SEX AND VIOLENCE AMONG THE PRIMATES

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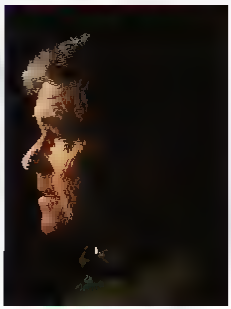
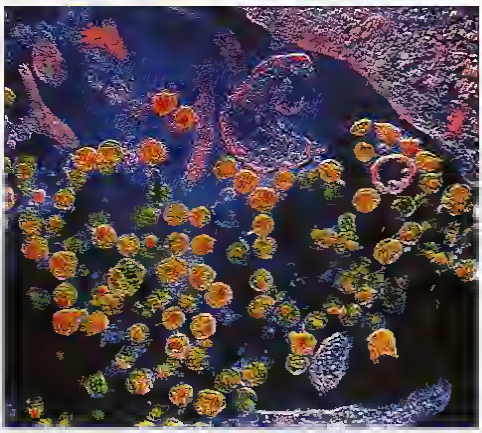
DEPARTMENTS





Controversy, contradiction, contentiousness—mention ozone and you'll likely run into all three. We've got heady opinion, provocative commentary, bold speculation. An atmospheric, as it were, issue. (Art and photo credits, page 94)

FEATURES

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FIRST WORD

POST–TIENANMEN SQUARE POLITICS: Should scientists engage in human-rights campaigns?

By Fang Li Zhi and Richard Dicker

Amid the protests marking the third anniversary of the killings around Tienanmen Square, the Chinese government received a petition with the signatures of more than 40 prominent American scientists, including 11 Nobel laureates. Among them were Linus Pauling, Hans Bethe, Burton Richter, and Herbert Brown. They were offering their prestige and support to Liu Gang, a former physics student whose story is galvanizing the scientific community in the United States and in Europe in the way the cases of imprisoned dissidents in the former Soviet Union did more than a decade ago.

Li Zhi (left), exiled Chinese astrophysicist and human-rights activist, is co-chair of the Committee to End the Chinese Gulag. Dicker (right) is director of the committee.

Liu, who was number 3 on the government's post–Tienanmen Square list of "most wanted" student leaders, was sentenced to six years in prison in February 1991. He has led several hunger strikes in prison and has been severely tortured. Last August a report was smuggled out of Lingyuan Prison, where Liu is being held, detailing the conditions for political prisoners there: beatings by guards, torture with electric batons, and punitive solitary confinement. According to sources, electric batons had been applied to Liu's genitals.

The physics community reacted vigorously to this horrifying report. 360 U.S.–based physicists issued a dramatic appeal to the Chinese government calling for Liu Gang's release. The signatories included Kurt Gottfried, Nicolaas Bloembergen, and Herman Winick. Another more highly charged arena for this growing human-rights activism was the round of international scientific conferences held in China in 1992. At the 21st International Conference on the Physics of Semiconductors (ICPS-21), which took place in Beijing last August, participants took significant steps to raise human-rights issues. One American physicist, Horst Stormer, the initial speaker at the important first plenary session, spoke out on behalf of freedom of expression. Two other Americans, aided by other participants, circulated a petition to Premier Li Peng, which called for the release of Liu Gang. The petition gathered nearly 75 signatures. A Polish participant, Piotr Boguslawski, who dedicated his paper to persecuted physicists, later said, "In our case, being from Eastern Europe, we had experience. We knew that pressure from the outside worked. Western opinion did have an influence for us. We did not have a moment's hesitation at ICPS-21." These activities became the main topic in the corridors and at informal evening meetings. Discussion raged over whether it was appropriate to take these actions, and many people—foreign and Chinese—came up and thanked those who had spoken out. Similar actions occurred at the 19th International Congress of Entomology held in Beijing.

Throughout this summer, another series of significant international scientific meetings will take place in China, including the 34th Congress of the International Union of Pure and Applied Chemistry and the International Congress of Crystallography. Despite claims by the Chinese government that all students who had "violated the law in 1989" have been released from prison, Liu Gang remains in "strict punishment regime" at Lingyuan. While questions about raising prisoner cases at these events do arise, past experience offers real guidance.

Should scientists be engaging in these types of activities? There is a longstanding tradition of scientists undertaking human-rights campaigns. These are not political activities. Rather, they are aimed at protecting fundamental human-rights values such as freedom of expression.

Can scientists make a difference? Based on the experience of human-rights campaigns for prisoners in many countries, repeated mention focuses attention on a prisoner's case and puts the authorities on notice that there is international concern. Rather than leading to more abusive treat-

CONTINUED ON PAGE 94

COMMUNICATIONS

READERS' WRITES

Science unsullied, of egos and egalitarianism, and can you hack a bit more off the sides?

Nobody Does It Better

Congratulations to Kathleen Stein [Forum, December 1992] for her impressive record of interview articles in *Omni*. I am a long-time subscriber primarily because of the Interview articles. No other magazine does it so well.

Sharon P. Bailey
Rochester, NY

Hate Those Split Ends

The article "The Walking Way" [January 1993] on bipedal locomotion was interesting, but I want to know if anyone has considered another attribute that is unique to us and has had a strong influence on our tendency to invent tools: hair on our heads that never stops growing (for most of us anyway). I can think of no other species of animal with hair that grows without stopping and must be cut to be manageable. Has a researcher investigated the connection between the need to cut our hair and the development of tools? In addition, since we don't wear down our fingernails with quadrupedal travel and at some point began wearing shoes, we probably had an early need for tools to manage nail growth, too.

Susanne Cleis
Seattle, WA

Blame Not

I am a scientist who completely disagrees with Bryan Appleyard's message [First Word, February/March 1993]. Mr. Appleyard forgot one important thing: Science in itself is nothing except a game of the mind. It looks like he takes technology for science itself. The important thing about science is what you do with it. I'm disappointed that he carries a message saying "science kills spirituality." It's like saying fire kills children—so let's get rid of fire—when by accident a house burns down.

C. Gilles Lalancette
Sherbrooke, Quebec, Canada

Passion and Productivity

Dennis Embry's First Word [December 1992] approach to "reducing violence" appears to be based on an uninformed perception of science and its relationship to humanity. Acts of aggression, hoarding and greedy self-interest, hostility and even mistrust remind me of what may have been necessary traits of our distant ancestors. Embry believes the resulting violence and unproductive behavior from such "negative" emotions may be suppressed by substituting "violent acts with neutral or kind acts." He makes me wonder what a neutral global community, one without ambition or drive would be like. Can a community exist without the individual?

Mark Tyler
Denver, CO

On the Battlefront

Your article on cancer [February/March 1993] and alternative therapies omitted a natural substance that has been documented for years: vitamin B-17, otherwise known as laetrile. Laetrile has been shown to act as an extremely effective "toxin-toting torpedo," as you referred to such substances in your article. It's widely used by holistic healers in this country in its natural form and is available in Mexico as an injectable fluid. Laetrile is naturally prevalent in substances such as the seeds of apples and apricots, among other things. The FDA, the National Cancer Institute, and now *Omni* have ignored laetrile.

John G. McManus
Wakefield, MA

When Only a Miracle Will Do

The Biblical account of the Red Sea parting when the wind blew [Continuum, February/March 1993] neither proves nor disproves believers' versus disbelievers' views on this wonder. The fact that a "strong east wind blew all night" is a natural phenomenon, but the true miracle is that it occurred when it was needed by the Israelites. Most Biblical scholars now agree that all of the Old Testament miracles can be explained by natural phenomena except for their timing at the moment of need. That's why they are truly "miracles."

Arnold J. Wolf, D.P.M.
Houston, TX

TRAVEL

THE ELECTRONIC CAMPOUT
High-tech trekking keeps nature intact

By Wallace Kaufman

It's an irritating paradox. The trekking of nature lovers poses a threat to the very environments they endeavor to celebrate. Now however, technology—so often a threat to pristine wilderness—may actually play a role in preserving it.

Electronic eavesdropping's first frontier was the deep ocean, where access is almost as limited as it is in outer space. At California's Monterey Bay Aquarium, for example, visitors settle down in front of a large video screen and share a 3,000-foot dive with scientists exploring deep-sea canyons not far away.

In the auditorium, an educator guides the viewers, commenting on the live transmission. When something unusual comes into view, he calls up stored footage from a laser disk. A scientist appears on screen to explain a thick tail of marine snow or the sudden arrival of a bizarre hagfish.

Not only does the scientists' camera take a visitor's eye where the body cannot go, but it can see in darkness what would leave the human eye blind. Engineers have modified the cameras for sensitivity to the blue-green light of ocean depths using technology developed for submarine infrared periscopes. A silicon intensifier brightens the images a thousand times.

"There is no other camera like it," says Steve Etchemendy, operations manager for the Monterey Bay Aquarium Research Institute. Next year, the Institute will place a time-lapse camera on the sea floor.

Aquarium officials note a positive change in audiences. Visitors usually stand in front of a tank or display for less than a minute. But they stay with the live link an average of 31.7 minutes.

On dry land, technology is still fighting suspicion that it corrupts our relationship with nature. To overcome the resistance, the technology is establishing a beachhead where we are most willing to accept help—among things microscopic and miniature.

Using devices known as Bioscanners, visitors at institutions such as the Smithsonian's Natural History Museum and the North Carolina Zoological Park enter the insect world eyeball to compound eyeball. Created by New Zealand's Optech International, the device places the visitor at simple controls outside a closet-sized box full of terrariums. The viewer chooses which insect to visit, focuses a miniature camera, and the undisturbed insect appears on a 20-inch screen. What more do you need to get a kid's attention than a TV screen and a joystick?

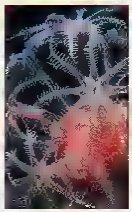
Optech is also developing a night-vision system and an underwater Aquascanner whose joystick-driven zoom camera lets the dry visitor explore shallow pools and their critters. The newest innovation, the Terra-trakker, whose weatherproof camera can stand anywhere in a wild habitat—inside a bear-resistant clear Lexan Dome or a fiberglass tree—while the viewer operates it by remote control from a distant platform. Some systems come with more than one camera, allowing the user to change viewpoints faster than a cameraman on foot or in a safari jeep.

The National Park Service's Interpretive Design Center, based in Harper's Ferry, West Virginia, is also creating technological aids for the ecosystems it manages. Senior producer Tom Kleiman combines laser disks, camcorders, and computers to do "things that were only possible in dreams a few years ago."

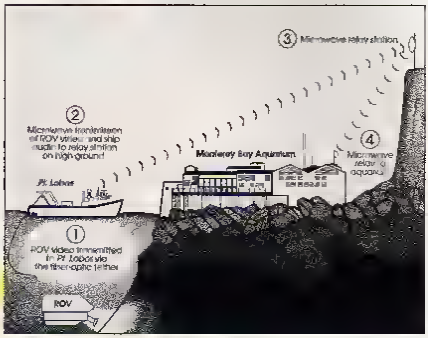
To protect campers and hikers from wilderness tragedy, guard the land from abuse, and save the Park Service from visitor lawsuits, Kleiman created a video of simulated wilderness experiences for Alaska's Denali National Park. Using a touch-screen computer, viewers choose a range of worse-case scenarios, from bear attacks to river crossings.

Technology under development in research labs may put future generations of electronic campers where even ardent wilderness advocates like Edward Abbey and David Brower never went. Vision researcher Robert Barlow, of Syracuse University's Institute for Sensory Research, has developed means for monitoring and deciphering the transmission from a horseshoe crab's eye to its brain and vice versa. He is close to fitting free-roaming crabs with tiny transducers that tap single optic-nerve fibers and transmit data on modulated sonar signals to a video recording system. The goal: to see nature as other beings see it.

Exploring wilderness with electronics and computers may seem less satisfying to the purist than stalking wildlife across a tangible landscape, but it's kinder to both the habitats and the animals. And there is little doubt what *they* would choose. ☐☐



Ocean views: The specially equipped cameras of Monterey Bay Aquarium capture life at the bottom of the sea, including the golf ball coral.



WHEELS

AUTOVISION
The art of driving while watching TV

By Steve Nadis

Millions of cellular phones have been installed in U S cars with minimal debate over the effects these devices have on driver safety Similarly, extensive safety research was done prior to the introduction of electronic navigation systems or HUD (Head-Up Display) units which enable drivers to monitor speed and other car functions without removing their eyes from the road But just

Using a projector mounted near the dome light, AutoVision beams TV images to a matchbook-sized mirror lens near the windshield. Due to an optical illusion, the picture appears to float about a dozen feet in front of the car.

mention the idea of watching television while driving a car and people go nuts. "Why does everyone consider this so crazy?" asks Jay Schiffman "Is there some scientific basis for that belief? *Absolutely not,* it's done using our patented methodology and configuration."

Schiffman an electrical engineer from Farmington Hills, Michigan, has researched car displays and TV systems since the late 1960s A configuration he's demonstrated AutoVision, is being prepared for commercialization in Europe and the Far East in about two years It uses a projector, mounted near the dome light which beams TV images to a matchbook-sized mirror lens near the windshield. Owing to an optical illusion, the picture appears to float above the horizon, a dozen feet in front of the car It's like looking at a 12-inch TV set from across a room except there's no TV and no room

The natural instinct is to dismiss the idea as sheer lunacy Drivers face enough distractions in this wacky world Do we really want them watching TV too? Yet AutoVision can't be dismissed so easily Today, 17 states have no restrictions against drivers watching TV The usual option, small plug-in units that sit on the dash, are much more dangerous than AutoVision because drivers have to take their eyes off the road to watch a show More important, vehicle navigation systems are already a reality An AutoVision-type unit performs that function, displaying traffic information rather than daytime soaps It may be preferable to the systems used today computerized maps mounted below the windshield

Schiffman claims AutoVision has been road tested by more than 400 drivers on more than half a million miles "without a single incident." He vouches for its safety on other grounds A driver can only see the picture if he's looking straight ahead, "in the place God had ordained you ought to be looking." Because the TV is only seen with one eye the driver's view of traffic, stoplights, and hazards is never blocked According to Schiffman, AutoVision also can reduce accidents by keeping people alert "A bored driver is an accident-prone driver."

In 1989, Schiffman sought the views of independent experts While the panelists stopped short of endorsing AutoVision they agreed that the concept warranted further study "Many people assume it would be hazardous, but that's not necessarily true," says D. Alfred Owens, an experimental psychologist at Franklin and Marshall College in Lancaster, Pennsylvania One problem he notes, is that we still don't understand how drivers do as *well* as they do with only one fatality for every 50 million vehicle miles traveled "Once we understand that we'll be better equipped to evaluate systems like AutoVision"

Another panelist University of Michigan Transportation Research Institute's Paul Green concurs "Considering how much time Americans spend in cars—typically more than an hour per day—it's amazing how little we know I can give you a detailed description of how people fly airplanes but not how they drive a car." Data, for instance, on where drivers focus their attention and for how long is virtually nonexistent In 1991 Green helped draft a new Michigan law permitting AutoVision and other display systems to be tested on the roads Research, using simulations begun last year at the university indicates that AutoVision-like systems can effectively convey traffic and navigation information to drivers "We still don't know about the entertainment part," Green admits

The biggest concern is "cognitive capture," a term coined by Ann Arbor engineering psychologist Daniel Weintraub. "If the display is too compelling, a driver might be looking at the right place without really paying attention." This issue could affect programming It may be safe for drivers to watch dull shows like *Wall Street Week in Review* but not superriveting ones like *Jeopardy!*

The greatest benefit of AutoVision, Owens says, may lie in the realm of education, not entertainment. "The issues presented by this technology will challenge us to learn a lot more about driving than we know right now That knowledge, in turn, can help us appraise other technologies that come down the pipe" DO

POLITICAL SCIENCE

STAR WARS: THE NEXT GENERATION
Has the time for particle beams arrived after all?

By Tom Dworetzky

Washington's mood right now about Star Wars research is to bring it down to Earth. Forget the ICBMs and focus more on so-called theater defense. That means building super-Patriots—antimissiles that actually work—to protect our troops against SCUD-style World War II vintage rockets. Such antimissiles are constructible today with off-the-shelf components, and they should be developed and deployed. But slashing the billion-a-year advanced-technology Star Wars budget to achieve this short-term goal is a long-term mistake.

Will new and better Patriot missiles be able to protect us in a world of proliferating—and increasingly politically unstable—Third World ICBM players?

At least that's what I argued with my mother, the world federalist, and, boy, did she bless me out for it. More money for the military just perpetuates the problem of violence, she argued. But there's violence, and then there's violence, I said to her.

If we're going to cut down our Department of Defense budget—our ability to project offensive strength around the globe, which I'm in favor of—we must look at the transitional period between the Cold War and a single-world government. What we've got now in the wake of the breakdown of superpower hegemony is a nasty brew of high-tech weaponry mixed in with violent tribal and regional conflict. To get from here to world federalism, we have to develop the technology that will put teeth into the loose confederation operating under the United Nations' blue banner. That's right. I'm talking about the anti-Intercontinental-ballistic-missile missile blues again.

I really don't like the idea of supporting military R&D, but I feel compelled to agree with those Strangeloveans who say the time for effective antimissile defenses has arrived. The problem: Nuclear proliferation is inevitable. Missile technology is growing more accessible to even the poorest countries, and the old rules no longer apply. That is, Mutually Assured Destruction was based on the existence of only two major ICBM players—the United States and the former U.S.S.R.—and now we have many players. Simply stated, if a nuke lands on Des Moines, we won't necessarily know who to strike back against; thus, we need to develop the ability to protect ourselves (and ultimately others) against the random hit.

It would be nice to think that we'll be able to stop nuclear wannabes from getting their hands on weapons of mass destruction. But we can't, so a United States Star Wars system is, I have to say, the only reasonable (though regrettable) option.

It might also be the first step toward a global system, one that the United Nations could someday control. The power to extend ICBM protection to recalcitrant nations (or withdraw it from them) would finally give the world body the serious bargaining clout it so desperately needs to bring diplomatic resolution to many of the bloody tribal and national factions that are springing up at the end of the imperial millennium.

Star Wars spinoffs, especially in the area of autonomous robots, might also prove important enough to justify the concept of getting your money's worth from military spending.

In fact, Star Wars could well do for robotics what code breaking in the Forties did in the realm of computing—become the driving force leading to key breakthroughs—especially in the fields of machine vision, navigation, and logic. For Star Wars to work at all, it must be able to see and differentiate real from dummy warheads, assign interceptors, and make sure they'll get there. And do all that in less than 15 minutes. The problems posed by these challenges extend beyond today's computing capability and sensing technology, so Strategic Defense Initiative researchers are developing such exotic devices as optical computers that use light instead of wires to pack much more computing power, and broad-band sensors to "see" the spectrum from ultraviolet to infrared, using funneling microscopy sensitivity to pick up warheads against the night sky.

In the long term, even the Star Wars equipment that has evoked such mockery—beam weapons—has tremendous civilian potential. This same technology, when harnessed for peace, could etch computer chips with a resolution a hundred times finer than the ones we make today.

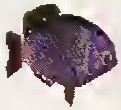
Packing that much into a smaller space, along with advances in sensors and optical computing, could actually produce the stuff that our robotics dreams are made of. At the same time, I don't see that Star Wars would make this corner of the galaxy any more dangerous than it already is, considering all those nuclear-tipped missiles poised for the black market. In fact, it might make our world a little safer. **DO**

ELECTRONIC UNIVERSE

THE BEST OF 1993

A glimpse at tomorrow's electronic fun

By Gregg Keizer



Betting on the future is a job best left to professionals as any fool can see simply by pulling down a copy of last June's 'Electronic Universe' column. Okay, so I wasn't right all the time. But I was close.

So, even though the year's but half gone, I'll give the crystal ball one more try and post *Omni*'s Top Ten for 1993.

TOP TEN REASONS WHY 1993 WAS GOOD FOR GAMES

10. *Strike Commander* shipped. One of last year's predictions that never happened, *Strike Commander*, the high priest of flight simulators, really did make it out of the disk duplicator. So, too, did other no-shows from last year, like *Buzz Aldrin's Race into Space* and *Jordan in Flight*. The year's bets for Great but Really Late? Interplay's *StoneKeep*, a dungeon-crawling simulation, and Spectrum HoloByte's *Star Trek: The Next Generation* video- and computer games.

9. Sex sold. Kids may have cornered the market on video- and computer games for years, but grownups finally saw the faint light of adult storylines and situations. Fueled in part by CDs on such systems as Philips' CD-Interactive machine (*Voyeur*) and Sega CD (*Night Trap*), the first offerings weren't much, but they do show what's coming. Look for the first X-rated game soon.

8. They built a better mousetrap. *The Incredible Machine*, a hard-to-categorize game that blended arcade action and puzzle solving, was one cool way to waste tons of time in 1993. From Dynamix, part of Sierra, *The Incredible Machine* let you assemble Rube Goldbergesque contraptions to solve increasingly difficult puzzles. Like the board game "Mousetrap" that it sometimes resembled, *The Incredible Machine* was best when balls rolled and levers sprung.

7. David Letterman went to CBS. Nothing to do with games, but anytime you put a list in reverse order, the guy gets credit. 6. Call me Bubba, he said. With a Southerner in the White House, it's a good year for Sid Meier's latest simulation. Based on the Civil War, this as-yet-unnamed game (at press time, anyway) lets you replay the war that made PBS famous. If Meier can duplicate the phenomenal success of his last effort, the outstanding *Civilization*, this may be *the* game to be played by the Bubba Twins, Clinton and Gore.

5. Jane Fonda not only did the Tomahawk Chop, she played videogames, too. Sega may have slipped behind Nintendo in the 16-bit game department, but its hardware is second to none. The *Activator*, a ring of plastic you stand in, let everyone work off a few extra pounds playing videogames. Kick your leg, and the character kicked hers, too. Fitness cartridges can't be far behind. Even funkier was Sega's *Virtua VR*, a set of virtual reality–like goggles you snapped over your eyes for some literal in-your-face videogame action.

4. Fish swam fields got plowed. The ultimate in screen savers, junk-food software, was *FI-Fish*. Maxis' aquarium in the PC. You got to build and breed fish, then add tons of accessories like plants and a castle for the guppies. Maxis' other release, *SimFarm*, may not have had the appeal of its urban counterpart, *SimCity*, but for anyone who wanted to work the land without getting their hands dirty, it was the best thing since someone invented Roundup.

3. SNES Ruled. Although a tour through the videogame aisle at Toys 'R' Us is like a walk through a ghetto of creativity—how many different ways can you punch a cartoon character on the screen, anyway?—the Super Nintendo picks were tops in 1993, thanks in part to such terrific cartridges as Nintendo's own *Star Fox*, a 3-D space-flight simulator, and Electronic Arts' *Bulls vs. Blazers and the NBA Playoffs*.

2. 3DO rhymed with "Standards, Mo' and Mo'." Yet another CD-based game machine shoved itself—and its "standard"—into the home and down developers' throats. But the 3DO black box, built by Japan and backed by Time-Warner and AT&T, actually made it into homes in part because of its future promise as a superdeluxe cable and movie-on-demand controller. This year: games; next year: HBO; 1995—the toaster.

1. Nintendo still owned the Mariners. Now if only we could get Sony to buy the Dallas Mavericks and Sega to pick up the New England Patriots, we'd be able to unload all the cellar-sucking teams on the Japanese.

What the future holds: seeing the world through Sega's *Virtua VR* goggles, and a few not-so-stupid pet tricks—like *El Fish* from Maxis Software.

EARTH

FOOD FIGHT
Burger deluxe, hold the biotech

By Linda Marsa

Chef's surprise: Chef Rick Moonen (seated second from left) rallied alarmed colleagues to join the Pure Food Campaign, led by Jeremy Rifkin (third from left).

Silhouetted against the backdrop of the New York skyline more than 20 of Manhattan's top chefs gathered at the elegant Water Club last June to call for restaurants to boycott genetically engineered foods. But these weren't just a bunch of publicity-seeking foodies in a snit because, as one reporter scoffed, genetic jockeys were riding roughshod over their gastronomic Eden. These self-styled stewards of the earth were mad as hell over the U.S. Food and Drug Administration's decision not to test or label altered fruits and vegetables.

The response of the men and women in white toques was swift—and surprising in its solidarity. In short order, nearly 2,000 of the nation's culinary superstars—among them Spago's Wolfgang Puck, Alice Waters of Chez Panisse, and the Russian Tea Room's Paul Ingenito—joined their fellow chefs in the Pure Food Campaign. They plastered the boycott's logo, a double helix with a diagonal red slash, on the walls of their establishments. "We're responsible for what we serve our customers," says Wolfgang Puck. "We want to know exactly what's in the food we buy and what the possible consequences are."

America's celebrity chefs say their opposition to so-called 'Frankenfoods' isn't just about compromising culinary purity. They fear shuffling genes from plants and animals like a deck of cards could inadvertently unleash deadly toxins and allergens on unsuspecting consumers. At the very least, this technology raises ethical, religious, and medical dietary concerns.

But agribusiness representatives dismiss the chefs as "nutritional neurotics," calling their movement just another example of fuzzy-headed environmental terrorism. And officials at the FDA, the focal point of this furor, wonder, why all the fuss?

The opening volley of this battle was fired on May 26, 1992, when then–Vice President Dan Quayle announced the new FDA rules on the same day that City Hall was honoring 50 of New York's premier chefs for their contributions to tourism. "A reporter asked my opinion about the FDA announcement," says Rick Moonen, executive chef at the Water Club. "I had no idea this was happening. I was completely taken aback." Moonen relayed the information to more than two dozen alarmed colleagues.

Indeed, numerous companies, including Monsanto, Upjohn, Calgene, and Frito-Lay are using biotechnology to produce novel strains of fruits, vegetables, poultry, fish, and livestock that are resistant to diseases, drought, cold, and herbicides or to enhance their ripening, taste, or nutritional value.

The first of these high-tech hybrids, Calgene's FlavrSavr tomato—which contains a bacterial gene that delays rotting to give it a longer shelf life—will debut this year. In the pipeline: potatoes with wax-moth genes to retard bruising; tomatoes with flounder genes to render them frost-resistant; and corn altered with firefly genes. Experts predict genetically engineered plants will blossom into a $300 million-a-year business by 2002.

But bottom-line concerns motivated America's eco-chefs, too. They worry diners will suffer unexpected allergic reactions, which would expose them to possible liability. There's also potential problems for vegetarians, Orthodox Jews, Moslems, and Buddhists when animal genes are implanted in vegetables.

The FDA, however, doesn't understand the outrage. These guidelines parallel their generally regarded as safe (G.R.A.S.) policy. Products made from components known to be safe don't need to undergo extensive approval procedures. Thus, splicing genes from foods recognized as safe won't change their composition, and these genes won't be considered food additives.

"All plant breeding involves genetic manipulation," explains James H. Maryanski, biotechnology coordinator for the FDA's Center for Food Safety and Applied Nutrition. "The only real difference is these techniques have greater power and precision."

But critics think otherwise. "Though many genetically engineered organisms are likely to be safe, if even a small percentage becomes hazardous, the consequences could be catastrophic to a species or an ecosystem," says Jeremy Rifkin, president of the Pure Food Campaign and a long-time foe of biotechnology.

So far, the Pure Food Campaign, which is recruiting restaurants, grocery stores, distributors, and growers to join the boycott, seems to have won the first round. New York City may enact a mandatory labeling law, and the FDA is reconsidering its original stance. Ultimately, though, this high-tech food fight may be settled in the supermarket.

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WHO YOU CALLING DUMBO?

