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DEPARTMENTS

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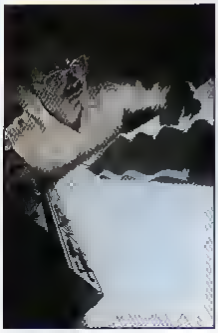

42

This month, *Omni* looks at the technology that makes vehicles, highways, and buildings smarter than ever before. Such technology wouldn't be possible without ground-breaking research of the type once done in Soviet labs or without a fundamental understanding of mathematics. (Cover by Tsuneo Sanda, additional art and photo credits, page 56)

FEATURES

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FIRST WORD

CYBERSPACE: Portal to transcendence?

By David Porush

There's a new frontier beckoning us, and we're growing it in our own backyards. Today many writers are looking toward cyberspace as eagerly as previous generations anticipated moving westward across the prairie or out into space. The prairies, however, held hardship and war. And the high frontier of space promises vast stretches of cold indifference punctuated by alien landscapes. But cyberspace lets us dream that we can build an inner frontier, a virtual reality, to our specs. So our culture is telling itself sexy, glitzy, wishful stories about discovering alien territories right here on Earth. About releasing ourselves from the burden of body and liberating ourselves from sex and race and class. About acting out our fantasies in an electronic nether world and tripping through that trapdoor in the mind that will let us, like Alice, fall into a dream.

Porush: "Surely we are no *less* likely to find transcendence in cyberspace than we are in any other space, whether a Gothic cathedral or a Himalayan monastery or the pages of the Talmud."

This is a fascinating utopian mythology based on a technology still in its infancy. So I have been trolling for new cyberpunk fiction (like Neal Stephenson's *Snow Crash*), going native on electronic bulletin boards, and listening closely to the technical researchers, sociologists, philosophers, hackers and writers who speculate about cyberspace. This is what I am hearing.

In the short run, cyberspace will require an elaborate cyborg armor—data gloves, goggles, bodysuits, helmets. Many believe, however, that some time in the next century, genetic engineering, biochip design, and nanotechnology will collaborate to produce functional wetware—computer interfaces that will enable us to jack our brains directly into a vast, worldwide, interactive network with its own geography and sensory realism. Eventually, we might achieve the Holy Grail of VR research: the delusion that our bodies are actually there, when, as William Gibson quipped in his 1984 novel *Neuromancer*, 'There is no *there* there.' The result will be a cross between the ultimate interactive computer game and telepathy.

While there may be no *there* there, many would-be cybernauts imagine there's something *else* there, waiting for us on the other side of the interface. A recurring theme I hear is the confidence that cyberspace will be a technology not just of the brain and of the mind, but of the *soul*. There's something quite primitive at work in cyberspace's allure. This yearning for mystical encounters seems unusually superstitious coming from otherwise rational engineers, academics, and writers. But good anthropologists learn not to dismiss all native beliefs as mere superstitions. So let's take them seriously, if only for a moment. How might cyberspace be a portal to transcendence?

Neurophysiologists suspect that lurking somewhere in the brain—most likely in a formation at the base of the brain stem called the dorsal raphe nucleus—lies a facility that makes us feel under the right conditions, like we're in communication with gods or that we have voyaged out to meet some Higher Presence. Certain configurations of data delivered to the brain by electronic stimulation could flood this region of the brain with serotonin, a neurotransmitter involved in many functions, including hallucination. In this way, the right software might evoke that oceanic, world-embracing feeling known so well to mystics and psycho-tropical beachcombers.

But let's not stop here with this portrait of cyberspace as some kind of electronic designer drug. It's hard not to wonder why the brain has this weird facility to make us feel like we're talking to God. Is something so irrelevant to survival and yet so distinctively human just a neurochemical accident, an evolutionary byproduct of the sheer complexity of the nervous system? Or is it, as Immanuel Kant suggested two centuries ago, that the laws of the "in here" are the same as the laws "out there"? Our minds are tuned to universal harmonies. Perhaps the brain is prepped to receive divine telegrams because there is, after all, an Intelligence informing the cosmos toward which universal evolution gropes—a Cosmic Anthropic Principle. Perhaps VR technology will be one of the ways to open the hailing frequency.

Surely we are no *less* likely to find transcendence in cyberspace than we are in any other space, whether a Gothic cathedral or a Himalayan monastery or the pages of the Talmud. Cyberspace could be our civilization's burning bush. ◻◻

David Porush is author of The Soft Machine: Cybernetic Fiction, *and professor at Rensselaer Polytechnic Institute where he codirects an AI research group.*

COMMUNICATIONS

READERS' WRITES:
Resolving differences, the thorny struggle of saving forests, and busting the blues

Only Connect

James Hornfischer's much needed article "The Soul in the Machine," [Books, November 1992] touches on many topics within the topic of modern-day science. Today's science dictates the basis (soul) of our society (machine) and until the differences between our description of nature through science and the description of nature through religion are resolved, we will continue to subvert what little understanding of nature we have so as to be incomprehensible to the general public. In so doing, scientific advances are made, confrontation with religion is averted, and a dysfunctional society is in the making.

Laurence Lavelle
Princeton, NJ

In James Hornfischer's Books column, he confuses Einstein's theory of general relativity with that of special relativity. The column states that the theory of general relativity, published in 1916, contained the notion that the experience of time varies with an object's (observer's) velocity. This concept actually comes from Einstein's theory of special relativity, published in 1905. General relativity deals with the "bending" of spacetime by mass energy, one result of which is that the experience of time varies with the strength of the gravitational field in which the observer is immersed.

Larry A. Barowski
Owosso, MI

Of Factions and Forests

I found Kathryn Phillips' article "Out on a Limb" [Earth, November 1992] enjoyable and well written. Finding out that there is an organization like the Association of Forest Service Employees for Environmental Ethics (AFSEEE) is a great thing. The idea of the Forest Service worrying more about the logging and mining industries and not about the forests they are supposed to protect is sickening. I hope AFSEEE continues to watch out for Forest Service employees and their right to do their job in a professional manner and not let the employees be pressured by industry.

Steve Prosser Jr.
Cupertino, CA

I would like to add my endorsement to Mr. Jeff DeBonis' efforts. We are currently using 1.5 billion trees annually in the United States, and the Forest Service policy of selling off old-growth trees to timber companies at prices as low as $2 per tree not only makes no economic sense (taxpayers bear the burden of USFS budget deficits), it is simply unconscionable. Virgin forests are nonrenewable resources on our accelerated human-time scale and are a precious commodity we should all take responsibility in preserving. Mr. DeBonis and his colleagues are taking the first step by raising their voices within the very agency that sets policies, and for that I thank them.

Kenneth Davies
El Cerrito, CA

Ms. Phillips seems to view environmental matters in black and white. As Marynell Oechsner recognized, her report was based upon research that led to a subjective opinion. Ms. Phillips draws the conclusion and states in her article that these opinions are truths. How unfortunate that the author lives in a world where she believes the environmentally correct employee is the beleaguered victim of the corrupt bureaucracy.

Marc Nagele
Illinois

Dosing the Doldrums

I finally got a chance to read the tale "The Man Who Rowed Christopher Columbus Ashore" by Harlan Ellison, which appeared in your July 1992 issue. I'm glad I went back to the issue. The story is fantastic. The world needs a good dose of insanity every now and then. Harlan Ellison is our man. His story and its kind are just the ointment my recently tedious life was looking for. Thank you for the opportunity to discover yet another wonderful author from your pages.

Nick Boldt
Waterloo, Ontario, Canada ◘◘


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FORUM

GOOD READING:
A brilliant young paleontologist sheds light on a continent and its creatures

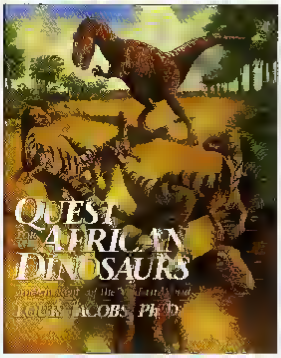
By Keith Ferrell

Let me tell you about a wonderful book, but let me also be honest. I know its author and I think he's an absolutely swell guy. He's a paleontologist of the first rank and, it turns out, an author who brings exuberant narrative gifts as well as scientific knowledge to the page.

His name is Louis Jacobs. His first book, *Quest for the African Dinosaur*, has just been published by Villard, and it's a terrific accomplishment.

I met Louis at a conference on the future of fossil resources, a topic not without controversy, dealing with the role and rights of commercial fossil collectors. In the course of several hours of conversation, it became clear to me that Lou Jacobs possessed a more mature perspective than was common at the conference. His point of view seemed far less parochial than those too often found among scientists, he was willing to give fair hearing to arguments that flew in opposition to prevailing scientific attitudes.

It was also clear that Louis is a fine raconteur and teacher, two roles not necessarily mutually exclusive. Louis teaches by telling stories, and he tells stories with the savor and smile of an entertainer. Sitting and talking with Lou, I came to envy his students at Southern Methodist University where he is the director of the Shuler Museum of Paleontology. This I could see was a man who could tell stories and teach science—a powerful combination.



Now he's consolidated both roles in print. This is a thoughtful and entertaining volume, as concerned with the fate of Africa's present and future peoples as with its prehistoric inhabitants.

There are few branches of science as romantic—at least on the surface—as that of field paleontology, and Jacobs' book captures nicely that romance. Lou Jacobs broke, you will pardon the pun, a lot of ground with his search for dinosaur fossils in Kenya, Malawi, and the Cameroon, so there is in the book a sense of exploration and mystery.

Quest for the African Dinosaur also contains a lovely and consistent sense of affection for the peoples of the various countries Jacobs visited. He is aware of the enormous challenges Africa faces, but equally aware of the continent's majesty and potential. Jacobs' insights and observations about Africa and the beleaguered Africans are an important and rewarding part of the book.

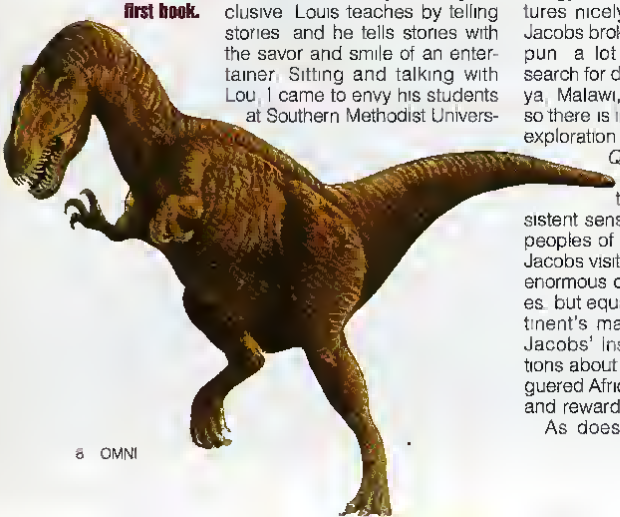
As does any good teacher, Jacobs knows just where to begin his story, and the book's opening chapters carry us not only through Louis's early days in Africa as a member of Richard Leakey's staff, but also through an instructive and concise introduction to geology and the rise of life on Earth. He sets the scientific stage on which his book's drama will be played out.

It's quite a drama, filled with anecdote and adventure as Jacobs and his team pursue hunches, hints, and rumors across lovely and forbidding terrain in search of new species of ancient life. There are red herrings, missed opportunities, impenetrable bureaucracies, physical and mechanical breakdowns, even a spitting cobra or two. Through it all, Jacobs maintains for the reader a sense of the excitement and joy of doing real science and also a special sense of the vistas afforded us by taking a view of our world guided by a geologic time scale. Jacobs reminds us how old our world is and how young our species.

The book is filled with intellectual as well as physical drama, and Jacobs makes good use of his opportunity to approach subjects as diverse and controversial as living dinosaurs and fundamentalist creationism. Wisely, he steers clear of cant and provocation, yet presents the scientific viewpoint clearly and in some ways definitively.

As noted, I know Lou Jacobs and like and admire him. If you met him, I think you would, too. Bearing that prejudice in mind, let me recommend that you go out right now and get a copy of *Quest for the African Dinosaur* by Louis Jacobs, Ph.D. It will entertain and inform you, and you may find yourself hoping, as I do, that for Lou Jacobs, this is the first of many, many books. ☒

Dinosaurs and Africa are a compelling combination, beautifully captured in Louis Jacobs' first book.



MIND

TEST-TUBE OBEDIENCE TRAINING
Nerve cells in a dish obey like Pavlovian dogs

By Steve Nadis

In a California classroom, obedient pupils study in perfect harmony, each learning precisely the same thing at precisely the same time. This classroom is an elaborate test tube: the pupils, some 10 million strong, the class a uniform stock of mouse brain cells. "Some people find the idea of disembodied consciousness kind of scary," notes Daniel Koshland, Jr., a University of California–Berkeley biochemist. Koshland's goal is to understand the chemical changes of learning and memory occurring within an individual cell.

Some folks don't like being reminded that the basic biology of bacteria, yeast, rats, and humans is remarkably similar.

"You can think of the brain as a computer made up of lots of microprocessing chips linked together," says Koshland, who edits the journal *Science* in his other full-time job. "We're trying to figure out what the chip itself is doing rather than the entire circuit." Koshland's lab employs for the first time in memory research a technique developed at MIT and Harvard to "immortalize" mouse neurons. A cancer gene is inserted into the cell to induce division. Identical HT4 cells are then grown in culture. "We work with the same cells every day, which makes it easier to understand the chemical processes," explains Bruce Morimoto, now at Purdue. Researchers performing comparable studies with slices of rat-brain tissue cannot avoid mixing different cell types, and that makes it all but impossible to do precise chemical analyses.

The Berkeley team demonstrated habituation and long-term potentiation (LTP) in the neural cell lines—hallmarks of learning and memory. Habituation occurs when cells diminish their response to a stimulus after repetition—the way people get used to the sound of a loud doorbell. Potentiation occurs as neurons become more sensitive after repeated stimulation and remain that way. "When a child learns to become scared of tigers, we call it potentiation," Koshland says. When HT4 cells were exposed to minute quantities of the neurotransmitter serotonin, they increased output of excitatory amino acids. But the effect was short-lived. If the cells were subjected to one very high dose of serotonin, the effect seemed permanent—that is, lasting for the five-hour life of the cell. One whopping dose made an indelible imprint on the neurons, perhaps like the imprinting of a car crash on a person's memory.

Koshland's team also saw long-term memory activation when they gave cells simultaneous repeated, but much smaller, doses of serotonin and glutamate, an excitatory amino acid. "By stimulating the cells again and again, you eventually push them over a threshold," Koshland explains. "The response becomes ingrained in long-term memory the way people remember multiplication tables forever if they initially worked at them hard enough."

The Berkeley scientists may have identified the cellular key facilitating long-term storage. "As a safeguard before opening the vault, two things have to happen at once," Morimoto explains. The serotonin receptor has to be activated, causing levels of a molecule called cyclic AMP to rise. The glutamate receptor must be stimulated at the same time, indirectly activating protein kinase C, an enzyme causing cyclic AMP levels to remain enhanced. That triggers a series of chemical changes in the cell. "It's surprising it looks so simple, but when cyclic AMP levels stay elevated, you seem to get long-term storage," Morimoto says.

Koshland's lab plans to test 80 new cell lines to see if the same mechanism is at work. If they confirm the hypothesis, the findings could aid researchers experimenting with animal models. "Our work could give these people clues," Koshland says. "They may be able to spot cells that have learned a certain function just by finding neurons with the highest levels of cyclic AMP."

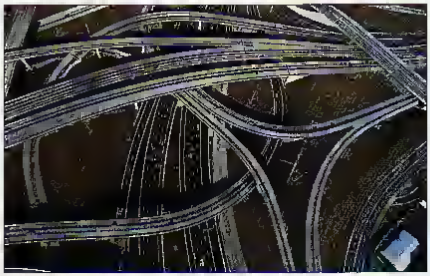
Charles Stevens, a Howard Hughes Medical Institute investigator at the Salk Institute says, "It's hard to know if the thing they're seeing in the test tube is the same phenomenon others see in the brain. However, the effects Koshland is studying are important, even if we learn human or animal memory relies on somewhat different mechanisms. His work will tell us, among other things, how cells respond to stimuli in the environment."

WHEELS

CARS AND COMMUNITIES
A welcomed return to a small-town ethos

By Jeffrey Zygmont

"Americans are pioneers and gunslingers, and we love jumping into our cars," says architect Barry Berkus, defending the visceral appeal of auto motion. Berkus has designed houses with eight-car garages, even some glass-walled garages that showcase autos as art.



To make a path to the new shopping mall in my town, traffic engineers widened the highway out front to nine lanes. They didn't bother to put in a crosswalk.

To be a pedestrian in landscapes like this is to be considered a pariah.' So pronounces Andres Duany, architect, town planner, and a leading voice in the cry to return building to a human scale. "In most communities in America, it's quite easy to conclude that the single most important principle is that cars must be happy,' he says.

Accordingly, modern American communities coalesce around large collector streets leading automobiles en masse to segregated business developments, shopping centers, or to freeways that lead them farther still. These collectors are fed by cul-de-sac housing subdivisions, which, says Duany, are sterile from a lack of diversity. Communities are isolated by their separation from shops and schools.

And their illogical layout of twists and curves and go-nowhere streets make them uninviting to pedestrians. Where can you go? Distances to shops and offices are too far to walk. And even the stout of leg are barred by uncrossable intersections and fast-moving traffic. 'The classic suburb is less a community than an agglomeration of houses, shops, and offices connected to one another by cars, not by the fabric of human life,' says Elizabeth Plater-Zyberk, Duany's partner. Continued suburban confinement to houses and cars, she warns, "spells the end of authentic civic life.'

Their remedy: A welcomed return to a small-town ethos, mixing homes, shops and offices in concentrated communities that can also serve as collectors for mass-transit lines. Laid out especially for pedestrians, with inviting footpaths to businesses and other community services, Duany and Plater-Zyberk's villages aim to lure people outside again, rekindling neighborly values.

From their Miami practice, Duany and Plater-Zyberk put these great ideas to work at such developments as Seaside on the Florida panhandle and Kentlands, a community under construction near Washington.

But such neotraditionalist building will grow only if it improves life in automobilia, the greatest threat to the movement is that it could degenerate into an anti-automobile utopianism. Utopian schemes to outright eliminate autos fail because they wrongly assume that people don't *really* want cars, that our dependence has somehow evolved independently of human choice and action. Truth is, cars only fulfill the roles people give them. Our reliance comes laissez-faire, collectively from individuals who use them to escape crowded urban living conditions—even if the suburbs are ugly and inconvenient.

"People are willing to make significant tradeoffs in order to be owners of single-family homes. And most people are willing to drive very far," says Professor Avi Friedman, who directs the affordable-homes program of McGill University School of Architecture in Montreal. Studies of residents of low-cost, space-efficient houses designed by McGill show that cars are key to the compromise: a few hours a day on cramped highways in exchange for a personal patch of green.

To the mass of people, automobiles equal empowerment. They let people travel once-unthinkable distances, door to door, quickly. They enhance comfort. Maybe people used to walk to market through the searing heat and numbing cold because they had no alternative. Unlike trains, automobiles enable individuals to make their own schedules. And they permit privacy. "You don't pick your fellow riders in mass transit," says Barry Berkus, whose Berkus Group Architects has offices in Southern California, Washington and Sun Valley, Idaho. Berkus himself thrills to commuting in his Porsche. "It's almost a ceremony in being able to drive my car. You're in control.'

Of course, the ceremony dims when, from a stop-and-go freeway, you espy the smog that domes the L.A. basin—hence, the impulse to restrict motor travel. But let's recognize that cars are so populous because they are so popular, and they're popular because they make for a better life. Defenders of the automobile hold out that coming technology will remedy its social ills while allowing it to maintain its social contributions. Berkus foretells the arrival of tiered transportation that includes clean and nimble electric cars for close-in errands and intelligent-vehicle highway systems for well-managed cross-town traffic.

"Technology can revive Detroit," he says, "if it's used to solve social problems.'

POLITICAL SCIENCE

WILL THE REAL GNP PLEASE STAND UP?
Now's the time for some really gross economics

By Tom Dworetzky

With the Administration and private attention fixed on the economy maybe it's time to reexamine a key indicator of financial health—the Gross National Product. For years, a small band of thinkers has argued that the way the GNP is calculated is the real problem, and I agree. Because we live and die on the altar of economic totems like GNP, we worship in ignorant bliss.

Coal is a natural resource whose irreplaceable, one-time depletion is not calculated in the GNP.

Here's the basic dilemma. Say your name is Ned and GNP stands for Gross Ned Product. You work at the local coal mine, and they pay pretty well. Of course you can only mine coal for a while before you get black-lung disease and retire kinda permanently. Then there'll be medical bills. So the good pay is sort of for using up your lungs, which you can only do one time. Those lungs are your own private, nonrenewable resource—like coal, oil, clean air and water, old growth forests, and even those damned spotted owls.

If Ned calculates his GNP only by considering his income, he looks in pretty good shape until he gets sick, the medical bills wipe out his savings, and he can't work any more. The Gross National Product figures things much the same as the Gross Ned Product. It looks at our gross product without subtracting for the one-time depletion of the irreplaceable resources necessary to create those products. Nothing in the figures leavens the GNP with a long-range consideration of how much stuff you're using up that's nonrenewable.

Experts have argued that the GNP is far from the only figure needed to measure the economy. Among the experts are Claremont College theologian John Cobb, his son Clifford, and the World Bank's Herman Daly. They've gone so far as to create an index, first published as an appendix in the 1989 book *For the Common Good* called "the index of sustainable economic welfare" (ISEW). It offers a different assessment of our economic world.

The major factors ignored by the GNP but part of ISEW according to Clifford Cobb, include:

1. Distribution of income. Extra dollars to the rich count less than to the poor. This has been an important factor over the last ten years because the distribution has gotten worse.
2. Estimation of resource depletion. Use once and it's gone.
3. International borrowing.
4. Household work.
5. Military and related government spending.
6. Work on infrastructure, including government spending on repairs and building of streets, highways, and sewers.
7. Environmental damage. This factor is *not* estimated by expenditures for pollution control and cleanups. (Was the Valdez cleanup or repairs after last year's hurricanes really a plus for the GNP? They count as such in our present calculations.)

Clearly, as Clifford Cobb says, "With ISEW you can measure quality of life better than with GNP. It measures how well off we are, not how fast the wheels are rotating on a car that's up on blocks. We've known for years that many things are left out of the GNP, but few attempts have been made to address this issue. Measures of economic activity are vital. In practice, policymakers use these numbers as a measure of welfare and base decisions on them. The mindset develops wherein people ignore what the numbers really represent."

What the Sustainable Economic Growthers found conforms to most common experience. We are not better off. Changing the overreliance on the GNP calculation would put the issue before us every day and make common sense out of calls for conservation. Would you drive a car with no gas gauge, with no thought to fuel consumed? Today's GNP calculation is like an odometer with no associated gas gauge. Isn't it time to start figuring out how many miles we're getting to the gallon instead of just how far we've gone? ∞

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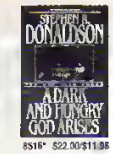

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SPACE

WHERE NO LAW HAS GONE BEFORE:
When astronauts blasted off to explore space, lawyers inevitably followed

By Susan Karlin

Who owns the moon? Throughout history, planting a flag in unclaimed territory has meant ownership, and the United States has its flag on the moon.

If several countries own a space station, what is the nationality of a baby born in space?

As the presence of humans in space increases, so must the body of laws governing their actions there. "The space movement seems to be toward international research, development, production, and operation and therefore joint ownership," says David J. Kuckelman, an international lawyer with the Los Angeles firm of Seyfarth Shaw Fairweather & Geraldson. "Things that are governed by place of occurrence—such as ownership rights, contract signing, how to try criminals, and nationality for birth—will have to be redefined legally. We're going to need an entire body of law for people growing up, doing business, and inventing new things in outer space."

