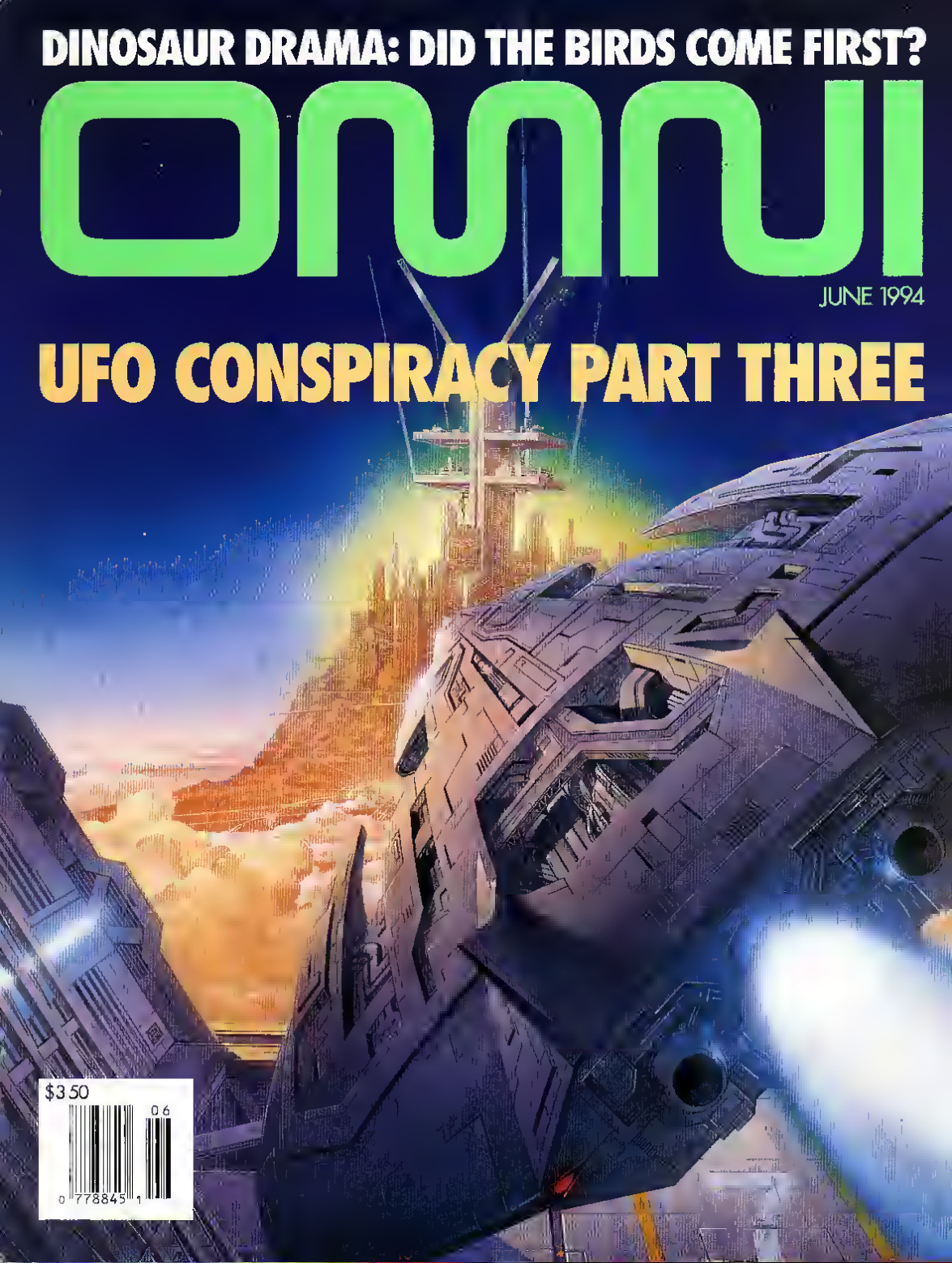
DINOSAUR DRAMA: DID THE BIRDS COME FIRST?

OMNI

JUNE 1994

UFO CONSPIRACY PART THREE



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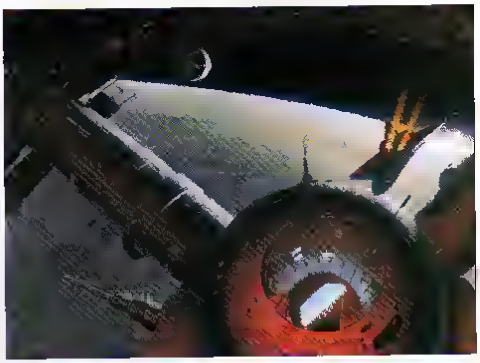