Researchers test the elephant's mighty memory

By Steve Nadis

It looks like child's play. Researchers at the Indianapolis Zoo place apples in eight covered pots arranged in a large circle. They guide an elephant to the center of the circle, turn him around, and then challenge him to find the apples—one at a time. True to the common wisdom, the elephant rarely forgets where he's been before. During the game, he routinely collects seven to eight apples.

Inspired by the old adage, 'elephants never forget," which first surfaced in modern lore in 1904, the zoo crew is carrying on a long tradition. Investigators have been testing the elephant's memory for decades.

Intrigued by decades of compelling anecdotal evidence, researchers are putting the elephant's brain power to the test. In time, they hope the information will help preserve the imperiled species.

Anecdotal evidence already suggests that elephants, which possess the largest brain of any land animal, are intelligent creatures with impressive memories. The animals can learn up to 100 commands. After mastering tricks, circus elephants seem able to recall them indefinitely.

Bernhard Rensch carried out some of the earliest laboratory experiments at Germany's Munster Zoo in the 1950s. He taught a five-year-old Indian elephant to single out the correct choice among 20 pairs of cards, each containing a different visual pattern. Tested a year later, the elephant performed admirably.

Leslie Squier, a psychologist at Oregon's Reed College, subjected three female elephants to similar "visual discrimination" tests in 1964. A fire destroyed his original data, so the researcher repeated the tests more than eight years later. "The first elephant strode right up to the apparatus without hesitation," notes Hal Markowitz, a zoologist at San Francisco State University who collaborated with Squier. "She knew exactly what to do."

These results—combined with the observations of zookeepers, trainers, and scientists in the field—indicate that elephants can remember things for a long time. "But they don't tell us anything about how they do that," says Butler University psychologist Robert Dale, who launched the Indianapolis Zoo experiments to shed light on that puzzle a year ago. "We're trying to identify the memory strategy elephants use—in the same way, for instance, that people rely on a strategy to memorize numbers," says Melissa Shyan, a Butler psychologist.

The Indianapolis team is particularly interested in spatial memory—that is, how the elephants remember the locations they've been to. Observers in Namibia, for example, have marveled at the ability of desert elephants to find watering holes more than 100 miles apart that they haven't visited for months. How do they know where to go?

Dale hopes to provide some clues with the find-the-apple tests, at which elephants do very well. The studies mimic "radial arm mazes" that scientists have used to test the memory of snakes, cockroaches, mice, rats, chickens, monkeys, and human infants. "One obvious way to solve the problem would be to remember the last pot you visited and then go to the next one on the right," Dale says. Rats often adopt this strategy, but the elephants don't. Although certain patterns have been observed, Dale cannot discern any grand scheme in the order of pots they select. "Apparently this problem is so easy for them that they don't have to resort to any special strategy. It's as if they make a mental map and check off the places they've been to." He suspects, although he can't yet prove, that the animals rely on outdoor landmarks—a barn or a fencepost—to navigate among the pots.

The next step is to make the task harder—by changing the spacing of the pots, by running the tests at more frequent intervals, or by interrupting them for long stretches—until memory starts to break down. "Those failures will tell us more about how their memory works than we can learn from watching them perform flawlessly," Dale says. Scientists use a similar technique to improve our understanding of human memory: they study people with damaged brains to see what functions suffer.

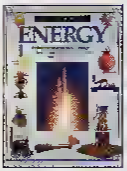
Other research groups are studying elephant cognition and memory. Among them, Cornell biologist Bill Langbauer is learning how elephants process, retain, and communicate information. One goal: to better define and protect the animals' habitat. "The more we know about how they feed, find water, and communicate, the more we know about the size and quality of the preserves we need," Langbauer says. With the survival of elephants in jeopardy worldwide, the results of such studies will have broad implications indeed.

KID STUFF

FINDING THE HUMAN SIDE OF SCIENCE

Wise books show kids the people behind the test tubes

By Robert K. J. Killheffer



Books by working scientists and a new Dorling Kindersley series show science's often-overlooked human element.

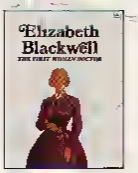
Too often, kids only encounter science as a mass of incomprehensible equations and abstract ideas to be memorized for a test (and promptly forgotten). Where history or English classes focus on people, science seems to have no ties to the human sphere. Science is not presented as something people do, but as something that happens to them, an inhuman force that can transform the world, but in which humans have no role.

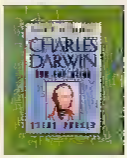
Small wonder that fewer and fewer American children are interested in scientific careers. But with care, parents can counter the antihuman image of science, and there are a number of good, solid, entertaining books available to help.

Last fall, the kids' science-book specialists at Dorling Kindersley launched the "Eyewitness Science" series (aimed at ages 10 and up), which places science concepts in colorful personal and historical contexts. In the *Matter* volume, lessons about crystals, electricity, and the properties of solids and gases are framed by the stories of the pioneer scientists who blazed the trails, including familiar figures like the revolutionary seventeenth-century chemist Robert Boyle and Antoine Lavoisier, who was the first to demonstrate the principle of the conservation of matter, as well as more obscure personalities such as German organic chemist Justus von Liebig (1803–1873). In the *Force & Motion* volume, kids can see how closely scientific inquiry and advancement are tied to everyday life—how pulleys, levers, and other simple machines were applied to specific tasks; how the early study of motion was linked to warfare (soldiers needed the equations of ballistics to aim cannonballs more accurately), and how studying the motion of waves and the wind can lead to new sources of energy. Photos of antique equipment and lively, information-packed text provide a vital sense of the history behind every scientific principle, from the ideas of the ancient Greeks and the mystical investigations of the medieval alchemists to the innovations of the scientific revolution. These books are so full of vivid illustrations and intriguing facts, parents may end up fighting their kids for a chance to look through them. Volumes on *Matter*, *Force & Motion*, *Light*, and *Electricity* were published last fall; in April 1993, Dorling Kindersley released *Chemistry*, *Energy*, and *Evolution*.

A couple of other series put the people back into the science with entertaining biographies of influential scientists. Steve Parker's "Science Discoveries" series (HarperCollins, ages 8 to 12) examines the lives and works of such preeminent thinkers as Galileo, Charles Darwin, Marie Curie, and Thomas Edison. Though Parker's unapologetic championing of his scientific heroes over their religious opponents won't play well in the Bible Belt, these inspiring narratives will show kids how important personalities have been in the advancement of science, and how courageous some scien-

KID STUFF





The lives of Galileo and Marie Curie can inspire kids to pursue science careers of their own; one series (top) showcases some of the possibilities.

tists have been in the pursuit and defense of their ideas. Likewise, a series of 'Easy Biographies' from Troll Associates (ages 9 to 11) offers enjoyable portrayals of science pioneers, focusing more on their younger years, showing kids how the things they do as youngsters can lead to exciting and important achievements down the road. They'll see how the bright, young Marie Curie, with her exceptional memory and precocious reading skills, faced discrimination (women were not allowed to attend college in her native Poland at that time) and personal tragedies (the early deaths of her mother, sister, and husband) on the way to winning two Nobel Prizes, and how the curious young Louis Pasteur observed the mysteries of disease and food spoilage, forming the questions as a boy that he would later answer as an adult. 'If you believe in yourself and study hard,' Louis' father tells him, *anything* is possible'—encouraging advice for young scientists everywhere. Troll's biographies have also covered Wilbur and Orville Wright, Albert Einstein, Thomas Edison, and Elizabeth Blackwell, with more to come in the future.

Another Troll series—'A Day in the Life of _____'" (ages 9 to 13)—shows kids some of the opportunities open to them in science. Each volume offers an up-close look at a fascinating science-related occupation, from beekeeper and forest ranger to marine biologist and veterinarian. Not only will these books inspire young readers to consider science careers, they also detail the special requirements and duties of each job, so kids will understand the dedication and study that are necessary. Troll also publishes a similar series aimed at younger (5- to 8-year-old) readers: "What's It Like to Be ____?" which profiles the careers of a doctor, an astronaut, a veterinarian, and an airline pilot, among others.

Crown's "Face to Face with Science" series (ages 7 to 11) provides a different sort of look at real scientists at work. In *Digging Up Tyrannosaurus Rex*, paleontologist John R. Horner and science writer Don Lessem take kids on a Montana fossil excavation, and they follow the fossil hunter's work from the dig to the museum labs and, finally, to the mounting and display of the skeleton. Biologist Katharine Payne's *Elephants Calling* tells how she discovered the subsonic communication of elephants and how she continues to study the voices and behavior of those great beasts. Payne focuses on one cute baby elephant she calls Raoul, watching him as he follows his mother and the rest of the herd across the plain to the swamp, plays with other young elephants, and slips away from the adults for a few scary minutes of private adventure—ending in an encounter with a squealing warthog. Vivid photographs and a clear, engaging text bring kids into the world of real-life working scientists on the cutting edges of their fields. Other titles include *Voyager* by Sally Ride and Tam O'Shaughnessy and *The Search for the Right Whale* by Scott Kraus and Kenneth Mallory.

Science doesn't go away just because it's ignored; if anything, it will be an even more undeniable part of our world in the future. With the help of books like these, kids will not only learn their science better, they'll learn what sorts of careers science offers and how exciting such work can be. ☐

CONTINUUM

ARE THE NINJA TURTLES MISINFORMED?

They know more about pizza than aerosols. Plus, how bears cross the road, and what may soon be missing from the salad bar

One Saturday morning, unable to concentrate on the novel I was reading, I clicked on the television only to witness a quartet of renaissance terrapins who call themselves the "Teenage Mutant Ninja Turtles" deliver the following "turtle tip": "The ozone layer, which shields us from the sun's deadly radiation, is getting thinner, and to protect the earth we have to stop 'using stuff that hurts it, like aerosol spray cans and foam cups.' Silly reptiles! I thought. Aerosols don't contain CFCs (chlorofluorocarbons)—not anymore.

Recent surveys, however, show that most schoolchildren and more than half of adult Americans think aerosol cans are dangerous. That says the aerosol industry is a myth about, their product fed mostly by the media which seem unaware that aerosols have been free of CFCs for 15 years.

Take, for example, the recurring episode of the *G.I. Joe* TV cartoon series titled "Nozone Conspiracy." In this segment, evil Cobra plans to destroy the ozone layer by siphoning CFCs from giant aerosol tanks of shaving cream. After bursting through the protective stratosphere, Cobra intends to become a trillionaire by selling Nozone skin cream to everyone on Earth for $500 a tube. (Shaving cream didn't use CFCs as a propellant even in the mid 1970s.)

And then there's the *Northern Exposure* episode in which Ruth-Anne holds up a can of aerosol hair spray in her store and refers to it as "ozone-depleting spray."

Even Johnny Carson got on the aerosol-bashing bandwagon when he announced in a 1991 monologue that the thinning of the ozone layer had been traced to the CFCs in Candice Bergen's hair spray.

In the past two years, there have been at least 200 examples of what the three-year-old Washington, DC–based Consumer Aerosol Products Council calls "Aerosol/CFC misinformation"—evidence that most Americans are unaware that CFCs have been banned as aerosol propellants since 1978 (barring a few government approved CFC uses such as asthma inhalers, which will also be phased out by the year 2000). In a massive letter-writing campaign, the group has responded to numerous cartoons, talk shows, educational books, television and newspaper stories, and advertisements that give aerosols a bad rap. And after attending a recent National Science Teachers Association meeting where 50 percent of the teachers in attendance admitted they were unaware that aerosols are CFC free, the council produced a 13-minute video called "The Aerosol Adventure" in order to convince schoolchildren that aerosols are their friends. Said one teacher: "It's hard to tell my seven-year-olds that the Ninja Turtles aren't always right."

With all due respect to the hard-shelled heroes, they do appear to be as misinformed as the rest of us. A 1991 survey commissioned by New Jersey–based Johnson and Sons reports that while three in ten Americans buy products in pumps rather than aerosol cans, they have little idea that refrigerants, car air conditioners, solvents, filler material in foam products, and cleaning agents—particularly for computer circuitry—do release CFCs and are far graver threats to the ozone layer. "By and large, the aerosol industry is correct," says University of California, Irvine, chemist F. Sherwood Rowland who, along with MIT's Mario J. Molina, discovered in 1974 that CFCs are responsible for the destruction of the earth's ozone layer.

While the United States accounts for 5 percent of the world's population, we produce 30 percent of the 2.4 billion tons of ozone-depleting CFCs released into the atmosphere each year. If the government went so far as to ban CFCs as aerosol propellants and aerosol companies reluctantly complied, where is the government leadership that dictates policy to the rest of the chemical industry? Many alternatives to CFCs are already available, but what is lacking is corporate commitment to make the switch. An EPA study reports that a 100-percent reduction of CFCs is necessary just to stabilize chemicals already in the atmosphere, and Rowland says that while the amount of CFCs going into the atmosphere is "considerably less" than it was, upper-ozone damage is accelerating at a quickened pace.

If the media really want to educate their public about saving our skies, where it's estimated that CFCs will double over the next 50 years, the aerosol industry—the only one required to change to safer methods—is the wrong target. Hair spray is not the culprit. Refrigerant leakage (from cars, homes), circuitry-cleaning solvents, cleaning agents, and blown plastics are.—*JUSTINE KAPLAN*

CONTINUUM

JUST WAIT A SECOND

If June 30, 1992, seemed like a particularly long day, that's because it was. At midnight, international timekeepers in Paris added an extra second to the day.

The addition of this "leap second" keeps the time as measured by atomic clocks close to the time as measured the old-fashioned way, by the earth's rotation. Periodic adjustments are needed because the earth's rotation is slowing down. The tides—which tug the oceans in one direction while the planet spins in another—create friction, just like brakes gently applied to a spinning wheel. Owing to this gradual slowdown, a day in the year 2000 will last some three milliseconds longer than a day back in the good old days of 1900.

International timekeepers now add a leap second about once every year and a half to keep the clocks synchronized. By 2020, they'll have to insert two leap seconds a year. "If we didn't do this, we'd eventually get out of synch with sunlight," explains Dennis McCarthy, an astronomer at the U.S. Naval Observatory. "It would be dark at noon."

The second added last June is important not only to perfectionists, but to anyone who navigates by the stars. Suppose a ship is at sea near the equator. If the captain knows the time, he can determine his whereabouts by measuring the position of a few standard stars. But if the clock he relies on is off by just one second, the captain will miscalculate his position by a quarter mile.

Seventeen leap seconds have been added altogether since 1972. If no one had bothered to adjust the official clocks, the atomic time and the rotation time would be 17 seconds out of whack. And those hapless mariners would have missed their port by a good four miles.

—Steve Nadis

TEN BOOKS ON A SHELF CAN BE ARRANGED IN 3,628,000 DIFFERENT WAYS.

THE SOLAR-HYDROGEN CONNECTION

In 1874, Jules Verne speculated that clean-burning hydrogen might become the fuel of the future. Although dozens of prototype hydrogen vehicles have hit the pavement recently, questions still abound regarding the merits and practicality of this fuel. A three-year demonstration project conducted by the Center for Environmental Research and Technology at the University of California at Riverside's College of Engineering aims to find some answers.

The system uses solar cells to convert sunlight into electricity. The electricity, in turn, is fed to an electrolyzer, which creates hydrogen and oxygen from water. The hydrogen gas then fills pressurized fuel tanks that will power a modified Ford Ranger truck. The entire operation was scheduled to begin running early this year, and it is believed to be the first state-funded system that uses solar energy to make hydrogen fuel for motor vehicles. "Where else can you convert sunlight to hydrogen and then use it for transportation?" asks Joe Norbeck, the center's director and the project's principal investigator.

Southern California's South Coast Air Quality Management District (SCAQMD) funds the project as part of a broad strategy to improve air quality. "We want to look at things we can do in the next few decades, not just the next few years," explains SCAQMD chief scientist Alan Lloyd.

The project will allow Riverside engineering faculty and students to conduct the first thorough environmental appraisal of hydrogen vehicles while also rating the performance of solar-energy systems in smoggy areas with noticeably reduced visibility. "We know these systems work in a polluted environment," Lloyd says, "but we still don't know how well they work."

—Steve Nadis

"If your morals make you dreary, depend on it, they are wrong."
—Robert Louis Stevenson

CRACKING THE SHELL

Autism is among the most stubborn and tragically intractable of all developmental neurologic disorders, resulting in extreme social withdrawal, communication deficits, and repetitive behavior patterns. But now a psychiatrist from the National Institute of Mental Health in Bethesda, Maryland, reports making new headway in treating autistic children. He uses a drug called clomipramine, which has been effective in treating obsessive-compulsive disorders.

Since 1990, C. T. Gordon has given clomipramine to 25 autistic children and compared the results with those from desipramine—another antidepressant—and from a placebo. While neither desipramine nor the placebo had much impact, clomipramine brought about significant improvement—less withdrawal and anxiety, fewer angry outbursts, and less ritualistic behavior. "The children were calmer and easier to deal with, and they showed increased attention span and productivity," Gordon says. "Their parents were very pleased, and eighty percent of them chose to continue clomipramine treatments after the study was over."

While he stresses that clomipramine "is not going to make autistic kids unautistic," Gordon remains cautiously optimistic. "Up to now," he explains, "nothing much has helped with autism. But with clomipramine, we did see improvements in social interaction. Many of the kids definitely brightened up and showed more interest in the people around them."—Bill Lawren

SICK PLANTS RUN TEMPERATURES FROM 0.1 DEGREES CENTIGRADE TO 2 DEGREES CENTIGRADE HIGHER THAN THOSE OF PLANTS IN GOOD HEALTH.

Clomipramine can help treat autistic children

Even fungi wither before the onslaught of modern pollutants.

MUSHROOMING PROBLEM

European mushroom collectors are shaking their heads in dismay at their empty baskets. The once-abundant chanterelle, long prized by gourmets for its delicate scent, and more than 100 other mushrooms that form "mycorrhiza"—a symbiotic relationship with trees—have turned as scarce as four leaf clovers. Indeed, Dutch mushroom expert Eef Arnolds reports that on average, roughly half as many of these species populate European woodlands today as in 1950. Forests in the Netherlands, Germany and Czechoslovakia have suffered the greatest losses, Arnolds reports. At a major mushroom market in Saarland, Germany, for example, chanterelles and other popular mushrooms, called boletus, have nearly vanished from sight. The dearth of chanterelles and other mushrooms results not from overzealous collecting but from pollutants produced by industry, traffic, and modern agriculture. The wind disperses the main destructive agents—sulfur dioxide, nitrogen oxides, and ammonium—which are then deposited on trees and the forest floor, leading to harmful acidification and nitrogen accumulation.

Owing to the lack of U.S. research in this field, scientists don't yet know if mushroom populations here face a similar fate. But Arnolds can see "no reason why fungi should resist pollutants any better in North America than in Europe." He emphasizes that the impact of a decline would be felt far beyond the culinary arts. "These mushrooms provide nutrients and water for trees," he says. "When the mycorrhizae vanish, they can take with them entire forests."

—Kathleen McAuliffe

CONTINUUM

STRESS SPECS

Scarsdale, New York, psychiatrist Richard Frenkel recently received a patent for a pair of high-tech specs that—if they're ever produced—could make Ray•Bans look positively retro. Frenkel's glasses monitor a person's stress levels by measuring skin temperature, electrical conductance and perspiration. When stress rises above a safe level, the glasses issue a discreet warning in the form of a quiet beep or flashing light. The person can then slip in a colored lens custom designed to calm the wearer.

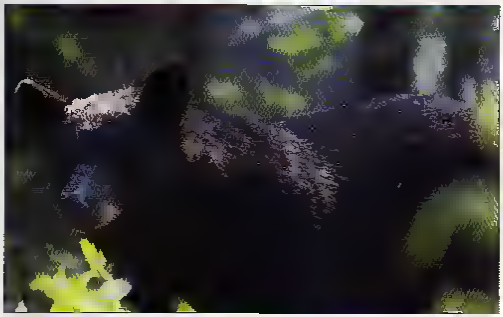
If this approach sounds unorthodox, it should, because Frenkel is the only practitioner of "colored-light therapy." Although colored filters have shown promise in boosting the reading skills of dyslexic children, many health professionals employ only white light, and then only to treat winter depression. This astounds Frenkel, who believes the mind encodes experiences in specific colors.

Unlike the drugs frequently prescribed for high blood pressure and anxiety, colored light has no side effects, Frenkel claims. And because light travels at 186,282 miles per second, its effects are felt immediately.

Frenkel initially developed the glasses to control stress in cardiac and stroke patients. "I've never had a heart attack, but if I have one and am lucky enough to survive, I'll probably start worrying about the next one," he says. "This device can tip people off if their stress goes too high." The glasses, however, would not be restricted to people with heart and high-blood-pressure problems. "Anyone concerned about stress could wear them. I'll be wearing a pair myself."

—Steve Nadis

INFRASTRUCTURE IS GOING TO THE BEARS



Florida loses about 40 of its rare black bears to highway accidents each year. That has proved reason enough for its Department of Transportation to test an eight-foot precast concrete culvert—essentially a bear tunnel—on state road 46 north of Orlando.

Fences along both sides of the road will funnel the bears into the tunnel, which is similar in concept to those placed elsewhere in the state to protect the endangered Florida panther. If the bears use the crossing, wildlife biologist Terry Gilbert of the Florida Game and Fresh Water Fish Commission says, the government may build similar culverts elsewhere in bear habitats, including the Ocala National Forest and the Big Cypress Wildlife Preserve. TV monitors in the first tunnel will help wildlife experts determine whether the bears actually take advantage of the tunnel.

John B. Wooding, another wildlife biologist with the Commission, estimates that Florida has between 1,000 and 1,500 black bears. The animals get hit by cars and trucks most frequently during what researchers call "the fall shuffle," the time when hungry bears are constantly on the move, trying to negotiate the perilous network of roads that crisscross their dwindling habitat.

The Florida government has yet to decide when to begin the bear-tunnel project, which could cost $500,000. The cost stems mainly from the major highway excavation and regrading needed to make the passageway fit flush with the highway surface.

—George Nobbe

"Always laugh when you can, it is cheap medicine."
—Lord Byron

"Madness is rare in individuals—but in groups, parties, and nations, it is the rule."
—Friedrich Nietzsche

IF ALL OF THE STATES WERE THE SIZE OF ALASKA, THE ENTIRE AREA OF THE UNITED STATES COULD HOLD ONLY SIX COMPLETE STATES.

A MANNED SPACECRAFT CAN REACH THE MOON IN LESS TIME THAN IT TOOK A STAGECOACH TO TRAVEL THE LENGTH OF GREAT BRITAIN.

CONTINUUM

TO DEFECT IS TO PERFECT

Finally, some positive press for genetic mutation. A recently identified genetic defect in some South Pacific islanders makes them immune to malaria.

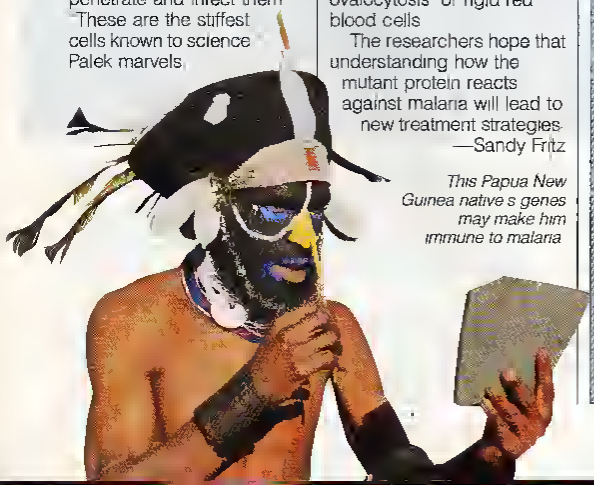
Jiri Palek, Shih-Chun Lui and their colleagues at St. Elizabeth's Hospital in Boston discovered that a number of people from the South Pacific carry a mutant gene that instructs red blood cells to produce an abnormal band-3 protein. This mutant protein bonds with the cell membrane, making the walls of the blood cells so stiff that the malaria parasite cannot penetrate and infect them. "These are the stiffest cells known to science," Palek marvels, "and yet they survive normally in circulation."

Up to 40 percent of the native populations in Papua New Guinea enjoy the mutant protein's enhanced protection from malaria. Native peoples in Malaysia, the Philippines, and Indonesia also show a strong resistance to the disease.

Palek believes natural selection is at work. "This is an area where malaria is endemic," he says. "People with this defect had a better chance of surviving, and they passed it on to succeeding generations." A more extensive search of the tropics, he suggests, would probably reveal other populations with ovalocytosis or rigid red blood cells.

The researchers hope that understanding how the mutant protein reacts against malaria will lead to new treatment strategies.

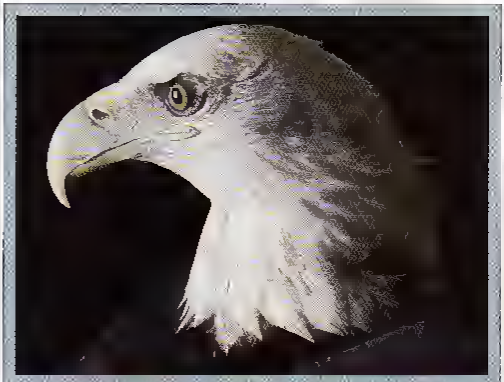
—Sandy Fritz



This Papua New Guinea native's genes may make him immune to malaria

IF THE WORLD'S TOTAL LAND AREA WERE DIVIDED EQUALLY AMONG THE WORLD'S PEOPLE, EACH PERSON WOULD HOLD 8.5 ACRES.

AT THE EQUATOR, THE EARTH SPINS AT A RATE OF MORE THAN 1,000 MILES PER HOUR.



Eagles have great eyes but not enough sense to avoid windmills.

EAGLES JOUST WITH WINDMILLS

Searching for a clean, safe energy source, some companies have taken a step forward to the past, relying on wind power for energy. Some 7,000 "wind turbines" sit in the foothills east of San Francisco, making it the largest wind-propelled energy center in the world.

Unfortunately, such modern windmills have not proven as environmentally safe as expected—albeit in an unexpected way. A two-year study by the California State Energy Commission found that a large number of predatory birds, including golden and bald eagles, turn up dead in the vicinity of these turbines. The study estimated that 500 raptors were killed in a two-year period and that 55 percent of them had collided with wind turbines. The birds might not recognize the blades of the 80- to 100-foot turbines as any more of a threat than tree limbs, with lethal results to any quixotic raptor who tilts at such a windmill.

U.S. Windpower, the largest of the turbine operators, has embarked on an ambitious series of experiments to determine how to create a "compatible coexistence" between turbine and raptor, according to William J. Whalen, a vice president of the company. Trained hawks and homing pigeons will be used to test whether high-pitched noises and colors painted on the turbine sails keep birds at a safe distance. "We hope to have data by the end of the summer," Whalen says. But for the present, as David Nesmith of the San Francisco Bay chapter of the Sierra Club admits, "there are no good safety measures."