Figuring out who owns the moon is no problem, but most of the issues space lawyers handle grow more complicated every day.

Still only a tiny legal field—just 300 of the country's 777,000 attorneys specialize in space law—it draws from a combination of legal disciplines including international relations, government, and patents and property rights.

Space law began in 1958 with the formation of the National Aeronautics and Space Administration in the United States. The following year, the United Nations created a committee to study legal issues involved in exploring and developing outer space.

Between 1967 and 1976, the United Nations drafted five international treaties that state: All people have equal access to outer space; an astronaut or space equipment that accidentally lands in one country must be returned to the launching country; countries are responsible for what they launch; everything in space must be registered; and the moon and other celestial bodies are the heritage of and to be shared by all humankind.

Space law grew to include commercial concerns with the advent of the commercial launch industry. Today, attorneys dealing in space law guide an $80-billion worldwide space sales market, says Daniel P. Byrnes, a Pepperdine University law professor and commercial space attorney with the Los Angeles–based firm Baker & Hostetler.

Such activity prompted the field's expansion to other legal areas. Space attorneys help companies acquire all mandatory government launch permits, from Department of Transportation satellite registration and launch permits to export approvals from the Department of State (because launched material is exported into space). They handle litigation against companies supplying faulty satellite parts, and they've begun to tackle environmental issues such as space debris and rocket-launch pollution.

The next decade will likely see the creation of new legal precedents. Plans call for the national aerospace plane, currently under development, to zoom across half the globe in less than three hours by traveling through outer space. It falls to space lawyers to decide whether to assign aviation or space laws to the program.

Space lawyers have wasted no time in devising solutions to this anticipated dilemma. Carl Q. Christol's Allocative Theory suggests that laws be allocated according to the carrier's expressed purpose. If the vehicle flies in space en route from one point on the earth to another, aviation law would rule. "But if its object is to go into space, say, to a space station, then it would be subject to space law," says Christol, an international lawyer specializing in space issues with Fizzolio, Fizzolio & McLeod in Sherman Oaks, California.

Perhaps the field's greatest challenge will be ironing out how to share the benefits of space. "People who spend money to further the space program are entitled to the profits from those expenditures," Kuckelman says. "I don't believe we should create a global socialism with respect to the uses of outer space. It would kill the incentive of the countries moving forward on it."

On the other hand, Christol adds, "just because we can exploit the area doesn't mean we can be monopolistic."

Which returns us to the question of lunar ownership. Consider the international treaty that determines celestial bodies to be the heritage of humankind. In other words, we all own the moon.

And that's a nice surprise for anyone who's dreamed of owning beachfront property—even if it is next to the Sea of Tranquility.

ELECTRONIC UNIVERSE

FUTURE LUST

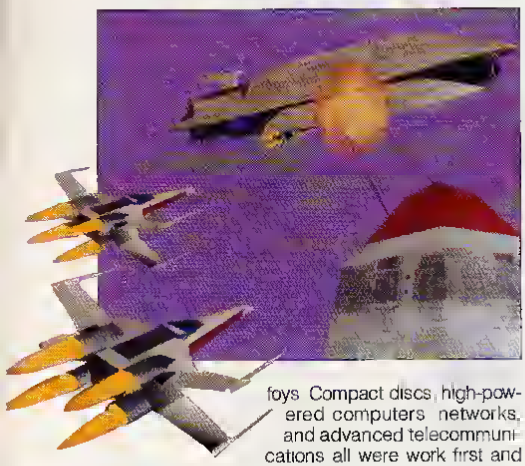
Business innovation today, gaming fun tomorrow

By Gregg Keizer

Future shock? No big deal. That's nothing compared to an even rougher psychological body blow. *Future lust.*

Techno addicts like me, like *you*—Hey, you play games that never saw a piece of cardboard or a chunk of wood, right?—just can't wait for the future. We're always looking for that next electronic fix to satisfy our lust for what will be, not what is.

There's no better place to see future lust in action than at COMDEX, the twice-yearly trade show for 100,000 or so technology junkies. Sure, most of what's at the show is business, not entertainment, but it's just as true that today's corporate technology usually transmutes—sooner or later—into tomorrow's electronic toys. Compact discs, high-powered computers, networks, and advanced telecommunications all were work first and fun later.



Defensive maneuvers: In this game developed jointly by Hughes Training and LucasArts, Rebel X-wing fighters are flying in formation when the Rebel tanker ship explodes—victim of an Empire ground gun's laser.

Some of the sexiest COMDEX business technology will undoubtedly have an impact on the way we play digitally down the road. To scratch that future-lust itch, all we have to do is look.

Take video, for instance. Thanks to Microsoft, the software behemoth that calls most of the shots in the PC world, video will be all over the desktop this year. *Video for Windows*, the software to run video clips on a PC, and a slew of supporting hardware—mostly boards that you plug into one of the empty slots inside your computer—will simplify the process of pulling video off the VCR or camcorder and putting it on the PC screen. Business thinks it will use moving pictures to enhance presentations, punch up training, and add faces and sounds to electronic mail.

But the ease with which video can now be added to PC programs—some of the capture and playback boards, the hardware you need to grab clips or single frames, cost as little as $400, like Media Vision's Pro MovieSpectrum—will drastically alter the amount of video we see in computer games. Some already use a limited form of video or base their computer-created characters on digitized images acquired from video. Dynamix's *Front Page Sports: Football* for example features the most realistic-looking players around because they're based on video of semipro players. Thanks to *Video for Windows* and the standard it will quickly set, look for a surge in gaming motion to start this year and continue building over the next.

(A more mundane application for video on the computer comes courtesy of other boards, which, when connected to cable, put a TV screen in a small window on your PC's monitor, letting you watch CNN or Nick at Night while you work. New Media Graphic's *WatchIt!TV*, a good example of such boards, sells for around $300.)

Other future lusts center around the portable gizmos that look ready to replace cellular phones with small, slate-sized tablets to keep business people organized *and* in touch with their offices via wireless networks. Going by a bunch of terms—Apple likes the name *Newton* for its personal data assistant (PDA), while AT&T calls its new mobile machine a Personal Communicator—these cellular phone/cellular fax/computer combinations will make use of the growing wireless networks the telecommunications companies are assembling. This technology, too, may come to work today, but will figure into our future play.

Once costs drop—both for the hardware and the associated calls—someone will figure out that we'll have fun playing games with other people no matter *where* we are. Online services heavy on entertainment already exist, but they chain you to the desk and the phone line. Wireless communication will break you free from both, letting you play group or head-to-head games with others—not the dumb computer—from plane, train, automobile, or backyard.

Future lust comes from even stranger places. Like companies once more interested in Department of Defense dollars than quarters dropped at the arcade. Hughes Training, a maker of advanced flight simulators, recently teamed with LucasArts to build a system of interactive gaming pods fit for theme parks. Each enclosed Mirage pod will hold two to four people and connect with as many as 63 other pods. You'll climb in, watch the curved screen, listen to the stereo soundtrack, and play with and against others.

Lust satiated? No? Not surprising, not when the one thing future lust forbids is satisfaction with what's here and now. But at least we know what we want—anything we don't yet have. ☒

ARTIFICIAL INTELLIGENCE

PUTTING THE BYTE ON CROSSWORDS: A programmer lets the computer fill in the blanks

By John Grossman

An eight-letter word for automated crossword constructor: Eric Albert's program for his home computer created a puzzle that won *Crossword* magazine's award for best puzzle of 1991.

On a bright, bud-popping spring morning, Eric Albert pushes his young son Gus in a stroller down a sunny sidewalk in Auburndale, Massachusetts. His wife is at work. And so is he.

A couple of blocks away, Albert's 33 MHz 80486 computer spends just a few minutes creating a crossword puzzle that's challenging enough to appear in the country's best puzzle publications. In fact, this very puzzle, titled "A Byting Observation," appears above. The answers can be found on page 88.

STOP. If you want to take a pencil to it before learning how it was constructed (and some of the answers), read no further.

Albert sells computer-generated crossword puzzles to such publications as the *Washington Post*, the *New York Daily News*, and the *International Herald Tribune*. Many of his early submissions went to initially unsuspecting editors. For competitive reasons, he didn't want his secret widely known while he worked to improve his program. And he worried about prejudice.

"Some people think compact discs sound flat and digitized," he says. "It's just that they know CDs are done by computer. I'm sure a lot of people don't want to think a computer can do something they consider creative."

Unlike most who have tried to fill crossword grids by machine, Albert, a crack programmer for nearly half of his 35 years, isn't just pursuing an interesting mental challenge. He aims to make a profession out of this—one that allows him to work at home. Without the computer, he wouldn't have a prayer. Checkout clerks make more per hour than the average crossword constructor, who usually nets only $40 for a daily newspaper crossword.

For *Omni*'s puzzle, Albert sets up a 13 × 13 grid and plugs in the theme words ALITTLE TALENT/PLUSACOMPUTER/CAN BEATGENIUS. We'll see.

Because the program can't yet swallow the entire puzzle at once, Albert must break it into smaller bites. Circling a P-shaped chunk in the upper right-hand corner defined by 5-down through 12-down, he fills in the appropriate letters from the theme.

"That's it. That's the end of my job," he says. In a mere eight seconds, the computer comes up with a solution.

"We could stop here," Albert says, "but usually I'll let the computer look for better fills."

The computer has prefigured a score of 22 as the best possible solution, Albert explains, and continues down toward that ideal, rarely reachable goal. It values the first solution at 87 or 22; the second, 82 of 22.

"I know of no one besides me even posing the question, 'How do we find a good fill?'" Albert says. "Everybody else is trying to

CONTINUED ON PAGE 88

ACROSS
1 Bloke
5 Record location
13 Taped sports event
14 "I" disease
15 Observation Part I
17 Command to a receiver
18 Street sign
19 Cheerleader's chant
20 Like some exercise
24 Business interest
29 Observation Part II
31 "Ain't Too Proud __ ___"
32 Heavy attack
33 Famed diarist
34 Gives a talk
40 Quarreling
44 Observation Part III
46 Be the basis of
47 Camper's cover
48 Court martial subject
49 Pindaric product

DOWN
1 Raised rugged rock
2 Eclipse sight
3 Kind of test
4 "Charlie Hustle"
5 Oracular
6 Ripen
7 Gale's dog
8 _ ___ *For All Seasons*
9 Bound bundle
10 Once more
11 Pinta's companion
12 "____ Lied" (Steely Dan song)
16 It's often in hot water
20 Fitting
21 "Telephone Line" group, for short
22 Summon a genie
23 Ear part
24 Elf or fairy
25 Excite with
26 __ _ loss for words
27 Frat-party staple
28 Before in palindromes
30 Boss
34 Patriot victim
35 Diamond face
36 Means justifiers
37 Busy as _ ___
38 Housewife humorist
39 NaCl
41 Conked out
42 Herbert opus
43 Jets
45 Bond

CONTINUUM

FIGURING THE COST OF THE GULF WAR

It looks like we got a good deal, anyway. Plus, why sometimes World Series teams need to lose to win, and why pigs love Ben & Jerry's

If you've ever had aspirations to become a detective, try this as your first assignment. Find out the cost of the Gulf War. Two years ago, when the United States became involved in the Persian Gulf conflict, we were in an 'R,' and Congress took the president to task on how he would fund the 'W," wanting to know who was going to pick up the bulk of the "$.' The administration's initial plan for funding the war called for $71 billion, with $54 billion—more than three-fourths of the total—coming from allied governments, according to the *Congressional Quarterly Almanac* of 1991. Quick subtraction: The United States would owe $17 billion.

After the end of the war, the same report says, Congress passed a bill that provided $42.6 billion to cover the costs of the war, stipulating that those costs be paid from $53.5 billion pledged by foreign governments. Quick subtraction: the United States is up $10.9 billion.

The report doesn't say how much the war did cost, nor does it say how much we collected in Allied contributions. Frustrated and confused, I turned to Bob Gaines, government documents librarian and Mark Schumacher, reference librarian at the University of North Carolina at Greensboro, for help. Between the two, they have 32 years of experience as research librarians.

Schumacher and I scanned the newspaper and periodicals index first. The *Wall Street Journal* reported at the end of April 1991, that, according to the White House Office of Management and Budget (OMB), the United States spent $31.5 billion on the war, although that figure didn't include the expense of shipping troops and equipment home. Both the *Wall Street Journal* and *New Republic* ran articles about the United States's possibly embarrassing windfall if the Allies paid their pledges. But the Persian Gulf articles tapered off by the summer of 1991, and we couldn't find the actual figure on the cost of the war or how much the Allies did, in fact, pay. The three-page summary of the war in the *1992 World Almanac* didn't mention cost.

I went to the second floor of the library—documents. Gaines, anticipating my arrival, had pulled out reports for my preview. "An Analysis of the President's Budgetary Proposals for Fiscal Year 1992," which came out in March 1991, suggested that the total cost of the Gulf operation would be about $45 billion, but it also noted that the Defense Department wasn't able to provide firm estimates of the cost at the time the report was prepared. The following year's report didn't even mention Operation Desert Shield or Storm.

A June 1991 report compiled by the Congressional Research Service reported that Allies pledged $54.6 billion, according to the Administration, of which $36.1 billion in cash and in-kind contributions had been received as of April 1991. I asked Gaines what "in-kind" meant, because he's a librarian and librarians know everything. He shrugged.

Gaines ran a search on Marcive, a database that covers all the documents issued by the Government Printing Office. He pulled microfiche for a number of committee hearings. Good news: At the beginning of the conflict, the House passed legislation, H.R. 586, requiring the OMB to submit incremental defense-related U.S. costs of the conflict and the amount of contributions made by foreign countries.

I looked at one more report from the Committee on Armed Services to Congress, dated February 1991. It couldn't have the figures I sought. But there was one dissenting view by Colorado Representative Pat Schroeder. H.R. 586, she said, "leads to the deceptive conclusion that the Allies are picking up most of the costs of Operation Desert Storm." She noted that the term "in-kind contribution" was not defined and that the bill "does not require the disclosure of any commitments which the United States made to countries to gain their support. We all know about the six billion in forgiven loans to the Egyptians. What other deals like this were made which we do not know about?" Schroeder proposed an amendment to H.R. 586 that would make it more accurate, but we couldn't find the outcome.

I called Schroeder's office. A staffer told me that no action had been taken on H.R. 586 in the Senate—Schroeder's amendment had been rendered moot. I called the OMB and asked for the most recent report, dated October 1992. In it, Richard Darman, director of the OMB, warned that the figures should be viewed as partial and preliminary. The Department of Defense estimated the full incremental cost of the conflict to be $61.1 billion. Total foreign contributions were $53.8 billion—$48.1 billion in cash, $5.7 billion in kind. The cost of the war in billions? Quick subtraction: $61.1 minus $53.8 equals $7.3 billion, kind of.—*JANET STITES*

CONTINUUM

WINNING THE WORLD SERIES BY LOSING

The home team has just won a big game in baseball's World Series. All the sportswriters say the team's on a roll. It has the "big mo'"—momentum—making it favored to win the next game. But recent research by Kenfucky psychologist Irwin Nahinsky calls this popular wisdom into question. He found that a team rebounding from a loss in the World Series is more likely to win its next game than a squad coming off a victory.

The University of Louisville researcher analyzed all 506 World Series games between 1903 and 1989. He discovered that the probability of a win following a win was .62, while after a loss it was .78. A win follows a win most often in game 4, with a probability of .75, while a team bouncing back from a loss in game 2 has a probability of .90 of a win in game 3.

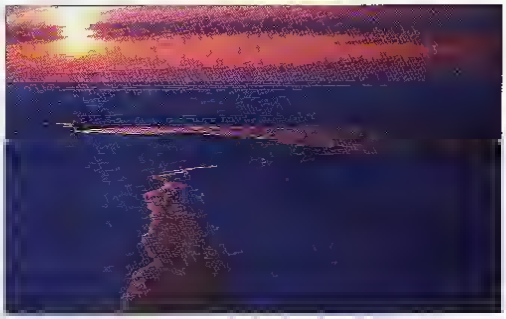
"It's the opposite of what you would expect," Nahinsky says. He speculates that teams may get overconfident after a victory or that "highly competitive athletes may try harder after a defeat."

Nahinsky calls his discovery "negative momentum." He hasn't yet determined if it applies to other sports or even to regular season baseball games, although he plans to study the latter.

—Paul McCarthy

PLANNING A PARK WAY UP NORTH

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



Conservationists want to turn area near the Bering Sea into a park.

Although the salty ocean waters freeze over for half the year, the region known as Beringia cradles vast amounts of wildlife and native peoples preserving ancient cultures. The area includes the Bering Strait, adjacent oceans, Russian and Alaskan coastlines, islands, and freshwater streams. Millions of waterfowl, shorebirds, and songbirds flock to Beringia's summer brightness, which lies at the northern end of migration routes for many of the world's birds, including snow geese and sandhill cranes. But overfishing by commercial vessels may threaten seabirds and marine mammals.

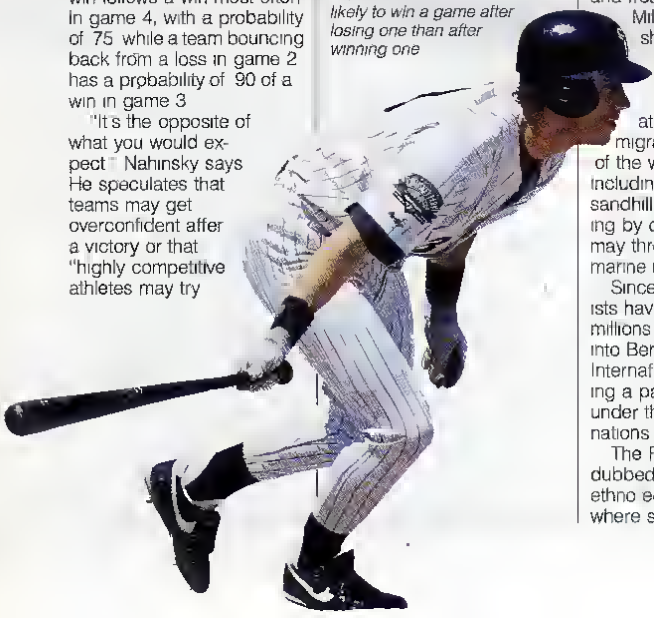
Since 1990, conservationists have been trying to turn millions of acres in this region into Beringian Heritage International Park. But crafting a park out of territory under the sovereignty of two nations is a challenge.

The Russians have dubbed the area an ethno-ecological territory where subsistence cultures, plants, and animals all receive protection. "The Russians are being very progressive," explains National Audubon Society representative Mary Core. "Especially on the Russian side, native cultures could be pushed into great difficulty by changes to subsistence lifestyles."

For its contribution to the park, Russia has offered millions of acres on the Chukotski Peninsula and coastal waters out to 60 miles. The United States plans to contribute the 2.7-million-acre (approximately 4,200-square-mile) Bering Land Bridge National Preserve on Alaska's Seward Peninsula, an area one-third again as large as Yellowstone National Park. Congress must still approve the park legislation. However, the United States has not offered any marine component for protection.

To express your support for this innovative park, write to Senator Frank Murkowski (R-Alaska), U.S. Senate, Washington, DC 20510.

—Liz Calle



A World Series team is more likely to win a game after losing one than after winning one.

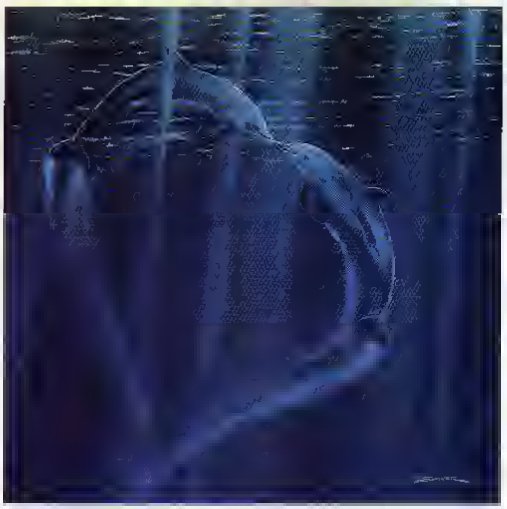
SURFING DOLPHINS

Sailors have long been delighted by dolphins swimming alongside their ships, providing friendly company on lonely voyages. Now U.S. Navy scientists in Hawaii who train dolphins for secret military missions report that the intelligent aquatic mammals actually save precious energy by hitching free rides on the bow or stern wakes of ships they accompany.

Research physiologist Terrie Williams accidentally discovered the dolphin's ability to utilize pressure waves. She was conducting tests to measure their respiration, heart, and blood-lactate levels at varying swimming speeds.

"We wanted to find out if they have different metabolic rates for long distance 'marathon' swimming and short-term sprinting," says Williams, who works at the Naval Ocean Systems Center Hawaii Laboratory at Kailua on Oahu.

Increasing the speed of the Boston whaler that the test dolphins accompanied from two meters per second to three meters per second caused their heart rate and other metabolic signs to increase. At four meters per second, the dolphins refused to swim alongside the boat, instead dropping behind it.



"It almost looks like they're gliding—the pectoral fins move out from the body, and there's almost no fluke movement," Williams says. "Even though they were at four meters a second, their heart rate, respiration, and lactate levels fell below the readings at slower speeds. It's like drafting on a bicycle behind a truck' and getting pulled along by the wind."

Dolphins can ride bow as well as stern wakes of ships and even whales. The personable dolphins also dive to 1,500 feet, far below the depth to which most submarines can plunge, which may be one reason the Navy is interested in their seagoing abilities.

—Ben Barber

A SENSE OF PLACE

Psychologists have traditionally maintained that infants cannot formulate long-term memories until the age of eight or nine months—about the time they start exhibiting language skills. Researchers at Rutgers University in New Brunswick, New Jersey, however, have disproved this belief in recent experiments with three-month-old infants.

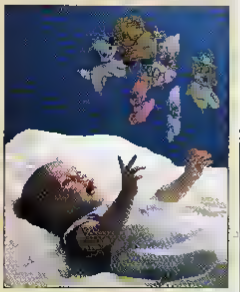
The researchers trained the babies to move a mobile suspended above their cribs by kicking when a white ribbon attached to the mobile was fastened to their ankles. Two weeks later, the infants demonstrated near-perfect recollection of the task, so long as they were placed in exactly the same environment—in the same room, in the same crib, and with the same color and pattern on the crib liner. The babies showed no retention whatsoever when tested in a different room, with a different color or pattern on the crib liner, or with no liner in the crib at all.

"They don't respond if you change the slightest little aspect of context, even though it is totally irrelevant to this game," says Rutgers psychologist Carolyn Rovee-Collier. "That's surprising, because the infants never seem to look at the crib liner when they're being trained. We learned that just because they don't look at the liner doesn't mean they don't see it."

Precise visual cues—such as the mobile's seven wooden figures or the yellow crib liner with green felt squares—help infants figure out the particular memory they're supposed to retrieve. "A baby knows what is supposed to happen in a given place," Rovee-Collier explains. "They know what happens on the changing table, in the kitchen high chair, or in the car seat. But they don't know the relation between places—like where the car is. Sometimes we don't know that either."