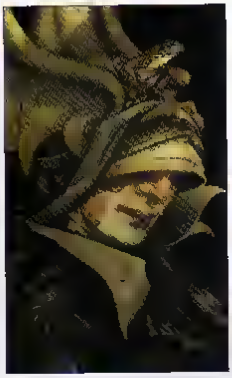

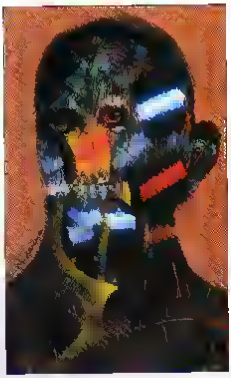

This issue of *Omni* is dedicated to the memory of our wonderful senior editor, Murray Cox (1946–1994) who did so much to ensure that *Omni* saw beyond the horizon Cover art by Tsuneo Sanda. (Additional credits, page 89)

FEATURES

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FIRST WORD

EXTRATERRESTRIAL NIGHTMARES:
Aliens aren't the first creatures to capture our dark imagination

By David Brin

David Brin offers a word of warning should E.T.'s visit our planet: "Wise uncles may be no better than nasty elves. We need friends, not sanctimony."

As a frequent "futurist/space expert" on talk shows, I've faced my share of calls from believers in UFOs. Some are polite, sincere. Others get rude when I suggest that vague anecdotes aren't impressive evidence for such an important phenomenon. As a participant in SETI (the Search for Extraterrestrial Intelligence) and author of science-fiction novels about "first contact," I don't like being called an Establishment shill, out to suppress unconventional thought.

The intense emotion behind UFOs intrigued me, but I never put it all together until my wife saw the cover of a famous book about alien abductions. "Huh!" she said. "When I picked this up, I thought it was about elves!"

Sure enough, there they were: huge enigmatic eyes, big smooth heads, long creepy fingers. I recalled fairy tales—not the sanitized, Disney versions—but old tales collected by the brothers Grimm or Native American legends of coyote or folklore of the Aranda, Yanomamo, Ibo. Although many fables are beautiful, spiritual, elevating, their nonhuman characters often behave in strikingly similar ways—capricious, mysterious, meddlesome.

It hit me. UFO aliens *are* elves! They fill the same niche as faery creatures, flitting at the fringes of the firelight. Only now, for better or worse, light from our civilization covers the planet, so faeryland has been pushed to outer space. Either something deep within us makes humans in all cultures hallucinate mysterious meddlers, or else they've been among us for ages—not visitors, but longtime neighbors. Familiar as the night.

Magical thinking. It occurred to me then that UFO cultism is a prime example of magical thinking, where what's objectively true is less vital than what ought to be. You cannot debunk such beliefs the way you would a flawed technical theory. No mountain of data can extinguish the enthusiast's glittering hope that "next time, E.T. will phone *me!*" Anyway, who wants to erase hope? Not readers of this magazine, who think themselves daring folk—the sort who should meet visitors, if they ever come. We and UFO fans share a sense of wonder at the vast cosmos. Only, we have no magical yearning for mysteries to remain mysterious. If aliens really are swooping down to twirl wheat, abduct folks, and stick needles in our brains, our natural question is *why*. Why high-IQ vandals instead of honest, open visitors?

UFO defenders plead that *they* are afraid of *us*, or we're not ready for contact. But such excuses sound whiny. Like the starship captain in the excellent but misunderstood movie *E.T.*, who abandons a crew mate when threatened with nothing more than flashlights, these aliens sound more like selfish cowards than the non-Earthly friends we dream of meeting.

Or take the excuse that "we have no right to judge. Their standards may be different." Perhaps. But this is *our* planet. If they're so smart, why not study how to be good guests? Don't kidnap people. Phone up JPL and we'll roll out the red carpet—landing sites, rent-a-cops, visas (of both kinds!). The Letterman show? You got it. But that's never been the way with elves. They don't like the light.

UFO myths include another type of alien—an "elder race" with answers to our woes. Today millions link the word *contact* with salvation. How ironic. After ages clawing our way upward by trial and error, through hard work by countless men and women, humanity seems poised at last to choose whether to take one final step—becoming civilized folk, planet managers, elder siblings to the species of our world. Now imagine a flying saucer lands and some austere, silver-clad envoy makes a speech provoking tizzies of euphoric new-millennia resolutions. After a hundred centuries of lonely struggle to grow up, just when we're on the verge of dramatic success or stunning failure, someone with a shiny suit and patronizing manner pops in, gives a lecture, then takes all the credit?

Thank heavens good science fiction offers countless more interesting speculations about alien life (if it exists) than condescending uncles or nasty little elves. But suppose those are our only choices?

Well, I don't mean to be a poor sport, and I hope we are gracious and mature hosts, however ill-mannered our guests appear to be.

But until then, I remain a big fan of the U.S. Air Force. Keep watching the skies, guys. Keep watching the skies. ◻◻

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FORUM

REMEMBERING MURRAY

By Keith Ferrell

May I tell you a bit about Murray Cox? For more than a decade, in various positions and roles, most notably as *Omni*'s senior editor, Murray brought a rare and special brilliance to the pages of this magazine. That brilliance bore many facets. Murray Cox was gentle, contentious, kind, reflective, vain, self-effacing, insightful, acutely critical, funny beyond words, passionate about social reform, joyous in his relationship to the English language and the articles he helped shape from it, deeply engaged with ideas and deeply disturbed by the widespread fear of ideas, energetic, deliberate, impulsive.