—Mark Sumlin

ARTICLE BY JAMES P. HOGAN

Every age has its peculiar folly: some scheme, project, or fantasy into which it plunges, spurred on by the love of gain, the necessity of excitement, or the mere force of imitation.—Charles Mackay, Extraordinary Popular Delusions and the Madness of Crowds, *1841.*

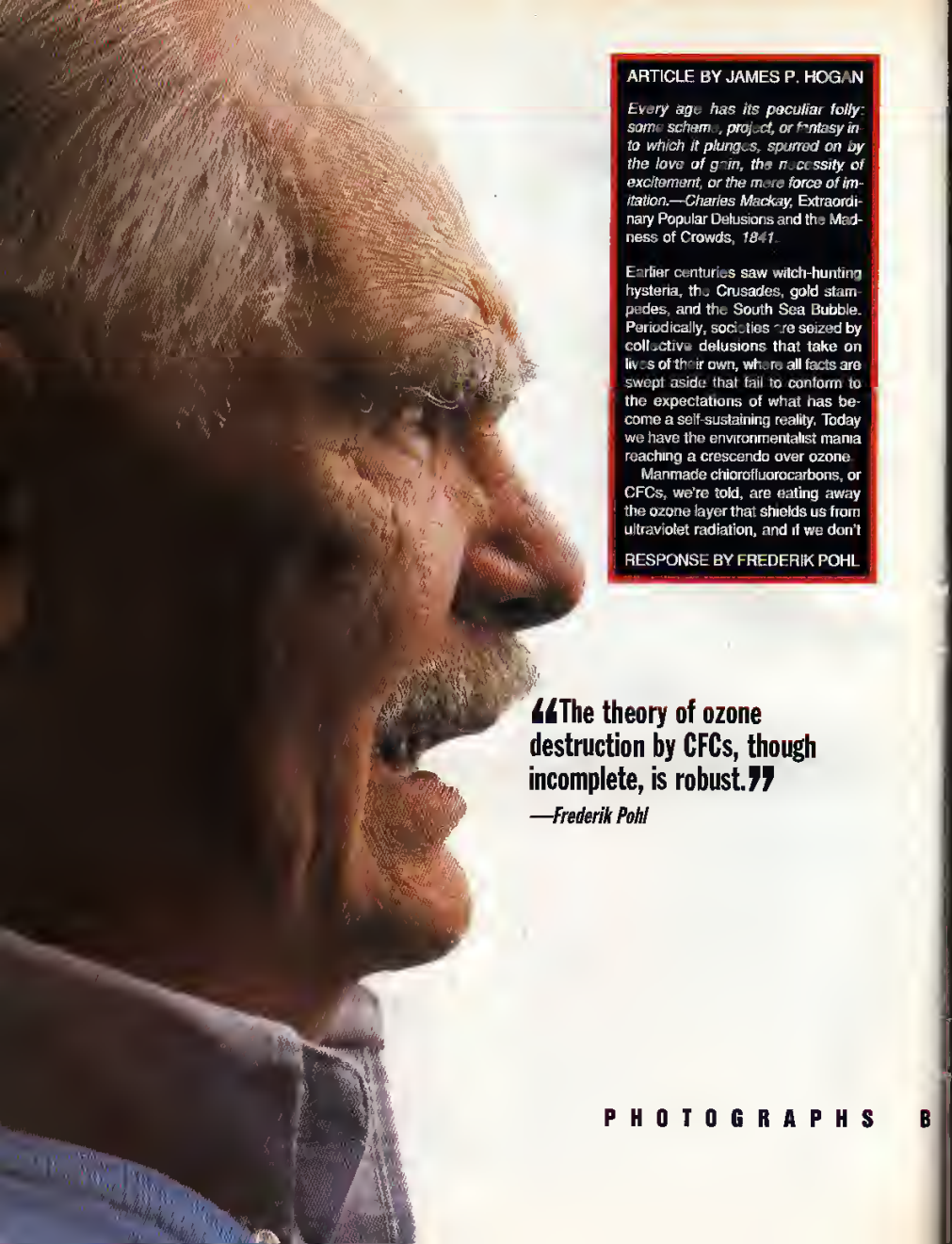
Earlier centuries saw witch-hunting hysteria, the Crusades, gold stampedes, and the South Sea Bubble. Periodically, societies are seized by collective delusions that take on lives of their own, where all facts are swept aside that fail to conform to the expectations of what has become a self-sustaining reality. Today we have the environmentalist mania reaching a crescendo over ozone.

Manmade chlorofluorocarbons, or CFCs, we're told, are eating away the ozone layer that shields us from ultraviolet radiation, and if we don't

RESPONSE BY FREDERIK POHL

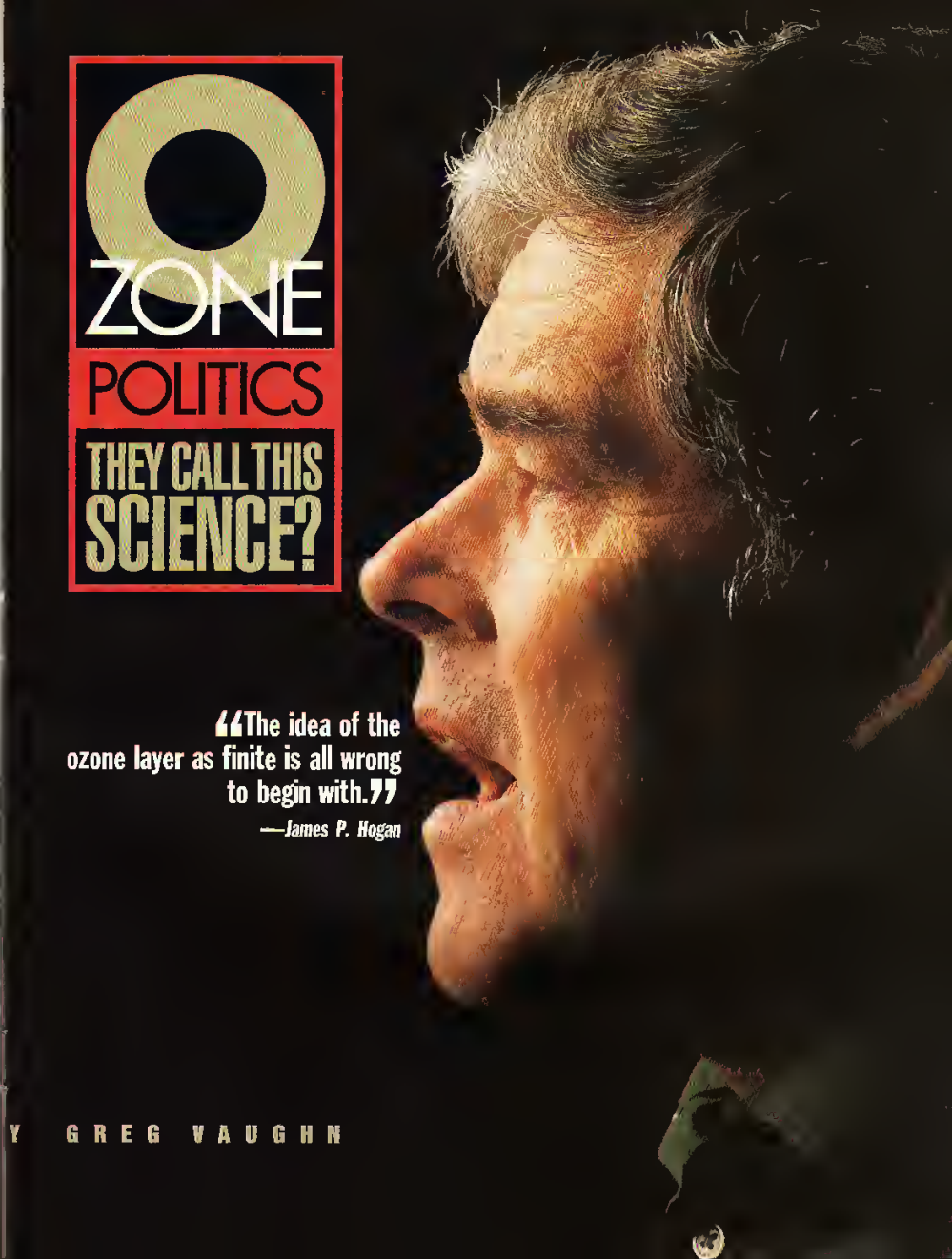
OZONE POLITICS

THEY CALL THIS SCIENCE?



"The theory of ozone destruction by CFCs, though incomplete, is robust."

—Frederik Pohl



"The idea of the ozone layer as finite is all wrong to begin with."

—James P. Hogan

PHOTOGRAPHS BY GREG VAUGHN

stop using them now deaths from skin cancer in the United States alone will rise by hundreds of thousands in the next half century As a result 80 nations are about to railroad through legislation to ban one of most beneficial substances ever discovered at a cost the public doesn't seem to comprehend but that will be staggering It could mean having to replace today s refrigeration and air-conditioning equipment with more expensive types running on substitutes that are toxic corrosive, flammable if sparked, less efficient, and generally reminiscent of the things people heaved sighs of relief to get rid of in the 1930s And the domestic side will be only a small part The food industry that we take for granted depends on refrigerated warehouses, trucks, and ships So do supplies of drugs medicines and blood Whole regions of the sunbelt states have prospered during the last 40 years because of the better living and working environments made possible by air conditioning And to developing nations that rely completely on modern food-preservation methods, the effects will be devastating

Now, I'd have to agree that the alternative of seeing the planet seared by lethal levels of radiation would make a pretty good justification for whatever drastic action is necessary to prevent it The only problem is, there isn't one piece of solid, scientifically validated evidence to support the contention The decisions being made are political, driven by media-friendly pressure groups wielding a power over public perceptions that is totally out of proportion to any scientific competence they pos-

OZONE REALITIES

Yes, Jim, that really is science, because that's what science is As the late Richard Feynman told us, "Scientific knowledge is a body of statements of varying degrees of certainty—some most unsure, some nearly sure, but none *absolutely* certain" Anytime any scientist offers one of those statements—or "theories"—it is the duty of other scientists to try to pick holes in it

But the theory of ozone destruction by CFCs, though woefully incomplete (mostly because few bothered to do any research on the subject until quite recently), is robust Its predictions are happening *Something* is destroying Antarctic ozone to unprecedented degrees, and it gets worse every year The latest Antarctic ozone hole, measured in September 1992, was the largest ever—up 15 percent from the year before to nearly 9 million square miles

Are CFCs doing it? We know that the reaction occurs, because it's demonstrated in the laboratory, but Jim Hogan argues that the CFCs are too heavy to rise up to the stratosphere That's disingenuous The atmosphere doesn't arrange itself in density layers like a pousse-cafe If it did, there wouldn't be a problem; we could install some giant vacuum cleaners in such low spots as Death Valley or the Qattara Depression and suck all the CFCs right out of the air

That doesn't happen, because the atmosphere is continually stirred—by thunderstorms, by winds, by solar radiation, by its own thermal movement—and so CFCs will sooner or later diffuse to everywhere Because they're heavy, they take a while to get to the stratosphere that's why most of the CFCs already manufactured are still in the troposphere, where we live but the ozone layer does not But the CFCs certainly do get to the ozone layer eventually, because they have nowhere else to go The quality of chemical inertness which makes them useful assures that They are not attacked by ordinary chemical reactions, they last indefinitely or until they come across something *really* reactive—something like the ozone layer

Ask a different question Is there any evidence that extra UV-B is reaching the surface of the earth and affecting living creatures? It looks that way For one thing, biologists have noted that in the Weddell Sea off Antarctica the plankton and krill seem to be slowly changing color Why? Best theory is that selection is favoring the ones with added protective pigment in response to increased UV-B

How about human beings, though are they suffering additional cataracts and skin cancers as a result? That s harder to measure, a cataract doesn't come with a label to identify its cause, and the normal incidence of such problems is much larger than the expected increases from UV-B—so far—so that even a statistical proof is hard to obtain That's true even in Australia, presumably the most severely affected inhabited part of the world—plus the fact that Australians for years now have been urged to practice Slip-Slap-Slop ("Slip on a shirt, Slap on a hat, Slop on some sun blocker") But they don't do that for their pet cats, and at the veterinary clinic of the Royal Society for the Prevention of Cruelty to Animals in Sydney, about 500 cases of feline skin cancer are turning up a year now—a few years ago there were almost none

The CFC reaction is not the only process that attacks the atmosphere's ozone layer Emissions from volcanic eruptions, as Hogan points out, may well be another—it is likely for instance, that the cataclysmic eruption of Mt Pinatubo in the Philippines contributed to the ozone losses that were recently, and unexpectedly, found over much of the north temperate zone of our planet But it takes a Pinatubo-sized eruption to project serious amounts of ozone-destroying chemicals into the stratosphere Mount Erebus's eruptions are comparatively feeble and unlikely to account for the observed major stratospheric ozone losses in the Antarctic

The CFC reaction, however, has one quite unique quality That is it is the only known ozone-destroying process that we human beings have any control over If we are to do anything at all, stopping manufacture of CFCs and similar synthetic chemicals is the only thing we *can* do

It is true that if we give up the use of CFCs we'll have to scrap and replace almost all our current refrigerators and air conditioners That's another nonissue, however since over the next couple of decades, we will certainly scrap and replace them all anyway The only question is whether we replace them with more of the same or with systems that don't use CFCs Such systems already exist

If the consensus of most scientists is wrong and there is, after all, no danger to the ozone layer, then doing what that consensus suggests will unnecessarily cost us all some money and inconvenience But if the scientists are right and we do nothing, it will cost us a great deal more money, a great deal more inconvenience, and a very great deal of suffering and human lives —Frederik Pohl

sess. But when you ask the people who do have the competence to know—scientists who have specialized in the study of atmosphere and climate for years—a very different story emerges.

What they're saying, essentially, is that the whole notion of the ozone layer as something fixed and finite, to be eroded away at a faster or slower rate like shoe leather, is all wrong to begin with—it's simply not a depletable resource, that even if it were, the process by which CFCs are supposed to deplete it is highly speculative and has never been observed to take place, and even if it did, the effect would be trivial compared to what happens naturally. In short, there's no good reason for believing that human activity is having any significant effect at all.

To see why, let's start with the basics and take seashores as an analogy. Waves breaking along the coastline continually generate a belt of surf. The surf decomposes again, back into the ocean from where it came. The two processes are linked. Big waves on stormy days create more surf, the more surf there is to decay, the higher the rate at which it does so. The result is a balance between the rates of creation and destruction. Calmer days will see a general thinning of the surf line and possibly "holes" in more sheltered spots—but obviously the surf isn't something that runs out. Its supply is inexhaustible as long as oceans and shores exist.

In the same kind of way, ozone is all the time being created in the upper atmosphere—by sunshine. out of oxygen. A normal molecule of oxygen gas consists of two oxygen atoms joined together. High-energy ultraviolet radiation, known as UV-C, can split one of these molecules apart (a process known as photodissociation) into two free oxygen atoms. These can then attach to another molecule to form a three-atom species, which is ozone—produced mainly in the tropics above a 30-kilometer altitude where the ultraviolet flux is strongest. The ozone sinks and moves poleward to accumulate in lower-level reservoirs extending from 17 to 30 kilometers—the so-called ozone "layer."

Ozone is destroyed by chemical recombination back into normal oxygen—by reaction with nitrogen dioxide (produced in part by high-altitude cosmic rays), through ultraviolet dissociation by the same UV-C that creates ozone, and also by a less energetic band known as UV-B, which isn't absorbed in the higher regions. Every dissociation of an oxygen or ozone molecule absorbs an incoming UV-B photon, and that may be what gives this part of the atmosphere its ultraviolet screening ability.

Its height and thickness are not constant, but adjust automatically to accommodate variations in the incoming ultraviolet flux. When UV is stronger, it penetrates deeper before being absorbed; with weaker UV, penetration is less. Even if all the ozone were to suddenly vanish, there would still be 17 to 30 kilometers of hitherto untouched oxygen-rich atmosphere below, which would become available as a resource for new ozone creation, and the entire screening mechanism would promptly regenerate. As Robert Pease, professor emeritus of physical climatology at the University of California at Riverside, says, "Ozone in the atmosphere is not in finite supply." In other words, as in the case of surf with oceans and shores, it is inexhaustible for as long as sunshine and air continue to exist.

If ozone were depleting, UV intensity at the earth's surface would be increasing. In fact, actual measurements show that it has been decreasing—by as much as 8 percent in some places over the last decade.

Ordinarily, a scientific hypothesis that failed in its most elementary prediction would be dumped right there. But as Dr. Dixy Lee Ray—former governor of Washington state, chairman of the Atomic Energy Commission, and a scientist with the U.S. Bureau of Oceans and the University of Washington—put it: "There are fads in science. Scientists are capable of developing their own strange fixations, just like anyone else." Even though the physics makes it difficult to see how the notion of something manmade destroying the ozone layer has always fascinated an apocalyptic few who have been seeking possible candidates for more than 40 years. According to Hugh Ellsaesser, guest scientist at the Atmospheric and Geophysical Sciences Division of the Lawrence Livermore National Laboratory, "There has been a small but concerted program to build the possibility of man destroying the ozone layer into a dire threat requiring governmental controls since the time of CIAP [Climatic Impact Assessment Program on the supersonic transport (SST), conducted in the early 1970s]."

In the 1950s, it was A-bomb testing; in the 1960s, the SST; in the 1970s, spacecraft launches and various chemicals from pesticides to fertilizers. All of these claimed threats to the destruction of the ozone layer were later discredited, and for a while the controversy died out. Then, in 1985 and 1986, banner headlines blared that a huge ozone hole had been discovered in the Ant-

arctic. This, it was proclaimed, confirmed the latest version of the threat.

In 1974, two chemists, Rowland and Molina at the University of California at Irvine, hypothesized that ozone might be attacked by CFCs—which had come into widespread use during the previous 20 years. Basically they suggested that the same chemical inertness that makes CFCs noncorrosive, nontoxic, and ideal as a refrigerant would enable them to diffuse intact to the upper atmosphere. There, they would be dissociated by high-energy ultraviolet and release free atoms of chlorine. Chlorine will combine with one of the three oxygen atoms of an ozone molecule to produce chlorine monoxide and a normal two-molecule oxygen atom, thereby destroying the ozone molecule. The model becomes more insidious by postulating an additional chain of catalytic reactions via which the chlorine monoxide can be recycled back into free chlorine, hence evoking the specter of a single chlorine atom running amok in the stratosphere, gobbling up ozone molecules like Pac-Man.

Scary, vivid, sensational, perfect for activists seeking a cause, politicians in need of visibility, just what the media revel in. Unfortunately, however, it doesn't fit with a few vital facts. And if you claim to be talking about science, that's kind of important.

First, CFCs don't rise in significant amounts to where they need to be for UV-C photons to break them up. Because ozone absorbs heat directly from the sun's rays, the stratosphere exhibits a reverse temperature structure, or thermal "inversion"—it gets warmer with altitude rather than cooler. As Robert Pease points out: "This barrier greatly inhibits vertical air movements and the interchange of gases across the tropopause [the boundary between the lower atmosphere and the stratosphere], including CFCs. In the stratosphere, CFC gases decline rapidly and drop to only two percent of surface values by thirty kilometers of altitude. At the same time, less than two percent of the UV-C penetrates this deeply." Hence the number of CFC splittings is vastly lower than the original hypothesis assumes—for the same reason there aren't many marriages between Eskimos and Australian Aborigines. They don't mix very much.

For the UV photons that do make it, there are about 136 million oxygen molecules for them to collide with for every CFC—and every such reaction will create ozone, not destroy it. So even if we allow the big CFC molecule three times the chance of a small oxygen molecule of being hit, then 45 million ozone molecules will still be created for every CFC molecule that's broken up. Hardly a convincing disaster scenario, is it?

Ah, but what about the catalytic effect, whereby one chlorine atom can eat up thousands of ozone molecules? Doesn't that change the picture?

Not really. The catalysis argument depends on encounters between chlorine monoxide and free oxygen atoms. But the chances are much higher that a wandering free oxygen atom will find a molecule of normal oxygen rather than one of chlorine monoxide. So once again, probability favors ozone creation over ozone destruction.

At least 192 chemical reactions occur between substances in the upper stratosphere along with 48 different identifiable photochemical processes, all linked through complex feedback mechanisms that are only partly understood. Selecting a few reactions brought about in a laboratory and claiming that this is what happens in the stratosphere (where it has never been measured) might be a way of getting to a predetermined conclusion. But it isn't science.

> "There are fads in science. Scientists are capable of developing their own strange fixations, just like anyone else."

But surely it's been demonstrated! Hasn't a thousand times more chlorine been measured over the Antarctic than models say ought to be there?

Yes. High concentrations of chlorine—or to be exact, chlorine monoxide. But all chlorine atoms look alike. There is absolutely nothing to link the chlorine found over the Antarctic with CFCs from the other end of the world. What the purveyors of that story omitted to mention was that the measuring station at McMurdo Sound is located 15 kilometers downwind from Mount Erebus, an active volcano venting 100 to 200 tons of chlorine every day, and that in 1983 it averaged 1,000 tons per day. Mightn't that just have more to do with it than refrigerators in New York or air conditioners in Atlanta?

World CFC production is currently about 1.1 million tons annually—750,000 tons of which is chlorine. Twenty times as much comes from the passive outgassing of volcanoes. This can rise by a factor of ten with a single large eruption—for example that of Tambora in 1815, which pumped a minimum of 211 million tons straight into the atmosphere. Where are the records of all the cataclysmic effects that should presumably have followed from the consequent ozone depletion?

And on an even greater scale, 300 million tons of chlorine are contained in spray blown off the oceans every year. A single thunderstorm in the Amazon region can transport 200 million tons of air per hour into the atmosphere, containing 3 million tons of water vapor. On average, 44,000 thunderstorms occur daily, mostly in the tropics. Even if we concede to the depletion theory and allow this mechanism to transport CFCs also, compared to what gets there naturally the whiff of chlorine produced by all of human industry (and we're only talking about the leakage from it) is a snowflake in a blizzard.

Despite all that, isn't it still true that a hole has appeared in the last ten years and is getting bigger? What about that, then?

In 1985, a sharp, unpredicted decline was reported in the mean depth of ozone over Halley Bay, Antarctica. Although the phenomenon was limited to altitudes between 12 and 22 kilometers and the interior of a seasonal circulation of the polar jet stream known as the "polar vortex," it was all that the ozone doomsday pushers needed. Without waiting for any scientific evaluation or consensus, they decided that this was the confirmation that the Rowland-Molina conjecture had been waiting for. The ominous term "ozone hole" was coined by a media machine well rehearsed in environmentalist politics, and anything the scientific community had to say has been drowned out.

Missing from the press and TV accounts, for instance, is that an unexpectedly low value in the Antarctic winter-spring ozone level was reported by the British scientist Gordon Dobson in 1956—when CFCs were barely in use. In a 40-year history of ozone research written in 1968, he notes: "One of the most interesting results . . . which came out of the IGY [International Geophysical Year] was the discovery of the peculiar annual variation of ozone at Halley Bay." His first thought was that the result might have been due to faulty equipment or operator error. But when such possibilities were eliminated and the same thing happened the following year, he concluded: "It was clear that the winter vortex over the

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South Pole was maintained late into the spring and that this kept the ozone values low. When it suddenly broke up in November, both the ozone values and the stratosphere temperatures suddenly rose." A year after that, in 1958, a similar drop was reported by French scientists at the Antarctic observatory at Dumont d'Urville—larger than that causing all the hysteria today.

These measurements were on the edge of observational capability, especially in an environment such as the Antarctic, and most scientists regarded them with caution. After the 1985 "discovery," NASA reanalyzed its satellite data and found that it had been routinely throwing out low Antarctic ozone readings as "unreliable."

The real cause is slowly being unraveled, and while some correlation is evident with volcanic eruptions and sunspot cycles, the dominant factor appears to be the extreme Antarctic winter conditions as Dobson originally suspected. The poleward transportation of ozone from its primary creation zones over the tropics does not penetrate into the polar vortex, where chemical depletion can't be replaced because of the lack of sunshine. Note that this is a localized minimum relative to the surrounding high-latitude reservoir regions, where global ozone is thickest. As Hugh Ellsaesser observes, "The ozone hole ... leads only to spring values of ultraviolet flux over Antarctica ... a factor of two less than those experienced every summer in North Dakota."

But isn't it getting bigger every year? And aren't the latest readings showing depletion elsewhere, too?

In April, 1991, EPA Administrator William Reilly announced that the ozone layer over North America was thinning twice as fast as expected and produced the figures for soaring deaths from skin cancer. This was based on readings from NASA's Nimbus-7 satellite. I talked to Dr. S. Fred Singer of the Washington-based Science and Environmental Policy Project, who developed the principle of UV backscatter that the ozone monitoring instrument aboard Nimbus-7 employs. "You simply cannot tell from one sunspot cycle," was his comment. "The data are too noisy. Scientists need at least one more cycle of satellite observations before they can establish a trend." In other words, the trend exists in the eye of the determined beholder, not in any facts he beholds.

February 1992 saw a repeat performance when a NASA research aircraft detected high values of chlorine monoxide in the northern stratosphere. Not of CFCs, nor was there any evidence that ozone itself was actually being depleted, nor any mention that the Pinatubo volcano was active at the time. Yet almost as if on cue, the U.S. Senate passed an amendment only two days later calling for an accelerated phase-out of CFCs. (It's interesting to note that NASA's budget was under review at the time. After getting its increase, NASA has since conceded that perhaps the fears were premature.)

But apart from all that, yes, world mean-total ozone declined about 5 percent from 1979 to 1986. So what? From 1962 to 1979 it increased by 5½ percent. And since 1986, it has been increasing again (although that part's left out of the story the public gets). On shorter time scales, it changes naturally all the time and from place to place, hence surface ultraviolet intensity is not constant and never was. It varies with latitude—for instance, how far north or south from the equator you are—with the seasons, and with solar activity. And it does so in amounts that are far greater than those causing all the fuss.

> "Research proposals to explore the other side of things are turned down, while doomsayers line up for grants running into the millions."

The whole doomsday case boils down to claiming that if something isn't done to curb CFCs, ultraviolet radiation will increase by 10 percent over the next 20 years. But from the poles to the equator, it increases naturally by a whopping factor of 50, or 5,000 percent anyway!—equivalent to 1 percent for every six miles. Or to put it another way, a family moving from New York to Philadelphia would experience the same increase as is predicted by the worst-case depletion scenarios. Alternatively, they could live 1,500 feet higher in elevation—say, by moving to their summer cabin in the Catskills.

Superposed on this is a minimum 25-percent swing from summer to winter, and on top of that, a 10- to 12-year pattern that follows the sunspot cycle. Finally, there are irregular fluctuations caused by the effects of volcanic eruptions, electrical storms, and the like on atmospheric chemistry. Expecting to find some "natural" level that shouldn't be deviated from in all this is like trying to define sea level in a typhoon.

Skin cancer is increasing, nevertheless. Something must be causing it.

An increasing rate of UV-induced skin cancer means that more people are receiving more exposure than they ought to. It doesn't follow that the intensity of ultraviolet is increasing as it would if ozone were being depleted. (In fact, it's decreasing, as we saw earlier.) Other considerations explain the facts far better, such as that sun worship has become a fad among light-skinned people only in the last couple of generations, or the migrations in comparatively recent times of peoples into habitats for which they aren't adapted, for instance, the white population of Australia. (Native Australians have experienced no skin-cancer increase.)

Deaths from drowning increase as you get nearer the equator—not because the water becomes more lethal but because human behavior changes. Not many people go swimming in the Arctic. Nevertheless, when it comes to skin cancer, the National Academy of Sciences [NAS] has decided that only variation of UV matters. And from the measured ozone thinning from poles to equator and the change in zenith angle of the sun they determined that a 1-percent decrease in ozone equates to a 2-percent rise in skin cancer.