—Steve Nadis

Babies have memories, too



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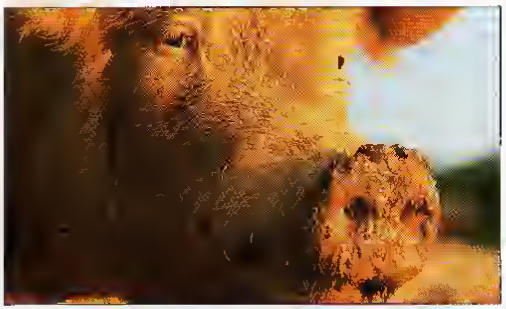


Soooooooeeeeee! Pigs not surprisingly love ice-cream slop

ICE CREAM FOR PIGS AND PROFIT

About five years ago, runaway growth forced the Ben & Jerry's ice cream company to drastically reduce waste water emissions at its Waterbury, Vermont ice-cream plant. Looking for an innovative solution to the problem, the company purchased about 300 pigs and started feeding them ice-cream slop—the same goop it had previously fed to sewers. "The pigs absolutely loved it, except for Mint Chocolate Chip," says spokesperson Rob Michalak. "We suspect it's the mint."

Although the pigs have made a serious dent in the volume of ice-cream effluent headed to the town's water-treatment facility, Ben & Jerry's didn't stop there. It built two large lagoons that pretreat liquid wastes without using chemicals through a process called aeration. Recently, the firm began diverting some of its dirty water to a "solar aquatics" system—a big greenhouse in which waste water runs through a series of tanks filled with a variety of plant life, bacteria, snails, and fish. The system will eventually handle 10 percent of the company's waste stream.

The waste-disposal situation calls for aggressive measures, owing to the potency of dairy residues. "A five-gallon pail of our ice-cream mix is comparable in terms of water pollution to a truckload of domestic sewage," explains facilities supervisor Gary Audy.

NEW YORK CITY'S CENTRAL PARK IS NEARLY TWICE AS LARGE AS THE SECOND SMALLEST COUNTRY, MONACO.

"We want to make cutting waste part of our everyday consciousness, not just a one-day Earth-day type of thing," Michalak adds.

—Steve Nadis

"Television is democracy at its ugliest."

—Paddy Chayefsky

WASHING CLOTHES CAN BE A GAS

In an effort to make doing the laundry, well, not exactly fun, but less environmentally burdensome, a Florida company has developed a laundry system that does away with detergents, hot water—and the rinse cycle, too.

Ozone is the key to the innovative system devised by Tri-O-Clean of Fort Pierce. The versatile gaseous molecule easily manufactured consists of three atoms of oxygen and it can lift all but the heaviest grease out of soiled clothes by breaking down the organic structure of ordinary dirt and grime. It has trouble with lipstick and really heavy industrial grease, but what washing machine doesn't?

The laundry system consists of a series of holding tanks, filters, and pumps, as well as an ozone generator and injector. Water combined with ozone flows through clothes, loosening the dirt and breaking down its structure. The decomposed dirt is absorbed into the waste water, which then runs back into a holding tank for reuse. It can be recycled hundreds of times before new water must be added.

"Normally you need three gallons of water to wash a pound of clothing," says Tri-O-Clean managing director Charles W. Pearsall. "With our system you use one-eighth of that, so think how much water a commercial laundry that washes three million pounds of clothes a year could save."

The system saves energy as well as water because it uses cold water rather than hot—unstable ozone molecules actually dissipate faster in hot water, Pearsall adds.

Current installations include prisons and hotels, with hospitals and nursing homes being added. Tri-O-Clean entered the Japanese market early this year by forging an agreement with Sumitomo Corporation.

—George Nobbe

Clean machine. This contraption uses ozone to wash clothes

RECONSIDERING THE SPHINX

In our August 1992 issue, Omni published "A Modern Riddle of the Sphinx" by geologist Robert M. Schoch. The article detailed Schoch's research on the Great Sphinx of Giza and his controversial claim that it is not 4,500 years old as Egyptologists believe but rather 7,000 years old. Omni invited Schoch and two of his most prominent critics, Egyptologist Mark Lehner and geologist K. Lal Gaur, to comment further on the issue. Lehner and Gaur declined our invitation. Below is Schoch's response.

In proposing a new dating schema for the Great Sphinx—that it was built in stages and that the earliest stage may date back to 5000 B.C. rather than to Old Kingdom times of 2500 B.C.—I have carefully considered all relevant data. I am sure of my stratigraphic correlations. I am well aware of the nature of the limestone beds of which the Sphinx is carved; some layers are softer than others, and I have taken this into account in my analyses. Though we continue to refine our knowledge of the details of the paleoclimatic history of the Giza Plateau over the last 10,000 years, we already know enough to associate certain dominant modes of weathering with certain parts of that climatic history. Portions of the weathering on the body of the Sphinx predate Old Kingdom times.

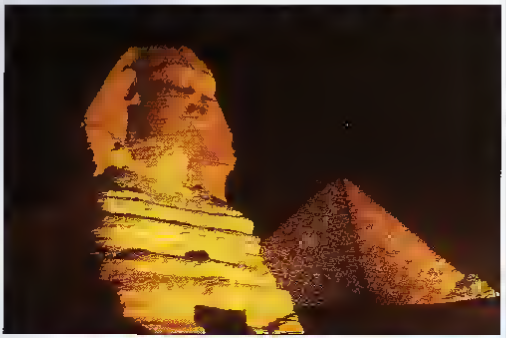
The analysis of the two-stage construction of temples associated with the Sphinx and the multiple repairs to the weathered and eroded body of the Sphinx—the oldest repairs date back to Old Kingdom times according to Egyptologists—lend further support to a pre–Old Kingdom dating of the Sphinx's core body.

The seismic analysis of differential weathering around the base of the Sphinx also corroborates the idea that the Sphinx was built in stages, the earliest stage dating to well before Old Kingdom times. Other explanations proposed to account for the seismic/weathering profiles do not hold up to close scrutiny. The seismic profiles do not simply map a soft layer of rock; they map the true depth of weathering, which does not follow the bedding planes of the strata. The seismic analysis indicates that the limestone behind the rump of the Sphinx, where shallower weathering is recorded, may possibly be slightly *softer* than the limestone that is more deeply weathered, it is definitely not harder nor denser than the more deeply weathered areas. The consistency of the seismic profiles—and the fact that differing weathering depths can be recorded—is confirmed by additional seismic profiles taken in other areas, including a north-south profile taken through the middle of the Sphinx Temple in front of the Sphinx.

Finally, though the Sphinx may be the earliest recognized monumental structure in Egypt, even earlier massive stoneworks existed in other parts of the Mediterranean. The walled city of Jericho, dating back to 8000 B.C., sits only a few hundred miles away.

Readers interested in a more detailed, referenced discussion of the evidence for an older Sphinx should consult "Redating the Great Sphinx of Giza" by Robert M. Schoch, published in the Summer 1992 issue of *KMT, A Modern Journal of Ancient Egypt*, volume 3, number 2.

—Robert M. Schoch



Has the inscrutable Sphinx revealed its true age?

GLOWING WITH LACK OF HEALTH

A farmer stands in a field with a rake in one hand and a light sensor in the other. With the sensor he checks on the well-being of his plants.

This unusual rustic scene is predicted by British scientists who have genetically engineered plants that give off a light blue glow when they're suffering from an ailment, such as drought, frost exposure, or fungal attack. The amount of light the sick plants emit, the researchers say, identifies the specific problem. And eventually, these plants can be positioned in a field so that they give a farmer a reading of the health of his entire crop.

The scientists at Edinburgh University's Cell and Molecular Biology Institute started by extracting a tiny amount of DNA from a glowing Pacific jellyfish. They next inserted it into such plants as tobacco, potato, and a type of cress. When these plants feel "stress," their calcium levels rise and react with a protein made by the gene, producing a faint, sky-blue light. The amount of light increases with the plants' stress level.

"The beauty of it is that the farmer receives warning that his crop is in danger before the damage is done," says Marc Knight, a member of the research team.

—Ivor Smullen

"Being a philosopher, I have a problem for every solution."

—Robert Zend

RUNNING THE NUMBERS:

The Ruminations of John Allen Paulos

Article By Janet Stites

This is not a test. You won't need a No. 2 pencil, a sharpener, slide rule, or pocket protector. If you don't know how to figure pi or that there are an infinite number of prime numbers, no problem. You won't be factoring any polynomials or inverting matrixes. You don't even need to know what a polynomial is. Put away your calculator. Pull out your common sense. Have a seat while Temple professor John Allen Paulos, 47, mathematician and writer, dispels the myth that Americans are hopelessly innumerate—that is, unable to deal comfortably with the fundamental notions of number and chance. Innumerate maybe, hopelessly, not.

It's been said there are two types of people in the world—those who divide the world into two types of people and those who don't. It's also been said that there are those who can divide and those who can't, left brainers, right brainers, numerates and innumerates, those who ponder pi and those who eat it. Paulos wants the segregation to stop. Saying someone can't learn math, Paulos warns, is equivalent to saying someone can't learn to read.

"You see someone who can understand anything," Paulos says, "the most complicated legal nuances, the most intricate emotional transactions, and with numbers, their eyes glaze and

Photography By Peter Liepke

"Mathematics is messy, full of false starts, dead ends. Half the time, it's incoherent."

their gut-level common sense evaporates." Paulos attributes this to a simple fear of math fostered by an educational system that emphasizes practice without incorporating concept, by professional mathematicians who retreat into theoretical speculation, by gender myths, and by a disregard for critical thinking. "Math is thinking," he says, "thinking about numbers, about space, quantitative relationships. It's akin to logic and common sense."

Ominous, Paulos calls the growing dichotomy between research mathematicians who are experimenting with the emerging sciences of chaos and complexity, rethinking the relationship between philosophy and math, and lay people—high-school sophomores stifled by algebra, grocers inundated by shoppers when there's a 20-percent chance of snow (which, of course, means there's an 80-percent chance that it *won't* snow), and people who feel perfectly safe driving without seat belts but won't get on a plane, fearing it will crash. "Certainly the mathematical and technical elite in this country are the best in the world," Paulos says. "People come here from all over to go to graduate school. But people don't come here to go to junior high. The knowledge doesn't filter down." Indeed, of the 1,050 people who received Ph.D.'s from universities in the United States in mathematical sciences during the period July 1991 to June 1992, less than half, 430, were U.S. citizens, according to the American Mathematical Society. Of the U.S. citizens, 103 were women, 6 were black—figures that give the word *minority* a whole new context.

This situation, Paulos insists, doesn't have to be. There is no genetic code, he says, predetermining that someone will have trouble figuring a 6-percent sales tax on a ten-dollar sale. To help solve the math problem in this country and to reduce the gap between people who can't subtract and those who do Fourier analyses in their offices, he published in 1989 *Innumeracy: Mathematical Illiteracy and Its Consequences*, which stayed on the *New York Times* best-seller list for 18 weeks—a surprise to Paulos and his publishers and, perhaps, a sign that innumerates secretly yearn to conquer their math phobias. *Innumeracy* introduces readers to a conceptual approach to numbers, statistics, and mathematical problems. For example, commenting on the common, almost flippant, transposition of millions and billions, Paulos writes, "It takes only about eleven and a half days for a million seconds to tick away, whereas almost thirty-two years are required for a billion seconds to pass." Or he adds, trying to help us grasp magnitudes, "Agriculture's been here for approximately 300 billion seconds (10,000 years) and writing for about 150 billion seconds, but rock music's the newcomer—appearing about one billion seconds ago." And the nuclear weapons on board just one of our Trident submarines, he asserts, "contain eight times the firepower expended in all of World War II."

It's figures like the last one that Paulos is especially concerned people understand. If a shopper thinks a coat that's been marked down 40 percent and then another 40 percent has been marked down 80 percent, that's discouraging, he says. It's potentially disastrous, however, if people don't understand that the annual Defense Department budget of about a quarter of a trillion dollars amounts to approximately $4,000 per year for a family of four.

> "There is no genetic code predetermining that someone will have trouble figuring a six-percent sales tax on a ten-dollar sale."

He calls the first simply bad decision making, the second, blindness.

"I'm distressed," he passionately says, "by a society which depends so completely on mathematics and science and yet seems so indifferent to the innumeracy and scientific illiteracy of so many of its citizens, with a military that spends one quarter of a trillion dollars each year on ever smarter weapons for ever more poorly educated soldiers, and with the media, who invariably become obsessed with this hostage on an airliner or that baby who has fallen into a well and seem insufficiently passionate when it comes to addressing problems such as urban crime, environmental deterioration, or poverty."

In print, Paulos can be justifiably pointed with his criticisms of innumerates and particularly intolerant of weather forecasters who pass off a 50-percent chance of rain on Saturday and a 50-percent chance of rain on Sunday as a 100-percent chance that it will rain over the weekend. He is vexed by people who can quote *Hamlet* but brag about not being able to balance their checkbooks. "I'm a people person, not a numbers person." Sit down with Paulos however, and you find that his intolerance is frustration, that he has a general sympathy for innumerates and rests as much blame on educational methods and cultural myths as the individual. He is quiet, seemingly more philosopher than scientist. He is funny, but because he is quiet, his humor is often missed, disregarded as an afterthought. He mumbles and digresses.

A doctorate in mathematics from the University of Wisconsin, Paulos has written four books. His first, *Mathematics and Humor*, is a lighthearted treatise on how much of humor—particularly riddles, paradoxes, and non sequiturs—is based on mathematical models. "Keep Litter in Its Place," the sign reads, which by definition of "litter" means "the ground." In his second, *I Think Therefore I Laugh*, Paulos relies on his background in the philosophy of math to link humor, philosophy, and mathematics. "This sentance has three erors." His third is *Innumeracy*. His fourth, *Beyond Numeracy*, he wrote for fans of *Innumeracy* who wanted more math.

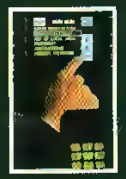
On the wall behind Paulos' desk in the math building at Temple is a photograph of British philosopher and mathematical logician, Bertrand Russell, who wrote often on the relationship between philosophy and mathematics, of which Paulos is fascinated. Russell was a political activist, an outspoken critic of everything from World War I to the mores of the church, often at the cost of jobs and friends. While lecturing in China in 1954, he became so ill that he was thought dead. One obituary notice in a missionary journal read, "Missionaries may be pardoned for breathing a sigh of relief at the news of Mr. Bertrand Russell's death."

But Russell disappointed the missionaries and went on writing and working, organizing the Campaign for Nuclear Disarmament, taking up the cause of Jews in Russia, and even serving as president of the British "Who Killed Kennedy? Committee" until his death in 1970. "It isn't common for people with a mathematical or scientific background to be involved in public issues," Paulos says, and it's evident that Russell's work has been an inspiration for Paulos' own writing. The philosopher's response to a letter Paulos wrote him as a college student is even included in Russell's autobiography.

Russell's paradox stated in terms of set theory involves a certain set in which *N* is a member of itself if and only if it is not a member of itself. Or in

CONTINUED ON PAGE 65

AUTOMOBILITY: CARS THAT DRIVE THEMSELVES



As your car "sees" approaching obstacles, as it "senses" the roughness of the pavement and "converses" with street-side information posts and even with other vehicles, its microprocessor brain will activate electromechanical motors that control steering, accelerating, slowing, and cruising. On priority roadways—urban freeways, tunnels, and bridges—your car's own decision making might be superseded by commands from a traffic-monitoring center that integrates vehicles in a coordinated traffic pattern, like air-traffic control. "It will be a modern version of the highway, where a lot of the typical functions of the driver will be controlled by the highway itself," says one expert.

Imagine waking from a nap in a near-future time, finding yourself behind the wheel of your car, careening at 65 miles per hour just a few feet behind the bumper of the automobile ahead of yours. Naturally, you stomp on the brake, *but nothing happens!* Your car is in control, and fortunately for you—and about a dozen other dozing motorists—it's a better driver. Had your brakes activated, you would have wiped out the car tucked just a few feet behind yours, and the one behind it, and so on. You are trapped in a highly congested corridor. The vehicles steer themselves by following a guidance signal transmitted from sensors in the cars. Other sensors and microprocessors and communication gear aboard each car create invisible couplers, enabling the group to pack together bumper to bumper. It's like riding in a private compartment aboard a train. But when it's time for you to exit the freeway, the car takes you off the ramp and you take the wheel again to make your way independently to home or office, or maybe to pick up your daughter after her weekend camping trip. ➢ In traffic-choked regions like the L.A. basin, such automatic driving will first appear probably around 2010. It will herald the second revolution in personal transportation: liberation from traffic and travel ills by automobiles that drive themselves. ➢ It's a notion that only technologists can love—one that environmentalists and ban-the-buggy extremists may loathe—that we develop better automobiles to treat the illnesses that automobiles themselves engender. According to the argument for intelligent vehicles and highways to accommodate them, cars aren't to blame for the congestion on our urban expressways. The real problem is that we human drivers simply cannot operate our autos well enough. Self-piloting ones will run with far greater precision. ➢ Automatic driving will close up the average 100-foot gap that freeway cruisers keep between vehicles as a cushion for human reaction times. Such measures increase highway capacity promising to unclog traffic congestion. Cars under autopilot will motor more efficiently, too, spewing less pollution. They'll make roads safer and more orderly, eliminating human misjudgments that cause most accidents. And the systems will remove the remaining drudgery from driving, freeing motorists to use travel time for fun or profit. "IVHS (Intelligent Vehicle and Highway Systems) will ultimately rewrite the whole book on transportation, on land use, on the choices people make about where they work and where they live," says John Vostrez, director of research and technology for IVHS America, the Washington-based transportation advisory group that unites politicians, inventors, business executives, and scientists. But to reach its full potential, automatic driving requires changes, concessions, and compromises from transportation consumers and creators alike. Auto companies must work cooperatively on compatible communicating equipment that will allow all cars on the road to operate in tight synchrony. Governments must provide the electronic infrastructure for the roads they own and operate. This, in turn, will require a lot more care and attention than many crumbling highways now receive. Eventually, individuals will have to acquire new driving habits, learning to trust vehicles that know better than to always do what we want them to. People will have to make personal investments too, purchasing autos specially outfitted to run in coordinated, self-directing traffic systems. IVHS America estimates that the creation and deployment of intelligent vehicles and high-way systems in the United States will require nearly $200 billion over 20 years. Most of that will be folded into the prices people pay for automobiles. ➢ The spending is just beginning. The sweeping 1991 U.S. Transportation Act allocated about $660 million over six years for IVHS, while across the Atlantic, the Prometheus IVHS project has the underwriting of virtually the entire European auto industry. Also, industry and government partnerships are conducting traffic-automation tests in Japan. "The whole thing depends on whether society decides that we will spend some of our resources to develop and deploy these technologies," Vostrez says. ➢ Meanwhile, the pace of technological discoveries and developments threatens to leave us behind. The machine in your driveway

BY JEFFREY ZYGMONT

ROBOT CARS

As a human assistant, automatic driving aims to augment decision making, or take over entirely only under certain conditions as when a car enlists in a platoon But research already shows that unmanned robot cars may yet arrive

The Transportation Institute of Texas A&M University created a self-piloting Dodge Caravan minivan by making surprisingly scant additions two video cameras for vision with depth perception a Compaq 386 personal computer for brain power and actuators from Johnson Controls for handicapped drivers "It's all equipment that you can go down to your local dime store to buy," says Sadler Bridges deputy director of the Institute

The van was taught to recognize stop signs and to convoy behind another vehicle But its MS-DOS computer brain posed limitations Because DOS performs only one task at a time, Texas A&M's robot car couldn't turn its camera eyes and its wheels at the same time in order to follow a car around a sharp turn

In Japan, Nissan also relies on video cameras in its Personal Vehicle System "The PVS is capable of running autonomously to a specified destination without receiving any support from the road by detecting white lines on the road surface and by avoiding obstacles in its path," reported researcher Akio Hosaka at a meeting of the Transportation Research Board last year

That's every bit as hard as it sounds Fuzzy logic and expert systems, both forms of artificial intelligence, perform control functions and determine speed and cornering angles The Fujitsu image-processing system includes measures to dampen the blurring caused by vehicle motion, and it sorts out breaks in the lane-marking stripes caused by passing cars

Even that's not enough In describing the complicated mental and physical process by which a driver maneuvers past an obstacle Hosaka notes that a person even predicts how the relative position between car and barrier may change Such mental finesse performed in ordinary driving is still well beyond practical computing capabilities the variables on ordinary urban roadways are simply too numerous Therefore it will be a long time before unmanned automobiles can even traverse a city block Hosaka suggests starting out on more controlled environments like freeways, where kids are less likely to bounce a ball in front of the car

today relies entirely on your sight, hearing, proprioception, and kinesthesia for guidance, and on your limbs for control But if it features antilock brakes or traction control, as many do your car is already taking over Eventually, it will assume total control through devices that monitor such variables as road speed, turning angle, the amount of gas pouring into the engine, and the level of braking being applied Radar will detect the position and even compute the speed of vehicles on the road around you As your car "sees" approaching obstacles, as it "senses" the roughness of the pavement and "converses" with street-side information posts and even with other vehicles its microprocessor brain will activate electromechanical motors that control steering, accelerating, slowing, and cruising On priority roadways—urban freeways, tunnels and bridges—your car's own decision making might be superseded by commands from a traffic monitoring center that integrates vehicles in a coordinated traffic pattern, like air-traffic control "It will be a modern version of the highway where a lot of the functions of the driver will be controlled by the highway itself," says Randolph Hall a manager for California's Partnership for Advanced Transit and Highways

Called PATH, the organization rides the forefront of automatic driving When the car-pool lane of Interstate 15 near San Diego closes after rush hour, PATH researchers test four Ford cars electronically tied into a single file—so far at speeds up to 75 miles per hour PATH researchers also teamed with the company IMRA America and are working on automatic steering A magnetometer beneath the car reads the field created by a trail of magnets embedded along the center of the lane PATH aims to combine the two capabilities to demonstrate platooning on a real freeway by 2001

The advent of automatic driving comes as a happy confluence of technology and societal need By 1990, America brimmed with 143 million registered cars about one automobile for every two residents, cites the Federal Highway Administration (FHA) That same year the average American male spent more than 16,500 miles on the road, nearly 20 percent more than the 14,000 miles he drove in 1983, says the FHA Female drivers increased their highway usage nearly 50 percent during the same period, averaging about 9,543 miles annually by 1990 The resulting traffic congestion, along with the hazards and pollution it breeds, cries out for a solution IVHS America—which serves as a coordinating body, encouraging industry and government to work together toward improving land transportation through a wide range of technologies—estimates that each commuter experiencing a ten-minute daily delay sacrifices up to $1,200 annually In lost time and extra fuel The U S government's General Accounting Office prices the annual productivity loss from traffic congestion at about $100 billion nationwide It can only get worse Since the 1960s, the number of vehicles registered in the States has grown faster than the population, according to FHA figures And the National Highway Traffic Safety Administration estimates traffic accidents cost U S consumers $130 billion annually

Better technology may be the only alternative to eventual limits and restrictions on motor travel A 1991 report to the Senate Subcommittee on Transportation by the General Accounting Office found that automated highway systems could increase road capacity by as much as 300 percent "by allowing vehicles to travel closer together at higher speeds" Projections by PATH find that the capacity of a freeway lane could increase to 6,000 cars per hour from the current average of about 2,200

Even better, those 6,000 cars would drive themselves so well that traffic would actually move, not lurch and stop and crawl and stall "You can minimize stream turbulence in congested traffic," says PATH director Don Orne Stream turbulence starts when brake lights appear As following drivers react, a shock wave passes through traffic, sometimes stopping cars that are far behind the original incident

Human reaction—especially over- and underreaction—is the bogeyman of auto motion "The majority of accidents are due to errors by the driver," says Hall Computers are simply less error prone, providing consistency and precision Automatic driving can also

CONTINUED ON PAGE 89

Smart Materials

From bridges to submarines to the walls of your home, the materials of the constructed world will take on the animated character of a Disney cartoon.

