lines on topographic maps, we can make 3-D-like oblique images of that topography. Line-of-site computer imaging highlights such things as location and elevation. Then we take positions on hilltops that would be lines of communication between signal towers. This analysis will tell us the best way to communicate from point A to point B. Later we'll go into the field again and excavate to verify the sites. If they prove to be towers, it may demonstrate these Iron Age [circa 1000 BC to 100 AD] people were more mathematically and scientifically sophisticated than generally thought. The engineering for tower height alone would include such factors as the distance and elevations of the two closest signaling towers.

Omni: Do you have any projects in the United States?

Sever: The Army Corps of Engineers has asked us to the Wright-Patterson Air Force Base in Ohio to pinpoint the Wright brothers' 1910 hanger. They've narrowed it down to a ten-acre area. We anticipate thermal sensors will also define a roadbed, a launch rail, privies, perhaps even a runway or a corridor leading out from the hanger.

We may fly a new instrument now being developed, the ATLAS. It represents a new generation—it's lighter, more sensitive, and better all around than TIMS. It'll record nine bandwidth channels of the energy spectrum in the visible and near infrared as well as the six narrowband thermal channels currently in the TIMS. A single, compact ATLAS is capable of recording 15 electromagnetic bandwidths at once, whereas before, the same coverage required two sensors flying at different times.

Omni: If you could go anywhere with the best sensors, where would you go?

Sever: The unexplored areas of the Amazon on the eastern side of the Andes, the Rio Abiseo region in Peru, Siberia, northern China, and parts of Mongolia. The cultural resources of Mongolia were damaged and some destroyed under communism; what's left must soon be preserved. While the tomb of Genghis Khan is an ultimate goal of many researchers, our investigations would focus more on the culture in its entirety. We're not looking for specific treasure, but rather the history of an entire group of people.

Omni: Will this technology be available to people in the future?

Sever: You might put on a pair of special glasses and see much that's invisible to the human eye. With a little calculator in your pocket, you could change programs to create different filters on the lenses, enabling you to experience vision in the invisible portion of the electromagnetic spectrum. With one filter you could walk across the landscape and see blighted trees and diseases in the grass. Turn to another bandwidth, and you'd see moist areas. By switching into the microwave range, you could see subterranean pipelines. The precursor of such glasses is now being developed. Some experts think this technology may be able to restore vision to more than 60 percent of people considered legally blind but who have some light retention.

The same technologies can be adapted to reveal many portions of the electromagnetic spectrum. No bandwidth is better than any other. Each phenome-

non or focus requires the part of the spectrum that best addresses that research question, be it finding Mayan pyramids or selecting hazardous-waste sites. Now that the GPS network gives us precise measurements to within a few meters, I've thought of several new projects. One is to see how accurately tenth- and eleventh-century Arab mosques are aligned toward Mecca.

Omni: What personal sacrifices have you made for your work?

Sever: Archaeologists traditionally maintain a stoic attitude toward hardships in the field. Sure, I've been thirsty, covered with ticks, bitten by snakes, stung by scorpions, captured by guerrillas. I've even caught malaria somewhere along the way. But many scientists and researchers go through similar if not worse hardships. It's unfortunate that people are attracted to this Indiana Jones–syndrome aspect of our work. It's the other side I'm in love with: the discovery, seeing things you've never seen or even thought about before, and testing hypotheses to sort the probable from the improbable.

Omni: Did you have any heroes as a young child?

Sever: They are teachers, colleagues, and friends. I admire these people for their uncompromising dedication to their work and because they maintain the highest standards of quality. It's discouraging when you see high standards being ignored. In my mid twenties, I went to a lecture by Erich Von Daniken whose *Chariots of the Gods* was very popular then. The auditorium was sold out. I was astounded that 2 000 people could give Von Daniken this enthusiastic support when he was obviously wrong. I was scandalized by the lack of his knowledge of archaeology and astronomy. Even though I'd been actively interested in these subjects for just a few years, I could see through what he was telling people. It taught me to be careful and try to educate people.

Omni: What does the extension of human senses through remote sensing technology mean for our future?