How you make a disaster scenario out of this, according to Ellsaesser, is to ignore the decline in surface UV actually measured over the last 15 years, ignore the reversal that shows ozone to have been increasing again since 1986, and extend the 1979–1986 slope as if it were going to continue for the next 40 years. Then, take the above formula as established fact and apply it to the entire U.S. population. Witness. According to the NAS report (1975), approximately 600,000 new cases of skin cancer occur annually. So, by the above, a 1-percent ozone decrease gives 12,000 more skin cancers. Projecting the 5-percent ozone swing from the early 1980s through the next four decades gives 25 percent, hence a 50-percent rise in skin cancer, which works out at 300,000 new cases in the year 2030 A.D., or 7.5 million over the full period. Since the mortality rate is around 2.5 percent, this gives the EPA's "200,000 extra deaths in the United States alone." Voilà, instant catastrophe.

As if this weren't flaky enough, it's possible that the lethal variety of skin cancer has little to do with UV exposure, anyway. The cancers that are caused by radiation are recognizable by their correlation with latitude and length of ex-

CONTINUED ON PAGE 91

HERESY!

3 Modern Galileos

ARTICLE BY ANTHONY LIVERSIDGE

1 Linus Pauling

"The physicians don't have open minds. There is a real bias on the part of the medical establishment about megavitamins."

Last autumn, at last, the Catholic Church confessed. The *New York Times* frontpage headline read: "After 350 Years, Vatican Says Galileo Was Right: It Moves." Following a 13-year investigation by an expert panel of scientists, theologians, and historians, Pope John Paul II was prepared to correct the record.

In 1632, Galileo wrote that he had evidence that the earth moves around the sun rather than vice versa. He should not, today's Pope now acknowledges, have been hauled before a tribunal, threatened with torture, forced to recant, banned from publication, and banished for the rest of his life to his country estate. As the Church panel now confirms, Galileo was right on the money all the time.

Stale news for most of us. Moreover, the story of a great scientist battling established religion seems irrelevant to the modern world—or is it?

Some leading scientists claim that the repression of Galileo's ideas only foreshadowed the politics they have to contend with today. They insist that another church has established itself, a more insidious enemy to truth seeking than the Catholic Church of old. This time the church shutting out new ideas as heresy and blocking the march of truth is the scientific establishment.

The modern iconoclasts aren't New Age freaks, homeopaths, or astrologers—outsiders typically hostile to scientists who scorn them. They rank among the most distinguished and productive men and women in American science and include Nobel laureates. They are, you might say, the "modern Galileos."

If they're right, the Popes and Cardinals of modern science are turning a deaf ear to potential breakthroughs in cancer, heart disease, AIDS, and the global energy crisis. Even if they're wrong, their claims that a heretic in science, however well qualified, can't gain a fair hearing if he or she threatens the status quo often seem justified.

Take Linus Pauling, the best known of these iconoclasts. He's a household name as a world-famous scientist and talk-show author of a popular book on diet, *How to Live Longer and Feel Better*. Pauling remains the only person in the universe to have won two unshared Nobel prizes, for Chemistry in 1954 and the Nobel Peace prize in 1962 for his crusade against nuclear weapons. James D. Watson, the decoder of DNA, joins many other top scientists in calling Pauling "the greatest of all chemists."

Pauling is hale and hearty at 92. His cheeks are rosy and his twinkling blue eyes clear and sharp. He seems the very picture of health despite a brief bout with prostate cancer last year, now under control, he claims. The only sign of age is a quaver in his voice. Pauling can brief journalists from memory on his latest work, quoting a slew of facts and dates without missing a beat.

What Pauling is asked about most often is his favorite theory: that vitamin C in large doses not only wards off colds, but also the major afflictions of Western man—heart disease and cancer.

The spry Pauling seems a living testimonial to his own advice. He stirs a whopping 18 grams of vitamin C into his orange juice every day, he says. But how about the prostate cancer? Pauling believes he delayed its progress by 25 years. Yet even as research piles up to suggest Pauling is correct, the medical establishment has scoffed and blocked publication of his theories in a top journal.

The *Proceedings of the National Academy* is the publication of the most exclusive club in science. Pauling, a member since the Thirties, was first prevented from publishing an article in it on vitamin C and colds 20 years ago. The editor was adamant, although Pauling objected that he was curbing a right all members had to publish in the *Proceedings* without prior review by colleagues.

A new rule was speedily cooked up, clearly to justify blocking Pauling. All articles that might be "of significant potential harm to the public welfare" would now be reviewed before publication. Under this rule, Pauling's theory of how taking vitamin C helps prevent heart trouble was also rejected in 1991. There was grave danger, the editors felt, that the public might be influenced by the authority of the *Proceedings* to challenge their doctors' advice.

Censored by the *Proceedings*, Pauling published in a friendly journal, quoting Galileo. "Verily, just as serpents close their ears, so do men close their eyes to the truth."

A recent review from Finland of all studies done so far backs Pauling on vitamin C and colds, and evidence now seems overwhelming that vitamins C and E do have value in preventing cancer. A big study by Dr. James Enstrom from UCLA reported recently that large daily doses of vitamin C cut heart disease deaths by nearly half in men and one-fourth in women.

adding more than five years to life expectancy. It seems that vitamin C works this magic by stabilizing cholesterol at optimum levels and also by preventing it from hardening in the arteries.

None of this has made life much easier for Pauling. He won the Vannevar Bush prize in 1989 from the National Science Foundation, but that same year the same institution turned down his grant request for an assistant and a computer. Pauling's aim was to pursue his new ideas in the nature of chemical bonds in metals and alloys, the field that won him the Nobel.

One reviewer suggested the money "would be better spent on creative young investigators, less fixed in their ways." Another accused him of "fiddling with the numbers ... to come out with the right answer" in his grant application. Pauling answered that the reviewer was ignorant of one of his (Pauling's) own discoveries 55 years earlier. The four other reviewers were complimentary and recommended funding, but that wasn't enough.

"If a scientist tries something original, he will have trouble getting grants and getting papers published," says Pauling philosophically. "Most say I have been right so often in the past, I am probably right about vitamin C, too. I don't have any trouble with them. It's the physicians who don't have open minds. There is a real bias on the part of the medical establishment about megavitamins."

Their prejudices exist, he believes, because doctors confuse vitamins with the drugs that have proved effective against disease in small doses and which are toxic in large doses. They fail to understand that while small doses of vitamin C are needed to prevent scurvy, larger doses might be beneficial, too. "Authorities who have lectured on nutrition to students for fifty years saying higher doses of vitamins have no value don't want to say they are wrong."

The National Academy of Sciences, in response to complaints from Pauling and others, has, however, set up a committee to review the books and articles it publishes that condemn megadoses of vitamins out of hand.

Pauling's frustration is typical of science in general, judging from the long list of latter-day Galileos who have been first trashed and then vindicated. The most famous is German meteorologist A. L. Wegener whose 1912 theory of continental drift met with generalized hostility and rejection. Wegener eventually gave up the struggle, complaining of scientists' "partiality" to the reigning paradigm, and pursued other goals. Fifty years later, mechanisms of plate tectonics and seafloor spreading were detected, and he's now admired as a revolutionary thinker.

But some of the blindest fanaticism in favor of the received wisdom seems to come in medicine. Louis Pasteur won honors, wealth and fame for proving that microbes cause disease and ferment beer, but only after weathering public attacks from his friends in the French Academy.

The most blatant case of medical blinkers is that of Ignaz Philipp Semmelweis. In 1847, the young Viennese doctor simply proposed that his colleagues wash their hands with disinfectant after dissection before they delivered babies. His program cut the death rate of mothers in his hospital ward from 16 percent to less than 2 percent. Semmelweis, only the equivalent of an intern, was hounded out of Vienna by his superiors. After applying the same regimen with striking success in a provincial city for some years, he himself died from a dissection wound and the very puerperal fever he had shown how to curb.

Knowledgeable observers are wondering whether Peter Duesberg of the University of California at Berkeley is another Semmelweis if not a Pasteur. An establishment heretic, Duesberg has run into a wall of rejection by scientists in his field, by the medical profession, and by the media. One reason is that his most sensational claims involve the highly politicized field of AIDS. Unlike Semmelweis, however, Duesberg has long been very prominent in his field. He is a virologist who specializes in retroviruses, the group of microbes to which the Human Immunodeficiency Virus (HIV) belongs. HIV is the virus almost universally thought to cause AIDS.

While he's never studied HIV in the lab, Duesberg's credentials to inspect the evidence for this dogma seem impeccable. The 55-year-old professor has belonged to the exclusive National Academy since 1986 for achievements which include being the first to decode the genes of retroviruses. He also identified the first of the oncogenes held to cause cancer. A letter in *Nature* said he deserved the Nobel Prize for his oncogene work. Others have won Nobels for cancer-gene research, but not Duesberg. One reason may be that he's now notorious for his skepticism

2 Peter Duesberg

"People naturally reject a challenge to orthodoxy. But the scale is larger than ever. I am not aware of anything so entrenched."

about human oncogenes. Although the field is fashionable and well funded, Duesberg himself has renounced any belief that such oncogenes have ever caused cancer in humans.

"There is no evidence or proof that a gene of a cell ever caused cancer," Duesberg says flatly. "Not one. The only proven oncogenes are carried by rare animal retroviruses and, fortunately, are very unstable." Even the possibility is "frankly very implausible. A true cellular cancer gene would be found in each of the 100 trillion cells in the human body, and we wouldn't be viable organisms. One would be activated far too often for us to live as long as we do."

Already distinctly unpopular for this view, Duesberg became a pariah when he turned to AIDS. Attracted by the rise in funding going to AIDS research, Duesberg visited the library to examine the data behind the belief that AIDS is an infectious disease caused by HIV. He reached a startling conclusion and published it in *Cancer Research*, a leading journal, in 1987. HIV was not the cause of AIDS, in his judgment, and the evidence indicated that AIDS was not infectious. The symptoms, he concluded, were caused by drugs, disease, and other conventional assaults on the immune system.

His retrovirology colleagues at first refused to argue, claiming that such doubt was absurd. A smattering of press coverage forced a response, however, and *Science* featured a limited, four-page debate between Duesberg and his detractors in 1988. Each side was allowed a statement and rebuttal, but further argument was sharply cut off.

3

Thomas Gold

"People shake their fists at me! And the venom—you have no idea! It's incredible! If they could, they would burn me at the stake."

Duesberg turned to the *Proceedings of the National Academy* to press his case. Among many reasons for skepticism, he argued that the actual virus was virtually absent from the bodies of AIDS patients, even those who were dying of the disease. Moreover, lab work failed to show that HIV would kill the immune system's T cells, the loss of which is the hallmark of AIDS. He noted that predictions of huge rises in AIDS cases have consistently failed to come true in the United States, especially for heterosexuals.

To date, he's published two articles, some 15,000 words, in that prestigious journal, and it's been an uphill battle all the way. The editors of the *Proceedings* enlisted a phalanx of special reviewers—26 at last count—to criticize his three submissions. None could identify a single uncorrectable flaw in fact or logic, as the editors acknowledged, only a difference of opinion. Nonetheless, this year the *Proceedings* refused publication of his third paper in the series, "The Role of Drugs in AIDS." Duesberg was forced to publish it in a French journal.

Naturally, Pauling was used as a precedent for censoring Duesberg, with the *Proceedings* editors invoking the principle of protecting the public from his logic. Members are normally free—since they are all leading scientists, by definition—to publish whatever they wish, as long as they run it by one knowledgeable colleague who is not a coauthor.

To Duesberg, it seemed obvious. The enlisted reviewers freely used blanket statements to damn his points, quoting little if any of their own evidence to contradict his more than 600 references to published evidence. "The response is unscientific, biased, and discriminatory," he says. "It violates academic freedom and the founding principle of the Academy, to evaluate and disseminate knowledge."

The leading HIV proponents seem to have trouble in genuinely answering Duesberg. Robert Gallo of the National Cancer Institute was expected to reply to Duesberg in the *Proceedings*, but in three years has never done so. Gallo eventually dismissed Duesberg in his autobiography, a forum in which, skeptics pointed out, he was safe from his own peer review. Luc Montagnier, the discoverer of HIV, likewise promised the editors of a French journal to answer Duesberg, but never delivered.

Since the major media inevitably follow the party line of their scientific sources in dismissing Duesberg, his views have won only limited coverage compared with the flood of news and opinion articles and government ads and TV films that drum the official message home. Behind the scenes, however, Duesberg has gained scientific support. Nobel Prize winner Walter Gilbert of Harvard, one of the most respected names in U.S. biology, agrees that Duesberg's arguments are strong and as yet unrefuted. "I would not be surprised," he says, "if there were another cause of AIDS and even that HIV is not involved." More than a hundred other biomedical researchers around the world have joined the Group for the Scientific Reappraisal of the HIV/AIDS

Hypothesis, which is publishing its own newsletter, *Rethinking AIDS*.

In a sizable book with the same title, published by Macmillan Free Press in March, professor and MacArthur fellow Robert Root-Bernstein of Michigan State University in East Lansing also argues that scientists must look beyond HIV for other causes of AIDS. Root-Bernstein indicates that the spread of AIDS hasn't followed the HIV-only model and that medical history shows myriad AIDS look-alike cases without HIV infection. Even Luc Montagnier the Pasteur researcher who discovered the "AIDS virus" now says that HIV is harmless by itself and has identified a cell-wall-missing bacterium called a mycoplasma as the essential cofactor.

Meanwhile, Duesberg has lost his exceptional $300,000-a-year Special Investigator Grant from the National Institutes of Health (NIH), one of a handful awarded to the most distinguished scientists in the United States. Ironically, the recipients were specifically urged to use the award to "ask creative questions" and "venture into new territory." The ten-member review panel who turned down the renewal mostly included scientists making a living off theories Duesberg is undermining. With the help of a letter from his local congressman, Duesberg has succeeded in getting the NIH to reopen the case.

Duesberg is more provocative than Pauling in explaining his treatment. He suggests that the ruling paradigm is consolidated by patronage. "People naturally reject a challenge to orthodoxy," he says. "They always did. But the scale is larger than ever. The orthodoxy never had $4 billion [of annual AIDS expenditure] in their court and a terminated grant in the other!" The huge inflow of funds has resulted in "totalitarian science," he says. "I am not aware of anything in history so entrenched."

Another example of a modern Galileo where there's a great deal at stake is Thomas Gold, the Cornell cosmologist. His original ideas have been overopposed throughout his career, despite a tendency to prove valid.

For his master's thesis, Gold worked on the theory of hearing, proposing the idea that the inner ear generates its own tone. The ridicule of medical specialists forced him from the field. Thirty-six years later, he was the guest of honor at a conference of cochlea specialists. Studies found one family emitting sound from their ears loud enough to be heard without instruments.

Gold was also the first to interpret pulsars as rotating neutron stars. When pulsars were found, the organizer of the first conference on the objects refused to allow Gold floor time, calling his analysis "crazy." Later, the same man began a paper with these words: "It is now generally considered that pulsars are rotating neutron stars"!

Still hotly debated is Gold's long-running theory of the origin of petroleum, which turns conventional wisdom inside out. Every school text tells us that oil and gas are produced biologically, the residue of plant life eons ago crushed and fermented, so to speak, in the interior of the earth. Gold says this is quite wrong. The origins of oil and gas are purely geological and not biological, he says. Oil and gas were formed as the planets cooled and should be found far outside the normal locations of drilling.

Fellow scientists and petroleum engineers greet his ideas with rage and spite, he says. "People shake their fists at me!" he reports. "And the venom—you have no idea! It's incredible! If they could, they would burn me at the stake, like Savonarola," the monk who briefly held sway over fifteenth-century Florence. To Gold, the evidence is obvious. "You find methane and ethane on Titan and Pluto," he says, and it emanates from comets. "It is ludicrous to say this is biologically generated!"

> "There's always the possibility that the new idea, like most inspirations in science, is wrong. The issue is one of fairness and prejudice."

Acrimony arises because the majority in the field have "built an enormous construct and they cannot conceive that it is wrong," Gold says. "They have added on a huge edifice of supplementary notions to hold their theory together." That tendency has been noted since the Ptolemaic astronomers, who developed ever-more sophisticated mathematics to hold back the heresy of Copernicus in 1543 that the earth orbited the sun, not the other way around. Only Galileo and his telescopes finally demolished their defense.

Gold tried to explain this scientific boneheadedness in a paper called "The Inertia of Scientific Thought." Why, he asked, is all criticism reserved for the new idea, while the old idea is automatically defended and any conflicting evidence simply brushed aside? Gold blamed a scientific "herd instinct" where safety and prosperity lie in running with the pack. This phenomenon is magnified, Gold argues, by the peer review system. When as many as seven respected colleagues turn thumbs up or down on grant applications or on articles for publication, herd decisions are virtually guaranteed. "It is virtually impossible to depart from the herd and continue to have support." Once a herd view becomes entrenched, says Gold, it becomes almost impossible to dislodge, as it becomes harder and harder for anyone to admit that a mistake might have been made.

Gold quotes Tolstoy. "Most men . . . can seldom accept even the simplest and most obvious truth if it obliges them to admit the falsity of conclusions which they have delighted in explaining to colleagues, which they have proudly taught to others, and which they have woven thread by thread into the fabric of their lives." There is also laziness, Gold notes. "Staying with the herd needs no justification. Doesn't everybody believe that?"

Ray Erikson, a distinguished Harvard biologist, says the public should understand that "scientists protect their turf like everybody else." But "the quality of data is what matters nowadays. People expect clean, crisp data, and when they see it, they can flip-flop very fast."

James Watson, now director of the Cold Springs Harbor Laboratory on Long Island, agrees. He points to Barbara McClintock. Her Nobel Prize–winning theory of "jumping genes"—genes that move from site to site on the chromosome—was so at odds with conventional wisdom when she first worked it out in the Thirties that she delayed its professional publication for ten years. After a wait of 30 years, the difficult theory, says Watson, had been "shown to be true by new types of evidence which was overwhelming, and no one could doubt it." McClintock died recently a heroine of science, the *New York Times* quoting one scientist who called her "the most important figure there is in biology."

Watson agrees that scientists may have a built-in prejudice against new ideas that challenge the status quo. "There is always some of that." But the real reason, to Watson's mind, why Pauling and Duesberg still hit a wall of indifference, is lack of "convincing evidence. People still get colds and cancer when they take vitamin C. Then it becomes, 'Has it made the cold less severe?' I take vitamin C myself to make

my wife happy, and I still get colds, but I don't know if as many!" Likewise, "Peter [Duesberg] hasn't come up with any smoking gun. You can give all the reasons [for doubt], but most of us tend to believe the simpleminded interpretation." Duesberg responds that this ignores the evidence that nearly all AIDS victims are involved with drugs in one way or another.

Gold is now pursuing his own irrefutable evidence in a Swedish oil well, where he reports finding methane at levels equaling those of good Oklahoma producers. If he's right, those who have stood in his way will have much to answer for. His theories promise a huge boost to global petroleum reserves, since oil and gas will be found far beyond the usual drilling sites.

With so much at stake, if there's even an outside chance that a reputable heretic is right, the public interest demands open-minded assessment, however critical. Anything less may let policy makers pour billions into wrong solutions. Science is not a democracy. One bright Galileo can be right and ten thousand traditionalists wrong.

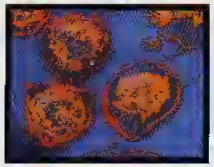
Could lawyers sort out the disputes? They're outsiders trained in logical argument, after all. One law professor, Phillip E. Johnson of the University of California at Berkeley, wrote a book recently, *Darwin on Trial*, which cheekily did just that—came in and castigated Darwin's theory of evolution as the unproven sacred cow of biology. But even Johnson thinks review panels of lawyers would be a bad idea. "External regulation would be too cumbersome. Scientists just have to learn to develop a cultural resistance to a few dogmatic voices cutting off lines of inquiry." Thomas Gold suggests that a panel of top scientists outside the field would do the job.

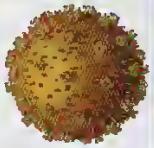
Duesberg, like many, says that divorcing funding from reigning theories could help. "Take the huge sources of income away and make science small and honest again," he suggests. "You can't expect millionaires to ask unorthodox questions. If I had a company paying me millions for counseling on HIV, I should probably be silent, too. Poverty makes you honest."

Short of these changes, a modern Galileo, as Pauling says, must simply wait. He quotes Max Planck, the German who won the Nobel Prize in 1918 for quantum theory. "Important scientific innovation rarely makes its way by gradually winning over and converting its opponents. What does happen is that its opponents gradually die out and that the growing generation is familiar with the idea from the beginning." ∞

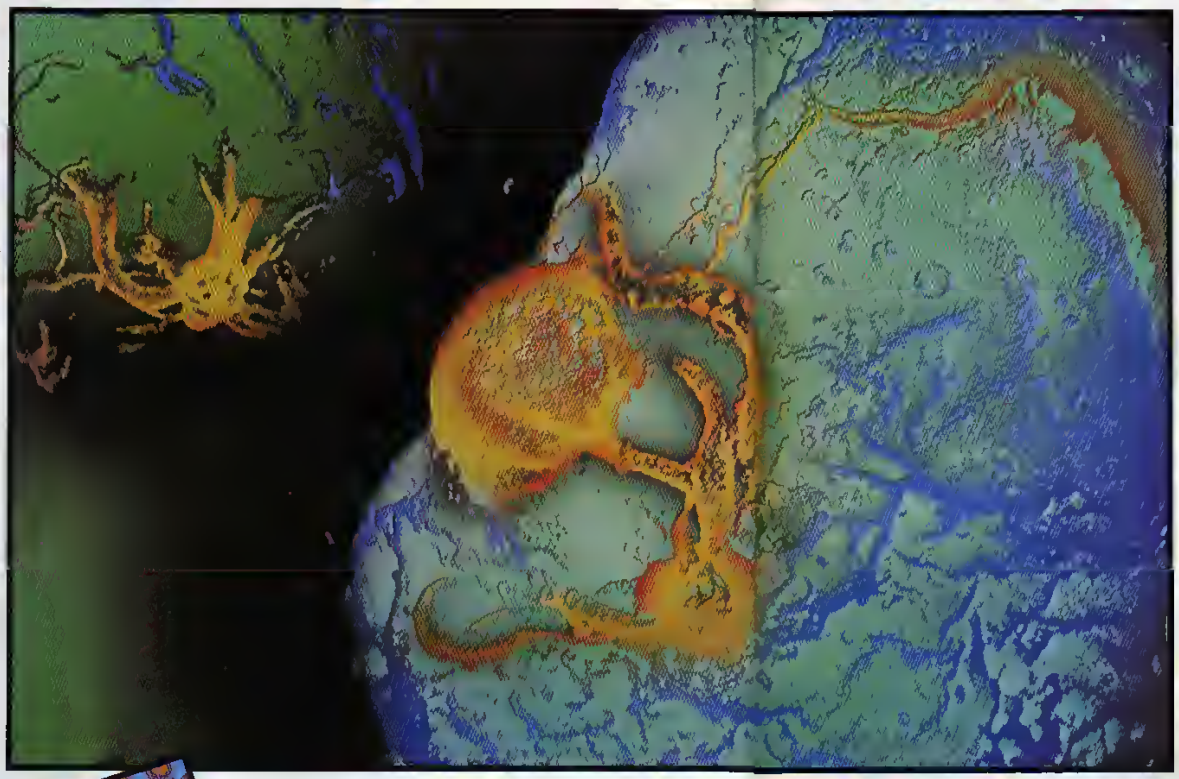
In the last decade, the virus has become the most studied infectious agent in history.

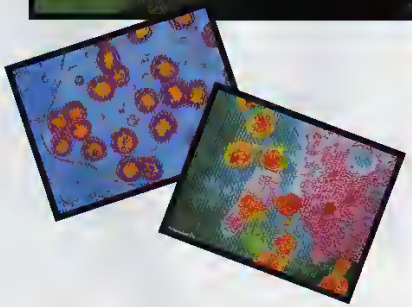
BEYOND HIV: ASSEMBLING THE AIDS PUZZLE



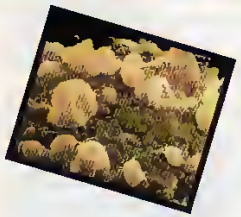


Images of invasion: The causative agent of AIDS—Human Immunodeficiency Virus (HIV)—measures 100 to 120 nanometers in diameter (top). A computer-generated image of HIV (above) created on a Cray Super Computer. HTLV-III-infected lymphocytes (right). The virus (in orange) is "budding" from the plasma membrane.





Enhanced transmission electron micrograph of the HTLV-III virus (far left) and false-color transmission electron micrograph of AIDS virus particles (near left) inside a stricken T4-lymphocyte, the white blood cell of the immune system AIDS destroys.



An infected T cell (left) typically has a lumpy appearance. The small, spherical virus particles are in the process of budding away from the cell membrane.

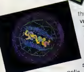
Almost a decade ago, Robert Gallo from the National Institutes of Health and, independently, Luc Montagnier from the Institut Pasteur in Paris announced that a virus, which subsequently became known as HIV, was associated with the panoply of exotic syndromes and rare diseases collectively known as AIDS. As we know now, AIDS is an immunodeficiency syndrome, which means the immune system is no longer capable of protecting a person from infection or disease. Hence, people readily succumb to fungal, bacterial, and viral infections.

The immune system is a mobile, trillion-cell network that flows through the body in the blood and in the lymphatic systems. It's composed of many different types of cells, each with different functions. Two of

BY COLM KELLEHER

HIV is a retrovirus—its genetic program is held in RNA, transfers into DNA inside the T4 cell, and then infiltrates the cell's own DNA. Once activated, the viral DNA replicates and its "progeny" bud from the cell wall, killing the host cell. A few of the players: Larry D. Arther of Program Resources, a subcontractor for the National Cancer Institute (top); Dani Bolognesi (left) of the Center for AIDS Research at Duke; Luc Montagnier, Institut Pasteur, Paris, discoverer of the virus (lower left).

Are we now nearly at the point at which some of the many enigmas are yielding to scrutiny?