Bracing against gale-force wind, the 50-story skyscraper on Miami's beachfront stiffens its skeleton like a giant Sumo wrestler under vicious attack. The tiny processors embedded in its walls enable the structure to stiffen with each new punch of the wind, avoiding the destruction caused by killer hurricanes of the past. Meanwhile, a hundred miles offshore, a submarine slithers smoothly through the water, avoiding debris and currents by curving its 200-foot-long sinuous body like a whale. And a thousand miles away, in New York City, a jumbo jet pummeled by violent turbulence finally lands and pulls up at the gate. The plane has suffered subtle damage—a tiny stress fracture just above the port engine. In the old days, the plane might have taken a hundred more journeys before the fracture was large enough to be found. But airline mechanics know just how to repair the tiny rift, thanks to instructions from the body-sensitive—and verbally gifted—plane.

Scientists are already making the first embryonic versions of intelligent materials that sometime in the next century will animate structures from buildings and roads to submarines and planes. The first generation of glass fibers that mimic the human nervous system—warn-

Article By Gurney Williams III • Photographs By Greg Vaughn

"In the future, material and machine will be designed as one."

ing of danger before structural failure—is insinuating its way into airplane wings at the University of Toronto. Sensitive rope for mountain climbing, developed by the Cairngorm Climbing Rope Company and the University of Strathclyde in Scotland, changes color to highlight damaging stress. Researchers in Illinois are equipping dumb concrete with enough smarts to bleed fluid, as needed, to fight corrosion.

Other more intelligent materials already under study not only detect the environment, but also react to it by instantly curing small stress fractures, smothering noise, and even changing shape or internal tension like muscles. Some researchers in Palo Alto predict that all of these devices are prelude to an age when hundreds

Center for Intelligent Material Systems and Structures (CIMSS) at Virginia Polytechnic Institute and State University in Blacksburg. Glancing about a single large room, one sees what seems like an ensemble of talking toys reminiscent of a Disney cartoon. A sensitive wire trailing across the floor generates a youthful self-portrait on a small video screen. The image looks like a bold line of Tinkerbell gold dust. Pinch the wire anywhere along its six-foot length and the trail on

resident Gepetto is none other than Virginia Tech's own Craig Rogers, Ph.D. "It's going to be even more difficult in the future than it is now to distinguish between the material and the machine," says Rogers, a boyish and bespectacled professor as animated as one of his smart machines. "Material and machine are simply going to be more integrated. They're going to be designed as one."

One of the most pervasive skills of the new smart materials will be an uncanny ability to sense danger and avert problems before they even occur. In fact, the prospect of accidents and natural disasters motivates much of the smart-materials research today. Some mention as an example a single aircraft crisis in April 1988 that underlined the need for

Scientists at Virginia's Center for Intelligent Material Systems design smart building blocks for walls (left and right) and airplanes (top).

passive warning systems comparable to the pain network in the human body. A 19-year-old Boeing 737 peeled open over Hawaii when roof rivets gave way. A flight attendant died after she was swept through an 18-foot-long hole above the passengers' heads, and 61 of the 94 others aboard Aloha Airlines flight 243 were injured before the plane landed safely on Maui. The National Transportation Safety Board in Washington later blamed the airline for failing to detect metal fatigue that caused the accident. The detection would have been child's play for some of the smart-material systems under development at the Fiber Optic Smart Structures Laboratory at the University of Toronto. In one project involving the Boeing deHavilland DASH-8 aircraft,

or thousands of tiny reasoning machines will permeate the walls of every home. These computers, salted through virtually all our material possessions and almost every cubic foot of a room, will endow ordinary surfaces and objects with enough pure intelligence to run and repair themselves, respond to environmental conditions and emergencies, and adapt to our human idiosyncrasies and needs.

The beginnings of this brave new world are laid out for all to see at the

the screen wakes up. The golden line dips at a point corresponding exactly to where you've tweaked the wire. On another bench across the room, a smart stick clamped in a vise also reacts to human contact. Pluck its end, and it vibrates like a miniature diving board on its side—until its computer brain tells it to fight the shakes and calm down. Then with the equivalent of fast-twitch muscles, it steadies itself, like a yogi, back into stillness. If the Blacksburg lab is any indication, Pinocchio lives. And the

hair-thin fiber-optic strands lace the leading edge of a wing like nerves embedded in human skin. Light piped through the strands appears as pale red parallel lines spaced about half an inch apart on the wing. But at points of even modest damage, the red laser light bleeds profusely from fractured optical fibers. With this stunning technology, failure points on flight 243 would have looked like open wounds.

More complicated sensors under study in the Toronto lab don't require human inspection at all. One is called the Fabry-Perot system, named after the two Frenchmen who invented the basic idea for use in barometers in the nineteenth century. Laser light fired down a fiber enters a kind of "hall of mirrors"—a chamber as small as a millimeter long—formed by two tiny reflective surfaces. Twisting, stretching, or compressing the fiber will alter the intensity of the light, sending a clear SOS to a computerized detector. An advanced version of this device can even measure strains in specific locations on the fiber. Wings and fuselages equipped with dozens of these sensing regions, checked continuously by laser beams, could pinpoint problems and alert pilots. And engineer and lab director Raymond M. Measures imagines that such fiber-based nervous systems will take off in more than just future aircraft. Networks of fibers could line the walls of nuclear reactors or storage vessels for hazardous materials, signaling danger before cracks appear. Similar sensors lining the walls of buildings could save lives as well. "One of the most serious questions after an earthquake, for example, is knowing which building you evacuate first because of internal damage and the prospect of aftershocks," Measures notes. "If buildings were fabricated with a resident sensing system, endangered structures could send signals to rescue workers, who would know just which residents to evacuate first."

A few notches up the material I.Q. scale are things that not only sense their own condition, but—like the human immune system—actively fight deterioration or damage. At the University of Illinois at Champaign, architect Carolyn Dry designs smart systems to stop corrosion in bridges or any structures made of reinforced concrete. Concrete itself in its dumb form is a wise choice for construction, she says. It's cheap, and generally strong. But it has two weaknesses: It's brittle, increasing the chance for cracking under loads, and it's porous, allowing water to seep through and corrode metal-reinforcing beams called rebars. Engineers deal with brittleness by adding fibers to con-

crete to make it more flexible. "So I thought, What if you just combined the fibers with something to alter the chemistry from the inside?" Dry says. In preliminary work at her lab, she wraps concrete with hollow protective fibers that look like angel-hair spaghetti. To make a smart strand, she fills each fiber with liquid calcium nitrite, an orange anticorrosive chemical. Then she seals the "spaghetti" with polyol, a waxy coating that dissolves in salt water. When moisture threatens a portion of a rebar, the nearest strand melts and bleeds enough chemical to provide protection. Dry is also drawing up plans to heal cracks by blending similar fibers into concrete. Hairline splits in bridge or road material would fracture fibers to release a glue, curing the crack on the spot.

Dry's long-term dream is to create materials with the life cycle of an animal or human. "My paradigm is that when you put a material into the environment, it adapts over time and is eventually recycled." It would become a laboratory version, in other words, of birth, growth, death, and rebirth.

No one has yet built the Adam and Eve machines to live through the full cycle—a self-healing bridge or airliner. But today's labs are already incubating body parts comparable to the slow-twitch muscles that propel distance runners in a marathon and the fast-twitch muscles that fire sprinters in the hundred-yard dash.

The slow-moving, slow-twitch materials include shape-memory alloys (SMAs) like nitinol, a combination of nickel and titanium. At room temperature, you can bend nitinol into any shape without breaking it. But when you heat it over a flame or warm it with an electric heating wire, nitinol returns in seconds to its preset shape—and pushes or pulls powerfully against anything that tends to constrict it.

You can watch animated nitinol in Craig Rogers' lab. Moving in slow motion, the small model of an aircraft wing is flat on the bottom and curved on the top. Nitinol wires inside the wing stretch like guitar strings from the trailing edge up to the top of the curve. When these wires are heated, they contract, pulling the trailing edge down. Built full-scale, such a wing would have no flaps; instead, the whole structure would change shape as needed, like the wing of a bird.

At Catholic University of America in Washington, D.C., researchers are already building a prototype of a smart helicopter blade equipped with nitinol. The SMA wires, 22 thousandths of an inch in diameter and a few inches long, run through the width of the blade from edge to edge. Current through these wires causes the wires to heat and contract, tugging the blade edges together with about 25 pounds of force per wire. When it's especially turbulent aloft, the energy of the wind will stimulate the current, warming the wires and firming up the blade like a tensed muscle. As a result, the copter in flight would be more resistant to wind-induced stress.

The goal at Catholic is using tensing-relaxing SMAs to build a chopper like a mosquito, whose wings and body can turn to steel in a storm. "We're trying to design lightweight equipment so you can add more payload without compromising the helicopter structure, which stiffens up when needed to prevent damage," says Catholic University mechanical engineer Amr Baz, whose work is funded by a three-year $300,000 U.S. Army grant. Smart blades might fly in real helicopters in the near future.

Meanwhile, as slow-twitch muscles in copters pump iron, other smart materials work like the fast-twitch muscles in your eyelid. The fast-twitch model in Craig Roger's lab, for instance, is a metal stick extending a few inches out from a vise. When you bat its end, it hums in vibration.

But every swing of this shaking stick is picked up by an inch-square patch taped to one side and connected to a nearby personal computer. The patch is piezoelectric, an off-white material made of baked ceramics and polymers. Piezoelectrics produce an electronic signal—a message to the computer—every time they're bent or squeezed. And they react faster than an eye blink by twitching when electric current flows through them. The computer samples the current from the piezoelectric sensor 150 times a second to gather enough data to calculate a way to stop the shaking. Then, with precise timing to dampen the vibration, the computer zaps current to other piezoelectric patches that generate forces equal to but opposite the motion of the stick. In less than two seconds, these sensors cancel out the energy in the stick, and the shaking stops.

Similar sensors, meanwhile, can also absorb vibrations caused by sound waves. Rogers' lab has already built silvery curtains of piezoelectric material that catch and kill noise. He raises his right hand in the air, like a prizefighter, to explain how the curtain works. "Think of incoming noise as pressure waves," he says, punching his hand forward. "And your hand is the curtain. Now if every time I push, you're pulling away at exactly the same time—like a boxer dodging a punch—then I can't

CONTINUED ON PAGE 91

THE DECLINE & FALL OF RUSSIAN SCIENCE

Political and economic anarchy threatens to destroy the very existence of Russian science. As institutions falter, desperate scientists scramble to make deals with Western corporations, and scientific and philanthropic organizations rally their own dwindling resources to keep science alive in the former Soviet Union. But is it enough to preserve the foundation of scientific research vital to a nation undergoing such cataclysmic change?

ARTICLE BY LINDA MARSA • PAINTINGS BY DOUGLAS FRASER

Collaboration is the only way to resurrect our computer industry," Dr Boris Babaian tells the packed house of reporters assembled at the posh waterfront hotel south of San Francisco The 60-year-old Babaian, a sturdy man with bushy eyebrows, coarse Mediterranean features, and an incandescent smile, doesn't look like the computer wizard who invented the Soviet Union's supercomputers But behind the rounded lar exterior lies a wily survivor who navigated for more than 30 years through the treacherous Soviet bureaucracy and kept his legendary computer-software design team intact in the face of an abortive political coup and economic anarchy

On a crystal-clear day this past September, Babaian, accompanied by a handful of his superstars, traveled from Siberia to Silicon Valley—light years in psychic miles—to discuss a joint computer-development deal with Sun Microsystems, one of America's most innovative computer companies. "This commercial agreement makes it possible to continue our work," Babaian says of the capitalist baptism of these former Communists, flashing his trademark smile "Otherwise, our team would have been destroyed "

The folks at Sun are equally thrilled. "This is not an addition, but a multiplication of forces," says Sun's CEO, Scott McNealy, beaming with pride It truly is an historic agreement They're pioneers They're contributing to world peace—and they're probably going to make plenty of money, too

Slightly different versions of this scene are playing themselves out in laboratories, government agencies, universities, and boardrooms as scientists from the former Soviet Union (FSU), once branded the enemy, are now warmly embraced by Corporate America and the scientific community It's all part of an ad hoc mission to prevent the collapse of the FSU's vaunted technological and scientific enterprise, which has fallen on some hard times

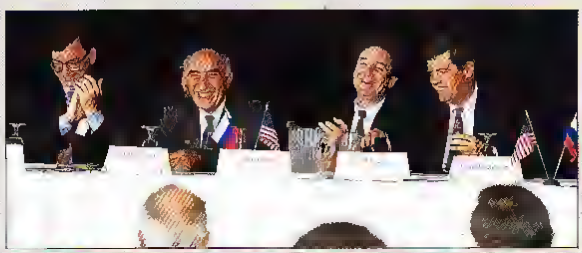
To help preserve Russia's scientific infrastructure Congress has earmarked $400 million to dismantle the former empire's nuclear arsenal, and more aid may be on the way American financier George Soros has pledged $100 million over the next two years to provide funds for research, equipment, and scientific institutions Government agencies and scientific and philanthropic organizations have launched more modest assistance and collaborative research programs A number of companies acting out of enlightened self-interest, are tapping into this vast—and remarkably cheap—pool of scientific talent through joint ventures like the partnership between Boris Babaian's software team and Sun Microsystems.

Some question this bailout, however, when American

Russia's glorious scientific tradition includes excellence in "blackboard" disciplines, like theoretical physics and applied mathematics, innovations in computer software design that compensate for a lack of basic technology, and an amazingly consistent space program.

scientists are hustling for dwindling research dollars and younger researchers are being forced out because they can't get grants. After all, they argue, an entire FSU institute could be supported for a year on the salary of a postdoctoral student, so the Russians are simply taking jobs away from Americans. But others believe this unofficial scientific Marshall Plan is vital to the future not only of the former Soviet Union, but to science itself.

Indeed, the picture experts paint of the current conditions within the FSU's scientific community appears pretty grim. The free-market economy certainly flourishes, and the well-stocked kiosks that line Moscow's streets sell the same items—and keep the same hours—as convenience stores. "If you are affluent or a foreigner with hard currency, you can live a relatively normal life," says Harley Balzer, director of Russian Area Studies at Georgetown University in Washington, DC.



Boris Babaien (second from left) with his new Western colleagues.

"But two-thirds of the people can't live like that—and they resent it deeply."

Runaway inflation has made the ruble practically worthless. Scientists' salaries no longer buy even basic necessities, essential equipment lies idle for want of spare parts, costs for subscriptions to foreign journals and trips abroad to conferences—key links to the international science fraternity—are prohibitive, and more than a few of the prostitutes prowling Moscow's tonier bars are unemployed engineers. Desperate Russian scientists are selling any piece of hardware that's not nailed down in exchange for hard currency.

But their biggest export is intellectual. More than 500 members of the Russian Academy of Sciences, along with thousands of other researchers, have emigrated. About 8,000 refugee Soviet scientists have flooded into New York City alone in the past two years. These defections to the West, reminiscent of the scientific exodus out of Germany before and after World War II, have left many of the FSU's premier research institutes half empty. Even Moscow's legendary Lebedev Physical Institute, which produced five Nobel Prize winners and once served as a bustling mecca for the world's best theoreticians, is now eerily quiet.

The internal brain drain is even worse. In a country where bus drivers earn more than chemical engineers, about 600,000 scientists have gone into another line of work. The Russian Academy of Sciences just announced plans to slash staff in its 300-plus scientific institutes by 40 percent, which could displace another 25,000. Those who remain are demoralized, work in many laboratories has stopped, and a few disciplines face extinction because the critical mass of researchers needed to stimulate each other's work has vanished. Some fear an entire generation may be lost, threatening the long-term survival of the world's largest work force of scientists and engineers.

But why worry about the fate of researchers halfway around the world when the careers of some home-grown scientists are in jeopardy? "The dangers of doing nothing are twofold," counters Balzer. "First, it would destroy a system of training large numbers of good people. Plus, we'd lose some top-flight scientists. Potential Nobel Prize winners are already driving cabs in Moscow. Suppose they were the ones who would have found a cure for AIDS or a way to reverse ozone depletion? To waste a resource like this given global ecological and medical problems is tragic."

Indeed, Soviet scientists were long stereotyped as the bumbling gang that couldn't shoot straight. But decades of isolation combined with the lack of even basic technology sparked highly original and unusual solutions to science and engineering problems. Pockets of innovation exist—in computer software, metallurgy, materials science, high-energy physics, and synthetic chemistry—where the Soviets are second to none. And in the so-called

blackboard disciplines, like theoretical physics and applied mathematics, where the only tools required are a sharp pencil and a sharp mind, the former Soviets simply know no peer.

"The loss of that community, with its unique flavor, perspective, and culture, would be catastrophic," extols Irving Lerch, a professor of medical physics at New York University and director of international scientific affairs for the American Physical Society. "If they are forced to do science in another environment, it will not be the same. It would be as if the Bolshoi Ballet or Tchaikovsky were suddenly to disappear."

Russia has a glorious scientific tradition—the Russian Academy of Sciences was founded in 1724 by Peter the Great—and its dazzling achievements—in space exploration and nuclear physics—have fueled a national pride that binds together the diverse nationalities of the far-flung Soviet Empire. What's more, in a totalitarian state where thought was molded by communist ideology, science served as a refuge from the scourge of Stalinism for independent thinkers.

Scientists like Andrei Sakharov, father of the Soviet H-bomb, used their protected positions to push for reforms. "All the great dissidents—most of whom were scientists—had a profound impact on changing that society," says NYU's Lerch. "So if the former Soviet Union is to be democratized, we must assist those elements that are most responsible for these changes."

Adding to the urgency of this increasingly dire situation is the fact that expertise is perishable. The longer scientists' attention is focused on surviving bitter Russian winters rather than staying current in their fields, the harder it will be for them to get back into the game. And modern science depends on teamwork. "If Russia does not keep its most productive scientific groups intact, it will be disastrous," warns Leon Lederman, a Nobel Laureate physicist and the former president of the American Association for the Advancement of Science (AAAS). "Everything depends on their becoming economically viable."

To help stem this alarming attrition, scientific organizations and government agencies have started or beefed up existing programs to work on joint projects, replenish needed equipment, and ship scientific journals to central Soviet institutions. In fact, one measure of the esteem with which FSU scientists are held is the outpouring of money and assistance from their colleagues in the West, even though many are battling economic woes of their own.

The American Physical Society (APS) raised $100,000 from members and an additional $825,000 from philanthropic organizations such as the Soros, Sloan, and Meyer foundations and the National Science Foundation to fund FSU research. Similarly, the American Astronomical Society (AAS), which has a far smaller membership than the APS, collected $50,000 from its members, including a whopping $4,000 donation from a group of graduate students at the University of Hawaii.

This money will provide journals and funding for grants selected from proposals submitted by FSU scientists. Though the awards have been a paltry $100, they mean far more, due to the exchange rate. In addition, winning a peer-reviewed competition carries far more cachet than receiving a grant bestowed like a party favor by the Soviet Union's top-down autocracy. "Part of the appeal is you can do so much for so little," says Stan Woosley, an astronomy professor at the University of California, Santa Cruz, who spearheaded the fund-raising drive. "We're doing this because they're our family, part of the community of astronomers and astrophysicists."

> "Potential Nobel Prize winners are driving cabs in Moscow. Suppose they were the ones who would have found a cure for AIDS or a way to reverse ozone depletion?"

The AAAS also plans to send science journals to key FSU libraries. And the National Institutes of Health, the National Science Foundation, and the National Academy of Sciences are sponsoring cooperative scientific programs to "take advantage of access to people, places, and things that were unthinkable a few short years ago," says Gerson S. Sher, program coordinator for Eastern Europe at the National Science Foundation.

In addition, the United States, the European Community, Japan, and Russia have pledged $71 million to establish the International Science and Technology Center in Moscow, which will fund civilian projects for former weapons scientists. This serves as part of a larger effort to safeguard the 27,000 warheads in the Soviet arsenal and to ensure that Russian bomb experts won't be tempted to freelance for Muammar Qadhafi or other such leaders. But some critics brand this program a type of "ransom," an instance of governments being held hostage to the demands of FSU nuclear physicists. "Who's taking care of the people who said, 'No, I won't work for the Soviet Military Industrial Complex,'" says Harley Balzer. "They deserve at least as much moral support."

The R&D Foundation, which won Congressional approval, would do just that: finance joint research projects and private ventures through a $25 million spending authorization.

But perhaps the most promising collaborations are synergistic combinations of American and Soviet strengths—which also offer unprecedented access to original technology at bargain-basement prices. Several proposed joint missions between NASA and Moscow's Space Research Institute (IKI), for example—the nerve center of the Soviet space program—are opening up new frontiers in space exploration.

Unhampered by the seemingly interminable delays that plague our space program, the Soviets catapult satellites into space with a metronomic consistency that amazes their American counterparts. The United States and other Western nations, on the other hand, excel in making the precisely calibrated hardware to gather data on astronomy and planetary science that can also withstand the rigors of space flight.

Planned missions like the Spectrum series, which use Russian spacecraft with American instruments—scheduled for liftoff starting in 1995—are a "marriage of what each one does the best," says Alan N. Bunner, chief of NASA's High Energy Astrophysics branch in Washington, DC. "The Russians get state-of-the-art instrumentation on their satellites, and we get a free ride into space—saving American taxpayers millions of dollars."

Another example: Sun Microsystems' deal with Dr. Boris Babaian and 83 members of his research team from the Russian Academy of Sciences' Institute for Precision Mechanics and Computer Technology. Babaian's latest brainchild, the Elbrus III, relies on primitive Russian semiconductor chips with a factor of 1,000 times fewer transistors than the best chips in the West. But it reportedly performs at three times the speed of the West's fastest supercomputers from companies like Cray, overcoming the hardware handicap through software.

This engineering feat is like jerry-

rigging a cumbersome station wagon to rocket at triple the speeds of an Indy 500 race car. Programming the Russians' novel software designs onto American hardware, with our ultrafast integrated circuitry, conceivably could create a new generation of work stations that operate at unimaginable speeds.

"Dr. Babaian has a very clever computer architecture and a spectacularly smart research team," says David R. Ditzel, director of advanced systems for Sun Microsystems Laboratories. "They knew they had good ideas. But stymied by the lag in hardware technology, they could never really prove they had been doing an excellent job." Now they'll get their chance to show the world just what they can do.

Chemist Victor Kartsev, for another, ultimately may not be remembered as one of the youngest winners of the prestigious Lenin Komsomol Prize—he was 33—for his work on anticancer drugs, but as the man who midwifed the birth of the Russian pharmaceutical industry. The energetic 42-year-old Russian scientist, who resides in a suburb of Moscow, helped found SYNTEST, a research cooperative that later opened up offices in Princeton, New Jersey. The cooperative serves as a clearinghouse for more than 300 FSU laboratories where 6,000 chemists experiment with biologically active compounds.

As with computer scientists, so with chemists. The isolation of these scientists led them to explore different avenues of research in practically all areas of pharmacology and agriculture. As a result, they devised exotic agents unknown to the West. The sudden access to these compounds is akin to the experience of American scientists who trekked through the South American jungles in the 1940s and returned with an entirely new pharmacopoeia of drugs.

One of these unique formulas may contain the cure for AIDS, heart disease, cancer, Alzheimer's disease, or any number of other fatal ailments. Kartsev has become a bicontinental commuter of sorts between his Moscow lab and his business offices in Princeton, New Jersey. The company is now negotiating licensing agreements for 40,000 compounds with giant pharmaceutical makers such as Merck, Bristol-Myers Squibb, Hoffman-LaRouche, Wyeth-Ayerst, Sandoz, Lederle, and Ciba-Geigy. (Drug development is a notoriously hit-or-miss proposition that normally requires roughly 10,000 compounds to produce a winner.) "All on a financial basis, of course," says the courtly Dr. Kartsev, with a slight accent. Of course. The Russkies are learning fast.