Sever: As a species, we've been literally blind to the universe around us. If the known electromagnetic spectrum—from cosmic rays to visible light to huge seismic waves of the earth's interior—were scaled up to stretch around the planet's circumference, then the human eye and conventional film would see only the visible-light portion, equal to the diameter of a pencil. Our ability to build detectors that see where we can't see and computers that bring invisible information back to our eyesight will contribute to our survival on Earth and in space. ☐☐

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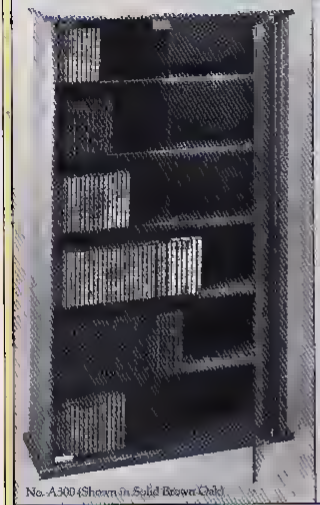

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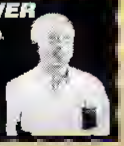

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GAMES

MARSHMALLOWS AND SPORTS
And a dash of Lewis Carroll thrown in for good measure

By Scot Morris

This month, I'm going to wrap up a couple of old puzzles and pose some of Lewis Carroll's favorite brainteasers.

In December, I asked what would happen to marshmallows in a vacuum. The answer can be seen below and at right. The marshmallows sit in a plastic vacuum jar equipped with an airtight seal at top and a detachable pump for removing the air. The jar is designed for storing coffee, nuts, or fruit. But unlike those items, marshmallows grow larger and larger as more air is pumped out of the jar. As the molecules of air gel spread farther and farther apart, so do the molecules inside the flexible marshmallows. Pinching a nozzle at the top of the jar lets air back inside, and the fluffy sweets immediately shrink back to normal size.

Before: What happens when you place ordinary marshmallows in a vacuum jar?

I also asked this question about sports and numbers. If snooker = 1, baseball = 2, football = 4, and basketball = 8, what's the logic behind the number match-ups? You don't have to know a lot about sports to solve this, I hinted, and once you've come up with the answer, you should be able to figure out the corresponding numbers for volleyball and soccer. It might require a visit to a sporting-goods store, but there you'd determine that the correct numbers are volleyball = 18 and soccer = 32. Can you solve the puzzle now? (Answer below.)

Try your hand at these puzzles, the first three were originally posed by Lewis Carroll.

1. A bag contains one stone, either white or black. A white stone is put into the bag, the bag shaken, and a white stone drawn out. What's the probability that the stone in the bag is also white?
2. Carroll said he had two clocks. One lost a minute a day, and the other didn't work at all. Which clock did he prefer?
3. 'Supposing on Tuesday,' Carroll wrote to the *Illustrated London News* in 1857, "it is morning in London. In another hour it would be Tuesday morning at the West of England, if the whole world were land, we might go on tracing, Tuesday morning, Tuesday morning all the way round, till in twenty-four hours we got to London again. But we *know* that at London twenty-four hours after Tuesday morning, it is Wednesday morning. Where, then, in its passage round the earth, does the day change its name?' The answer is well known and should pose no problem. But there's something remarkable about the question. What is it?
4. What is the difference between six dozen dozen and half a dozen dozen?
5. Which of the following words doesn't belong with the others and why: Father, Aunt, Sister, Cousin, Mother, Uncle
6. If three cats catch three mice in three minutes, how many cats will be needed to catch 100 mice in 100 minutes?
7. Name four U.S. presidents whose last names are spelled with four letters.

ANSWERS

Balls and numbers. The digits represent the total number of areas into which seams, if any, divide the ball. Thus a snooker ball is one solid surface, a baseball consists of two pieces of leather stitched together, a football is made of four pieces, and a basketball's surface is divided into eight areas. Most volleyballs consist of 18 pieces, and soccer balls traditionally are stitched from 32 pentagons.

1. The probability is ½. Let White #1 be the white stone that may be in the bag to start with and White #2 be the one added. After a white stone is removed, three possibilities remain.

In bag	Out of bag
White #1	White #2
White #2	White #1
Black	White #2

All possibilities are equally likely, and in two out of three cases, the stone remaining inside is white.
2. Carroll preferred the broken clock. The one that lost time is correct once every two years, he argued, but the stopped clock is right twice a day.
3. Days change when a traveler crosses the International Date Line, which was drawn by international agreement to settle such questions. It was established in 1884, however, long after Carroll had posed his question.
4. 864 - 72 = 792
5. Cousin is the only word in the list that doesn't specify gender.
6. Three. The same three cats are already averaging one mouse per minute, so in 100 minutes, if they don't get tired, they should clear out 100 mice.
7. Polk, Taft, Ford, Bush.

After: The air gets pumped out, and the marshmallows get pumped up.