A panel of experts discuss the latest discoveries (top). A human HTLV-III cell (middle). The orange and light-blue snake-like features (above) represent the components for replication: genetic information in the form of RNA and the enzyme reverse transcriptase which transcribes viral RNA into DNA.

the most important types are B lymphocytes and T lymphocytes B lymphocytes make the antibodies which can bind to and immobilize such foreign threats as bacteria and viruses that enter the body T lymphocytes, on the other hand can only recognize foreign molecules when they're on the outsides of cells In AIDS, a subset of a person's T cells, which are called "helper cells," are the hardest hit Some AIDS patients literally have no helper cells Without T helper cells, the immune network is incapable of distinguishing what is foreign from what is a normal part of the body This means that viruses, bacteria, and fungi can run rampant in the person Current World Health Organization projections estimate that by the year 2000, as many as 40 million people worldwide will be infected with HIV of which an unknown percentage will eventually die of AIDS

Gallo and Montagnier's announcements set the world ablaze with optimism In the intervening decade the scientific community has gathered evidence that not only is HIV associated with AIDS, but that it causes AIDS Based on this premise, medical research has mobilized its vast resources to unravel the mechanism by which the virus causes the disease Billions of dollars have been spent During the press conference at which was announced the discovery of the virus by Gallo's laboratory officials from the department of Health and Human Services confidently predicted that a vaccine against the virus would be available within a few years In hindsight, that optimism was premature Nonetheless in the last decade, the virus has become the most studied infectious agent in all of history

The last two or three years, however, have witnessed an explosion of unexpected results HIV may not act alone in killing T cells; most of the AIDS vaccination strategies have yielded negative and confusing conclusions, HIV can superbly mimic certain key molecules in the immune system, the outside of the virus carries parts of the outside of human cells with it, AIDS may be a disease in which the immune system turns on itself and destroys itself—the virus is just the first trigger What follows is the story of how this new picture of AIDS has recently unfolded

After the first flush of excitement following the discovery, one of the questions that surfaced was, Why are there so few virally infected cells present at any one time in the blood of an AIDS patient? Although recently with the aid of powerful new molecular tools researchers have shown that more cells than initially thought carry copies of the virus—especially in the tonsils and the lymph glands (which are under the arms and in the neck and groin)—the enigma remains How does this small packet of genetic information cause such devastation to so many cells? There has always been a gap in understanding between the properties of the virus as observed in the laboratory and the actual clinical course of AIDS Today, this gap has been highlighted by the discovery of a small but growing number of people who come down with the symptoms of AIDS but who clearly have no trace of HIV in their bodies

Montagnier, the discoverer of the virus, has devoted much thought to this question and has come up with a controversial answer He thinks HIV might have at least one accomplice—an important cofactor In the development of AIDS—a microorganism called mycoplasma. He suggested that mycoplasma and HIV might cooperate in killing T cells—something like sending in two hit men rather than one to do the job Mycoplasmas—small, single-celled, primitive organisms that lack cell walls—have been isolated from many normal human tissues They also are used regularly in many laboratories to grow cells in test tubes or tissue culture. Until now mycoplasmas have been associated with diseases such as walking pneumonia, arthritis, and some spontaneous abortions, but not with fatal diseases Montagnier's results confirm work done earlier by Shyh-Ching Lo a scientist at the Armed Forces Institute of Pathology in Washington, DC So far the rest of the scientific community has been hesitant about Lo and Montagnier's findings. Many suspect that the two scientists are simply looking at mycoplasmas that grow naturally in nearly every laboratory cell culture and have nothing whatsoever to do

with AIDS. Montagnier, however, defends his theory and has recently launched a new foundation in Paris, together with Frederico Mayor, general director of UNESCO, to help scientists exploring new research ideas.

Another conundrum surrounding AIDS is that large amounts of circulating antibodies against HIV are routinely found in the blood of AIDS patients. This baffles scientists. If the infected person can easily make so many antibodies against the virus, why is this not sufficient to stop it dead in its tracks? If the antibodies are doing what they should be doing and blocking HIV in an infected person, then why does the person come down with AIDS?

In 1988, Geoffrey Hoffmann from the University of British Columbia proposed a very novel solution to this puzzle. Suppose, he argued, that the virus had a similar shape to some very important components of the immune system and that the antiviral antibodies which were made after HIV infection were actually directed against the immune system as well as the virus. Then the immune system would begin attacking and destroying itself. In other words, Hoffmann was predicting that AIDS was actually an autoimmune disease. (The idea that AIDS is an autoimmune disease was first proposed by a group of French researchers and two American scientists in 1986.)

To back up his theory that the virus might mimic important immune molecules, he and his colleague Tracy Kion reported that when mice were injected with cells from another mouse, the recipient mice made antibodies against HIV—even though these mice had never been exposed to HIV. There was no virus whatsoever in his experiments, yet the immune system of the mice, which had been injected with normal cells from other mice, reacted *as if* they had been injected with HIV. To Hoffmann, this meant that HIV must be mimicking a molecule that's found on the surface of normal cells.

In fact, there is evidence that no less than four different parts of HIV were mimicking the shape of a central molecule of the immune system called MHC—a family of molecules found on all cells in the body, including immune cells. (Hoffmann's group identified two of the substances that mimic MHC.) And, since HIV looks like MHC, Hoffmann thinks this shape similarity triggers waves of inappropriate immune responses all directed not only at HIV but at the immune cells themselves. According to Hoffmann, the immune system is triggered to destroy itself.

Hoffmann's theory is very radical because he claims that HIV itself isn't necessarily doing the damage; it just happens to have a shape that provokes a strong self-destructive response from the immune system. But these data are only mildly surprising compared to some unexpected results that have emerged in the last couple of years from HIV vaccine research.

The idea behind HIV vaccination is to fool the immune system into mounting a response against HIV without actually injecting a patient with it, which, of course, might raise difficult ethical issues. Instead, most vaccine researchers inject only part of a virus (like the outside coat) or a killed virus to provoke an immune response. The hope is that in the future, when the immune system sees the real virus, it will remember to act, and, if all goes well, will eliminate it. So far, however, things have not gone according to this basic plan.

> "Current World Health Organization projections estimate that by the year 2000, as many as 40 million people worldwide will be infected with HIV."

In 1991, E. J. Stott from the National Institute for Biological Standards and Control in Hertfordshire, England, reported that during his attempts to vaccinate macaque monkeys, he injected the animals with a monkey equivalent of HIV that had been grown in human cells. Not too surprising, the monkeys became protected against subsequent challenges to the virus. But what sent shockwaves through the scientific community was Stott's finding that when monkeys were immunized only with the cells that had been used to grow the virus, they too were protected. Apparently the cells themselves produced an immune response which seemed to be the source of protection against the virus. The virus itself wasn't necessary in the vaccination procedure.

The finding was completely unexpected and clashes with a widely accepted, central tenet of vaccination dogma which states that the way to vaccinate against a virus is by using either a killed virus or some part of the virus the immune system can recognize. Stott wrote, "Our results, if confirmed, may reveal another unique property of immunodeficiency viruses which requires explanation." The unique property Stott alludes to is that you don't necessarily need the virus to induce an immune response against it—human cells without the virus will do the trick.

Stott's findings with monkeys seem eerily similar to the Hoffman-Kion discovery with mice which showed that injecting cells alone actually provoked an immune response against HIV even though HIV wasn't present. This protection-by-cells-alone phenomenon has now been verified by many researchers even though they aren't sure how the protection is working. Something strange is going on.

Dani Bolognesi from the Center for AIDS Research at Duke University in North Carolina thinks that maybe the virus can grab other cellular proteins such as MHC when it's growing in the same cells, and that the protection which he, Stott, and others see in monkeys is from an immune response to MHC proteins rather than one against viral proteins.

What exactly are these MHC protein molecules that, according to Hoffmann and Bolognesi, seem to be so closely tied in with AIDS? MHC stands for *major histocompatibility complex*. The molecules are on the outside of every cell in the body and are major signposts to the immune system for defining the cellular self-identity for each individual. (In immunology, any protein or cell that's manufactured by itself is defined as having "self-identity.") It's critical that the immune system of a person be able to distinguish anything that's part of its own body from anything that's foreign. Otherwise, the system might attack and destroy a perfectly innocent part of one's own body, believing it to be a virus or some other foreign entity. Everyone has different MHC proteins on the outsides of all of their cells. One person's MHC proteins are sufficiently different from another person's MHC proteins so that both people's immune systems are able to tell the difference between the two sets of cells.

The MHC proteins are crucial in bone marrow or other organ-transplantation operations in determining whether the transplant will be rejected or accepted by the host. When someone receives a transplant of incompatible cells (a different MHC type), the body reacts and rejects the transplant. When a person's immune system has been weakened, a transplant of foreign cells can cause a severe disease known as graft versus-host disease (GVHD).

Since 1983, researchers have no-

CONTINUED ON PAGE 88

GRAND PRIX

Fiction By Simon D. Ings

Illustrations By Vern Dufford

"1000 hp on this circuit? Madness."
—*Niki Lauda*

The sea is off-white, banded by blue wave-shadow. A line of clotted cloud lies between it and the cobalt sky of La Rochelle. Angèle talks but I'm not listening. I'm building sand castles.

I lie down in front of the model and pick away the square and the Boulengrins with a fingernail. I press my little finger at a slant into the model to indicate the tunnel through to the harbor. The finishing touch: I trail sand between my fingers along the edge of the cliff to make the concrete wall Frasange demolished last year when his throttle jammed at 600 kph.

The Monaco Grand Prix is fifteen days away.

Angèle peels off her shirt and heads for the water. I want to join her. The afternoon has steam-ironed my face and my shirt is dripping sweat. I want to dive into sea so cold it churns the gut but I can't risk getting sea water in my jacks this close to a race.

It's sunset. The haze turns brown and rotten before Angèle reaches the diving tiers. When she fails her silhouette is as sharp and black as the wave shadows, a black slash piercing a hyphenated surface. I think of trajectories, Gs and vectors, fire masks, halogens, wheel jacks and robots, flags like bunting and visors filled with drunken kangi.

The jack behind my anus is itching.

We walk back to town through the arcades to the market. A man is hosing the forecourt with seawater. The gutters are full of tabloids and endive.

We get a room above a café with a view of the market roof. We fetch our luggage from the station. Angèle puts her PC at the foot of the bed, pulls up the IBCN lead and crawls about the floor cursing. We miss the first five minutes of 'Danseuses Nouvelles.'

They came from Dijon a year ago and they're top of the TVP ratings. They dance to Saliert and Skinny Puppy, to De Machaut and The Crucial Bridging Group. They are a women-only company and espouse the politics of the *Programme Pour Femmes Fermées*—the Agenda for Expressionless Women. Last year the French parliament, outraged by the atrocities of Août '34, placed a media ban on the Programme. The Amazons of the Sorbonne and the Academie Julienne are silenced now, but *Danseuses Nouvelles*, whose pieces are the product of their more sober semiotic researches, have never been more popular.

Few have forgotten or forgiven the sack of the *Sacre Coeur*, the on-stage emasculation of Bim Bam's drummer and lead guitarist the siege of the *Jeu de Paume* or the situationist over-painting of Seurat's *Baigneurs*.

And yet. A glamour surrounds *Danseuses Nouvelles*. Its dances play out strange deconstructed stories, and act their warped yet familiar roles with an inhuman grace. Their performances whisper of the world as the Programme wants to shape it. They are the dream in its pure state—a glimpse of an end uncompromised by violent means.

After the show Angèle and I make love. It is love with a fluid rhythm. There is a sweet, shared violence to it. Angèle gasps and clutches at me, the bed, anything; I gaze into her widening eyes. There, in the wet blankness of the pupil, I can see them. I gaze closer, closer—Angèle's tongue flicks at my chin and I catch it in my lips, my teeth, suck at it like a baby put to the breast. *Danseuses Nouvelles*—missionaries from the land of strong women—are dancing in her eyes.

> "She held the orange carcass of her latest victim between finger and thumb and twirled it by its claw. I treated her to a bitter smile."

The thing I remember most about Catharine is the way she ate Dublin Bay prawns. She broke their backs with casual, sadistic gestures. When her red tongue flicked back the white pus within them, she put me in mind of a cat.

This was six months ago, in Quimper. I don't know how she got my number. She told me quite openly who it was she worked for, and since the *Programme* had never to my knowledge worked with men, I was intrigued at her invitation. Perhaps it was naïve of me.

"They say racing drivers talk more and do less about sex than men in any other sport." She held the orange carcass of her latest victim between finger and thumb and twirled it by its claw over her plate. I treated her to a bitter smile. The playboy reputation and its sarcastic flip side, is one we no longer deserve. There is no Baron von Trips on the circuit now, no Count Godin de Beaufort, no Ines Ireland, no Lance Reventlow. Everything has become too competitive and commercial. Indeed, by the nineties the playboy image had all but expired. "Formula Zero has rekindled our infamy," I explained. "New cars. New regulations. They want to rekindle the old magic. It's plastic. Packaged. Our sponsors twist incidents into publicity gimmicks. It sells ratings."

"It does not anger you?"

I shrugged. "If it did not, would I be here?" The claw broke and the gutted corpse soft-landed in a pillow of saffron rice. It was her turn to smile.

She pushed aside her plate, lifted her PC onto the table, licked her fingers and typed. She read. "Cool, rational, seldom angered, seldom sulks when disappointed—" She gave me a cool glance. "Bisexual, last cruised in Groningen four years ago, in '42 had a short relationship with hypertext writer, male, in London, long-standing correspondence with lesbian activists in Seattle, New York, Brisbane, Porto—"

She turned the screen round for me to see. "Hardly the stuff of blackmail," I said.

Catharine tutted. "Of course not. What would be the point? 'Publish and be Damned'—that would be your attitude, no?"

"It has been for a long time. But Havers has a way of buying off the papers before things like that get too far."

"You must be quite a headache for her, a 'new man' at pole position."

"Maureen Havers is *old*," I said. "Because she's old, she's a legend. If a legend runs a company it has an interest in creating subsidiary legends—*appropriate* legends."

"So she puts you in the closet."

"I'm glad of the privacy. If I were Don Juan I wouldn't get any privacy at all. She'd make sure of it."

Catharine stroked her chin. "Is she an evil woman?"

"She is sad," I replied. "She lost her son to *Formula Libre* in Brazil. Her engineers built a car that cornered too well for him. The Interlagos circuit curves the wrong way round. He wasn't properly prepared for the extra G-strain."

Catharine waved her hand dismissively. "I'm not interested in technicalities."

I looked at her a long time then said, "He was still burning when I pulled him out. His visor had melted into his face." She pursed her lips. She even had the decency to blush. "I'm sorry."

"*Formula Libre* is just what it says," I went on, ignoring her apology, "a free-for-all, a freak-show for fast cars. But Formula One was outdated, and good new designers were turning to *Libre* rather than be straight-jacketed. Havers built up Formula Zero to codify some of *Libre*'s better ideas. She made it, and dominated it, and now, because she's old,

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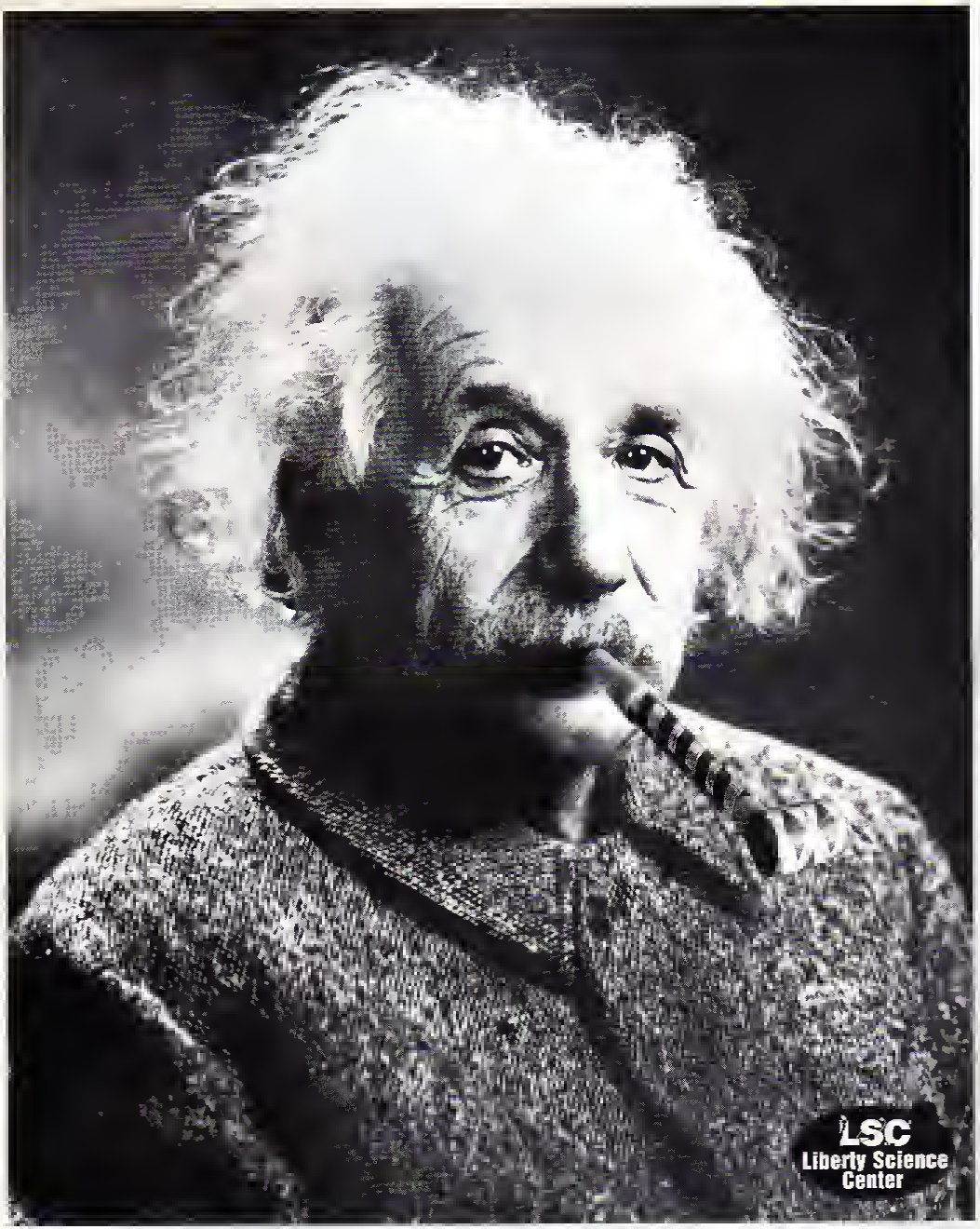

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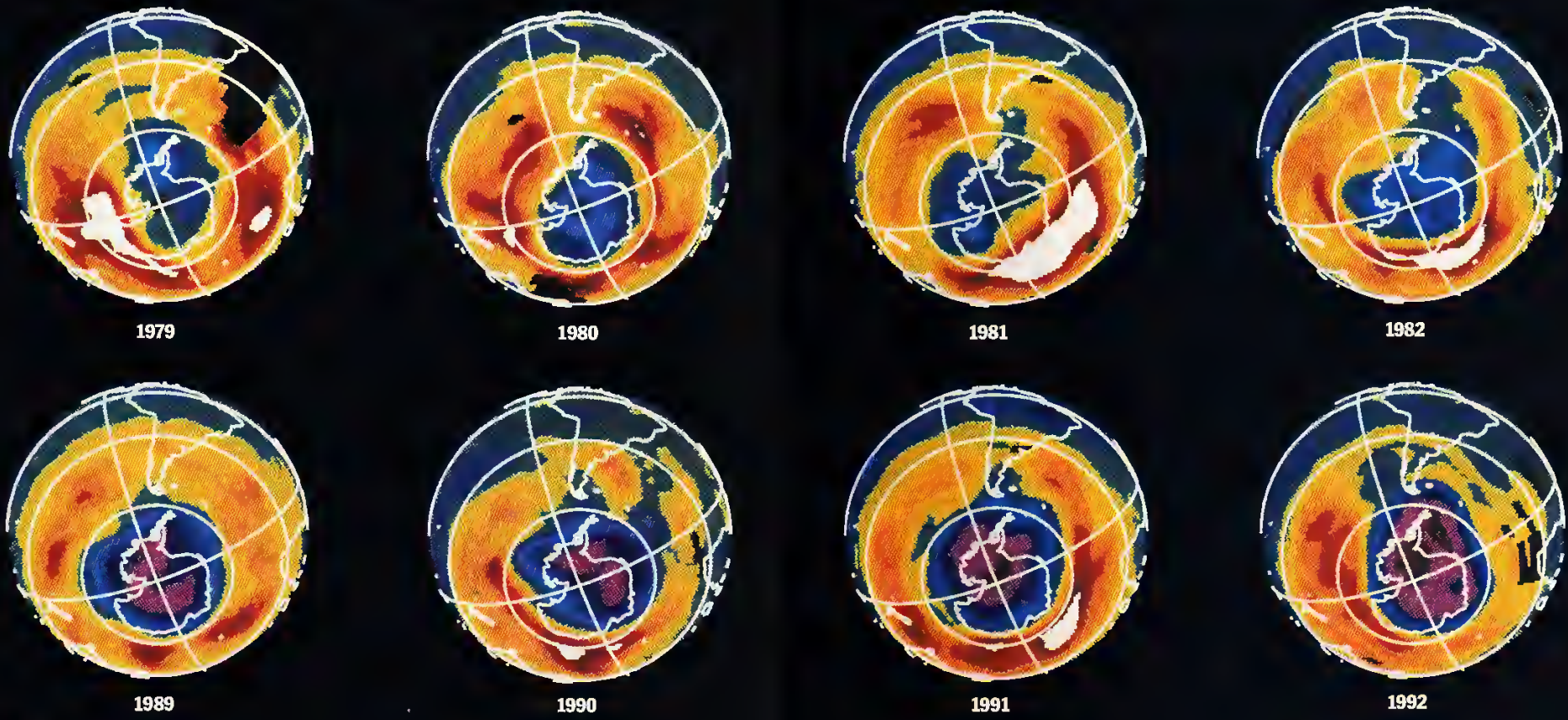
In the future, geoengineers tinkering with the sky may patch up the ozone hole, stem global warming, and reverse the ravages of pollution.



Air Repair

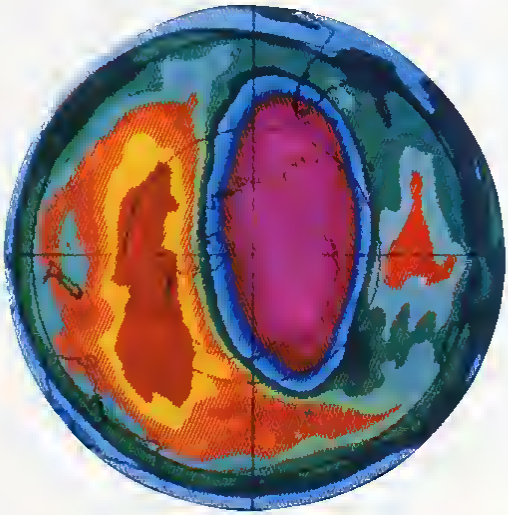
Article By Owen Davies

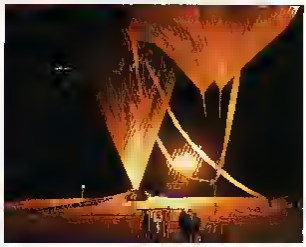
In the South Pacific, rusted old freighters send clouds of smog into the sky and drip iron-rich liquids into the ocean. Overhead, aging airliners with inefficient engines spew out soot and hydrocarbons. And around the world, coal-fired power plants send toxic sulfur fumes into the air. It seems an environmentalist's nightmare. Yet this is planned pollution, on the global scale.

Welcome to the brave new world of geoengineering, built on the premise that what technology has given us–global warming and ozone holes–it may also take away. To date, we have changed the climate only through ignorance. But soon we may have to change it deliberately. Would-be geoengineers warn that if we continue to produce carbon dioxide and other greenhouse gases currently heating up the planet, environmental tampering may be our only hope of averting drought in critical farm regions and other catastrophic changes due to shifts in the

The maps show the expansion of the Antarctic ozone hole from 1979 through 1992, when the damage was most extreme. The colors represent ozone concentration from white (highest) through red, yellow, green, blue, and purple (lowest).

Can emerging technologies restore what pollution has taken away?





The large, oval-shaped, mauve area at left is the ozone hole, which stretches from the South Pole to the tip of South America, at top. Right, top, a scientist checks a steel vessel with cells for sampling ozone-depleting pollutants. Right, bottom, is the sort of weather balloon used to measure atmospheric ozone and related pollutants.

climate. And, they add, chemicals to patch up the ozone hole caused by industrial and consumer release of chlorofluorocarbons (CFCs) may be the only way to prevent the entry of harsh solar rays and the extra skin cancers that would result.

If the idea of changing the biosphere sounds risky, respectable scientists nonetheless are taking it seriously. Rob Coppock, who recently directed a National Academy of Sciences (NAS) study of geoengineering for the U.S. Congress, says, "We were skeptical at first, but many ideas seemed both feasible and cost effective."

In fact, perusal of the NAS report reveals much to choose from. Some of the 59 so-called mitigation strategies were as simple as painting roofs white to cut down on heat absorption or improving the efficiency of lights and water heaters to cut demand for electricity from coal-fired generators. "Just getting every household in the United States to replace three incandescent bulbs with high-efficiency fluorescents would cut residential energy demand in half," Coppock, now with the World Resources Institute, notes.

But according to former NASA Administrator Robert Frosch, who wrote most of the geoengineering report, these inexpensive options won't be adequate. "If you did all the relatively cheap options, they would reduce the effect of greenhouse gasses by no more than forty percent and perhaps as little as twenty percent," notes Frosch, now vice president for environmental compliance at General Motors. "You really need something more."

That's where geoengineering comes in. At its simplest, geoengineering offers to reforest more than 28 million hectares—about 17,500 square miles—of marginal U.S. farmland, so trees can absorb the carbon dioxide that industry and consumers give off. More spectacular proposals include lofting vast mirrors into space to reflect excess sunlight away from the planet and thus avoid global warming, deploying naval guns, rockets, or balloons to carry dust or soot into the stratosphere as a planetary sunshade, fertilizing the ocean to promote the growth of algae that would absorb carbon dioxide, and dumping hydrocarbons into the Antarctic stratosphere to react with CFCs before they can destroy the ozone layer.

As it turns out, say the experts, space-based options can be dismissed out of hand. The price of orbiting mirrors would be as far out of this world as the reflectors themselves. If each mirror were 100 million square meters—about 39 square miles—it would take 55,000 of them to counteract the world's output of greenhouse gasses. To offset only U.S. emissions, 110 mirrors would be required. But at space-shuttle prices, the tab for putting them up would come to at least $120 billion, not counting the reflectors themselves. Even by Washington standards, space reflectors seem expensive.