Numerous other agencies and firms are scrambling to lock up top-flight Russian research teams, almost like major-league scouts elbowing each other at rural high schools for a chance to sign the next Bo Jackson or Larry Bird. Among them: the Department of Energy, General Atomics, Corning, and Bell Labs, and the research arm of American Telephone and Telegraph.

The Department of Energy has purchased high-precision magnets from the Institute for Nuclear Physics in Novosibirsk, Russia, for use in the Stanford Linear Accelerator Center (SLAC) and in the Superconducting Super Collider Laboratory (SSCL). General Atomics, a U.S. company that researches nuclear fusion (generating electricity from nuclear reactions), recently signed a $90,000 contract with physicists at Moscow's Kurchatov Institute of Atomic Energy to conduct tests on their T-10 Tokamak reactor.

> "If they are forced to do science in another environment, it will not be the same. It would be as if the Bolshoi Ballet or Tchaikovsky were suddenly to disappear."

In May of 1992, Bell Labs contracted the services of 100 scientists at the General Physics Institute of the Russian Academy of Sciences, headed by Nobel Laureate A. M. Prokhorov. The Institute serves as the world leader in research in optical fibers, the hair-thin glass strands used to transmit phone calls and computer data via pulses of laser light. Coincidentally, on the same day, Corning signed agreements with 100 researchers at two state-run institutes in St. Petersburg, Russia, to conduct a series of glass-research projects.

Despite all these encouraging developments, though, they represent a mere Band-Aid on a situation that threatens to hemorrhage out of control. Formidable obstacles remain—not the least of which is the lingering legacy of 70 years of socialism and its stifling, inefficient system based on patronage, not merit. "Institutes were run as fiefdoms," says Irving Lerch. "The result: Unproductive areas were promoted, political hacks were in responsible positions, and corruption was rife throughout the bureaucracy."

American scientists can bypass bureaucratic channels and fund the truly productive scientists, rather than the dead wood—those accustomed to simply collecting a paycheck—which some say comprises 60 to 70 percent of the work force. But they have no way of identifying and lending support to the most promising of the new crop. And the erosion of the traditional prestige of science, coupled with the newfound freedom to move into better-paying fields, will make it tough to keep good scientists in the pipeline.

Even the logistics of providing assistance can be daunting. With the banking system in disarray, it's difficult to transfer funds to needy FSU researchers short of simply handing them a suitcase full of money, as some companies are rumored to have done.

There are no quick fixes for these endemic problems, and clearly the behemoth Russian science structure must be downsized. But offering FSU scientists moral support and some alternatives to emigration are key steps toward integrating them into the global scientific community. And the majority have chosen to weather out these cataclysmic changes and use their talents to rebuild their nation. "The most intelligent people have stayed," Moscow-based software designer Yuri S. Rumyantsev tells me after the Sun Microsystems press conference. "We love our work, and we have very long connections with each other. It's hard to leave those human relations. Besides," he adds, his face hardening almost imperceptibly, "science can make the world better." ◻◻

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At left, JUPITER and ZEUS shown slightly smaller than actual size

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Like My Dress

Oh *God,* to have style and money in those days, to take my place up there on the stage with hot Stud Ridley, the magnetic emcee with the neon eyes, my love. Bliss to be in the studio—but to be a contestant! Who wouldn't kill for the thrill? Imagine starring in the global sensation, the absolutely only TV show that keeps dogs away from their dinners, kids home from the malls, and lovers out of each other's arms, everybody too mesmerized to turn it off, and, yes!—all eyes on me in my most death-dealing costume, now *that* is power.

Imagine being the all-time winner in the grand playoffs at the end of the season, taking the trophy in front of the biggest TV audience in the history of competition. Feel the drumroll, hear the shouts as Stud Ridley—*Stud Ridley* crowns you all-time universal winner on LIKE MY DRESS.

Listen. I almost made it. And if the show went down in flames right afterward, so be it. Fine.

With a loss like that, the skies should weep.

There was another winner that season, but there was never another season. All the heart and fire had gone out. Am I sorry? There's a hole in my heart that pills won't reach. Glad? Okay. Yes.

But if you want to blame somebody, blame Lola. Lola Garner did it, my putative best friend. Lola, that I trusted, we used to wear each other's clothes! It was Lola with the baby-blue sweetie-pie stare and her raunchy little ass and all her treachery that brought me down. And I thought she was my friend.

If you want to know the truth, I got into it because of her,

ILLUSTRATION BY SANDRA HENDLER

I flew so high—before I fell. But I am getting ahead of myself.

We worked in the same office, and I ran into her in Labels for Less one day at lunch. She was trying on an orange sequined catsuit that made her ass look like a pumpkin going away. She was preening in front of the three-way mirror as if it didn't even show the back of her, and I had to intervene.

"Hi. you may not know me, my name is Gaby, from the office?"

Well the smile she gave me was flattering, to say the least. "Everybody knows who you are. You're that terribly chic girl."

"Oh, do you really think so?"

"This is such an honor. Everybody wants to look like you." She twirled in the jumpsuit. "What do you think?"

I did it without even hurting her feelings. "I've seen you in better colors."

"Oh, thank you." She took my word for it.

By the time we left, I had talked her into a mauve number that was *very* slenderizing and looked good with my gray suede boots, and she thought I was God. We were bonded from then on.

Or she let me think we were. To think I trusted her! But that was before we even dreamed of LIKE MY DRESS.

Now let me explain a few things to you about costume, so you can see what made that show take off and fly. Now I'm not just talking about us women in the work force. this holds for every guy I know, just look at the ads for man makeup and the eye fucks for men and the hair plugs and the fluorescent shirts, the ass-hugging trousers and natty ties and the two-toned shoes—you think that's for fun? It's for survival. When all about you are losing theirs, at least you know you look good. Shopping is nature's way of telling you you're not dead.

Plus, the pressure is intense. Look at any magazine and you can see it. Look at TV. This world we live in could care less about what's going on inside a person, it's the wrappings that count. So everybody goes to work, we all do our jobs, and no matter how good we are at what we're doing, the world is judging us according to something else.

And you wonder why the whole world fell for LIKE MY DRESS?

Maybe you're too young to remember the show in its heyday: the brocades and sequined jobs designed to stun, the ermine trim that could take out entire battalions, jewels that killed instantly.

And the great thing was, you didn't have to be rich. On the best nights, the judges overlooked your elaborate hand-sewn one-of-a kind evening gowns and your rich people's Issy Miyakes and Christian LaCroixes to give first prize to the Army Surplus coverall with the gold belt or the simple sack dress while a studio audience that numbered in the thousands rose as one person and cheered. It was about how you put things together, whether you had an eye.

In the world of LIKE MY DRESS, money wasn't everything. sometimes money wasn't *anything*. Style was. That imponderable *chic*. You either have it or you don't. Which is what provided the suspense. There would be Ms. Keypunch Operator of Dallas, facing off with one of the crowned heads and some big star who'd dropped a bundle on Rodeo Drive. At the end of the evening she would parade, as good as anybody, and the applause meter would do the rest. She could win! The judges and the audience went for a certain totality of *look* that surpasseth understanding. How else could you account for the excitement, the surprise, the harmony of tension that made an international cult around a television show? I mean, the Golden Calf had nothing on LIKE MY DRESS. Those were the days. If you were old enough to shop, you could not help but hope.

> "In the world of LIKE MY DRESS, money wasn't everything; sometimes money wasn't *anything*. Style was. You either have it or you don't."

And now I'm going to tell you something interesting, and if it splits the difference between men and women, fine. In the first thirteen weeks, there were also men contestants, but the producers dropped them for two reasons.

One, men's clothes are not nearly as good, so except for the one transvestite, in thirteen weeks there was not one male winner.

And two, the bottom line. It was that when push came to shove with those guys they were born losers. They Did Not. Know how to accessorize. Men don't know squat about style. They think they're competitive, but when the going gets tough, they just can't handle it. Give me a woman every time.

What had Lola said the first time we met? "You're that terribly chic girl." My heart rose up.

If only I could bring back that first night. We were on our way out to a Singles Fondue Party when Lola flipped on my set and Stud Ridley came up on the screen and I fell in love. He just sauntered into a pool of light, whistling the theme. the most hypnotically sexy man in the world, with the wavy hair and the sweet, sweet grin that made amazing promises. I died. Is it enough to say that since that night I've never wanted another man?

And this is what hummed along under the theme music, and radiated in his smile. If you won, Stud Ridley was part of the prize. Magnetic, gorgeous. Mine. Who wouldn't fall in love with him? Who wouldn't tune in week after week after week? Lola and I could barely tear ourselves away. There were women just like us wearing these beautiful clothes in front of all those people with the music playing. there was Stud Ridley with the neon eyes; there was the applause! The applause.

The show was broadcast live from Los Angeles and relayed by Telstar, so that in certain foreign capitals, even though it would be repeated later, people struggled out of bed at 3 a.m. just so they could see it live. Broadway producers buckled to the pressure and provided hour-long intermissions between acts of their new hits, with sets provided in the lobbies and the restrooms. At the opera, everybody went to the special second-act TV lounge. In factories, management found the hour LIKE MY DRESS break increased productivity. Is it any wonder Lola and I refused dates and shuffled exercise classes to be home Wednesday nights?

Friends like to be with friends in times like that. Lola and I were close in those days. We used to do each other's hair!

We shopped together on lunch hours, and on Wednesday nights we went over to each other's houses for the show. At 6 we would sit down with our notebooks and tomato soup and Brownies on TV trays, frying on clothes until showtime. We made sketches of the winners, so we could sew copies for ourselves. I did the machine work and Lola put in the hems—the innocence! The joy! Would it be better to be forever the winner, or to be forever young?

I'll tell you what is worse. Not being either.

Ah, but at the time. I thought I was going to have it all.

All right, all right, it was Lola's idea for one of us to go on the show. But I

was the bankroll. Didn't that give me rights?

It was the second Wednesday in the first season we were going to a party, but only after the end credits rolled on LIKE MY DRESS.

I saw Stud Ridley walking off through the circles of light and I wanted to melt into the TV and go after him.

This frumpy rock star won; her hair was a mess and the idea of her out on the town in the limo with my beautiful Stud was killing me. And then just like that, Lola turned to me and said innocently, "Listen, we could do better than that. You could—"

"Right. Me and Lady Di."

She looked so *sincere*. "Listen, Gaby, you have style. You look better than that winner in what you have on right now."

It was my new black outfit with the neat boots. I'll admit I blushed, but it made me walk a little taller. "Maybe you're right."

"By the way, can I borrow your lizard sandals?"

Longing like fire smoldered in my joints and went flickering along my bones. I even loaned her the matching shoulder bag. And when we went out that night, we took large steps.

Lola led me along. "So, listen. We look as good as they do. We could win."

Do you wonder why the show was such a hit?

Lola and I spent the whole night talking about weight training and jazzercize, just in case. When push comes to shove, a person has to look good in something tight. Not our fault that we got so far into it that our guys felt left out. We didn't say it right out, but even then Lola knew where this was heading, and I knew.

Still we didn't watch *every* week, or we tried not to. At least not that season. We still had lives. But in the second season we were pulled in tight. Lola was over at my house; we had two really sweet computer programmers from Mobil coming over—she was trying to bring in MTV so we would have dance music, but she got the season premiere and there he was back in my living room. Stud. Oh yes, I was in love.

Plus, there was a new feature. Listen. They showed movies of contestants in training, including everyday people just like us. LIKE MY DRESS sent a camera crew to follow you around for two weeks before the show. We saw this sweet woman getting breakfast for her family, knitting her own dressy tank tops, going out to shop. . . . Then we saw this rich lady exec, she had staked her corporation and her reputation on winning, so most of the pictures were of this woman shopping, shopping; she was so rich, the stores sent models over to her office! Then they showed us the girl from design school—at class, in the dorms gluing bottle caps to the hem of her velvet evening dress so it would shine and clatter when she turned. Who wouldn't love her? Who wouldn't envy them?!

And one of those women was going to be the first winner of the year. She would get the crown, the night with Stud Ridley. She would get the week in Acapulco, the evenings in London, Paris, Rome, the lifetime purchase card backed up by American Express and honored in every major store around the world. As it turned out, the lady exec won it that night, but it *could* have been one of the common people.

It could have been us.

Lola looked at me. "TV," she said. Her lips were wet. "We could be on TV."

"On our bankroll?"

"If we pool our talents." Her eyelashes were like flocked velvet. She was wearing my little red thing. "With our chic—"

I said, "We could," but even then a little bell was sounding somewhere inside. I would find out too late what it was jingling about. *One of us could*.

When the guys rang we were too hypnotized to buzz them in. That was the season my ficus died of neglect. It was the season Lola and I moonlighted at a Bagel Nosh to help support our wardrobes, working every night of the week except during the show. It was the year we bought the Polaroid to take pictures for the nationwide talent search and the camcorder to shoot videos of us in our pretty clothes, and the year we gave up men because there wasn't time for that and weight training too. When we won, there would be plenty of new men and they would all be rich, and handsome, and elegantly dressed.

And I would have Stud.

If I could just win, I knew I could make him mine for good. And Lola—when I confided, she was so generous. The bitch. "You want him? You should have him. All I care about is the glory." She was so cool; she made me think she didn't even care which one of us went first.

That year we sent three dozen sets of snapshots and videos and all we had were rejection slips. By that time, the cheerleader from Temple, Texas had been declared the winner for October and Lloyd's of London was covering wagers that put Lady Di out in front in the end-of-the-year finals, although Sheik

"Now that your money is gone, I'm afraid a normal life is out of the question."

Ahmed Fouad's entire harem was considered the dark horse because their ensemble breakfast costumes stopped the show.

Lola said, "Maybe next week."

We had just gotten rejected again. I was so depressed. I groaned, "Maybe not."

Was she looking at me sideways? Stupid. I never saw. Her eyes got all slitted—strange. "Maybe if we spent more on photographs..."

"Maybe if we had a million bucks."

"I'm not kidding, Gaby." God, the woman was quick. She slipped it in like a needle full of Novocaine. "If only we could afford to get Venuto to take our photographs."

Now that sounded innocent. Of course it turned out we could only afford one set of photographs, so on the way to Venuto's studio we had this heart-to-heart, and Lola said, "Which one of us gets photographed first?"

"I don't know," I said.

"It doesn't matter who goes first," she said, "Whoever wins, we'll use the money to get the other one on the show." Then, boy, you should have heard her, that voice clear and empty as a glass of water, Lola beginning the lie of all lies. "Tell you what, why don't we let him choose?"

It sounded fine to me. Oh sure, I thought. I was going to win, and why? Because all these months Lola had been telling me so.

So we went to his studio. I have spent two decades on the couch trying to get over this one.

This Venuto was an artist, right? Well he decided Lola's cheekbones (which I happen to know she'd sucked in her cheeks to get the effect) made her the one. Plus she had stuffed herself into my *best* white thing so she looked better than me. The bitch.

Those photos got her the show. Okay. I tried to be glad for her.

"Oh don't worry," she said, when the DRESS crew comes to make the audition video, you can be on the video too. Stud can choose."

Sure.

All our money for the one set of photographs. But it got her the show. Not three weeks later, my best friend was coiled on my chaise like Cleopatra waiting for the asp, all dolled up in honor of the DRESS audition video crew. We were going to be on the show.

I mean, she was. I tried to be glad. I even promised to sew her a new dress. Gaby, the brave little tailor. Gaby, the tool.

I *tried* to be glad for her. She didn't make it easy. Once I had fallen into the sidekick role, she started using me like toilet paper, you know? If I said maybe it wasn't fair, her going first, Lola would string me along with promises. "Oh, Gaby, just think of the two weeks in Acapulco. Think of the perpetual charge account. Think of the *shopping* we could do."

Lola, with her everlasting WE, when what she meant was I.

But I ended up letting her take the pick of my closet, and after we pooled our savings for her wardrobe, I carried all the damn packages. I even altered her rotten evening clothes.

Well I showed her.

It was kind of an accident. I mean, she was trying on costumes at my place (which I had kindly agreed she could use for the audition shoot because her dump was not presentable and mine was, even with the sewing mess and the ficus dead) and she was still going, "Prizewinner's date with Prince Albert" this and "Year-end championship date with Prince Edward" that, worse and worse, and then, "Imagine, Stud Ridley," the other thing.

I just couldn't help it. I said, "Listen, Lola, friends are friends and you can go first on the show and no hard feelings, but there is this one very important

thing.'

She was so busy looking in the hand mirror that she hardly heard. "Sure, Gabes, anything."

Can I help it if everything in me boiled up and popped? "Keep your damn hands off of Stud Ridley. He's mine."

Then she said as cool as cool, so offhand that I wanted to murder her, "Oh, him. I wouldn't touch him with a stick."

After which *my best friend* did this awful thing to me. The words just fell out, like garbage on the rug. "I bought something for you."

I was doing up her hem. I tried to smile. "Oh Lola, how nice." To think I was ashamed for what I was feeling right then.

She was all pink and big-hearted and smiling. "Here it is."

You can imagine my emotions as I opened the box—the *thud* when I saw what it was! "A maid's uniform!"

"Don't you like it? Now you can be with me on the show."

"In *this?*"

"Better that than nothing." She was wearing my best rhinestone clips on her shoes.

"Don't do me any favors, Lola. After you win the everlasting charge account I will get on the show in my own right. After all."—dumb thing to say, bad timing—"I am the one with chic."

She choked.

"Why are you looking at me like that?"

She was trying to swallow the words, she knew they were garbage. I yelled at her to speak up. She couldn't help herself. She said, "You'll never make it, you're too fat. Your clothes all look better on me."

"Fat!" So much for her flattery. All lies. All these years and the bitch had been using me so she could wear my clothes.

I lunged for her throat, but she stopped me in midflight, squeaking, "Gaby, the doorbell. The camera crew! Gaby, my hair!"

"In hell."

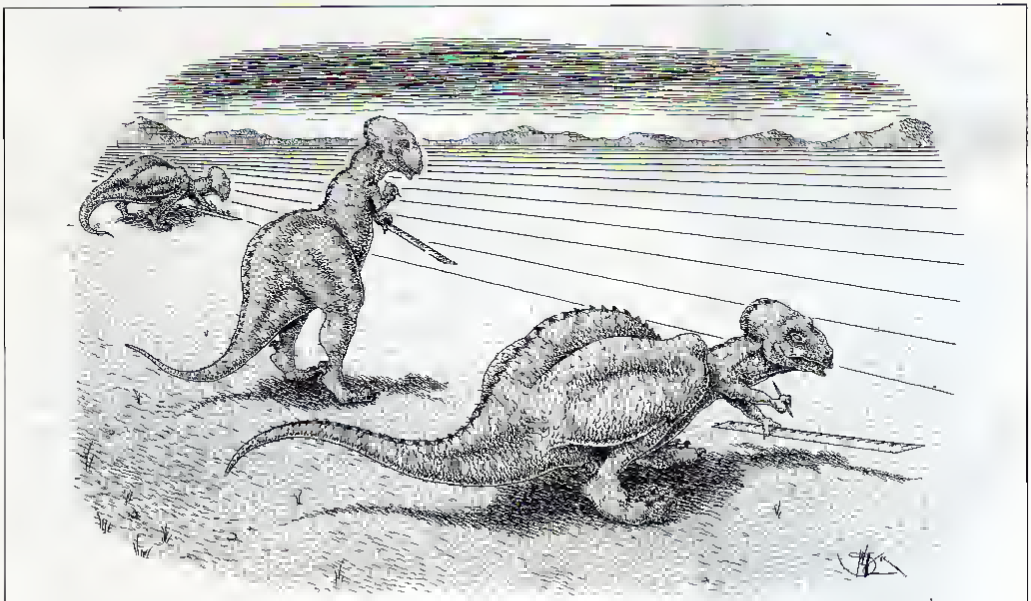
So much for Lola. I bopped her and locked her in the closet. Right, my mistake. I should have murdered her. Little did I know.

The first thing was I couldn't get at my best shoes. Instead I had to wear her rotten narrow dress-up pumps, but when the crew came, they didn't seem to notice that I limped. She ruined my aqua sweater the last time she wore it, so what if I did stretch her rotten shoes? After the crew knocked off for the day, I went to the closet and revived Lola, but before I did, I took precautions. I got out my toenail scissors and cut off all her hair.

I will not describe the scene that ensued when she saw herself in the mirror, but I will say this for Lola. She is a practical girl. I reasoned with her. Since she couldn't do the show with no hair, it was only right for me to do it—after all, I had put up half the jack. Besides, they already had me on the video. Plus, after I promised to split the prize money and the everlasting charge account—in fact, everything except the night with Stud Ridley, which I swapped her for the date with Prince Edward—she agreed to go along. By the time she had access to the winner's credit cards, which I signed in blood that I would share, her hair would be back. After I promised to throw in a free sitting with Venuto, she was positively philosophical. Her time would come. She would get her chance to be on the show.

What I would never forgive her for was the garbage she had spewed on the rug between us, that would not go away. All these years the two-faced bitch had been wearing my clothes when she secretly thought I was fat.

In the next weeks I was so happy I forgot. There was no way I was going



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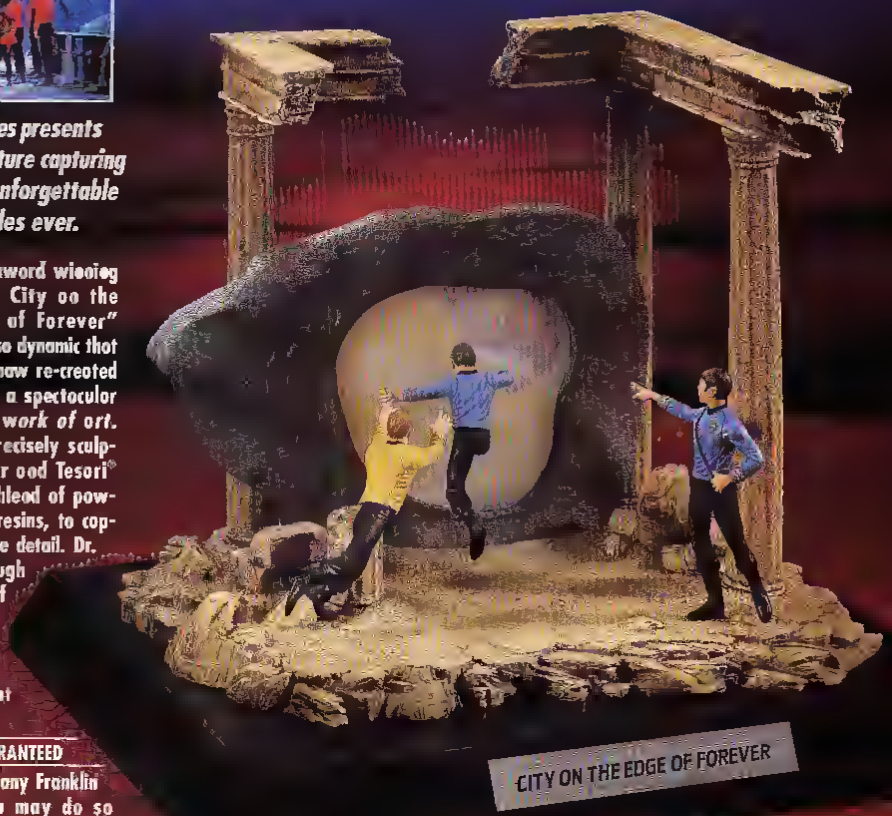

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to take Lola along to Hollywood as my maid or my secretary or any other thing. Not now that I knew she was a liar and a sneak. She wasn't about to be seen in public anyway, because of the hair. In fact, she took a leave of absence from work to grow her hair back, so she was out of my hair. Sorry. Instead of her being the queen, I was going to be the queen.

Los Angeles!

You should have seen it. You should have seen me, going around in the studio car. Unfortunately, even the last pirate tapes have been destroyed. Nobody wants to remember because nobody cares. *Sic transit*. You know.

They got me there a whole week early, which I spent in hair salons and nail parlors and makeup clinics which the funny-looking short woman with the clipboard sent me to twice—I suppose because even though Lola and I bear a passing likeness, she couldn't make the Venuto photo match my face. But I was in heaven, stashed in the Beverly Wilshire. I didn't mind.

Before the show, we waited in the Green Room, me and the Japanese manufacturer's wife, who had taken anabolic steroids to make herself tall enough by American standards of beauty, along with the ex-wife of the chairman of the board at Lord and Taylor, who had divorced her husband so she could compete in spite of the conflict-of-interests clause. Nobody wanted us to rumple our opening-round costumes, so we were leaning against tilted ironing boards. As we were in competition, it seemed best for us not to talk. Instead, I eyed them, and they eyed me.

I know I looked fine. Even before Stud Ridley kissed me—*kissed me* in the winner's circle and gave me the crown for that night, I knew I looked fine. And that kiss. I have lived a lifetime on that kiss. You can have your Prince Edward *and* your Prince Albert of Monaco. Listen. Stud Ridley kissed me. Once.

I was leaning against my tilted ironing board with my simple cashmere spread out around me and the amazing find I'd made on Rodeo Drive carefully draped, touching my deceptively simple jewels. Then the music came up and I thought I would asphyxiate as the manufacturer's wife tottered out on her platform sandals into the light and the show began. The light! The applause was only a prelude to mine. I could tell you a thing or two about applause.

I can't tell you much about the rest because all I remember are the lights and the applause—the applause! The clapping, whisper of the billions out there watching, via satellite relay.

What can I say about Stud Ridley in person, the eyes, that seductive touch? And the betrayal. Terrible.

How can I describe what he and Lola did to me? In the first round they show your clips—hard to watch because it brought it all back, the ugly scene with Lola, the closet, how I cut off all her hair. I couldn't nurse the guilt because I had to look happy for the second round, where the contestants reverence the all-time winners while dressed for afternoon. The hall-of-famers make little speeches about how hard it was for them, how great we look. I remember thinking, *Every one of these women has been with my Stud.*

Then I looked into his very special eyes and jealousy disappeared. I triumphed in the third round. I had designed and made the evening dress. I'd only had to let it out in a couple of little places to make it fit me as well as it fitted Lola.

After the commercials, we were called back to tell the studio audience, in our own words, where we got our clothes.

I was halting. I was eloquent. I was wonderful. I was so good, I won. I could hear a little murmur that began way back in the enormous studio, gathered force and broke like surf over me, wave after wave of applause. Stud Ridley put the crown on me—I could feel his fingers trailing promises across my bare back—and then I got what I had always wanted—I got to show off in my party dress in front of everybody. I headed onto the Mylar runway to the music and the applause. Behind me was *my picture* on this giant monitor above the stage. It was wonderful. I will never forget the feeling as I started out. . . I never should have turned my back on that monitor.

But I am forgetting Lola. No. I had forgotten about Lola then, the bitch. What she might be up to that night. I don't know how she managed it, I don't know what she promised Stud Ridley or what they did to make it work.

All I do know is that at the beginning of the prizewinner's promenade, just as I was heading down the runway and out over the heads of the audience, the runway lights went out. Like that. I was there but nobody saw.

Never mind, I thought, trying to make the best of it. They can see me on the monitor.

So I was on the runway, looking, I thought, double gorgeous in Lola's dress, and if only the people sitting nearest could see, no matter, because I was backed up by the giant monitor, I

thought, Gaby Fayerweather in the prizewinning costume and thirty feet tall beamed out to every TV screen all over the civilized world

It was what I had been working for all these years. It was better than anything, it was better than sex, it was like being queen of the world

And something was wrong

I was lost in the wild blue waiting for applause First there was nothing Then this *awful sound* started somewhere down deep and ripped through the air it was—it was this hideous rattle, a whip of scorn, followed by a guttural angry rumble followed by something I had never heard before so final and terrible that I gave up the promenade and for the first time I looked at the giant television screen

It was horrible

It was me and it wasn't me

There I was, thirty feet tall in front of thousands and being beamed to the entire civilized world, and what did they see?

My golden dress was gone and the crown was gone and the cape was gone the me that was up there on the screen was not me in my moment of triumph, being broadcast live

It was me on tape There I was smiling for Lola's camcorder on a sunny afternoon back home I tried yelling, *Look everybody I'm still here, and I'm still all dressed up, REALLY,* but nobody heard, they were all looking up there at the me on the screen And they hated what they saw

The bitch Who did she sleep with to make this happen, who did she have to bribe?

Up there on the screen Gaby Fayerweather in her shame, with a pink string of words trailing across the screen underneath LIKE HER DRESS?

Then Stud Ridley *Stud Ridley* said into the microphone "Okay, people, like her dress?"

It came from a hundred thousand throats in the studio and out there all over the globe. it was enormous "Noooooooooooo . . . .

I died

Then it disappeared TRANSMISSION INTERRUPTED TEMPORARILY the screen said, DO NOT ADJUST YOUR SET It was all over for me

Then transmission resumed There was a winner on the stage and on the giant screen, but it wasn't me Stud had put Lola in my place Lola—in a wig, I suppose, since there wasn't time for her to grow her hair back after what I did to her, Lola was up there in a copy of my evening gown—I looked from her to Stud Ridley and back again and all I could see was treachery. That duplicitous heartbreaking lying bastard Stud Ridley wrapped his arm around her waist and said "Look everybody, this is the real queen," and then my God he said, "After the finals we're going to be married, let's all greet Lola Garner my winner and my fiancee " You know it didn't matter how I waved my arms there in the dark at the end of the runway in the dark Gaby Fayerweather in the prizewinning golden dress, poor Gaby shouting, *I'm still heeere,* nobody saw

Instead they all looked at Lola and cheered

And me? They threw me out Just as *my best friend* accepted the prizewinning kiss from Stud Ridley studio guards on orders from that same Stud Ridley lifted me like a log and carried me off

If that had been all, I might have handled it, but I am ruined for life No matter how I disguise myself, people know me for a failure, they follow me in the street like dogs laughing and pointing at poor Gaby the pretender Gaby Fayerweather, who thought she was so cute

See, in addition to cheating me of my triumph, Lola and Stud Ridley ruined my life What they did was, they exposed me to the final unspeakable horror, the hell from which nobody returns and which nobody survives which is why I firebombed the studio the following Wednesday, causing Stud Ridley extensive plastic surgery that took him off the air and effectively eviscerated the show

What it was, was that video that started them howling at me? It didn't look half bad I mean, in that particular video, I had on my best purple thing with my rhinestone earrings and my hair done special with the pretty little poufs over the ears? I even had on my favorite orange shoes That wasn't one of your embarrassing home videos, it was the real me, okay? And the rotten hateful final insult, that sent me over the edge in a barrel?

They hated me anyway

So if I am not much to look at these days, if my teeth are long gone and my hair is going, if my figure went first a casualty to despair, if dogs bark at me in the street and children cover their eyes and run, there is a reason Failure makes you ugly, and this was the worst

I went on LIKE MY DRESS all right? I had to lie and cheat to do it, I locked my best friend in the closet and I cut off all her hair and took her place I went on LIKE MY DRESS and it was the end of everything

They didn't like my dress ☒

DANIEL JANZEN

We've done it, we've won. You say it's man against nature? Baloney! Man has killed nature. Now, do you sweep the battlefield clean, or do you try to save some of the pieces? That's the rational part of humans I hope will kick in." So declares Daniel Janzen, Professor of Biology at the University of Pennsylvania and pioneering restoration ecologist. Since 1963 Janzen has campaigned tirelessly to protect and restore the dry forests of Costa Rica, a country roughly the size of West Virginia and home to 4 percent of Earth's terrestrial species.

In 1989, Janzen helped found Costa Rica's National Biodiversity Institute (INBio) for the purpose of conducting, sorting, and storing a complete inventory of the country's estimated 500,000 species of plants and animals. Janzen sees INBio's future as Costa Rica's biological company store, promoting the nondestructive use of its genetic and bio information to corporations and institutions and plowing the various kinds of profits back into the wildland forests. To that end, Janzen and his wife Winnie have raised millions of dollars to endow INBio and train rural Costa Ricans to collect and identify plant and insect specimens from the seven conserved wildlands that cover 27 percent of the country. Once this ten-year inventory is complete and laws that assign ownership of its living resources to Costa Rica are created, biodiversity may become big business there.

Janzen foresees the formation of a "green cartel"—an OPEC-like collection of countries, based on the INBio process, who sustainably use their biodiversity rather than destroy it. Before that can happen, the owners of the world's tropical and subtropical forests, wherein dwell more than two-thirds of the earth's estimated 5 million species, need

INTERVIEW

NOTES FROM THE GUANACASTE

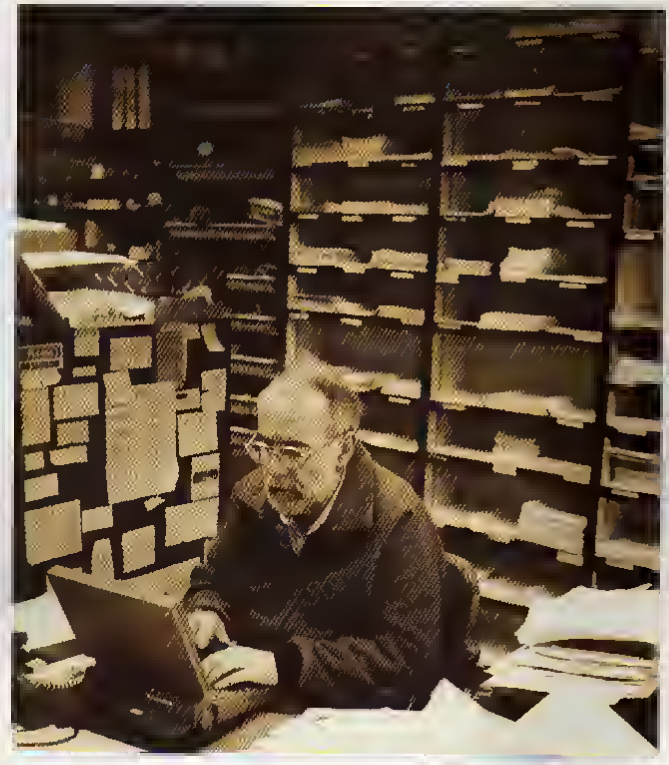
DEFINITION OF COSTA RICA:
A corporation with 3 million shareholders and a greenhouse of 500,000 species

CORPORATE PRODUCT:
"Information. It might be genes, chemicals, whatever. We won't sell you the greenhouse; we'll sell you the information."

MANAGEMENT COSTS PER YEAR IN ALL COSTA RICAN CONSERVATION AREAS:
$20 million

WILDLAND MANAGEMENT COSTS:
"Wildlands eat and chew on each other, rot and grow. Management costs are associated with human use. As human use goes up, you charge the human users. It becomes a self-financing elevation in activity."

TIME LEFT TO SAVE TROPICAL FORESTS:
"If we can get big pieces of the tropics in the next ten to twenty years, we'll be okay."

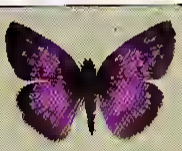


AN ECOLOGIST WORKS TO CREATE A "GREEN CARTEL," AN ORGANIZATION OF TROPICAL COUNTRIES WITH CORPORATE STRATEGIES FOR PROTECTING THEIR WILDLANDS AND THE AMAZING BIODIVERSITY THEY CONTAIN.

proof positive that these treasure troves are worth more to them alive than dead. Considering the demand for cheeseburgers and lawn furniture and the crushing burden of debt under which almost all of these countries struggle, success remains a longshot.

Born in 1939, Janzen grew up in the North Woods of Minnesota. He loved to hunt and trap and thought nothing of sawing down an occasional pine just to count the rings. Graduating from the University of Minnesota in 1961, he earned his Ph.D. from the University of California-Berkeley in 1965. Since 1962, he has authored 300 papers on such topics as "Why Are Embryos so Tasty?," "Seeds in Tapir Dung in Santa Rosa National Park," and "Coevolution of Mutualism Between Ants and Acacias in Central America." That study of coevolution—where two species evolve a dependence upon one another for survival—in 1984 won Janzen the Crafoord Prize, biology's equivalent of the Nobel.

I spoke with Janzen on the porch of his cluttered shack in Santa Rosa, a speck of a town in the huge Guanacaste Conservation Area. While we talked, Winnie, a former biology graduate student at Cornell, treated us to a gulp-by-gulp description of a snake swallowing a large frog in the upper limbs of a nearby tree. From where we sat, under a cool, green canopy, it was hard to believe that the world's great tropical forests are disappearing at one acre a second. —Bill Moseley



HOW TO SAVE THE TROPICS IN ONE FELL SWOOP:

"Every time a company's R&D gets cranked up over a given drug or food item, they throw into the budget a little cream-off of one percent for the forest."

TROPICAL DIVERSITY SCORECARD:

"If we could save eighty-five to ninety percent of the world's tropical biodiversity, we'll have won."

CONTRIBUTIONS:

Tax-deductible contributions are needed to support the training of Costa Rican curators and for the purchase of rain forest. Send contributions to The INBio Fund, The Nature Conservancy, Latin American Program, 1815 N. Lynn Street, Arlington, Virginia 22209. For more information, call Randy Curtis at TNC, (703) 841-4864.

***Omni*:** One night a large toad hopped into a local cantina. When some kids began to pester it, their mother shouted, "Watch out, it will squirt milk out of its eyes!"

Janzen: Not the eyes—a pair of glands behind the eyes. And it's not milk; it's a secretion containing bufagenins, compounds well known in the medical community that speed up heartbeat. If you get it into your blood, it's like taking a heavy dose of digitalis, which doctors normally administer in small quantities to make your heart do what they want it to do. Every species of toad produces its own slightly different chemical, but all of them do things to your nervous system.

There's a big frog here, *Phrynohyas venulosa*, that comes into rural houses during the dry season and camps in the water behind the toilet or in the shower. The wet surface of its skin contains a chemical that can temporarily paralyze tear ducts. If you touch one and rub your eyes, your tear ducts stop, and it's like sandpaper in the eyes! So these frogs have a reputation of being very nasty to the eyes. It happened to me years ago. Once was enough!

***Omni*:** Walking through the forest, I noticed an acacia tree covered with ants. Was that the focus of your study leading to the Crafoord Prize?

Janzen: Yes. There are about 12 species of that tree, all having big thorns, from central Mexico to Columbia. And about 14 species of ants are involved. Any species of that acacia may be occupied by any number of ant species, but each tree has only one ant colony. I once took the ants off the ant acacia to see what would happen to the tree. Everybody and his little brother came to eat the leaves. The leaves are like lettuce; there are no chemical defenses. The ants are analogous to the chemical defenses that most plants have, but which for the most part are not present in the ant acacia.

In the Sixties and Seventies, chemicals in plants was a hot topic. Some plant physiologists felt they were waste products. A smaller but growing group thought they were chemicals built specifically by the plant to defend itself. The ant acacia was useful because, in a sense, the ants were a chemical you could remove. You can't walk up to an ordinary tree and take away its defensive chemicals, but with a little parathion or other pesticide, you could take the ants off.

Those chemicals are what give the green world its flavors, odors, medicines. If you were interviewing someone here 2,000 years ago, a big piece of their lives would relate to these plant chemicals. Today, people here are almost entirely divorced from that. Their chemicals—often the same ones—come from the drug store. Generally, these are more effective in combating disease because dosage and purity are better controlled. Still, specific diseases were often effectively treat-

ed by soups, teas, grinding up or smoking leaves.

Chemicals play an enormous role in how the vertebrate, insect, fungus, and bacterial world treat this big green wall. To us, it's green. To a beetle, it's the colors caffeine, morphine, nicotine, L-dopa. He runs around and takes a nibble out of this and that until he hits the plant in which he's a specialist. He has enzymes allowing him to gobble up the chemical, chop it into pieces. That's host specificity. Almost all of the 20,000 or more species of insects that live here and eat leaves eat only one species of plant. That's primarily due to the specific chemistry in that leaf. [Janzen points to dozens of plastic bags hanging over our heads, each containing a different caterpillar and its favorite food.] Every species has the internal chemistry to degrade one or more of those funny chemicals. Each caterpillar is a walking biodegradation factory.

Omni: Destroying the tropical forests, aren't we digging our collective grave? Stanford's Paul R. Erlich predicts humankind will die out by the middle of the next century. Do you share that doomsday prognostication?

Janzen: I tend to share the pessimism of Erlich or E. O. Wilson [Harvard professor of zoology]. The difference between us is that while I agree that things are going to hell in a handbasket, I also believe they can be repaired. There's a strong sense of frustration in the conservation community. Many conservationists believe the only way to mobilize the public is to put out a message so violent, so gloomy, that it will generate a strong reaction. There are times that tactic works. But if you scream "Fire!" too many times, people stop listening. Overall, enough people will respond to a more positive approach. When we talk about ways to fix things, we have to get more specific, divide the world into geographic and administrative pieces: Mexico, Ethiopia, Malaysia, Columbia, Brazil. I have different levels of optimism for different areas.

I view Costa Rica as a pilot project. The optimism I feel here doesn't come from international planning commissions, big institutions, or massive volunteer efforts. While they have a role, the real solution is setting up processes whereby individual countries come to view tropical biodiversity as one of their major resources. It's essential that these countries believe these resources are *theirs*, not that they've been given some mandate from the bigger world to shepherd what is *ours*. The politician, store owner, guy in the street, won't feel motivated to take care of the biodiversity unless he begins to see an advantage for himself.

We need to get host countries involved in preserving their own biodiversity or we're dead in the water. For a politician in Costa Rica to support a wildland area, either he's got to have voters happy to have it or economic forces in the national budget that look upon it as a resource like water, electricity, or roads. The Guanacaste is one of seven mainland conservation areas encompassing all the country's conserved wildland. How do you make them something of value? First, you must make them user-friendly to the visitor, whether Costa Rican or traveler. An employer is a user, just as much as a tourist. Of the 100-odd employees here, 70 percent come from the immediate vicinity. The rest are Costa Rican—no gringos. Right away that gives you 100 votes, plus the families, relations, and neighbors. Secondly, we take gradeschoolers from all 12 schools in this area, physically bring them out here in the woods, and teach them basic biology. The conservation area maintains that cost as part of its management budget, like fire or police protection.

> "I'm happy to sacrifice five percent of the biodiversity to keep the remaining wildlands in shape. That's the negotiator's position, not the ivory-tower one."

Omni: Was this your idea?

Janzen: It's been around a long time. My effort was raising money to bring the kids here. We're also working to attract the Costa Rican equivalent of the guy who lives in Ohio and vacations in Yellowstone. The job search for the park director is conducted by a committee of prominent businessmen and government people who live here in Guanacaste Province. The committee must approve annual work plans and strategy of running the park. This piece of land is owned by the government of Costa Rica. If something went wrong, in the worst possible case, the government could sit on this system and claim ownership. We've tried to set up the politics so that doesn't happen, so the people accept that they are the custodians in many different ways.

Not long ago, a sulfur mine wanted to open on the park boundary. The Ministry in San José authorized a permit for the mine to operate. The regional committee here got up on its political bandwagon and stopped the mine. They protected this conservation area as though it were their own land.

Omni: How do you develop these areas in a commercial, profitable sense?

Janzen: Farming the international tourist. You make the parks user-friendly for paying visitors. Invest in roads, buildings, information folders, guides and so forth, to bring the parks up to world-class speed, and you get a serious return on your investment. It may sound callous, but that's the way a minister of finance will understand it. Measured in dollars, tourism is in the top three. It's bigger than bananas or cattle, but less than coffee and the accumulation of minor manufacturing products. Measured in local impact, tourism trails behind both bananas and cattle. However, most all of the tourist dollars entering the country do not flow into the conservation area and its neighbors.

The tourism industry has gotten away with using Costa Rican resources, especially the parks, without paying for them because the national parks budget wasn't charged to the tourism industry but to conservationists. The parks were not initially set up to service tourism. That industry came in and made use of a resource set up for other people. That's going to change quickly. When you entered the park, you paid what?—100 colones [about 80 cents]? Soon the fee will be commensurate to Yellowstone Park, which is roughly $10 for a weekly visitor's permit.

Omni: Won't you turn this area into another Yellowstone or Yosemite?

Janzen: If we can organize the conservation area so our income flow resembles theirs, we'll be happy to give you 5,000 of the park's 110,000 hectares to turn into Yosemite. This area is big enough and has enough replicated habitats that you can have one piece of habitat untouchable, another piece for wilderness camping, another for the guy who rides his bicycle through the woods, another for the guy who wants his TV set, tent, the whole package.

The movement's been around since 1971. In 1986, it bought up adjacent land any conservationist would consider trash. It bought low-grade cattle ranches, low-yield rice fields, failed cashew orchards, all sorts of agricultural disasters, because there was more land onto which the bits of preserved forest could expand and reoccupy. This space had almost nothing to do with the territorial requirements of tapirs, jaguars,

or monkeys. We had enough for them. But if you allocate too little space—say, the minimum for the tapir population—you run into big problems. Over time, you develop sets of 500,000 people here, a million there, who come to see the park as their rural national theater. You have conflict between the guy who's trying to save the tapir and keep its habitat from being trampled and the tax-paying community who thinks it's their park to do with what they will.

Omni: In Yellowstone, 90 percent of the tourists use 5 percent of the park.

Janzen: Exactly. So what I've described is the traditional economic use of a national park. But in the tropics, there's a second use. We have a hell of a diverse, big, greenhouse. The seven conservation areas here contain 500,000 species of organisms. This conservation area has roughly 65 percent of them.

If I own a greenhouse, the first thing I need to know is what's in it. The world used to finance the collector of beetles, say, through esoteric funding, the National Science Foundation, the wealthy patron. Suddenly, the development agency becomes interested: doing this inventory is a class of development that stimulates a whole inside-the-greenhouse effort to classify those 500,000 organisms. Costa Rica has a lot of intelligent but underutilized rural people. We now train people with little more than a sixth-grade to high-school education to conduct an inventory. We give them biological, technical, and philosophical backgrounds and turn them loose to do the kind of work Ph.D.'s and graduate students traditionally do.

Omni: You tell them to go collect one of everything?

Janzen: That's largely right. Obviously, some people specialize. There are nine working here now. We call them parataxonomists. They bring their specimens to one building where we begin to sort and organize them. People mistake the building, which functions as the management center for this biological information for a museum. Traditionally, museums had a terrible time getting funded. They're esoteric, scientific, and don't seem pertinent to anything. Suddenly this museumlike building is fundable as a clearinghouse: the National Biodiversity Institute, INBio.

Omni: Who wants this stuff?

Janzen: In the old days, the inventory information might be published in scientific journals read by four professors and a few extratropical researchers. Now we distribute this information into commercial networks. Say Merck [a pharmaceutical house] is interested in rainforest chemicals. They don't want scientific papers describing what's here, they want a goddamn computer printout listing what's available and what it costs. For the biologist, it's a whole new world of commercial negotiating.

Omni: What's on the printout?

Janzen: There are two kinds of search. One is a blind search. A chemical company wants samples of our inventory but has no idea how to pick out of a thousand species those having a higher probability of being useful. You send them a long list of samples, and maybe they're interested in sample number 63. For a plant part, it might be 100 grams of leaves. If it's an insect, it might be five grams of ants from a colony ground up in a bottle of alcohol. Should the need arise, the companies would want us to go back to the hillside where that ant colony exists and dig up a half kilo of ants. The search demands absolutely reliable identification and information about how the samples were treated. If you pull a leaf off a plant, throw it in the oven and dry it out, or freeze it, you may destroy or alter its chemicals. The companies want exactly the same thing they got before.