The obvious alternative is what Frosch calls a "space parasol," an orbiting dust cloud to screen out incoming sunlight. Ideally, the dust particles should be small so

that a few tons of them can cover the largest possible area keeping launch costs to a minimum But the solar wind quickly sweeps tiny particles back into the planet s atmosphere And if the particles are large enough to remain in orbit, the price of putting them there soars out of sight

According to the report, some terrestrial options for geoengineering may be more economic, to say the least One category, flippantly dubbed "pollution pro bono" is the ultimate quick-and-dirty answer to global warming Just add some soot dust, or sulfuric acid to the stratosphere and make a sunshade *without* paying for space launches It s not as outlandish as it sounds—Mt Pinatubo did just that in 1991 Since then, according to the National Oceanic and Atmospheric Administration the planet has cooled about 1 5 degrees, and the temperature seems likely to dip another half degree or so—four times more than enough to reverse all the global warming believed to have occurred since the last century

In facf, acid pollution spewed into the lower atmosphere by factory smokestacks may already shield much of North America and Europe from global warming, according to the United Nations Intergovernmental Panel on Climate Change Burning fossil fuels throws sulfate particles into the air, filtering out sunlight much like volcanic dust Atmospheric chemist Robert Charlson of the University of Washington in Seattle calculates that pollution cools the northern hemisphere down to the tune of one watt of solar energy per square meter, counteracting about 40 percent of the global warming caused by the greenhouse effect

Pure dust at very high altitudes in the stratosphere, according fo NAS calculations, would be even more effective at counteracting the greenhouse effecf A single kilogram offsets 400 tons of CO_2 in the air, according to the NAS calculations At fhaf rate 20 million kilograms would eliminate any warming due to U S greenhouse emissions The atmosphere already receives between 1 and 3 billion tons of dust each year, most of it from natural sources, so the amount to be added seems likely to prove harmless

The NAS report suggesfs three ways to distribute the dust Launch it with rockefs like the surplus *Nike Orion*, lift it with the helium balloons now used to carry scientific payloads or shoot it into the strafosphere with naval guns Rockets and balloons would cost from $80 to $100 per kilogram of dust so naval artillery at only $10 to $30 per kilogram, seems the best choice At fhaf price, it would cost less than $1 per ton of CO_2 to prevent global warming If we must shop for geoengineering strategies this is the bargain basement

A fourth Frosch idea is to use planes and boats to give off pollutants that would in furn counteract fhe effecfs of global warming For instance, geoengineers could detune the engines of commercial aircraft flying higher than 30 000 feet so that 1 percent of fheir fuel gets spewed out as soot At that altitude, Frosch explains, particulates remain in the air for only 83 days, on average, compared with two to three years for stratospheric dust So the sun screen must be renewed more often But the price is lower—it would cost just a penny a year to offset fhe damage of a ton of CO_2

Similar results would come from burning sulfur on ships steaming back and forth across the Soufh Pacific, sending a sulfur-dioxide aerosol into the lower atmosphere Water would condense on the sulfur-dioxide droplets, creating artificial clouds And according to several studies it would take only a 4 percent increase in cloud cover over the oceans to offsef the warming caused by a doubling of atmospheric CO_2 Again, the cost seems reasonable as geoengineering plans go It would take an estimated 6 million tons per year of sulfur to produce the desired clouds Assuming fhaf a single ship can burn 100 tons per day then 200 ships at sea 300 days per year would do the trick If the ships cost $100 million each, plus $10 000 per day to operate it would cost a dollar per ton of CO_2 fo eliminate the greenhouse effect That s an attractive price, even compared with the cheapest energy-saving strategies

Predicfably, all fhese schemes came under attack as soon as they were announced Chief among the critics is Seattle's Robert Charlson, whose work helped inspire this line of geoengineering in the first place "Some people have misinterpreted our findings" he declares Using sulfafes or dust to counteract global warming 'is an unworkable proposition You would have to have a designer sulfate and distribute it in jusf the right fashion It's impossible to get that level of control"

Even if you could he adds "if still wouldn't solve the problem The goal isn't just to avoid a slight increase in average global temperature but fo avoid climatic changes—droughts or flooding where we're not prepared for them Greenhouse gases trap heat both night and day, but sulfates or dust

would screen it out only during the day You might get the average temperature to balance, but you'd alter the day-night temperature difference In principle, that might render whole portions of the planet uninhabitable

In light of these objections geoengineers have come up with less contentious ways of fighting global warming In fact, the only plan that virtually no one argues with is to stop cutting down trees In nature, trees are an important sink for CO_2 Wood is about half carbon, and trees absorb carbon dioxide very efficiently until they mature In some species, this fast-growing period can last 40 to 50 years And when burned or allowed to rot trees are a major source of CO_2, methane, and other greenhouse gases Some ecologists estimate that protecting just one forest, the Golfo Dulce Forest Reserve in Costa Rica s Corcovado National Park will save 8 7 million metric tons of carbon over the next ten years

Take the next step planting new trees and the Johnny Appleseed option becomes a form of geoengineering as well A few U S utility companies are already creating forests in order to offset the CO_2 produced by their coal-fired generators For example, Applied Energy Services of Arlington, Virginia is planting trees in Guatemala on the theory that they ll soak up as much CO_2 as their Connecticut power plant emits

The real goal, however, is not just to grow trees but to substitute biomass energy for petroleum Oil constantly pulls carbon from deep in the ground where it's been locked away for tens of millions of years and spews it into the atmosphere In contrast biomass emits no more carbon dioxide than the plants absorbed from the air in the first place In theory, switching to biomass energy *could halt the increase in global* CO_2 According to biologist David Hall of King s College of the University of London in fact, the strategies of reforestation increased energy efficiency and conversion to biomass wherever possible could cut CO_2 emissions in half in about 60 years

Unfortunately, it takes a lot of biomass, mostly in the form of trees to make a difference, that s why something as simple as planting trees is called geoengineering in the first place Hall himself estimates that offsetting just 5 4 billion tons per year of carbon generated by fossil fuels might require as much as 600 million hectares of biomass plantations—which would encompass an area equal to 40 per cent of the world's cropland, or more than half the size of the United States

Then again, not all crops require land At the Electric Power Research Institute (EPRI) in Palo Alto California, engineer Dwain F Spencer is designing giant kelp farms to produce biomass energy under the sea Eventually they could cover some 7 million square miles of the ocean's surface "Each farm would produce about eighteen million cubic feet of methane per day" Spencer reports "It would take twenty-five hundred of them to equal U S *production of natural gas*"

Geoengineers interested in the ocean have also been exploring another option—absorbing excess CO_2 with the equivalent of an ocean rain forest, the huge quantities of marine algae that can be cultivated in the sea The idea was first spawned by biologist John Martin of California's Moss Landing Marine Laboratory Martin s plan was born of a mystery that has puzzled marine biologists for years In parts of the Pacific, the water is rich in nutrients like nitrogen and phosphorous, yet microscopic plants—phytoplankton—grow poorly It isn't that the water is too cold or the light insufficient The limiting factor it turns out is iron Whenever Martin and colleagues fertilized water from

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INTERVIEW

The primal dramatist: He sees the script of human evolution vividly played out by the great apes.

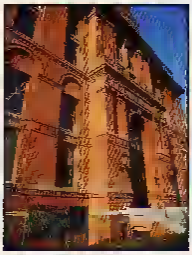
IRVEN DeVORE

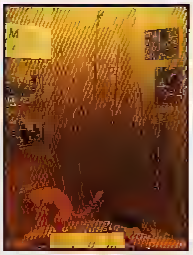
PHOTOGRAPHS BY PETER LIEPKE

Harvard University. Four hundred students watch as a slide is projected of a large silver-backed gorilla in his natural habitat. The lecturer shifts back on his heels, throws out his chest, and intones, "And this individual rejoices in the scientific name, *Gorilla gorilla gorilla*." As a warm laugh spreads across the crowd, a teaching assistant lurking in the shadows thinks to himself, "My God, DeVore gets a laugh out of merely stating the species' name!"

Irven DeVore is in *his* natural habitat, explaining the facts and implications of human evolution to a highly appreciative crowd of Harvard undergraduates. Of course, DeVore doesn't always please the crowd. There are times when—through neglect or profound intrapsychic disconnect or whatever—DeVore fumbles and fails, and Harvard's fickle undergraduates turn from adoration to scorn, filling the lecture hall with loud sounds of hissing. In this situation on the way out of the hall DeVore will stroke his chin and declare to his retinue of teaching assistants, "Another case of casting false pearls before real swine." Now it's their turn to laugh. By God, nothing fazes this man, and by implication, nothing should faze them either.

Teaching human evolution is a little like juggling. The more topics you keep in the air, the better the show. By this criterion, Irv DeVore puts on a good show, indeed. A master of primate behavior, he has 20 years of field experience studying human hunters and gatherers. He routinely keeps up with the latest work in paleontology and archaeology as well as





Harvard's Peabody Museum: DeVore recently curated an exhibit featuring his photos of Kalahari kushmen.

IRV ON:

SOCIOBIOLOGY:

"It has brought about a revolution in understanding how evolution has shaped behavior. At heart is the demonstration that natural selection is most accurately seen from the 'point of view' of the individual and the gene rather than a process operating on a group or species. We can now analyze with some rigor complex behaviors such as aggression, altruism, parental care, mate choice, and foraging patterns. Almost from the beginning, many of us felt this theory would revolutionize the study of human behavior."

WAR:

"It's difficult to argue that strategies being employed by chimps in their 'wars' differ significantly from the raiding by human males from tribal kinship units on males in an adjoining territory, where the intent is to secure larger land resources and capture females and young."

RESEARCH STRATEGY:

To understand culture-less, stripped down animal societies as a way of thinking about individuals in social groups in general terms.

VALUES:

"It's tragic to find chimpanzees and their habitats heading toward extinction. What would happen if space probes discovered a planet with creatures who shared 98 percent of our genes? We'd spend billions to send expeditions!"

neurobiology and psychology. And unique among anthropologists of his generation, he has mastered the new research in sociobiology.

Born and raised in rural Texas, DeVore did undergraduate work at the University of Texas. Pursuing his doctorate in American Indian archaeology at the University of Chicago, in the late Fifties, he fell under the sway of Sherwood Washburn, a noted anthropologist with the wit at that time to study baboons instead of humans. In his doctoral study on the social life of East African baboons, DeVore discovered a central hierarchy among the adult males in a troop. Several support each other in interactions with males outside the hierarchy, so victory between two males is often contingent on the behavior of a third baboon. This was the first clearly demonstrated case of *reciprocal altruism* seen outside our own species: each male tending to solicit for support a male who had recently solicited him. DeVore's research was part of the new wave in primatology in which social relations in monkeys and apes are scrupulously studied in the wild to gain perspective on human evolution.

DeVore's embrace of primate behavior soon led him to evolutionary theory. This had a shattering effect on his relationship with mentor and friend Sherry Washburn. Washburn was used to thinking about baboon and human behavior within the comfortable "group selection" paradigm of the day (individuals act for the benefit of the group or species). But in biology, the new paradigm was individual action for *individual reproductive gain*, or even worse, individual *genes* acting for individual *genetic advantage*.

DeVore's conversion to sociobiology was about as pleasant as "Saul's on the road to Tarsus." At its conclusion, DeVore stood firmly on his own, but his relationship with Washburn was ruptured, his reputation as a political liberal at risk. For him, the separation between humans and other creatures—between biology and social sciences—was forever eradicated.

As befits a person of his intelligence and warmth, DeVore has attracted a swarm of outstanding students who now populate major universities throughout the United States and beyond. Perhaps those who give him greatest pride are the women, some of whom (such as Sarah Hrdy at the University of California at Davis and Barbara Smuts at the University of Michigan) are defining a feminism firmly rooted in evolutionary biology.

Married to Nancy Skiles, who runs Anthro Photo, DeVore is the father of two children and grandfather to three more. Now silver haired himself and busy with a thousand and one commitments, DeVore sat down for this interview in his spacious office at Harvard's Peabody Museum of Anthropology.

— Robert L. Trivers

Editor's note: Bob Trivers, the DeVore teaching assistant "lurking in the shadows" is now an eminent sociobiologist. Professor of biology at the University of California at Santa Cruz and author of Social Evolution, *Trivers was the subject of an* Omni *interview in July 1985.*

Omni: Have the thousands of recently gathered fossil hominid specimens changed our understanding of human evolution?

DeVore: In almost every way I know. These specimens

stretch across Europe, Asia, and Africa and cover the last 5 million years. The new finds are so rich that we can now argue about the fine details of human evolution.

Omni: You and I know there's no "missing link." So what do we have?

DeVore: There never was a "creature" between ourselves and the chimpanzee. Chimps and hominids have had 5 to 6 million years of independent evolution. We stand in relation to chimps as say second cousins who are descended from common great-grandparents. Nevertheless, when you examine the remains of the earliest australopithecines—*Australopithecus afarensis*, "Lucy" and her kin—you're looking at a creature 3 to 4 million years old that comes amazingly close to combining human and ape traits.

These early australopithecines had clearly adapted to bipedal walking, yet neither the pelvis nor the feet are fully modern. The arms are long and "apelike," the fingers and toes long and curved. This suggests they were still spending a lot of time in the trees or they had only very recently evolved into upright walkers. Both could be true. Add to this that they had ape-sized brains and the males had much longer canines than females, and you have a creature that is a mosaic of ape and human traits. Someday we'll find an earlier and even more apelike hominid, but *afarensis* is already so close in time and body form to the great apes, we can almost predict what a creature that is even closer to the division of apes and hominids will look like.

Omni: Can you describe how our ape ancestors behaved?

DeVore: Not really, but one colleague has postulated that the evolutionary success of the early hominids is based on the fact that males and females were pair-bonding and males heavily invested in their offspring. I think the chance that this was true is near zero.

Early australopithecines showed too much physical dimorphism between the sexes. Estimates of the greater size of *afarensis* males over females range from 1.5 to 1.8 depending on what you measure. There is no living mammal and certainly no living primate in which such a big difference in male/female size has led to pair-bonding or significant male investment in offspring. Looking only at relative body weights, male to female, of the apes and ourselves, we find the following: gibbons are 1:1; we are 1.2:1; chimpanzees are 1.4:1; gorillas 2:1, and orangutans 2.3:1. Only the gibbons, who are physically monomorphic, are monogamous, pair-bonding apes. So it's exceedingly unlikely that australopithecines could have been pair-bonding.

Omni: Can we assume that the upright, tool-using hominid adaptation was so successful that it swept all other creatures before it?

DeVore: Exactly! Only a few years ago, when fossil finds were scarce and dating methods poor, it was perfectly feasible to squeeze all forms into a single line from a primitive ancestor right through to modern *Homo sapiens*. In retrospect, we shouldn't be surprised that the later hominids coexisted.

One of the most perplexing problems is the Neanderthals. Until recently, we thought of them as a genetic population isolated by the continental ice sheets in Western Europe. Now, Ofer Bar-Yosef [Harvard] and colleagues have clear evidence from caves in Israel that Neanderthals and *Homo sapiens* lived contemporaneously—sometimes in adjacent caves—for about 100,000 years. Both used comparatively simple Mousterian tools, based on flakes struck from rock cores.

> "My first reaction to the new theories of sociobiology was to dismiss them. But after six months, my previous view of the world crashed. Almost overnight I was converted."

Cro-Magnon *Homo sapiens*, best known from Western Europe, emerged only 35,000 years ago. About 20,000 years ago, *Homo sapiens* emerged triumphant with the complex, late-Paleolithic tool kit: harpoons, needles, knives, arrow points, and so on. Poor old Neanderthal sticks to Mousterian tools for 100,000 years and goes kaput about 33,000 years ago. At the very latest stage, on the threshold of domination by *Homo sapiens*, two exceedingly similar species are coexisting.

Omni: Are humans pair-bonding?

DeVore: In the West, we assume the "natural condition" is monogamy, with significant investment in offspring by husband/father. But a worldwide sample of over 1,500 human cultures strongly argues that the vast majority either encourage or at least tolerate polygyny—several women married to a single man. I know of no society outside nation-states, and societies over which they hold dominion, that are not polygynous. High-status males almost always have numerous wives, and lowest-status have none. Clearly, culture makes a huge difference.

In a few societies, polyandry—several men, usually brothers, married to the same woman—predominates. Other matrilineal societies trace kin relations through women. The bond between husband and wife is often weak, sexual infidelity high, and divorce easy. Such societies commonly rely on a brother/sister household. The male authority figure is not the father, but the mother's brother, the uncle. Child rearing is not entrusted to a male-female bond based on sexual interests between husband and wife, but is organized around the more stable brother-sister unit. Husband/fathers may come and go, but the underlying stability of the domestic unit is not jeopardized by the shifting sexual interests of the parents.

Omni: Haven't you just described a world of male chauvinist fantasy, where males of strength and status give vent to their basest sexual appetites and reproductive drives?

DeVore: That is the judgment of most people in our society, and it's heavily reinforced by church, state, and cultural values. But in most cultures, women would be furious if a law were passed that decreed they could not become the second, third, or sixth wife of a wealthy, high-status male when the alternative was a monogamous union with a poor, low-status male.

Omni: Why might a woman join a polygynous household?

DeVore: Polygyny seems more frequent in the tropics and in sections highest in parasites. This makes sense if the polygynous male has better genes. Where parasite load [variations in mortality and fecundity due to parasites] is higher, people will emphasize parasite-resistant genes in choice of mates at the expense of parental investment.

Omni: What criteria might humans use to select for such genes?

DeVore: That's the question! In other species, especially birds and lizards, bright coloration and complex song reveal absence of parasites, but except for song and dance—which may indeed be better developed among tropical peoples—we know of no trait obviously evolved to reveal parasite load in humans. David Buss and colleagues find that parasite load correlates with emphasis on physical attractiveness in mate choice. Where average parasite load is higher, people pay more attention (or at least claim to) to physical beauty in choosing a mate in contrast to fi-

delity and wealth. Even in a society with a relatively modest parasite load such as ours, we know from vast experience that physical beauty is an important factor throughout our lives.

Omni: But what is physical beauty?

DeVore: Symmetrical faces seem to be especially pleasing to other humans. Judith Langois has shown that when a series of real faces is computer averaged, people prefer the averaged faces. And averaging makes the resulting face more symmetrical. This hooks up with evidence from biology that male symmetry is an important contributor to male mating success.

Parasites are likely to be a major cause of asymmetry in the body, since parasites typically have localized effects, and where these interfere with development, they'll lead to asymmetries. As so often happens in nature, male-male competition and female choice appear to go hand in hand. Asymmetries will also make it less likely that males will succeed in aggressive encounters with other males. It's greatly satisfying to see symmetry reemerge as a central concept of evolutionary biology, not in some abstract way, but in a concrete form that links detection of parasite damage with physical beauty.

Omni: You were a social anthropologist and many social scientists soundly rejected sociobiology. What led you to be an early advocate of this theory?

DeVore: That's a planted question if I ever heard one! As you know very well, it was you who sat at my kitchen table night after night and patiently explained the intellectual revolution being brought about by William D. Hamilton, G. C. Williams, and John Maynard-Smith. Within a few years, your own contributions were to transform the field. These new theories ran contrary to almost everything I'd learned, and my first reaction was to utterly dismiss them. But after about six months, my previous view of the world crashed, and almost overnight I was converted.

Omni: Converted?

DeVore: Yes. This theory is so fundamental that you can't accept just little pieces of it, rejecting portions you don't like. It's all or nothing. Sociobiology was immediately attacked by the left as a gene-driven theory of biological reductionism. Since we saw it as the current culmination of the Darwinian synthesis, I found this quite ironic. Darwin's original work was attacked by the Establishment of England and America as being "radical," and now the logical synthesis of Darwin and modern genetics was being attacked as "conservative."

The critics of sociobiology succumbed to a form of fallacious reasoning that grows out of the fear that whatever is biological must be "natural and good"—hence, a scientific justification for all of the evil in the world. This is nonsense. Diphtheria and typhoid are "natural," vaccines against diseases are "cultural." Ninety-nine percent of all species in the fossil record have either gone extinct or evolved into forms so different they cannot be referred to their ancestors. Natural selection is a terrible and selfish machine, but to pretend it does not exist, to sweep it under the intellectual rug, is to remain willfully ignorant of the facts.

I came to realize that "social scientists" had been suborned by their informants. While a few—especially economists—recognized selfish motives in human nature, most anthropologists, sociologists, and psychologists accepted the received cultural values that exhort individuals toward altruistic behavior as the behavioral norm—as truth. I now see individuals exhorting each other to behave altruistically while privately behaving selfishly. Certain politicians and televangelists come immediately to mind. On the other hand, many of the most enduring cultural and religious values are precisely those that exhort humans to rise above their self-centered "nature" and embrace altruistic values.

Omni: I know this led to contradictions in your social and intellectual life.

DeVore: It certainly did. But after nearly a decade working through what I initially saw as contradictions, I came to

see that most social science was based on "group-selection thinking"—that because humans are a social species, individuals must suborn their selfish motivations for the good of the group. This logic is both compelling and humane. "If we do not hang together, we shall surely hang separately." Unfortunately, every attempt to model group benefit, as opposed to individual benefit, has failed. Since we are the first species sentient enough to recognize the inexorable and awful implications of natural selection, we are the first to have opportunities to ameliorate the process. But as I look about me, I see the vast majority of humans following the ancient, selfish, and ultimately destructive dictates of natural selection.

Omni: Why did social theory refuse to acknowledge biology for so long?

DeVore: The relationship between biology and social theory has a sad history. For more than a century, biologists have put forth deterministic theories about human social behavior. Almost all had a hidden agenda—some variation on the "master race." So social scientists have quite rightly rejected such theories forcefully. On the other hand, the major social theorists turned to biology for the underpinnings of their theories. Marx even wrote to Darwin asking if he could dedicate *Das Kapital* to him. While biology has moved forward rapidly, attempts by social theorists to harden and biologize their theories have served them ill in every instance. Small wonder that many colleagues, thrice burned, feel they must slay the dragon on sociobiology.

Critics from social science and philosophy must now argue that humans are not part of the natural world. Anthropologists have argued that natural selection and other biological processes brought hominids to the threshold of modern humanity, but then culture took over entirely. Such an argument is fatally flawed. Those characteristics that have become incorporated into the human genome were incorporated because they increased inclusive fitness and so were adaptively patterned. To assert anything else is to maintain that somehow a large number of innate characteristics, ones that did not correlate with fitness, displaced those that were more fit. Advocates of this position must explain how evolutionary processes systematically produced maladaptive traits!

Omni: Are you still being attacked by feminists?

DeVore: Oh yes, but not much anymore. At first, our investigations were largely devoted to analyzing strategies of male reproduction—male behavior tends to be far more flamboyant and male reproductive success tends to vary more than females'. Yet my female graduate students knew in their guts this could not be the whole story. They began to educate themselves and me. Together we worked through the reality of male-female relations in animal and human societies. Perhaps I'm proudest of the fact that these bright young women, confronted with fundamental theory in biology, are able to reconcile social and feminist concerns with it.

Omni: Can you give me an example?

DeVore: Male domination of women—as measured by the grievous statistics on murder, rape, spousal assault, and infant killing, and myriad lesser costs—is unquestionably a major problem in human society. What has been in doubt is how recent a phenomenon this might be. Barbara Smuts' review suggests it is not recent at all. A general pattern of male coercion of female sexuality exists in many primates. Male aggression toward females commonly rises as the females become more sexually attractive, because dominant males seek to prevent female sexual congress with other males, some of whom may be preferred by the female. Forced copulations, infanticide, aggression toward and murder of females occur throughout primates but with very different frequencies in different species.

> "As I look about me, I see the vast majority of humans following the ancient, selfish, and ultimately destructive dictates of natural selection."

Female vulnerability may depend strongly on the existence or nonexistence of female kin and/or friends who can provide support. Gorilla females, for example, live in one-male units without adult female relatives to help them. The male is twice their size. They are very vulnerable. If there's no support available, the female may need to seek protection from a single male in exchange for more or less exclusive sexual rights. This logic, Smuts suggests, is at work in our species. In many societies marriage protects a woman from rape by outside males while legalizing it by the husband. This new work may force even you biologists to enlarge your understanding of sexual selection.

Omni: How is that, Irv?

DeVore: You see sexual selection as consisting usually only of male-male competition and female choice. But Smuts' work calls attention to male coercion of female sexuality as an evolutionary force. Male coercion limits female choice, but it may also force costs on females, causing them to pursue a less profitable life than without the coercion. Male sexual coercion uses the cost or threat of cost to manipulate the female. If 10 to 30 percent of the offspring in each generation are lost to male reproductive coercion, we're dealing with a major evolutionary force.

A common theme is turning up all over the animal world. Females may be forced to buy into a degree of domination and abuse by one male to protect herself from worse abuse by others. This may be the fly-in-the-ointment of sexual selection. In the Eighties, many of us came to imagine a world where female choice often ruled for female benefit. Male-male competition would evolve under female control, as I used to say, like a giant tournament designed to reveal to choosing females the fittest genes for future progeny.

Male coercion takes the system downhill, subverts female choice to choosing the lesser of two evils, limiting female choice to become an offshoot of male coercion. The only challenge to female choice as an overriding force for female gain is that male coercion may force the female into a relatively narrow choice—which male can best help prevent molestation by others.

Omni: What is most cogent about field studies of monkeys and apes?

DeVore: We've only begun to throw off the straitjacket of theories that tended to "decorticate" our subjects. We have a fundamentally similar brain to the primates and perceive our world the way they do. Today, we realize social groups of primates are rich tapestries of individual strategies, coalition formations, friendships, and social memories.

Omni: Social memories?

DeVore: In highly specialized species like baboons and chimpanzees, individuals have strong expectations that a favor done for a fellow group member will be returned in the future. If this returned favor is not forthcoming, we see a reaction ranging from a subtle distancing of the relationship to an explosion of righteous indignation. Because we are so like them, we probably can interpret the chimpanzee expectation of "fair play" with considerable accuracy. Many of us now feel similar behaviors

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ANTIMATTER

UFO UPDATE:

Are the monuments of Stonehenge and the patterns in Britain's cereal crops part of the same orgy of circular construction?

Beginning some 5,000 years ago, England's Stone and Bronze Age inhabitants indulged in an orgy of circular construction, erecting more than 900 stone rings and another 30,000 to 40,000 earthen round barrows. Many of the rock rings, of which Stonehenge is but the best known example, served as solar and lunar calendars, while the barrows were typically used as burial sites. But why the fixation on circular forms? And even more puzzling, why were some of these forms built slightly off-center in an elliptical egg shape when a true circle would have been much simpler to create?

The latest explanation, proposed by meteorologist Terence Meaden, seems controversial, to say the least. "I suggest some were built squarely atop sites where crop circles were seen to form," says Meaden, author of *The Goddess of the Stones* and a leading cerealogist, the name for students of the mysterious circular patterns appearing in British fields. In the last decade alone, more than 2,000 of these mysterious circles have cropped up worldwide, with the overwhelming majority appearing in the area south and west of London.

All of the more complex formations, known as pictograms, are undoubtedly the product of human hoaxing, claims Meaden. Others, he theorizes, are caused by tiny, electrically charged whirlwinds. According to Meaden, such vortexes can glow visibly at night and could conceivably be responsible for many UFO reports and related phenomena. If Meaden is correct, these vortexes might have resulted in UFO sightings and led to extraordinary monuments like Stonehenge in ancient times as well.

For one thing, Meaden argues, the predominant religion of the Stonehenge era was a matriarchal, goddess-based one in which notions of fertility reigned supreme. A circle forming in a fertile cereal crop would thus have been viewed as a sign from above by both priests and peasants alike. Priests, says Meaden, would have seen the crop circle as a "sacred space," with the spiral center representing the vagina of Mother Earth and the flattened surrounding area representing her womb. Burial or any other ritual conducted in the center of such a circle would have been symbolic of seasonal fertility and a form of religious rebirth.

And what of the slightly off-center stone and earth rings? As it turns out, Meaden says, most authentic crop circles are similarly skewed, as one might expect of a random natural phenomenon. The ancient architects weren't being cryptic, in other words, they were simply replicating patterns found in nature.

Meaden's theory that crop circles could have supplied the template for Stonehenge and similar structures has met with skepticism from some archaeologists and cerealogists. "It's nothing but a wild guess," says John Michell, himself a student of British antiquities and editor of the triannual journal, *The Cerealogist*.

Aubrey Burl, England's foremost authority on stone circles, concedes the idea is "superficially interesting," but he doubts it will ever hold water. "For starters," he notes, "cultivated crops were on hand for a thousand years before the earliest known stone rings. Where were crop circles and their emulators during all that time?" Moreover, the majority of the elliptical rings appear to have their long axes astronomically aligned. "I think we can attribute that coincidence to the alignment of stars and deliberate human activity rather than to any attempt to mimic the patterns of whirlwinds," says Burl.

Meaden, whose new book, *The Stonehenge Solution*, concentrates chiefly on the construction of Stonehenge, didn't create the situation but maintains that he "only tried to explain it." In fact, says Meaden, "an absence of stone circles in the first millennium only means that no one thought of making rings of stone then. Instead, it was a period of the earliest timber circles, which unfortunately did not survive."

—DENNIS STACY

ANTIMATTER

UFO ARCHIVES

The formal study of UFOs is almost half a century old. Over the years, many researchers have retired and died, and their papers and sighting files, have fallen by the wayside. But now, all that is about to change. Mark Rodeghier, director of the Center for UFO Studies (CUFOS) in Chicago, has begun a campaign to acquire old materials for an archives.