The other search is driven by outside information. Suppose someone noticed that when people in Southern Panama get strep throat, they make a tea out of a certain plant. The chemical in that plant, say, is the active ingredient in Sucrets. The company that wants to make the better Sucret comes to us for samples of the five most closely related plants in that family. Looking through the list of Costa Rican plants, we discover there's a patch of one on the side of a volcano. We go to the guy who's been doing the inventory in that area, and he tells us where and how many. It's like going to the shelf and getting what you need.

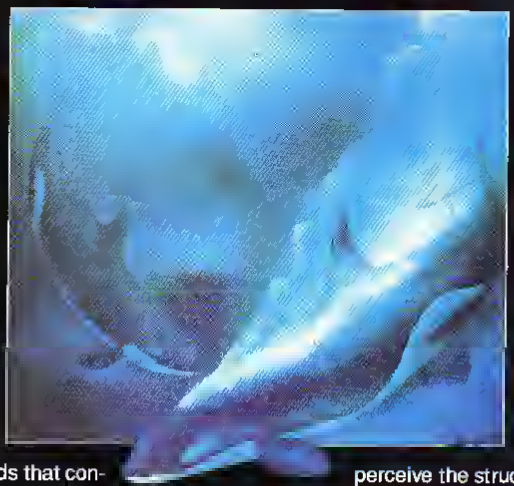
Retrieving that batch of plants may cost only one day's salary in real money, but we can charge $5,000 because nobody else can do it. INBio is not just charging you for labor, but for information. The commercial world never justifies what it charges. It charges what the market will bear. You could argue that there's a training cost for the parataxonomist, a maintenance cost for the conservation area, and a cost to keep it from being turned into a cornfield.

Years ago I crudely calculated how many cups of coffee are drunk in the world each day. Based on that number, if every cup carried a one-cent tax, there'd be enough money to endow all conserved wildlands in all the tropics forever. And coffee's just one plant! A company's development budget for some new drink or drug contains the salaries for the advertising, research, and factory people. It might contain 5,000

CONTINUED ON PAGE 94

ANTIMATTER

COSMIC BABBLE:
Until we talk to ETs, we can commune with the porpoises and whales



Human evolution has led us to communicate with sequences of symbols we call words. It has also led us to use special symbols, called numbers, for counting. We assume that words and numbers, and the technologies we create with them, are characteristic of intelligence throughout the universe. But consider the porpoises and toothed whales. They evolved senses like ours, and one more as well. Using the sense of *sonar*, porpoises and whales create high-pitched sounds that constantly bounce off objects, creating echoes that the animals interpret to tell them where they are.

Imagine engaging in the human equivalent of sonar by shouting at an object and timing the echo to calculate the object's distance. Doing this continuously would mentally exhaust you. Whales, on the other hand, have brains that are hard-wired to do the interpretation automatically. Add a little pattern recognition to their innate skill and you have a sense that is more like vision than hearing.

Whales at close range may thus communicate with sonar "pictures," using sound that varies not only in time, but in space. They may even send several pictures simultaneously in different frequency ranges—like television channels. To them, our simple sounds may seem like crude signaling rather than speech. And even if we listen with arrays of underwater microphones and convert the sounds to sonogramlike images with computers, their complex communication—if it exists—may be forever unintelligible to us because it doesn't consist of wordlike sequences of symbols.

Now, geologically speaking, whale and human evolution diverged only recently. What makes us think that if we have so much trouble communicating with whales, we will be able to communicate with ETs? Today we try by sending radio waves representing streams of ones and zeros, which the aliens could presumably assemble into a picture. We might, for instance, send the laws of physics or some other concept presumed to be universal. But the aliens may have no concept of words—or at least our version of words—and might thus be unable to perceive the structure of our message.

The ETs might lack the concept of numbers as well. Suppose, for instance, that an alien had some of its brain cells organized like a computer. In some sense, this is true of humans as well. We see because circuits in our brains almost instantly perform operations on data from our eyes that would require hours of ordinary digital computation. Our computer-brained ET might take this ability further: It might know that "right" amount of anything without counting, enabling it to create complex technologies without consciously using numbers. To such a creature, our number stream may have aesthetic qualities, but no meaning.

Finally, those ETs who do talk and count may have evolved to behave on time scales incompatible with ours. We and they may ignore each other's messages because we communicate at different rates.

So if the Search for Extraterrestrial Intelligence (SETI) finds nothing recognizable, take heart; there may still be intelligence out there—just nobody like us. Let's work harder on communicating with whales. It may teach us something.—*JOHN FUTTERMAN*

Editor's note: John Futterman is a physicist at the Lawrence Livermore Laboratory in Livermore, California.

ANTIMATTER

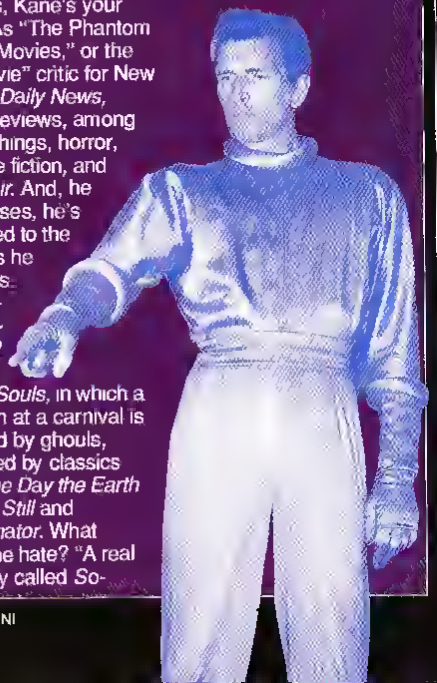
PHANTOM OF THE MOVIES

Remember the horror flick that gave you nightmares as a kid? You know, the one about aliens putting implants into people's necks What *was* its name? Joe Kane will tell—*Invaders from Mars*. For those who care, Kane can also give a scene-by-scene rendition of *It! The Terror from Beyond Space*, the black-and-white saga of a monster that offs a spaceship crew.

If you're looking for an expert on those old SF movies, Kane's your man As "The Phantom of the Movies," or the "B-movie" critic for New York's *Daily News*, Kane reviews, among other things, horror, science fiction, and film *noir*. And, he confesses, he's addicted to the movies he reviews. His all-time favorite? *Carnival of Souls*, in which a woman at a carnival is chased by ghouls, followed by classics like *The Day the Earth Stood Still* and *Terminator*. What does he hate? "A real atrocity called *Solarbabies*, about a roller-skating team of the future and a guru.

The best part of his job, says Kane, is "finding something great, such as *The Dark Side*, a Canadian movie made in the Eighties about a cab driver caught up in a web of weird people. It would have been totally unnoticed unless a reviewer like myself bothered to look at it." The down side of the job is watching movies that turn out to be junk —Anita Baskin

***The Day the Earth Stood Still*: A "B-movie" great**



FORBIDDEN SCIENCE

Vallee

Is the U.S. government withholding information on UFOs? Yes, according to computer scientist and UFO expert Jacques Vallee, whose new book *Forbidden Science* (North Atlantic Books, 1992) reveals the diary he kept from 1957 to 1969

According to Vallee, he was organizing the private files of astronomer and UFO pioneer J. Allen Hynek back in 1967 when he discovered a memo marked "SECRET—Security Information," signed by a project manager Vallee has dubbed "Pentacle." The memo cited some unusual UFO patterns and suggested a serious scientific investigation.

IF PENTACLE'S MEMO HAD BEEN RELEASED, SAYS VALLEE, THE HISTORY OF UFOLOGY MIGHT HAVE BEEN RADICALLY CHANGED.

For some reason, the Pentacle memo never reached the so-called Robertson Panel, made up of top-level scientists investigating UFOs for the Air Force and the CIA. The panel ended up debunking UFOs. But Vallee believes that UFO research would have taken a different course had the panel seen the data reviewed by Pentacle. "The scientific approach to a complex new phenomenon is to look for patterns," he says, "and that is exactly what Pentacle did."

But aerospace writer and UFO skeptic Phillip J. Klass believes that Vallee places too much emphasis on the Pentacle memo. "The more than twelve thousand UFO reports that were submitted to Project Bluebook, some of which this memo refers to, are now available in the National Archives, in the public domain," Klass says. "I invite Vallee to pick out what he believes are the best of those reports and demonstrate that they cannot be explained in prosaic terms."

Vallee, however, says this approach would not be useful. "It is unlikely that any single case or group of cases will demonstrate anything," he says, noting that researchers would have benefited most from studying the pattern as a whole.

—Keith Harary

VISIONS OF HELL

Mention the near-death experience, and the image is beatific—tunnels of light, deceased friends and relatives, and flowing pastures of green. But recently, psychiatrist Bruce Greyson of the University of Connecticut and pastoral counselor Nancy Evans Bush have begun to document the dark side of the NDE.

In one type of NDE nightmare, say the researchers, people report the prototypical, peaceful experience, from bright lights and tunnels to life reviews. But instead of perceiving these images as soothing, the NDEer is seized by fear.

The second type of NDE nightmare usually occurs during childbirth, says Greyson, and includes "a sense of eternal emptiness." One new mother who had a momentary brush with death reported "spinning around and screaming I realized that this was eternity for all mankind."

Finally, the most frightening of *all* NDEs involves demons and other images of hell. "Demons were all around me," one percipient reported. Another reported people "blackened and sweaty and moaning in pain."

Surprisingly, the negative NDE appears to have less impact than does the garden variety blissed-out kind. Perhaps, Greyson speculates, those who have bad encounters are "trying to put the whole thing out of their minds."

—Paul McCarthy

MOVE NEAR DEATH, AND YOU MIGHT GLIMPSE A BEATIFIC TUNNEL OF LIGHT OR ETERNAL EMPTINESS AND PEOPLE IN PAIN.

MURPHY'S LAW

Some thirty years ago, Michael Murphy cofounded the Esalen Institute, the pioneering center for human potential in Big Sur, California. Located on a stretch of Pacific coastline south of San Francisco, Esalen became the premier center for a broad range of transformative practices, including yoga, contemplative prayer, and martial arts.

Murphy

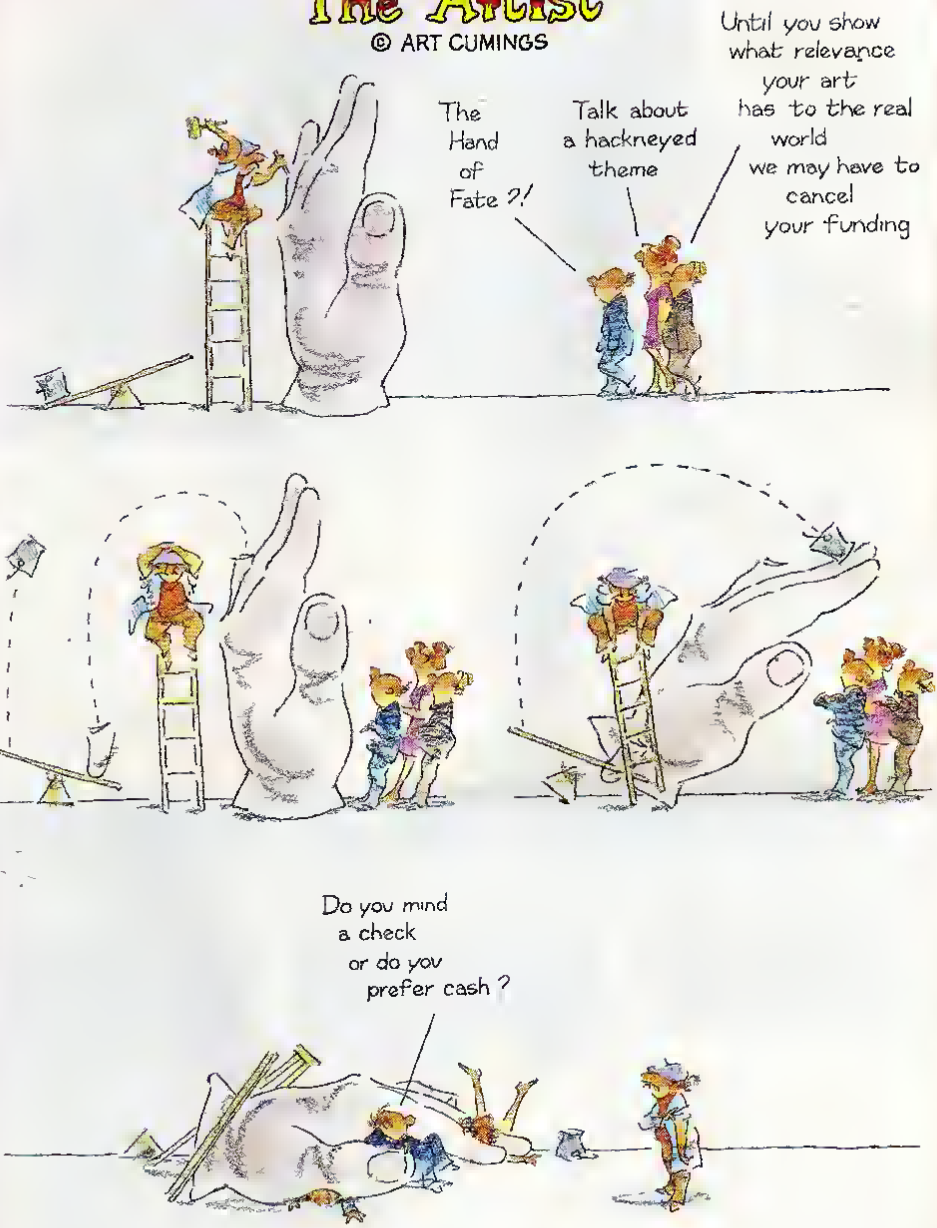
Murphy recently reached a new milestone with the publication of *The Future of the Body* (Tarcher, 1992) in which he describes "latent human capabilities," from exceptional athletic skill to the ability to influence objects at a distance. Such abilities, says Murphy, "can be seen as the most advanced part of a developmental continuum stretching back to animal life."

As far as Murphy is concerned, however, humans will not have to wait for evolution to bring these latent capabilities to the fore. Instead, he says, such transformative techniques as meditation and biofeedback can help practitioners evolve in the here and now. "Do we really believe," he says, "that human beings have lost life's ancient capacity for transcendence?"

Although Murphy's views are controversial, members of the mainstream scientific and religious press have delivered favorable reviews. *Science Books and Films*, a publication of the American Association for the Advancement of Science, called the book "the right book, by the right person, at the right time." The Catholic Book Club, meanwhile, has made *The Future of the Body* its featured monthly selection.

—Keith Harary

The Artist



RUNNING

CONTINUED FROM PAGE 36

English. If the barber of Seville is ordered to shave all of only those men who do not shave themselves, does he shave himself? If he does, he falls into the set of those who do, and so he shouldn't. If he doesn't, he falls into the set of those who don't, and so he should. But then he does.

If you listen to Paulos long enough, you'll find, as a nation, that we're twisted into several paradoxes of our own, paradoxes that if left unreconciled could implode and drop us into a mathematical black hole reminiscent of the Middle Ages.

Right Brainers vs. Left Brainers

Math is accessible to everyone, Paulos claims, and attractive to many as long as it's not described as math—as long as it's cards or chess or batting averages. He doesn't object to the thesis that there are functional differences between the right and left brain, but is afraid it's oftentimes used as an excuse for people to disregard their own abilities and elevated to the status of some grand explanatory principle that distinguishes art from science, men from women, toads from frogs. "This apotheosis is generally courtesy of the same people who ask, 'What's your sign?'" he says.

Of course, there are disparities in mathematical ability. "But everybody can learn the basics of mathematics and problem solving," Paulos says. Some people have perfect pitch, but that doesn't mean those who don't can't sing. To Paulos, the basics have to do with being able to estimate the height of the Empire State Building [approximately 1,200 feet], to gauge everyday risks, or to convert dollars per pound into francs per kilogram.

Some people are needlessly insecure about their mathematical acumen. He tells a story of meeting a woman on the train who told him how she figured a 15-percent tip. She knew how to figure 10 percent, took that and added half again as much. "But she said she knew that was wrong because her husband told her she had to multiply by 15," Paulos says. "His attitude is typical of people who impart mathematical knowledge like, 'This is the only way, this is the gospel.'"

Conversely, some people think in figures, but they wouldn't fare well guessing the number of jelly beans in a jar at the church bazaar. Common numerical sense is something even some numerates need to hone. "What I'd like to see

is not so much a facility with various mathematical computations," Paulos says, "but just a better feel for numbers. I know people who can compute backwards and forwards but have no idea what the population of the world is [5 billion–plus] or the distance from coast to coast [2,500 air miles]."

MTV, The Mall, and The Coach

According to Paulos, math skills among Americans haven't necessarily gotten worse. More people know a modicum of math now than, say when Columbus hit the rock or at the time of the Civil War. The problem is that we haven't improved sufficiently to deal with the technologically sophisticated society we live in. "The lack of math skills is more stark given the nature of our society," he says. "In the nineteenth century people's math skills were sufficient. But given the science and technology of the twentieth century, our skills aren't enough." And yet he is not encouraged by his own students. "There are some strong students coming in," he says, "but the average has declined. The usual bromide about MTV, lack of parental supervision, the mall—I think there's something to all those things."

He understands, however, that MTV is more appealing than math class, and if he could find a way, he might try using music videos to teach math. His own classroom experience was not entirely positive. "I didn't particularly like mathematics because of the way it was taught," he says. "It struck me the way it strikes a lot of people—it's mechanical and boring. There's a quasi-militaristic atmosphere in the classroom. Generally, the coach taught math."

'Math Class Is Tough'—Barbie

People are quick to blame math teachers for the lack of number savvy among Americans. Paulos maintains that children are fairly open to mathematics—born without sin, so to speak—and pick up their math phobias from adults. Not to say that the classroom situation is ideal. Some teachers have as much or more background in method as in the subject they teach. But the National Council of Teachers of Mathematics and the National Council of Accreditation are working together to encourage states to require more math courses for certification of math teachers.

Paulos suggests certifying retired engineers to teach or having several math specialists in the schools who float from class to class. In fact, several states now offer "alternate route" certification programs that allow people from other professions to work toward certification without leaving their jobs. The intensive training courses last anywhere from four to eight weeks.

Another problem, says Paulos, is simply the hierarchical way math is taught—"geometry, algebra, calculus and serious gum disease," as he jokingly said to West Point cadets. (They didn't get the joke.) "Algebra is like a filter that keeps students *out* of mathematics," he says. "Kids who have a bad experience with it in high school come to college and have to take it again. That's a mistake." To change the way math is taught—to instill an appreciation for mathematics—Paulos proposes we also teach topics more applicable to everyday life: probability, statistics, game theory, inductive reasoning, informal logic. "Puzzles, games, and riddles aren't discussed—in many cases, I'm convinced—because it's too easy for bright ten-year-olds to best their teachers," he says.

> "It takes about eleven and a half days for a million seconds to tick away, but almost thirty-two years are required for a billion seconds to pass."

Paulos' own enchantment with mathematics began at the age of ten when he calculated that a relief pitcher for the then Milwaukee Braves had an extraordinarily bad earned-run average (ERA) of 135. His teacher asked him to explain to the class how he figured it and then informed him that he was wrong, asserting that ERAs could never be higher than 27. But Paulos was right, and he was vindicated when the *Milwaukee Journal* published the same statistic. "I remember thinking of mathematics as a kind of omnipotent protector," he says. "You could prove things to people, and they would have to believe you whether they liked you or not."

He suggests that teachers put dollar signs in front of some numbers to make math pertinent—give numbers some practical significance. At the very least, teachers could use math problems to tell stories and promote class discussion. "Mathematics should be taught in conjunction with courses in logic or philosophy of science, critical thinking in general," Paulos says. "Kids should be required to write mathematics, talk mathematics."

By writing, he means writing out a problem instead of just submitting the answer, allowing for mistakes, eraser marks, scrap paper. Writing is process, Paulos contends, forcing students to organize their thoughts, to format the problem, apply the math to it, and interpret it. "More often than not, the reason students can't solve a problem is because they don't understand it," he says.

If Paulos were your teacher, you'd be calculating the likelihood of inhaling a molecule exhaled by Julius Caesar or figuring why volume constraints show that Bigfoot is impossible—and you'd do it with the help of all the available technology. He criticizes teachers who resist technology when teaching math, who consider calculators crib sheets. What if fifteenth-century Italians hadn't given up cumbersome Roman numerals for the new, more efficient Arabic software, as it were?

"Why do we spend innumerable hours teaching algorithms for Roman numerals?" he asks. "We've got programs to graph surfaces and perform statistical operations and calculators that figure out correlations and invert matrixes." Technology and computers free us to understand conceptual backgrounds, mathematical models and heuristic problem-solving techniques.

Many teachers agree with Paulos. They'd like to teach math more intuitively but feel forced to teach skills that allow students to do well on standardized tests. According to a study released in October of last year by the Center for the Study of Testing, Evaluation, and Educational Policy at Boston College, standardized and textbook tests given to most U.S. students adversely influence the teaching of mathematics and science skills recommended by curriculum experts. Researchers say this finding is especially true in classrooms with high minority enrollments. For example, only 3 percent of the questions on standardized mathematics exams tested conceptual knowledge, and only 5 percent tested for problem-solving and reasoning skills. "The tests studied overwhelmingly measure low-level skills such as rote memorization and recall rather than high-level skills such as conceptualizing, problem solving, and reasoning," says George Madaus, the study's principal investigator. In interviews with more than 300 teachers, 60 percent of mathematics teachers described negative effects on student learning resulting from district or state testing programs.

From these standardized tests come reports the media are quick to pub-

lish recounting how lousy American students are at math how low they rank internationally But the media, a notoriously innumerate bunch according to Paulos rarely discuss the problems inherent in such surveys

A 1990 article in *Phi Delta Kappan* by Iris C Rotberg, who was then program director at the National Science Foundation outlines just a few of the problems For instance, the decline of scores on the Scholastic Aptitude Test (SAT) can be attributed largely to the fact that more students are taking the SAT and attending college Moreover, state rankings of SAT scores reflect the proportion of students who take the test The states with the highest proportion of students taking the SAT tend to have the lowest average SAT scores Rotberg is concerned that the focus on test scores deflects attention from our real problems the large proportion of our students who live below the poverty line, vast disparities in education expenditures between rich and poor school districts and the rising costs of higher education—and what that does to student motivation

When U S test scores are compared to other countries, say Japan and Switzerland, the United States usually ranks behind them The results, however, can be skewed Internationally, not all countries emphasize the same subjects In many countries virtually all advanced mathematics students take calculus, while in the United States, only about one fifth of students taking twelfth grade math study calculus Not surprisingly those who don t take calculus which is included on the test, generally score lower Rotberg notes that while there is room for debate about whether a higher proportion of U.S high school students should take calculus this issue cannot be resolved on the basis of test scores of students who have never taken the subject. The geographic and socioeconomic composition of a sample can vary tremendously and also factor into test results

In many countries, only the highest achieving students go to upper secondary academic schools How this affects results is shown most blatantly in what Rotberg calls "reversals " In one math assessment test that included students of Hungary and England, Hungary ranked near the top in the eighth grade comparisons but fell to the bottom in twelfth-grade comparisons England s ranking was the opposite low in eighth grade high in twelfth Hungary, however, has more students studying math in the twelfth grade, while only a select group of students in England, presumably those who will go on to study the sciences at universities take math in the twelfth grade Only those students were tested

The tests can be damaging themselves, according to Monty Neill of FairTest, a Cambridge Massachusetts, organization that promotes fair and open testing for students and workers American students may take up to ten standardized multiple-choice tests a year, Neill says with the most typically given in poor urban school systems Over 100 million tests are given nationwide during the school year Most school districts use the tests for tracking some are required by state law But FairTest contends that the tests are not accurate enough to base decisions such as denying a student a diploma And in many cases the tests can be biased by race, class, and gender

Gender bias has been particularly prevalent in math and science Historically men supposedly are more inclined toward the sciences But girls in elementary school traditionally test as well or better than boys, according to Paulos and only start to fall behind in junior high The myths lead to a gender acquiescence in a sense with women who shy from the sciences locking themselves out of higher-paying fields " I've seen too many bright women go into sociology and too many dull men go into business " Paulos writes in *Innumeracy* "the only difference between them being that the men managed to scrape through a couple of college math courses "

The myth is so ingrained in our society that Mattel which no doubt has more product consultants than you can count on your hands and toes, made the gender faux pas of the year last fall when it introduced a Barbie who said "Math class is tough "

Mathematicians in the Ivory Cylinder

Paulos dreams of a day when the world is not so divided into numerates and innumerates, and he calls his profession to task for perpetuating the myths about the inaccessibility of math But professional mathematicians he points out are caught in a culture that simultaneously exalts them for their expertise and dismisses them as impractical whizzes Senior mathematicians engineers, or scientists wooed by industry often find themselves in subordinate positions to young MBAs According to Paulos, it's not surprising that mathematicians perpetuate myths about the inaccessibility of math

"Some people think math is sort of handed down by the gods " Paulos says "that it wasn t something created or discovered by our species " Mathe-

maticians often further the illusion by flaunting a finished theorem without showing the actual work. "Mathematics is messy, full of false starts and dead ends," he says. "Half the time, it's incoherent. When mathematicians finally formulate a theorem, they then go back and clean everything up. What's left is a pristine, purely logical deduction. All evidence of human endeavor has been eradicated."