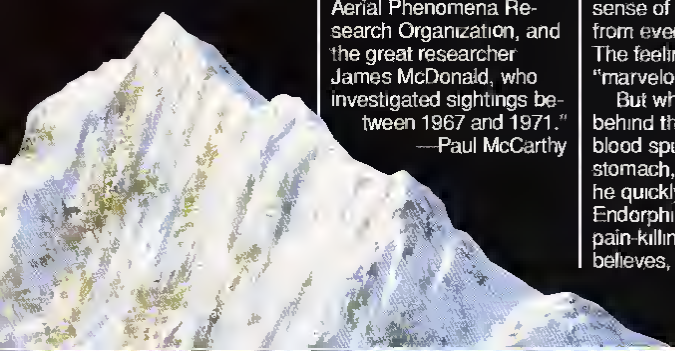
Thanks to these efforts, CUFOS has managed to acquire case materials from pioneer UFOlogists such as J. Allen Hynek, the father of UFOlogy, and Isabel Davis of the National Investigations Committee for Aerial Phenomena (NICAP). Beyond that, Rodeghier reports, he has acquired a microfilm copy of the Air Force Project Blue Book files and a computerized database called UFOCAT, which contains thousands of UFO sightings on disk.

Rodeghier points out that original UFO papers can be found in other specialized libraries as well. One, the American Philosophical Society Library in Philadelphia, contains the files of the late physicist Edward Condon, whose studies convinced the world that alien craft dubbed UFOs weren't real.

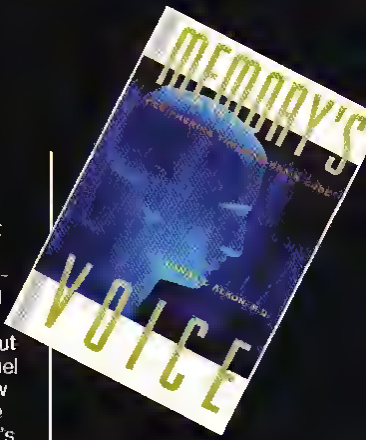
As Rodeghier builds his own archives, meanwhile, he has a wish list of documents he hopes to acquire. "Included in the treasure trove of data still out there," he asserts, "are documents from the early UFO group, Aerial Phenomena Research Organization, and the great researcher James McDonald, who investigated sightings between 1967 and 1971."

—Paul McCarthy

THE FILES OF DECEASED UFOLOGISTS ARE LANGUISHING IN BASEMENTS AND STORAGE LOCKERS ALL OVER THE COUNTRY; NOW A NEW UFO ARCHIVES MAY PROVIDE THEM WITH A HOME



NEAR DEATH EXPLAINED



"In the darkness, I felt totally awake as time stopped and the memories of my life rushed before my eyes . . . A strange giddiness suffused my being," Daniel Alkon writes in his new book, *Memory's Voice* (HarperCollins). Alkon's tale is typical of the accounts of 8 million Americans who claim to have had near death experiences. However, as a physician, neuroscientist, and memory specialist heading laboratories at both the National Institutes of Health and the Marine Biological Laboratory in Woods Hole, Massachusetts, Alkon is in a unique position to analyze these close encounters with death.

While vacationing in Florida more than a dozen years ago, Alkon suffered a gastric hemorrhage. As he faded into unconsciousness, he was overpowered by a sense of relief and release from everyday concerns. The feeling, he says, was "marvelously pleasant."

But what was really behind the episode? As blood spurted into his stomach, Alkon surmises, he quickly entered shock. Endorphins and other pain-killing chemicals, he believes, contributed to his sense of euphoria. He saw a "kind of light against a blue background," perhaps owing to anoxia—lack of oxygen to the brain. Oxygen deprivation, Alkon speculates, might have triggered the firing of visual neurons, creating an image not unlike that produced by pressing against the eyes. By collapsing to the floor and abandoning all struggle, Alkon then increased the flow of blood and oxygen to his brain and boosted his chances for survival.

The neuroscientist even suggests an explanation for the flood of memories that raced through his mind. "It's as if you are reviewing all of what you are about to lose."

Alkon says he has drawn one particularly valuable lesson from his journey to the precipice of death. "It's helpful to know that there are times to abandon all effort," Alkon says, "times to let go. And you don't have to be dying."—Steve Nadis

ABDUCTION SURVEY

In the so-called abduction phenomenon, people claim they have been whisked off to alien starships for intrusive medical exams. But individuals fitting the description of abductees are rare, right? Not so, according to a recent Roper Poll of 6,000 Americans. According to the poll, an astounding 2 percent of the adult population, or some 3.7 million people, may be abductees, even if they don't quite know it themselves.

The questionnaire was nothing more than a marketing survey augmented with indirect questions thought to be indicative of the abduction

SECRET LIFE:
ARE MILLIONS OF ADULT AMERICANS HIDDEN ABDUCTEES?

experience. The telltale questions, supplied by abduction researchers, asked respondents whether they had ever awakened paralyzed, flown through the air, experienced a time loss of an hour or more, seen unusual balls of light in a room, or found puzzling scars on their bodies. According to UFO buff Bob Bigelow, the Las Vegas real estate developer who anted up $100,000 for the survey, some 2 percent of respondents answered yes to four out of the five questions, just like those who actually *claim* to be abductees.

But the numbers don't impress University of Oregon psychologist Ray Hyman, who says the study was poorly controlled. There are all sorts of commonplace reasons for the positive answers, Hyman says.

—Paul McCarthy

HOTLINE TO HEAVEN

During the 1992 presidential campaign, a group of "angelologists" worked quietly behind the scenes. "We weren't trying to influence the election," explains artist Karyn Martin-Kuri. "We just wanted to make sure that the new president had a rapport with Uriel, the archangel of our nation," elevated to that lofty post in 1988. Martin-Kuri says she and her associates at Tapestry—a Falmouth, Massachusetts, firm devoted to the study of angels—have also worked hard to promote freedom in the former Soviet Union, and world peace.

To spread the word, Tapestry hosted the first American Conference on Angels in May of 1992. For the 82 attendees, the

primary goal was strengthening connections with guardian angels through "creative offerings" to the higher world. An even bigger, Second American Conference on Angels, will be held in Boston this June. "It will focus on the specific tasks angels want us to do," Martin-Kuri says. A grocer may act nicer to his customers. A politician may try to unite spiritual concepts with pragmatic goals."

According to Martin-Kuri, Tapestry's focus is not on "trendy upstarts like aliens," which have recently invaded the angel turf. Rather, Tapestry deals with the good, old-fashioned angels described in the Old Testament and other "good books."

For more information of the heavenly kind, you can call Tapestry's hotline at 1-800-28-ANGEL. For interested callers, Martin-Kuri will even consult, at a cost of $100 per hour, over the phone. One client, who had a history of exploiting other people, for instance, was encouraged by his guardian angel to give up that way of life. The man now works for the homeless, Martin-Kuri claims. Another client—a woman living what Martin-Kuri calls "a cloistered existence" in a trailer home—was urged to become more sociable. A few years later, says Martin-Kuri, she was given a large Victorian home and used it to entertain and help people interact on "a higher spiritual plane."—Steve Nadis

CONTINUED FROM PAGE 74

exist in other primates such as baboons less like us in gestures and other methods of expressing behavior

Omni: Can behaviors in the living great apes be used to help understand human evolution?

DeVore: Recently we've discovered behavior in chimpanzees no responsible scientist would have imputed to our hominid ancestors even a decade ago. Jane Goodall's study sites at Gombe and Toshisada Nishida's site in the mountains of Tanzania indicate that chimps use tools and that males will occasionally surround and kill young animals. At Gombe, it was not clear whether males were actually hunting or simply aggregated in an area and fortuitously captured a small animal. In the Tai Forest of the Ivory Coast, as reported by Christophe and Hedwige Boesch, it's clear the hunt is highly organized. Female chimps in the Tai Forest are expert tool makers, using a variety of hardwoods to crack different kinds of nuts. They systematically cache rare stones, fetching them when a hard-nut tree is in fruit.

Omni: There's a division of labor between males and females?

DeVore: Yes, and this until recently has been considered a hallmark of the human economic system. One of my favorite anecdotes from this study concerns two males seen gathering large quantities of hard nuts. They brought them to an old female who was sitting at the foot of a tree with cracking stones. The males dumped the nuts into her lap and waited patiently while she cracked the nuts for all three of them.

The so-called pygmy chimp or bonobo lives in such a remote region in Zaire that studying them in the wild has proven frustrating. Frans de Waal and his colleagues at Emory report that male bonobos in captivity regularly exchange food for sexual intercourse with females. Bonobos may be the sexiest of all primates. Bonobo females mate through the menstrual cycle, during pregnancy, and lactation. Female bonobos frequently bond with each other by what observers call "G/G rubbing," bringing their genital areas to bear and rubbing vigorously with obvious mutual pleasure.

Female bonobos also seem to prefer copulation in the ventral/ventral position, whereas males apparently do not. The clitoris in the female bonobo is positioned much more toward the front than in the common chimpanzee. One afternoon at the captive colony at Emory I watched a male repeatedly solicit a female. She came forward eagerly to embrace him in the face-to-face position, which he refused, trying to turn her around for dorsal/ventral intercourse. Finally, she accepted intercourse "doggy style" but immediately afterward insisted on a second copulation in the face-to-face position. This struck me as a chimpanzee version of the film *Quest for Fire*, which in any case should have been called *Quest for the Missionary Position*.

Omni: These chimpanzee behaviors suggest a social organization and adaptation we assume our ancestors led. But the most distinctive human characteristic is missing: language.

DeVore: Language has led to a human adaptation in which we view our closest relatives, the chimps, across a narrow but deep chasm. Nonetheless, I see no reason to suppose anything like modern language preceded by any appreciable period of time the appearance of *Homo sapiens*. Although many colleagues would disagree with me, I consider it an open question whether Neanderthals had what we'd call a "modern language."

> "The bonobos' copulations struck me as a chimpanzee version of *Quest for Fire*, which in any case should've been called *Quest for the Missionary Position.*"

Omni: Are you suggesting a protolanguage, or prelanguage period?

DeVore: Unfortunately, every language today is equally modern in that it follows the same basic linguistic principles. One can imagine from studies of language acquisition in children a stage with stripped-down and simplified linguistic ability—a few nouns, a few "operator" words as action words—would have benefited the rapid evolution of traits in the human line without coming close to a modern language.

Omni: What about the great apes that have been taught to "speak"?

DeVore: Like everyone, I've been intrigued by the various labs that have taught American sign language to chimps and gorillas. I've always had serious doubts about the enterprise, because the greatly enlarged areas of the human brain that facilitate information processing and the subtle use of the vocal apparatus are simply not large in chimpanzees. It's remarkable that chimps have progressed as far as they have toward linguistic communication, and most of the earlier studies are now viewed with considerable skepticism. We are just beginning to appreciate the complexity and subtlety of the chimpanzee mind and behavior and that it's an anthropocentric pretense to insist that they meet a human measure, to communicate in a modern language.

Omni: Why have you become involved in dolphin studies?

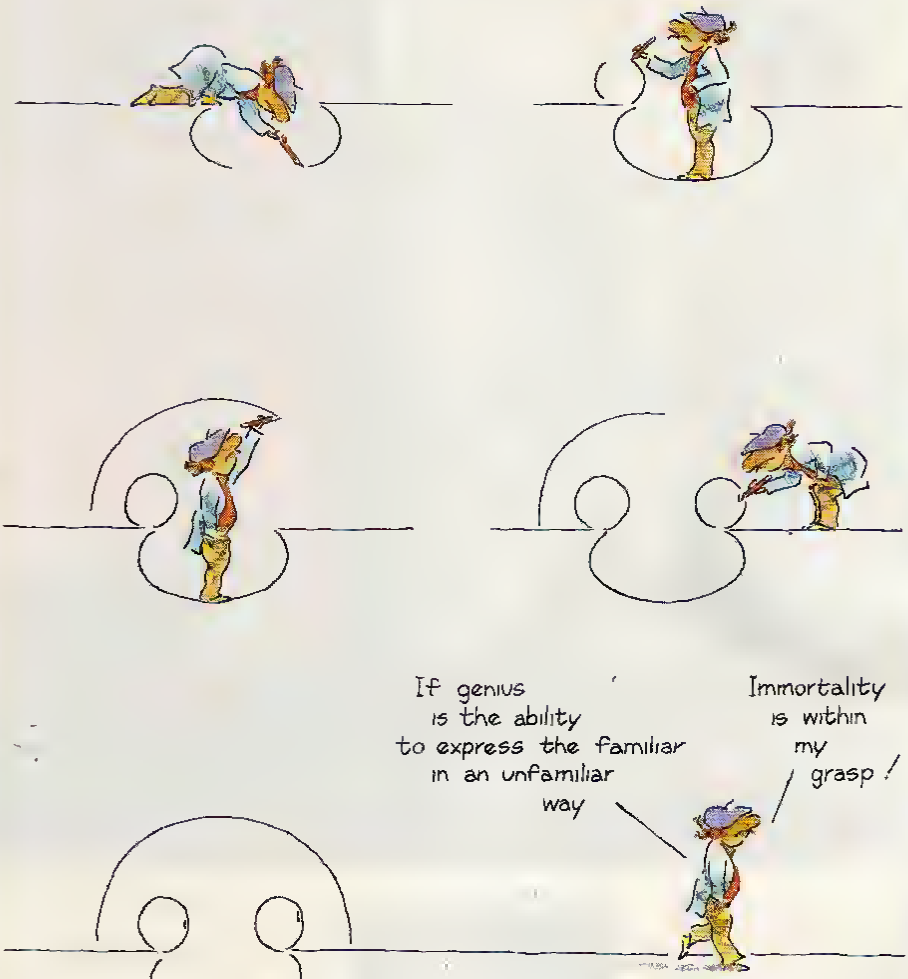
DeVore: There's a strong temptation to test the principles of behavioral ecology on a species that's been separated from land vertebrates by 50 million years. The opportunity came when a group of dolphins at Monkey Mia, Shark Bay, Western Australia, sought human contact over a number of years. Nine or ten come in daily to interact with humans in ankle-deep water.

Dolphin and whales studies have suffered because one normally only has a few weeks a year to observe their behavior, then they're off at sea. This dolphin population remains throughout their lives at Monkey Mia. We observe them day after day as if watching a troop of baboons. We've identified more than 200 individuals. Dolphins appear to have a social organization remarkably like chimpanzees'. Coalitions of males patrol areas within which females and young have individual foraging zones. There's a dominance hierarchy within each male subgroup. Two gangs will merge for an hour or so, but when they divide again, the membership will not have changed. Watching them from a boat, I felt I was seeing a marine version of *West Side Story*.

Omni: You've invested heavily in your students rather than do fundamental research yourself. Any regrets?

DeVore: Early on I realized there were at least a hundred questions about the nature of behavior I'd like to investigate and that with the best will in the world I might make it through four or five. So I made a strategic decision to guide graduate students toward questions I felt important. This was painful, because my happiest days were watching baboons go into their trees at dusk and sitting around the campfire with bushmen or Efe Pygmies. Although I had numerous regrets in my thirties and forties, looking back as I approach my sixties, I feel I made the right decision. My best efforts were spent for others to carry out fieldwork in areas I could never achieve in one lifetime. ∞

The Artist



GRAND

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it dominates her."

"And she is hated, is she not?"

"Havers' constructors spend half their time back-stabbing each other, but there's no real power to be had till she goes. But that's not what you meant is it?"

A smile played about her lips. "Touche."

There's a lot of bad blood between the *Programme Pour Femmes Fermées* and Maureen Havers. When she was young and cared nothing about cars, Maureen revived *Psyche et Po*, Antoinette Fouque's 1972 outfit which dominated the French women's liberation movement into the eighties—all red jumpsuits and internecine foulness and right-wing religious overtones.

The Programme grew up at the same time Maureen was wiring *Psyche et Po*'s corpse to the lightning conductor. Ensuing battles levelled the tactical gulf between the two movements till the main differences were intellectual ones. *Psyche et Po* read Lacan; the Programme read Levi-Strauss. *Psyche et Po* were crypto-Capitalist; the Programme were Structuralist. *Psyche et Po* played the system; the Programme deconstructed it.

The Programme won, but it was a Pyhrric victory. Without intending it, they became not unlike *Psyche et Po*, an elite with no popular support.

Catharine drained her wine glass. "Ms. Havers is not our prime concern. I don't suppose she will like what we have in mind but—" She shrugged. "What do you know of the language of dance?" The link between *Danseuses Nouvelles* and the Programme wasn't known then. I was thrown. I muttered something vague about semiotics and looked like an idiot. She told me about *Danseuses*. It was an honor. Some weeks passed before *La Monde* got the tipoff.

"Are they the revolution?" I asked.

"A small part."

I toyed with my food. "Top ratings eight weeks running. *Small?*"

She was silent for some while, staring at me. I'd touched something important. "Since when did the man without a television read TV small print?"

I had to smile. "I don't," I assured her. "My manager does. *Danseuses* pushed my profile out of prime time last week. PTV wouldn't negotiate."

Catharine nodded. '*Danseuses*' dancer/choreographer is Helene Ritenour. In '41 she had an accident with a heavy goods vehicle. Surgeons in São Paulo rebuilt her. Nanotech CNS upgrades saved her from spending the rest of her life in a wheelchair."

I nodded. "And some." Helene is a good dancer. Still, I thought about it. '41. In '42 Helene and *Danseuses* went on TV. Quick work. "Programme' money?" I asked. I knew rushing the São Paulo technique cost a great deal.

"We look after our own," Catharine replied. "So does Havers. Doesn't she?"

The jack behind my arse itched.

We catch a train to Nice. It's out of recession now. It even boasts a sand beach (imported) and a few working public telephones—which is more than could be said of it before.

We eat at *Le Safari*. Angèle is pissed off and she won't tell me why. I'd show her the town, God knows I have sufficient plastic in my wallet, but hers is righteous anger, not to be bought off.

We haven't been together long. Catharine gave her to me—a contact and Woman Friday—not two months back. I find it hard to predict her moods. Maybe it was Catharine's idea she sleeps with me, maybe she's got tired of playing the whore. It's not a thought I want to go to bed with so I try to get her talking.

Like an idiot I mention the Programme. She screws up her face like she's swallowed something fatty. "I've no time for that," she snaps. "It's just play to them. Can't you just see them wanking off to the press reports after one of their sadistic little outings?"

"They're pointing up the language of repression," I say, all the while wondering at my own arrogance. Angele doesn't know these kinds of words. She's an Arab street kid who was kicked once too often to stay lying down, not a semiotics graduate. "They're targeting metagrammatic nodes in the cultural matrix—"

Her look is enough to shut me up. "Don't talk to me about language!" She's the first woman I've met growls when she's angry. What do I care that *this* word and *this* color and *this* dress mark the boundaries of chauvinism? What comfort is that to the mother with a husband who beats her? Or the rape victim or the dyke or the pensioner? Go tell your good news to every lacerated clit in Africa then look me in the eye and say *this* is worth the money!'

She slams her hand down on the table, lifts it, and there's a tiny gold wafer winking at me like the promise of El Dorado from the marble tabletop.

I pick it up and weigh it gingerly in my hand. It's a ROM wafer—a packet of hardwired information. It slips into the port between my shoulders—the same

kind of port they fitted to Helene Ritenour.

It's strange how Angèle can read me so well, even in anger. She leans over and strokes my hand with dark fingers. "Do you want to talk about it?"

I don't, but it's the only way I can thank her for tacitly forgiving me.

"It was bad," I say. "I slid off the track sideways—the near side of the monocoque took the impact. The whole thing failed in tension at the rear bulkhead. The engine and avionics went one way, the rear wheels the other. The heat exchanger was torn off. The steering column broke. All the underbelly ceramics sheared—"

"I didn't mean the car."

"So—" Something misfires inside me and the old anger is back. "Papers have back issues."

She starts back like I'd slapped her. "That wasn't fair. I'm not a ghoul. I didn't mean the accident, anyway. I meant the treatment. How you got better. What it did to you." She rubs her face with her hands. "I want to know you. What am I to you? A friend or a whore?" Maybe this playboy bullshit is rubbing off on me because I really don't know. Sorry is the best answer I can come up with. We sleep in the same bed but we don't touch.

I want to tell her what she wants to know. I want to tell her about São Paulo, and what they did to me. And why. I want to tell her it hurt like hell.

She is asleep.

The Grand Prix is six days away.

Maureen Havers honestly believed she was doing me a favor. No one spends eight figures sterling on one man without *some* feeling behind it. She could have left me in a wheelchair. It wasn't her fault I was in that state, after all—I was the one who crashed. Instead, she saved me. After a fashion.

I remember how proud she was when Dr. Jacobs demonstrated the lumbar jack. I swear she made eyes at it. As far as she was concerned then, I was just the meat it plugged into.

Did I resent that? Not at the time. I was still in shock from the accident. I still couldn't quite get my head round the fact I could walk again—walk with a spine shot in five places.

Imagine you're lying there with a hospital bed your only future. Then they plug ROM cartridges into your back. On them are programs which teach your brain how to access and control a whole new nervous system. You can walk again, even shit when you want to. It's a miracle—and it takes a while to adjust. Then, but too late for it to make a difference, it occurs to you—all that expensive tech, just to get you toilet trained again? Of course not.

At least when the Programme paid for Helene they let her be her own boss—or so the popular science programs tell us. She uses an expert system, writing her prize-winning solo choreography direct to a ROM cartridge.

Me? I get fresh ROMs sent me every month from Achebi, where they analyse my race data. It helps me drive better. Only they went one stage further.

They built me a second jack, behind my arse. When I strap myself in, I hotwire myself to the car. I don't drive it. I *become* it.

This has its consequences. My body is a corporate concern. It has no solid boundaries. In short, it is a whore.

One of Formula Zero's damn few rules states: one car, one driver. Havers got round that—they saved my spine and in return have turned me into a databus, a way of loading the aggregate wisdom of Achebi's Research Institute into a racing car, a smart messenger with a spine full of—what? Software? Limpware? Wetware? Why not a new term altogether? *Slime*.

The Casino is fashioned in flamboyant

style with towers at the corners and sitting on the roof, great bronze angels, picked out by floodlighting which extends into the Boulengrins. Angèle and I walk among the cacti. She is scared. Maybe it's the race. More likely it's being undercover, working for terrorists. I wonder how much they're paying her—she has no respect or liking for them. Her politics are much more homely. Maybe they've agreed to fund some rape-crisis centers.

"Do you think that wafer will kill you?"

"Maybe." Is this her job—to frighten me? Test my nerve? She may be right. To have the world's best speed driver die twirling in flames through the bijou houses of Monte Carlo—

No. Accidents themselves have their own phallic semiology. No sport on Earth so quickly forgets its widows. Grand Prix's finest take Death as their bride. Whisper their names in awe. *Depailler, Villeneuve, Willy Mairesse.*

I do not think the Programme will kill me. Perhaps I lack the cruelty to credit such deception. Perhaps, if I were a woman, I could be that cruel. Perhaps (I look at Angèle, the stoop of her shoulders, her tired eyes, the way she twitches her fingers through her hair)—perhaps I would have to be, to survive.

We return to the Hotel de Paris. We have a suite overlooking the Casino. Tomorrow Angèle will sit on our balcony, she will see the cars as they stream in to the square and snake down the hill.

Perhaps she will think of me.

We watch *Danseuses Nouvelles*. There are only five dancers in the company, including Helene. I count while I watch—if I didn't know better, I would say there were twenty-three. This is the heart of *Danseuses'* enduring novelty. The way they dance alters their appearance. They toy with the semiology of movement, with their audience's stereotypic racial and social expectations. They move in a way we expect certain kinds of people to move, and they become those people. The eye is tricked by the conditioned expectations of the brain. The Government are outraged by the Programme's violent acts. But I suspect they fear this quiet revolution far more. They can handle terrorism.

But seduction?

The credits spool and I undress. I sit cross-legged on the bed. Angèle pushes the wafer into my back.

It does not take long for the headache to clear. Two green circles appear, one above the other, center-vision. In an eyeblink they are gone. They are the first and last I will see of the Programme's system. It will perform its acts regardless. I will have no opportunity to intervene.

'It's all right now,' I say.

Angele turns on the light. She looks at me and she is afraid.

Inside me, something flexes.

Formula Zero is a race for cars, not drivers. It is a vicious testing bed for crackpot ideas, the way Formula One used to be till the nineteen-seventies and the iron rule of Jean Marie Balestre.

Formula One's rule book ceased to reflect technical progress around that time. Formula Zero was conceived in the nineties as a way round the rule book and into the twenty-first century. Anyway, crashes are good for business.

My eyes are full of lignocaine. Underlids count off the seconds. I tense my arse and spool the revcounter into the red, just out of my line of focus. I pop the clench plate into my mouth and bite down. The throttle glows green. I blink. The visor snaps down. It's made of Kevlar. A projector micropored to my head beams eight external views onto the inner surface of the visor then settles for center-forward.

Eight seconds.

At minus seven point two seconds the car handshakes the processor behind my lumbar jack. Point nought nought one seconds into the race the handshake is complete and all this touch-and-blink gear takes second fiddle to Achebi's direct-feed wizardry.

Four seconds.

Engine status icons mesh and flow behind my eyes.

Zero.

I'm in a different place. A green hillside. The track is a smooth black nothing under my wheels, swirling round the hill. I follow it with cybernetic eyes. Gentry in the Ferrari is a blue proximity-danger icon on my left near-side. He cuts me up on the first corner. I'll use him as a pacemaker. I'm so far ahead of the league table I'd be happy to let him win. But if I don't pass the post first, then Catharine's meme-bomb sits in me, waiting for the next victory. It only triggers if I'm race champion. A kind of sick fascination is driving me. That and a hope that the Programme's attack on the machismo-oriented Grand Prix might dovetail with my own wish for vengeance on Maureen Havers.

My tires are the sort that go soft and adhesive in the heat of acceleration. I have five laps advantage over the opposition, five laps glued to the road, before they lose their tack and I slip into something more hard-wearing.

There's the sea—a grey graphic nothing. My eyes spool white prediction curves and hazard warnings. I take Gentry on the skid in a maneuver that shortens my tire life by a lap. I *feel* the dif-

ference the loss of traction. I'm picking up sensory information from every stressed member of the vehicle directly, through my spine. I *am* the car—and the car is feeling queasy. At the pit robots tend me, probing and swopping and inflating the things that make up this surrogate body of mine. My wheels feel tight and warm, hugged near to buckling by fresh, high-pressure tires. I scream away from the pit. The Longines people send me a stop time and ETF. They're counting me down for the World Record—a special etherlink tells me how I'm doing. The real danger now is the back-markers don't have the decency to pull in for me. They do not like me, because Havers and Achebi have made me far too good. With me around, no one else can hope to get near the championship.

By next season, I reckon FISA will rule against my kind of driving for the good of the sport. Then I'm back to the clench-plate and dataskin and honest dangerous driving. And in another twenty years Formula Zero will have accreted its own four-inch-thick Yellow Book and the whole process will start over again. A new breed of *Formula Libre*. From São Paulo, maybe.

My shoulder blades itch. There's something strange in my nervous system. I wonder what it does.

Something dreadful happens.

I'm tearing towards the tunnel (look no hands) when there's the most appalling jolt. The gearbox tears its guts out and my ribs try straining themselves through the crash-webbing. I round the bend along the harbor road and my neck isn't up to the G-strain.

I slide into the pit and nausea overtakes me. The car realizes I'm going to throw up. The helmet snaps open and the clench plate grows hot to make me spit it out. I throw up over the side of the car. A valet trolley wheels over and scrubs off the mess, revealing a smeared ELF decal.