The lack of communication between professional mathematicians and educators also promotes the myth that math is inaccessible. "Mathematicians never talk to educators because they think educators don't know any math," Paulos says. "Oftentimes they don't," he adds. "Educators don't talk to mathematicians because they think they're not interested in education. Oftentimes they aren't." In Eastern Europe and Russia, however, world-class mathematicians sometimes teach in the high schools. Paulos suggests secondary math teachers and math professors switch jobs for a week. Both might learn something.

Math Is Finite

Those of us who are innumerate and still add by using our fingers often wonder if there are any problems left for mathematicians to solve. "Isn't math, as a discipline, a closed subject?" we ask. What are mathematicians messing around with in 1993? "Mathematics has a lot of life in it," Paulos says. He rattles off a few unsolved problems, including the Riemann hypothesis, which if proven will prove other hypotheses, and the Poincare conjecture, a topological problem. According to Paulos, most problems, however, are internal to mathematics. "Some are intractable," he says, "in a theoretical sense, solvable, but it would be practically impossible to find an exact solution."

Computers, of course, are changing the scope of mathematics, allowing for a new set of problems to be studied with a new approach and some old problems to be refigured. "Recent work with computers on chaos and fractals has made parts of mathematics into a quasi-empirical field for the first time in its history," Paulos says. "It's made mathematicians more diffident, because they've realized how difficult it is to predict the evolution of various systems, and it's also made them realize how little is known about the complex evolution of systems such as the economy."

Computer scientist Gregory Chaitin used the computer to reprove early twentieth-century mathematician Kurt Godel's theorem of incompleteness, which states that any formal system of mathematics that includes a modicum of arithmetic is incomplete OR there will always be true statements that will be neither provable nor disprovable with the system—no matter how elaborate it is. Chaitin proved it by running on the computer a random sequence of numerical codes for which, because of its randomness, an "equation could not be formulated." "One way to interpret Gödel's theorem is that mathematics will always have a lot of life in it," says Paulos.

Considering math only in terms of problems and solutions, however, undersells process. "The benefit of studying a problem is often broader and more amorphous than the solution," Paulos says. "New ideas are generally of more value than the particular problems that prompted their discovery." He uses Fermat's last theorem as an example, where seventeenth-century mathematician Pierre Fermat said that there do not exist whole numbers x, y, z such that $x^3 + y^3 = z^3$. Although the consensus is that his theorem is true, no mathematician has been able to prove it. "All kinds of other mathematical tools have been developed in the effort to prove or disprove Fermat's theorem," Paulos says.

This Sentence Is False

Call it Paulos' Dilemma. How do you convince students they can do math, that they even need to know their numbers, to make decisions in life. How do you prevent the field of mathematics from becoming infinitely internal, from swallowing itself up? How do you merge the sets of numerates and innumerates so that more people get a piece of pi? Keep writing math, as Paulos plans to do, with a fifth book he's keeping undercover that's already in the works. His motivation comes from his belief that there really is a latent hunger for mathematics. The success of his books seems evident of that. But where does the hunger come from? Paulos isn't sure. The answer is intractable and incomplete, something you can't solve using a computer or that even makes common sense. "In an increasingly complex world full of senseless coincidence and baseless pseudoscience," he writes, "what's required in many situations is not more facts—we're inundated already—but a better command of known facts, and for this a course in probability is invaluable. Probability, like logic, is not just for mathematicians anymore. It permeates our lives." Quietly, almost as an afterthought, a digression, he adds, "In a way there's nothing more basic, more fundamental, than numbers." ∞

AI

CONTINUED FROM PAGE 22

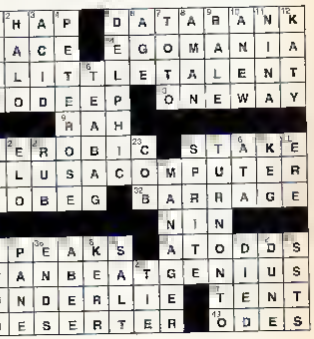
find a way to put words in the grid." Assigning a value from 0 to 12 to each, 0 denoting a personal favorite or fun-to-clue word and 12 a word that the program won't even consider using, Albert has poured 750,000 words and phrases into his database. He dumps in the entries en masse, using dictionaries and thesauruses available on disk. He's even written programs to cull words and apt phrases from various software, such as rock-'n'-roll trivia games. But he's found no shortcut to tagging the entries. It took him more than two months to tag the 67,175 eight-letter words in his database.

The computer comes up with two more solutions for the upper right-hand corner and decides—after 51 seconds—that it can do no better than a value of 66 of 22. Albert then readies the computer for a second, much smaller chunk, which, as it happens, offers a more formidable challenge than the first simple grid he attempted to fill with an early version of his program.

"I can't tell you how long it took," he says. "I started on a 386 machine at work on a Friday afternoon, and when I came in on Monday morning, it was nowhere close to done." So far, Albert guesses, he's increased the program's speed by roughly a million times. Computing time on today's puzzle: 2 minutes, 36 seconds.

He smiles when he sees PETE ROSE in the 4 down slot, and he thinks Motown when he spots TOBEG running 31-across. He enjoys being surprised by his own puzzles. Although he currently writes the clues by hand, he could partially automate this final phase of puzzle constructing.

"I'm using the computer in every possible way I can to stress my advantage," he says. "But also because it's fun, it's kind of a metapuzzle." ∞



AUTOMOBILITY

CONTINUED FROM PAGE 40

place vehicles in traffic schemes that are inherently less hazardous. Take a platoon. "If the vehicles are very close together and their velocities are the same, a collision would have a very minor impact," says Hall. It could probably be absorbed by heftier bumpers, letting the caravaning autos continue their journey, he says.

What's more, the sensors and microprocessors used for automatic driving could also power sophisticated warning devices to help when drivers operate their cars in manual mode. In fact, most sensing systems will start out as mere driver aids until they're proven reliable enough for actual vehicle control. Collision-avoidance radar from Ford Motor Company will appear first as a vision-enhancement device. In poor visibility, it may project simplified icons onto a windshield in a head-up display, overlaying the position of other vehicles and hazardous obstacles. "For the moment, we're not taking control of the vehicle, but the day that it becomes acceptable to the driving community, the system will be able to do so very accurately," says Eduardo Peralta, manager of the research program.

"We need to go up the development stairway a step at a time; that's the whole history of the automotive industry," says Robert Ervin, codirector of the University of Michigan's IVHS program. The process begins with autonomous, free-standing safety and convenience features that show up first in high-priced autos and then trickle down as they demonstrate their worth. Highly coordinated functions like platooning won't become widespread for at least 20 years, predicts PATH director Don Orne. Others are more cautious. Joseph M. Sussman, professor of engineering from the Massachusetts Institute of Technology and former distinguished university scholar with IVHS America, doesn't expect such capabilities to reach the cars of average motorists for another 25 to 30 years. "There's a lot of technical work that needs to be done," not to mention the engineering, education, and public-policy changes, Sussman says.

The evolution of thinking cars began when antilock brakes appeared in the mid 1980s, followed by traction control. Both countermand the command of the driver in order to keep tires rolling under control. An antilock brake system, or ABS, using a series of rapid pulses, automatically reduces brake pressure when it determines that a wheel is about to lock during hard stopping—a condition that would cause it to slide out of control. Traction control piggybacks onto ABS to prevent spin-outs during acceleration. The system available on Infiniti Q45 models borrows the car's ABS sensors to detect when a wheel is spinning too fast. It then applies selective brake pressure to keep an errant wheel under control. At the same time, the computer may reduce the amount of gas going into the engine, even though the driver is trying to pour it on all at once. Not only does the system provide better starts at stoplights, it can assure stability during risky maneuvers like passing a truck in rain or snow.

Engineering, manufacturing, and operational experience from one milestone system—antilock brakes—roll into another, traction control. They even share some of the same hardware and software. "One of the reasons this technology is so appealing to me is that it's relatively inexpensive once the fundamental building blocks are in place," says Gene Farber, who directs IVHS strategy and planning for Ford. With enough sensors, actuators and processing power on board, adding control features becomes primarily an exercise in computer programming.

Two key building blocks yet to come are collision-avoidance radar and integrated power-train control. Elements of each are arriving fast. Integrated power-train control eliminates the mechanical linkage that currently connects the gas pedal to the engine. In the future, the accelerator will be a mere electronic input device, registering your intention by sending impulses to a control computer much the way your kid makes Mario jump and run with a Nintendo joystick. A significant first step in that direction is the electronically controlled accelerator on the new BMW 750iL luxury sedan. Its gas pedal operates a potentiometer, like a radio volume control. A simple wire connects it to the computerized engine-management system.

Such drive-by-wire arrangements make it easier to add fully automatic speed control because they give a computer full charge over the physical mechanisms that govern the engine. Today's cruise-control devices share the engine with the gas pedal, and the driver's foot has priority. That would never do in a platoon, where speed would have to be adjusted precisely, automatically to keep each member in synch with the group. With drive-by-wire, the computer could turn off the gas pedal when appropriate.

What's more, a processor between driver and engine can mollify the ped-

al so that the engine operates at peak efficiency all the time "A driver doesn't know exactly how to use his toe to optimize fuel consumption and minimize emissions," says Ralph Colello, head of the automotive practice of management consultants at Arthur D Little. With fully integrated power-train control, he says, "the computer would decide how much fuel to add and how quickly to add it."

As a first step toward collision-avoidance radar, intelligent or adaptive cruise control should begin appearing on cars by about 1995. A prototype adaptive cruise system on a Cadillac Seville running around the General Motors Technical Center near Detroit uses a radar-like device to gauge the distance to the car ahead. A controller then constantly adjusts the car's speed to maintain a safe following distance, adapting to faster speeds by staying farther back. If the leading vehicle should slow suddenly, GM's system automatically applies the brakes while at the same time sounding an alert to let the driver know that additional action is needed.

A similar intelligent cruise system being developed by Mercedes-Benz uses an infrared distance sensor. "There's a Mercedes test car on the road every day in which the driver sits there with arms folded while the car drives itself," Dieter Zetsche, the new head of Mercedes-Benz research and development in Germany, said recently. A production Mercedes with intelligent cruise control is possible by 1994 (probably for the 1995 model year). In Japan Nissan is working on a range finder that reads the reflections of lasers. Already Japanese truckers can buy a version that warns them if they're closing too fast. And the 2,400 buses of Greyhound Lines are being equipped with radar warning systems from VORAD Safety Systems of San Diego. These devices are all stepping stones to fuller-functioning collision avoidance like the system under development at Ford, which uses multimode radar that adapts to changing traffic conditions. The system may stare at faraway obstacles, it may slew—slowly scan—to get a better read on objects at intermediate range and then rapidly scan threats nearer the vehicle. "It has to recognize a tree beside the road from a car on the road," says Eduardo Peralta, a former weapons engineer who transferred from Ford Aerospace to the car business in 1987. The device differentiates between two side-by-side vehicles at 500 yards resolution that would have required a ten-foot diameter antenna until Ford developed an alternative barely five inches across. "This will be the smartest system on the car," says Peralta, his pride subdued but apparent.

Other technologies will play significant supporting roles. Vehicle navigation can tell a car where it is and how to get to where it's going, typically by combining an external positioning technology, like satellite tracking, with onboard dead-reckoning that charts the car's progress on computerized maps. In the TravTek test project now underway in Orlando, video screens in 100 Oldsmobile Toronados display traffic information as well as maps directing drivers to their destinations. Future nav systems could be linked to automatic vehicle controls to allow a car to guide itself. With roadside communication beacons to transmit information like speed limits and turn restrictions, a properly equipped automobile could conceivably freewheel from driveway to, say a restaurant punched into the nav system from its own Yellow Pages directory. The most challenging barrier to roadway automation is not scientific knowhow, but nagging societal issues. Pollution remains a big concern. There's little doubt that individual cars will emit less pollutants once consistent computerized control nullifies erratic and inefficient driving. Advocates hope that even if travel volume increases, overall emissions will decrease as automatic driving cuts out the stop-and-go traffic in which engines are least efficient. "There may be pollution benefits, but those benefits are not proven," concedes PATH's Hall. At the same time, development of alternative engines and fuels, electric cars, and even better gasoline engines may ameliorate emissions.

> "There's a Mercedes test car on the road every day in which the driver sits there with arms folded while the car drives itself."

Another concern holding up the systems is product liability. Auto makers fear being nagged into bankruptcy by claims for equipment failures or, even worse, perceived equipment failures in automobiles outfitted for automatic driving. "Our substantial concern is about its misuse," says Farber. According to Vostrez, we need to legislatively improve the environment for developing these systems. "We must recognize that especially during the early development stage there will be some risk," he says. "Society must agree to share it."

Yet probably the greatest concern among IVHS advocates is how to make room for drivers once cars no longer need them. The inevitability of human presence means that automated systems must be excruciatingly simple to operate. They must allow for safe, easy transitions between manual and automatic modes. And they cannot distract or overload operators. That's where computer-processing power can be used to great advantage. For instance, in Ford's collision-avoidance system, "all the processing is done internally, within the radar, to keep the driver from being distracted by needless information. Only the threats are presented to the driver," Peralta says.

He worries about price tags, too. At introduction around year 2000, Ford's radar won't exceed $1,200, the sum motorists already pay for power moonroofs. Fact is, the auto makers are pretty consistent in turning marvelously complex and concatenated machinery, both electronic and mechanical, into products for the masses. After a century competing in consumer markets, they've learned that the success of such concepts as automatic driving ultimately hinges on popular acceptance.

At the same time, we motorists have demonstrated an eagerness for equipment that makes driving more comfortable and convenient, from electric starters and automatic transmissions to air conditioners and even car radios. Operator skill improves with successive refinements. "When I was a kid, driving was so all-consuming that you never thought of bringing food or drink into the car," says Jerry Palmer, a GM future thinker and Design Center executive. Automatic driving will make possible a game of chess, a chapter of *War and Peace*, even a nap. "Your relationship with your vehicle will be such that you'll actually look forward to a long journey," Palmer predicts.

Automatic driving will improve relationships among vehicles, relieve crowding, reduce hazards, all the while allowing people to amass their beloved automobiles. To that end, careful rethinking and reorganizing of transportation policy should begin today, before it's too late. "When you look at the speed at which the technology is evolving," warns Vostrez, "it may arrive a lot faster than we anticipate."

SMART

CONTINUED FROM PAGE 48

move you. There's no force between us." Sensors in the noise-killing curtain pick up the incoming waves, the punches of sound, and trigger piezoelectric movements to absorb the punches thousands of times a second. The result of this high-speed boxing match is silence. In some contests, such silence means victory. The U.S. Navy, for example, carefully tracks noise-suppression work in labs like this so that someday it can commission submarines so quiet that no enemy can hear them coming. The principle for muffling the racket is simple, according to Harry Robertshaw, a professor in Rogers' center. Sensors on the outer hull would pick up any vibrations from the sub. The piezoelectric patches would produce vibrations that would cancel out the sounds.

In the future, say material scientists, submarines will not just be silent; they will also move through the water with the sheer natural grace and speed of a fish. According to electrical engineer L. Eric Cross, sharks and other marine animals can speed though the water with so much agility because of an adaptive body shape. "There are a number of marine creatures," Cross explains, "that in fact swim faster than their power sources should let them. They do this by streamlining the flow of water over their body surfaces. We'd like to mimic that. We'd like to know how we can benefit from millions of years of marine evolution."

One way, Cross adds, may be through the next generation of piezoelectric materials, which are some ten times more sensitive than the materials in use today. Once these new sensors come into play, says Cross, the skin of such water babies as submarine ships and torpedoes will continuously monitor their flow through water, changing shape depending on the strength and direction of currents and the depth of the sea.'

But subs and torpedoes are just the beginning. The true goal, says Rogers, is perfecting a new generation of animated machines with multiple applications for every aspect of our lives. These smart systems would be put together piece by piece, forming a consistent constructed world in the same way nature uses basic cell structure in everything from muscles to neurons. Reaching that goal shouldn't take more than a generation, he says. "I'm convinced that twenty years from now, smart materials will be just as ordinary as many of the most common structural materials are today."

It Rogers is correct, smart machines will be everywhere by the year 2012. In fact, researchers at the Xerox Palo Alto Research Center are writing scenarios for what they call "ubiquitous" computing. It may be the ultimate in smart materials. If their plans are realized, computers will reside invisibly in all of our stuff, hundreds or thousands of them per house or office. A central computer, costing no more than $300 to $400, will coordinate them, according to engineer Mark Weiser, head of the center's Computer Science Laboratory.

"The big change we'll see is many more computers in all parts of our lives," Weiser says, "but we'll be much less aware that they're there." Weiser and his colleagues have already built models of some of the gear that he thinks will insinuate itself into smart homes, offices, and cars over the next 20 years. One is called a tab, about the size of a packet of Post-it notes with a 2×3-inch video screen. Tabs carry the bookmark concept to an extreme. "Things will come with tabs built in," Weiser says, "or you'll stick them on things." Tabs will use radio or infrared signals to communicate with the central computer in your home. The central computer, in turn, will know where everything is and coordinate the action of all the individual tabs. Your bedroom alone may house more than 100 tabs, Weiser says. To find lost socks, adjust the heat, receive short messages from your children in other rooms, or control the computers in the wall, you can simply read or adjust a tab. Next to your bed, you'll also find a few "pads." Weiser's term for flattened computers the size of yellow legal papers. You can scribble on these pads or call up pages from a book, magazine, or database. The walls, if you choose, will display one or two hanging "boards" a yard or so in width to let you view news or the neighborhood scene.

Ultimately, Weiser says, computers will disappear, literally, into the walls. These animated computerized surfaces will provide future Americans with far more control over their environment and an extensive vision of their immediate world. Knowing where everything and everyone is, he says, will lead future Americans back to a simpler past. "We can return to the kind of society in the early part of this century," he says, "when everyone sat out on the porch and watched and cared about what was going on in the community." But when that day dawns, the community will be considerably enlarged—by a whole new species of sensing, moving, reasoning, animated machines. ∞

GAMES

APRIL FOOLERY
Spend the silliest month with our fiendishly difficult board game

By Scot Morris

A tricky new solitaire game recently came my way. To play it, you'll need a grid of squares, like a chessboard, and a bunch of counters, such as checkers or coins.

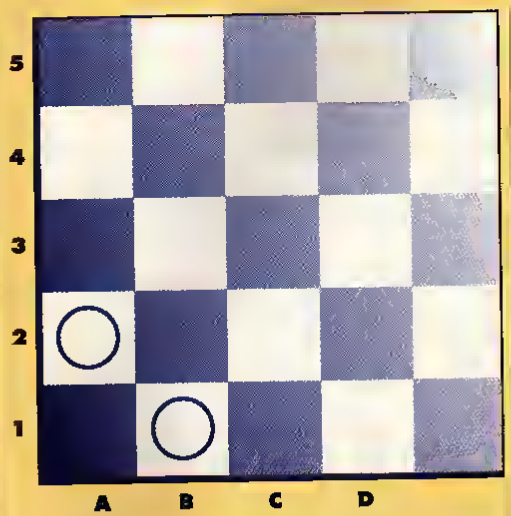
Start with one counter in the square in the board's lower left corner. Each move consists of choosing a counter on the board and putting down two new counters—one on the square just to the right of the chosen counter and the other on the square just above it, you then remove your chosen counter. Squares can hold only one counter at a time.

The first move leaves the corner square empty and two counters on the first diagonal squares (right). With three more moves, you can empty these two squares.

How many moves will it take to vacate the lower left six squares—that is, the three mentioned above, plus three along the next diagonal?

In practice, a standard 8 × 8 board will suffice for this game, but in theory, the rules allow for the board to be infinite. Since the moves always progress to the right and up, it seems intuitive that the lower left corner squares will eventually all be empty. But how many moves will it take?

This solitaire game had its start in the former Soviet Union at the "Tournament of the Towns," an intercity mathematics competition. In the spring 1981 contest, M. Kontsevich posed the checkerboard puzzle, the problem of vacating the six corner squares differs somewhat from the original puzzle. The "Tournament of the Towns" has since become an international event. In 1990, at the first World Federation of National Mathematics Competitions Conference, N. Konstantinov of Moscow presented his surprising analysis of the game. Attendees report that the assembled mathematicians found his insights so elegant that they gave him a standing ovation.



I'll give more information about the problem in a future issue. Meanwhile, I offer to award $5,000 to the first reader who sends the correct solution with the fewest finite number of moves. Let me caution readers that no solution has been found to this problem. But if you think you've got one, send it to me at Counter-Intuitive Problem, Omni Magazine, 324 W. Wendover Avenue, Suite 205, Greensboro, North Carolina 27408. The moves must be numbered sequentially and identified by the coordinates of the vacated squares. Use chess notation, numbering the rows from the bottom up 1, 2, 3, and so on, and lettering the columns A, B, C, and so on, starting from the left.

While you've got a chessboard out, try this one.

1. Can you construct a knight's tour that starts in one corner square of the board and ends in the square diagonally opposite? A knight's tour starts on one square of the board and ends 63 knight moves later on another specified square after visiting every other square once. If you can't do it, can you prove that nobody can?

And in honor of the month, here are a few amusing puzzles. The answers follow.

2. My brother and I were born in the same hour of the same day in the same year. But we are not twins. How can this be?

3. A woman pushing her car stopped outside a hotel and immediately went bankrupt. Explain.

4. Hogan and Snead are professional golfers and long-time rivals. One day during a game, they had each scored 30 when Hogan hit a bad shot. Snead immediately added 10 to his own score. Snead then hit a good shot and won the game. Why?

5. Barrel A is filled with 55 gallons of water. Barrel B, the same size, is half-filled with water. What could you fill Barrel A with to make it lighter than Barrel B?

ANSWERS

1. It isn't possible. A knight on a square of one color changes to a square of the other color on every move—black to white or white to black. If it starts on a black square, after an odd number of moves it's on a white square, and after an even number of moves it's back on black. Diagonally opposite squares on a chessboard are the same color, but the tour takes 63 moves, an odd number.

2. We are two of a set of triplets.

3. She was playing Monopoly.

4. They were playing tennis.

5. Holes.