My whole body burns green fire.

Every nerve sings with power.

Achebi's unmistakeable Go signal. I scrabble under my seat for the clench plate. Its taste of sour saliva is nauseating and I wonder idly if I'm going to be sick again on the circuit. My helmet slams itself down and the graphics blink on. It only takes a moment to become a car again. But this time it's different. This time, I'm way down the field and will be lucky to be placed. This time—the first time this season—I will have to *race*.

I am compelled. What atrocity have they given me to perform? Will I karate the neck of the President of FOCA? Will I tear Maureen's eyes out—or my own—in front of a billion couch potatoes?

Some of Angèle's special anger flows through my veins and into the car.

It feels good and dangerous, like the Grand Prix I remember. The difference is, back then I *knew* when I was stretching the car to its limits. Now I can *feel* it. I'm an athlete with a steel body, a middle distance runner doubling speed on the last five laps.

My arrogance is rewarded.

The car starts falling apart.

It's not anything you can see. Even though they're wired up my back. I nearly miss the signs—ticks and prickles and a hot metal taste in the back of my throat. I'm an athlete, pushing my body and doing it damage and before long my knees are crumbling, my toes are burning away, my lungs are full of acid phlegm. I'm screaming cybernetic agony into my helmet as I come in sight of the prize pack. They are jockeying for position with all the cumbersome grace of whales. My scream becomes a roar. I think of the horror dozing fitfully in my spine, I think of the hurt behind Angèle's eyes, and every hurtful stupidity under the sun—and I hurl myself forward. Danger icons spill blood behind my lids.

Four and Three concede with grace and let me past. I run tandem with place 2—Ashid in the Bugatti. I know from old he's no gentleman. We hug wheel space through the square.

Data chitters through me. I take hold of the wheel. I want to be ready. If this goes wrong it might crash my systems. The wheel recognises my grip and unlocks, shaking me boisterously like an over-friendly scrum half.

I watch the odds window, turn the car in, Ashid jerks sideways and back and already I'm wheeling past him. Our back wheels kiss and make up, then I'm running for pole. Martineau leads and he is Havers' Number Two. If I can get within five lengths of him he'll slow down like a good boy and let me win.

All of a sudden I have a pacemaker to get me there.

I leave Gentry behind at number three. Why Gentry—why not Ashid? The Bugatti is still sound, my icons tell me—which is good because even a kiss can send an unlucky car tumbling—so maybe Ashid's nerve's gone, 'cause he's more than a match for this prick. I think Gentry must have popped a pill.

I let him come alongside. I know he rides with a clear visor so I let go the wheel and wave to piss him off.

Then I change gear.

Time for my 550 kph Sunday drive.

Longines send regrets. The record is safe. But my mind's on something

else. Martineau is tootling towards the line. I'd ride a dignified half-length ahead of him only Gentry's been driving like a madman behind me for the past two minutes and I'm too hyped to slow down.

And as I pass the line I realize I'm no different. I too am wedded to danger, which is a longer name for death. Achebi made me fast, yes, but they also made me *safe*. I don't hate Maureen Havers, or what she did to me. I hate Achebi for protecting me. I hate the doctors for repairing me. I hate *myself*. I'm like all the others. A life-hating thing—a phallus cocoon finding new ways to die. Why else did I let the Programme infect me? *What have I done to myself?*

Whisper their names. *Depailler. Villeneuve. Willy Mairesse.*

Me. My helmet snaps up on a view of a hundred thousand cheering would-be suicides. I smile and wave. The sun and the wind dry my tears.

I pull the jack out and adjust my flight pants and get out of the car.

Next stop the champagne.

Maureen Havers is up on the podium. She has a smile like death and I envy it. A nude girl hands me the champagne magnum. It's very hot here.

My hands are shaking. It gets dark. I look up at the sun, puzzled.

A blood-spot on my retina, receding fast.

I wake up in my hotel room. Catharine is sitting by the bed. I look round. Angele's not there. "Is it over?"

Catharine smiles. "It's over."

"Did I do—what did I do?"

"Rest first."

"No!" I sit up in bed and it feels like I just shoved my head in a mincer. I take a deep breath. "Show me now."

She lights up Angèle's PC.

Where is she? I watch the rerun. I see what a billion TV addicts have lived for all season.

Me. I don't believe it. There, on the podium, in front of them all—

I'm masturbating. Wanking myself through my overalls.

It's terrible. I don't know whether to laugh or throw myself out the window. When it's over my voice is high with hysteria. "How did you—how could you—I didn't—I—" I force myself to stop. Tears of rage heat my cheeks.

"You didn't. Do. Anything. Look again."

My eyes are drawn to the screen.

She is right. I don't *do* anything, but by the end of it I'm shaking afresh with disgust and self-loathing and fascinated revulsion. It's worse than the act itself could ever be. The power of suggestion.

"I can't believe I did that—*didn't* do—I'm babbling again. I turn to Catharine Angèle must have told her I like Irish She's pouring me a tumbler full.

"You didn't. Our wafer did. It took you through a very special dance. Helene's been working on it for months."

"A dance."

"Yes." She hands me the tumbler.

I drink it down in one. "A repulsive dance." When I calm down she sits beside me and says, "The Grand Prix. A phallocentric institution, wouldn't you say? But will men ever be able to draw that kind of strength from it, now its figurehead has lampooned it so ably—so *cleverly*?"

My eyes widen with shock. "Oh, you *bitch*." The truth clicks home. "I'll never race again."

She shrugs. She is prepared for my reaction. I feel vivisected.

"There are other ways fo drive," she says. "When Havers sacks you, as she surely must, we have other games for you to play. Networks. Security systems. Stock exchanges."

Through a veil of shock I sense the potential behind her words. I glimpse the power that is mine as a servant of the Programme, the riches my skills and my lumbar jack might yet yield—for me, and for the women of Brazil, Africa, the whole twisted world.

But. "How will I ever show my face again?"

"Which face?" She gets off the bed and walks over to unplug the IBCN lead and as she walks her legs grow stocky, her hair lengthens, her skin grows dark and when she turns to me her mouth is more full, her forehead less pronounced, her cheeks have swollen a little—and Angèle smiles. It is beautiful.

"Everything has its place in the matrix of signification," Angèle says, in a voice I do not recognise. "You claim no prejudice, no chauvinism—yet a gesture, a turn of the head, a way of lowering the eyelids, all of that plays on your stereotypic view of things. See how the white bitch becomes the dusky whore."

"Oh no," I murmur. "Not now. Not anymore." I slip off the bed and walk clumsily toward Angèle and hold her in humility and run my hand over her back. I feel for the first time the ROM port between her shoulder blades. Her disguise hid that, too, till now. What a clever dance Helene has written for her!

My heart jolts up into my mouth. "*Helene?*"

"Hello." Her tongue is hot on my cheek. She laughs, and the sound is a promise . . . peace . . . riches . . . *revolution* . . . ∞

AIDS

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ticed that AIDS shares a striking number of similarities with GVHD. AIDS patients and GVHD patients frequently exhibit skin lesions—scaly, psoriasislike skin. Both groups share frequent intestinal diseases, and even more strikingly a strong susceptibility to infection by different viruses, bacteria, and fungi. The trouble was, for almost a decade, researchers couldn't fit AIDS and GVHD into the same conceptual picture classifying AIDS as a viral disease and GVHD as a transplantation reaction. By the early 1990s, however, the similarities between AIDS and GVHD had too many obvious parallels, a reason which prompted Hoffmann to propose his theory that the shape of HIV is similar to MHC and therefore provokes the immune system into destroying itself. And the common link between AIDS and GVHD was MHC. But if Bolognesi and others in the vaccination field are correct, HIV may not be just mimicking MHC antigens as Hoffmann suggests. The virus may actually be grabbing the molecules from every cell it infects.

Strong confirmatory evidence for these predictions came in December 1992 from a group led by Larry Arthur of Program Resources, a subcontractor of the National Cancer Institute in Maryland. Arthur examined highly purified HIV preparations that had been grown in human cells and found huge amounts of MHC and other related proteins studded in the viral coat. Surprisingly, he found that MHC molecules actually outnumber the viral coat protein molecules on each virus by about two to one. In other words, the outside of HIV carries a mixture of its own proteins and MHC molecules from the cells it last infected. Since the immune system of the infected person is trying to distinguish the virus from its own cells, such a mixture on HIV would be incredibly confusing for the immune network.

Arthur's astonishing results mean the major immune response against injected HIV might be against cellular MHC and its cohorts rather than against HIV itself. It represents a beautiful vindication of Stott's original results—that something on the outside of normal cells can provoke the same kind of immune response as HIV, even when no virus is present—and of Bolognesi's findings.

The observation that you could induce the same response in the immune response regardless of whether you used HIV or just the cells in which it had grown seemed to be a major setback for the design of specific AIDS vaccines that are based on the use of killed viruses. After all, how could you try to induce a specific immune response against HIV if you could induce a response without the virus? Many people in the field were at a loss. Bolognesi, however, is intrigued by the possibility of designing a vaccine against HIV by first injecting a person with bits of normal cells with MHC or with proteins like it. He thinks that once a person's immune system is primed with a cocktail of MHC molecules, the person will be protected against HIV through immune responses directed against these targets that are carried by the infecting viruses and cells.

But transfusing somebody with foreign bits of cells is a bit risky, and the procedure is a long way from the original intention of designing a specific vaccine directed against HIV. "We are getting transfused all the time with foreign cells, and maybe the risks of transplantation reaction were not as great as we thought," Bolognesi says. And Hoffmann's discovery of how HIV can mimic important immune molecules such as MHC underlines how extraordinarily clever the virus is. This tiny packet of genetic information—about 500,000 times smaller than our own allocation of genetic information—is able to utterly turn the tables on our immune systems: by fooling it, by evading every attempt of the system to neutralize it, and finally, by turning the immune network back on itself in a self-destructive frenzy.

The late Albert Sabin won widespread acclaim and numerous honors for his work in designing the polio vaccine in the Forties and Fifties. In September 1992, he wrote a groundbreaking—and blunt—article in the prestigious scientific journal, the *Proceedings of the National Academy of Sciences*, in which he said that the approaches being presently used in the worldwide search for a vaccine against HIV were futile. Sabin, a microbiologist whose research spanned six decades, said that most of the AIDS vaccines currently being developed are aimed at neutralizing an injected HIV that lies outside of cells in the blood.

According to Sabin, injecting monkeys with HIV or its monkey equivalent, SIV, is artificial. In the real world of AIDS, most circulating copies of HIV are safely tucked away inside cells and, hence, are protected against any immune responses. Trying to develop a vaccine against a "cell-free" virus is doomed to failure, Sabin said. Hundreds of millions if not billions of dollars have been invested in a false premise, he contended, with the premise being

that the AIDS virus could be targeted as if it weren't hiding safely inside the infected person's cells. Because of this false premise, "the vaccine field is filled with distortions," he said. Bolognesi disagrees. "I don't think its doomsday as Sabin suggested, but Sabin raised some very important issues about the virus's sites of immunity."

In the article, Sabin contends that a major port of HIV's entry into the body is via the anus and rectum and that it's important to test whether a vaccine can eliminate the virus from the mucosal cells that line the wall of the rectum. Very few studies have focused on designing HIV vaccines for these cells. According to Sabin, a vaccine that's effective in the blood will be useless in the mucosal cells of the rectum where the protection is really needed. By the time the virus reaches the blood, it will be inside blood cells where it's safe from immune surveillance.

Bolognesi disagrees with Sabin's contention that the usual location of the virus inside cells automatically means that it would be hidden from the immune system. He and others point out that because the same cells from one person would be foreign to another person, the cells would be quickly destroyed by the recipient's immune system. These arguments notwithstanding, both of these eminent scientists agreed that the search for an AIDS vaccine has so far been fraught with unexpected complications and barriers.

The implications of Bolognesi's and Arthur's work, however, do hold promise for future vaccine design. For example, there's probably no sense in saying that the virus is something foreign that a person's immune system can be primed to kill. It appears unobtrusively in our bodies, adopts MHC proteins from the cells in which it grows, and becomes hidden inside our cells. It displays MHC molecules as if it were part of the immune system, but at the same time, it fools the immune network into killing itself. The poet William Butler Yeats posed the famous question, "How can we know the dancer from the dance?" Arthur's results pose a modern version, "How do we separate the virus from the cell?" This question is much more than an exercise in semantics. It lies at the heart of Bolognesi's and Arthur's proposals to explore new AIDS vaccines based not on viral but on cellular proteins.

Five years ago, people thought AIDS was a relatively simple disease. A virus gets into the body, it replicates in T cells, and so the story went, it kills them. Once the T cells are really low, then a person is exposed to all sorts of infections. In 1993, the novel ideas that HIV carries MHC molecules with it, that it mimics the immune system, that it fools the immune system, that AIDS might possibly be an autoimmune disease, have prompted the question, "What actually causes AIDS?" Are we nearly at the point at which some of the many enigmas are yielding to scrutiny?

Montagnier's tantalizing data take some of the limelight off HIV and introduce another actor on stage. Mycoplasma may be important, but many more experiments need to be done to demonstrate the fact. Hoffmann's experiments and hypotheses suggest that HIV mimics MHC and provokes a strong perturbation of the immune network, which results in the destruction of the immune system at its own hands. Indeed, MHC may be the long-sought after missing link between a tiny virus and the cruel disease we call AIDS. And this is a new twist to a story that's a decade old. Although nobody (with few exceptions) is saying that HIV isn't the cause of AIDS, from Hoffmann's, Arthur's, and Bolognesi's perspectives, AIDS could be viewed as the result of an immune system that, over time, is fooled into destroying itself. **OMNI**

"Well, here goes nothing."

OZONE

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posure to the sun and are relatively easily treated. The malignant melanoma form, which does kill, affects places like the soles of the feet as well as exposed areas, and there is more of it in Sweden than in Spain.

So, what's going on? What are publicly funded institutions that claim to be speaking science doing, waving readings known to be worthless (garbage in, gospel out?), faking data, pushing a cancer scare that contradicts fact, and force-feeding the public a line that basic physics says doesn't make sense? The only thing that comes through at all clearly is a determination to eliminate CFCs at any cost, whatever the facts, regardless of what scientists say.

Would it come as a complete surprise to learn that some very influential concerns stand to make a lot of money out of this? The patents on CFCs have recently run out, so anybody can now manufacture them without having to pay royalties. Sixty percent of the world CFC market is controlled by four companies who are already losing revenues and market share to rapidly growing chemicals industries in the Third World, notably Brazil, South Korea, and Taiwan. Some hold the patents on the only substitutes in sight, which will restore monopoly privileges once again if CFCs are outlawed. Mere coincidence?

Ultraviolet light has many beneficial effects as well as detrimental. For all anyone knows, the increase that's being talked about could result in more overall good than harm. But research proposals to explore that side of things are turned down, while doomsayers line up for grants running into hundreds of millions. The race is on between chemicals manufacturers to come up with a better CFC substitute while equipment suppliers will be busy for years. Politicians are posturing as champions of the world, and the media are having a ball.

As Bob Holzknecht, a Florida engineer in the CFC industry for 20 years observes, "Nobody's interested in reality. Everyone who knows anything stands to gain. The public will end up paying through the nose, as always, but the public is unorganized and uninformed."

Good science will be the victim, too, of course. But science has a way of winning in the end. Today's superstitions can spread a million times faster than anything dreamed of by the doom prophets in days of old. But the same technologies which make that possible can also prove equally effective in putting them speedily to rest. ∞

AIR REPAIR

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one of these regions with iron, the phytoplankton bloomed. So, to cure global warming, Martin suggested, just fertilize the ocean with iron and sit back while the plankton grow and absorb CO_2 from the air above.

In fact, Martin says this may have happened naturally some 18,000 years ago at the beginning of the last ice age when evidence points to far more dust and three times more phytoplankton than today. None of this proves that plankton were fertilized by the excess dust and caused planetwide cooling, but as circumstantial evidence, many scientists find it pretty convincing.

While no one knows what set off the change, doing it artificially would be pretty simple. According to a study by the National Research Council, 270 ships, each emitting iron dust over a distance of 240 miles a day for ten months per year, could fertilize 18 million square miles of ocean. As a result, according to the NRC, the scheme could eliminate as much as 25 percent of all CO_2 from the atmosphere at a cost of $10 billion to $110 billion per year.

As plans to halt greenhouse warming go, this one sounds cheap and easy. But as with other blueprints for geoengineering, critics abound. According to geologist Jorge Sarmiento of Princeton University, by the time the plan is up and running, say, a hundred years from now, atmospheric carbon dioxide would be so elevated that the amount marine algae could remove would fall from 25 percent to something like 10 percent. What's more, the side effects might be unacceptable. Krill digesting marine algae would ultimately die and drop to the ocean floor, forming carbon deposits. The deposits, in turn, would be digested by bacteria, a process that requires oxygen. Sarmiento believes so much oxygen would be consumed that it would create a dead zone through much of the southern ocean. The bacteria would also release nitrous oxide and methane, greenhouse gases far more powerful than CO_2 itself.

Martin, however, says Sarmiento's estimate may be unduly harsh. "Some phytoplankton also produce dimethyl sulfide," he points out. "That stimulates cloud formation, which should add to the cooling effect."

With luck, we'll know more by the end of the year. Though the American Society of Limnology and Oceanography (ASLO) remains skeptical about iron fertilization for global warming, it has endorsed a small-scale test to confirm

iron's role in the ocean ecosystem. If his grant proposal is approved, Martin hopes this coming autumn to fertilize an area 50 to 100 square kilometers about 400 miles south of the Galapagos Islands. Any large phytoplankton bloom should be visible from the new SEAWIFS satellite scheduled for launch this August. And on-site monitoring should reveal a lot about iron's effect on the atmosphere—enough, perhaps, to recommend the fertilization technique to future generations hoping for any means of lowering terrestrial temperatures even a bit.

But global warming isn't the only problem facing geoengineers. The other pressing issue is the hole in the ozone layer created by industrial and consumer use of chemicals called chlorofluorocarbons, or CFCs. Some scientists believe ultraviolet light leaking through the ozone hole each spring is already harming life in Antarctic waters and increasing the rate of skin cancer, and there are signs of ozone loss over Australia as well. In addition, CFCs promote global warming up to 18,000 times more efficiently than CO_2. And CFCs, used in everything from manufacturing to air conditioning, persist in the air for up to a century. If we stopped producing CFCs tomorrow, our great-grandchildren would still have to cope with them.

One possible answer comes from atmospheric scientist Richard Turco of the University of California at Los Angeles and his colleague Ralph Cicerone of the University of California at Irvine. CFCs do not destroy ozone directly, the researchers point out. Instead, they provide chlorine that reacts with other chemicals when the sun strikes them during the polar spring. The products of those reactions are what do the damage. So what we need is something to block formation of the ozone-destroying compounds. Ethane or propane could do the job, they suggest, by reacting with chlorine atoms that play a key role in the process.

In theory, the plan is simple. Just use several hundred airplanes to pour 50,000 tons of ethane or propane into the Antarctic air during the months-long night. Give it a month or two for the wind to mix the gas uniformly. And when sunlight returns to the Pole in late September—nothing will happen. The CFCs will still be there, of course, so the treatment must be repeated every year. But in other respects, the atmosphere will be no more polluted than it was at the beginning.

Of course, even Turco and Cicerone admit the concept needs a lot more work before it could ever be implemented in the real world. "There are so many complications that we wouldn't dare to suggest actually doing it," Cicerone laments. "The propane must be spread through the air very uniformly, and we have no idea how to do it. If you get too little hydrocarbon, it actually makes ozone depletion worse."

So far, only one alternative has surfaced—in the form of a Star Wars–style attack on CFCs. According to Princeton University physicist Thomas Stix, infrared laser light, tuned to the right frequency, can zap CFC molecules, selectively breaking them apart and stopping them in their tracks while leaving the rest of the atmosphere unscathed. The lasers, working from the surface of the earth, Stix adds, wouldn't even be polluting. In fact, with the deployment of the lasers, virtually all the CFCs—and the ozone holes—would be gone in a decade.

But like other geoengineering schemes, the laser concept comes with obstacles. "So far, lasers aren't nearly efficient enough," Stix reports. "Using the lasers we have today, the electric bill alone would cost more than ten billion dollars a year. I hope someone will come up with a scheme that doesn't need such intense beams."

And that, for the moment, is where the field of geoengineering stands. Virtually all would-be geoengineers concede that a painless cure for global warming or ozone depletion remains closer to hope than reality. The blueprints for an engineered atmosphere need far more fine-tuning if they're to be pragmatically implemented, if they're to work.

"We've heard a lot of ideas, many of them preposterous," Irvine's Cicerone concludes. "A lot of our colleagues feel it's dangerous even to talk about some of these things because it reinforces the view that there's nothing to worry about, we can just come up with a technological fix. And there's no doubt that for global warming or the ozone hole or whatever problem we're talking about, society should deal with the root causes.

"And yet," he adds, "these environmental problems are getting bad enough that we may be forced to consider other ways of dealing with them in the future." When that future arrives—and it may not be too far off—many pundits say the blue-sky concepts of the geoengineers will come out of the theoretical closet to be developed and refined. Ultimately, it is the vision of geoengineering, radical as it seems, that may one day be utilized to avert an ecological disaster of nightmarish proportions on planet Earth. ☒

FIRST

CONTINUED FROM PAGE 4

ment, this kind of attention almost always has a positive effect, and it bolsters nonimprisoned colleagues as well. In the words of Dr. Boguslawski, one of the Polish participants at ICPS-21, "It is important that the scientists in these repressive countries feel that they have some support. In Poland, we felt as if someone were with us. If you are alone, then you are lost."

Will this activity jeopardize future conferences and Chinese colleagues who host the events? The Chinese leadership has much to gain by hosting scientific conferences. In addition to enhancing China's access to scientific knowledge, these meetings lend legitimacy to Beijing's tarnished international image. Thus, there is real incentive for the government to authorize these conferences and little likelihood that they will be halted. Furthermore, it's possible to speak out for those imprisoned and persecuted in a manner that shields the scientific hosts from any suggestion of involvement, dedicating papers and circulating petitions.

Andrei Sakharov and Yuri Orlov recognized the contribution the international scientific community made in securing their freedom by use of these same methods at meetings sponsored by the former Soviet government. Governments tend to respond to human rights pressure when it suits their interests. Because China urgently seeks scientific exchanges, visiting scientists are in an excellent position to sound the call for improvements in Beijing's human-rights practices. ☒

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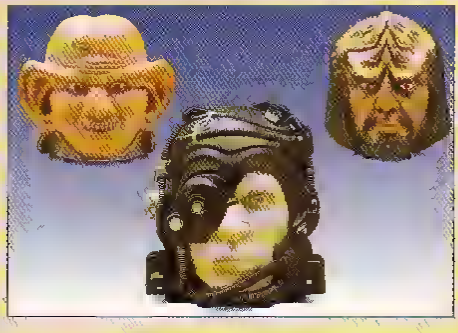

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GAMES

A GATHERING FOR GARDNER

Puzzle, magic, and math devotees pay homage to the man who inspired them

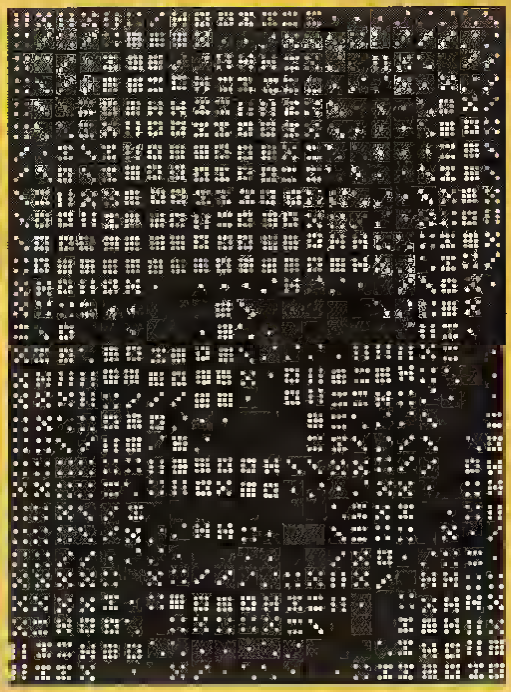
By Scot Morris

Illusion maker Harry Eng launched his slow paper airplane off the railing of the thirty-fourth floor of the Atlanta Marriott Marquis hotel, and it circled for more than three minutes before landing on the lobby floor. Magician Michael Weber shot a rubber band off his finger in the hotel foyer and it rolled back to him from more than 25 feet away. And I, using an Orvis Ritz-Cracker Thrower, sailed a standard Nabisco disc more than 150 feet from the Atrium Café up to the third-floor balcony on the opposite side of the lobby.

It was quite a weekend. Atlanta hosted "A Gathering for Gardner"—Martin Gardner, best known as the Mathematical Games columnist in *Scientific American* for 25 years, and the man who has probably interested more people in mathematics and science than anyone else alive.

The event came about because the Atlanta International Museum of Art and Design was launching a three-month show on puzzles, and Tom Rodgers, an Atlanta businessman and puzzle collector, invited Gardner to be the honored guest at the show's opening. Ordinarily, Gardner, 78, would have refused. His wife, Charlotte, won't fly, and Gardner doesn't like to go anywhere without her. But Atlanta is a daylight drive away from Gardner's home in Hendersonville, North Carolina, so he decided to attend.

Once Gardner was booked, Rodgers sent out



invitations, and six weeks later, nearly 100 of Gardner's friends from all over the world had agreed to come. They hailed from three main fields: mathematics, puzzles, and magic. Two journalists—Will Shortz, editor of *Games* magazine, and I—tagged along.

At Saturday night's dinner, Ken Knowlton unveiled a portrait of Gardner made from six complete sets of double-nine dominoes (above). The original is poster sized, and Gardner's face only becomes visible when the portrait is viewed from 30 feet away. Scott Kim performed *Frère Jacques*, simultaneously humming one part and whistling the other. And mathematician Ronald Graham delivered letters of appreciation from both the American Mathematical Society and the Mathematical Association of America.

Here are what I consider the best of the fest.

Best paper-and-pencil puzzle from Mel Stover of Winnipeg, Manitoba, Canada. He writes –|O|O|O and asks "Can you move the minus sign to make this equal nine-fifty?" (The answer is below.)

Best business card: "James Dalgety, Metagrobologist, Manmead, England." The word means "puzzle enthusiast."

Best book inscription, in *Max Maven's Book of Fortunetelling* (Prentice-Hall, 1992): "TRUTH LIES HERE . . . —Max Maven."

Best line overheard on a crowded elevator, from magician James Randi: "Isn't this a great hotel? The towels are so nice and fluffy—the last time I was here, I could hardly get my suitcase closed!"

Favorite memory: On Thursday night, Rodgers looped a pencil on a chain through Persi Diaconis' buttonhole. The magician and Harvard mathematician remembered this gag from childhood but couldn't remember or figure out how to get it off. On Friday, he still had the pencil hanging from his jacket, and I asked him if he wanted a hint on how to get it off. "No," he said. "I don't mind wearing it. It's like a badge that I've been here."

Incidentally, many people don't know that Gardner is a revered magic creator, unfortunately, he never performs. *Martin Gardner Presents*, published in March, is a hardcover collection of all of Gardner's magic articles since his first contribution to *The Sphinx* in 1930 when he was 16 years old. It's available for $50, postpaid, from Richard Kaufman, 8385 16th Street, #124, Silver Spring, Maryland 20910.

ANSWER

|O|T|O|O (ten to ten)