Murray possessed one of the most adventurous minds I have ever encountered.

Senior Editor Murray Cox brought to these pages a grace, wit, intellect, and elegance seldom seen in the magazine world. His contribution cannot be overestimated.

Over the past two years alone, Murray's lively intellect carried him and the writers he worked with through features dealing with an amazing range of subjects: dinosaurs, education reform, particle physics, the Food and Drug Administration, complexity and chaos theory, an E-mail debate on the nature of science and the humanities, the dangers of post–Cold War nuclear weapons proliferation, and more. In the past few months two of the pieces Murray edited have been recognized with major national journalism awards.

Editing became something special under Murray's touch. The writers who worked with Murray could speak volumes about the level and degree of commitment this man brought to their work and to the bargain that exists among editors, writers, and readers. For Murray, as for all of us at *Omni*, the readers come first in that relationship. Among the many things that Murray loved about *Omni* was your intelligence, your willingness to wrestle with difficult subjects, challenging topics, provocative issues. You come to *Omni* because you crave intellectual adventure and stimulation. Murray helped you find that here.

This meant—as his writers will tell you—that pieces went through a rigorous and often exhausting process as Murray sought, sentence by sentence, to help writers build pieces more substantial and more carefully crafted, more thoughtfully argued and more thoroughly researched, to force them to be good, and then better, and then the best. His approach was no different for seasoned and well-known professional writers than for those at the beginnings of their careers, although I suspect that Murray took a special pleasure in working with new writers. Certainly those who received the benefits of his instruction will carry those lessons with them throughout their professional lives. Their personal lives as well, whoever you were.

There is no such thing as perfection, as Murray would have been the first to tell you, but that doesn't mean there's no such thing as the quest for perfection. Murray pushed, his writers responded, Murray edited, the readers reaped the rewards.

As a writer, Murray's brilliance equaled and perhaps exceeded his editorial skills, although his production, at least for publication, was at best parsimonious. That's probably unfair. Murray was as generous on the page as he was in every other aspect of his life. It was just that he brought to his own work the same standards he communicated to others. He put himself through the same unflinching process.

This was not easy, and there was a certain amount of pain for Murray in writing for publication. That the effort was worthwhile can be seen on the page. I think of a Forum Murray wrote for our August 1991 issue and, particularly, the stunning feature, "Notes from the New Land," which appeared here last October. More than one reader called "Notes" the best feature *Omni* ever published. Murray would have denied that. But, then, he wrote it. He did.

Writers first must live, and Murray filled his 48 years with several centuries' experience. Away from the desk, Murray was every bit as special and brilliant as he was professionally. His circle of friends was enormous and deep, an extended family as diverse as any group you could imagine. What they had in common was Murray, and their devotion to him is as much monument as any man could wish. Conversation with Murray fared across the range of human learning and experience. A meal or a drink could become a revelation, a celebration. He could be profane, but he was never obscene. His laughter was infectious, and echoes among us still.

Murray Cox died of AIDS in his beloved New York City on March 13, 1994.

We will miss him forever.

He made us better. ∞

ARTS

ALIEN INSPIRATION
On the set of *Roswell*, the movie

By Bill Moseley

Something crashed outside of Roswell, New Mexico, in July of 1947. The U.S. Army would have us believe it was nothing more than a weather balloon. But hundreds of eyewitnesses, military men just now daring to break their oath of silence, claim that what the Army discovered, recovered and covered up was a ship from another world, complete with flight crew—one of whom was still alive.

This mother of all UFO stories is the subject of the Showtime original movie *Roswell*, scheduled for a summer 1994 debut. Based on the nonfiction book *UFO Crash at Roswell* by Kevin Randle and Donald Schmitt, *Roswell* was written by Arthur Kopit, produced and directed by Jeremy Kagan, and stars Kyle MacLachlan (*Twin Peaks*), Kim Greist (*Brazil*), and Martin Sheen (*Apocalypse Now*).

Strange metallic debris strewn over three quarters of a mile of a sheep ranch near the Roswell Army Air Field prompts Major Marcel, played by Kyle MacLachlan, to make public his suspicion of a UFO crash.

The movie begins with a 1977 reunion of the 509th Bombardment Group from the Roswell Army Air Force Base, where through the use of flashbacks (or, as director Kagan calls it, a "Rashomonlike" approach), several of the men who participated in covering up the crash open up to Maj. Jessee Marcel (MacLachlan), the former base intelligence officer now in his seventies, and a startlingly different version of the Army's "weather balloon" story emerges.

As I spent three days poking around various sets in Los Angeles, it was emphasized to me that *Roswell* is not a science-fiction movie per se, but a film about relationships, secrets, and cover-ups. "The *JFK* of UFOs," as unit publicist Cid Swank put it so eloquently. However, if only to educate the nonbelievers (and titillate those in the know), Kagan has spiked the movie with references to such icons of conspiracy as the Majestic 12 (Truman's alleged clandestine UFO disinformation group) and Area 51 (the site where aliens supposedly have been overseeing the construction of spacecraft).

Executive Producer Paul Davids, who originally optioned the Roswell book and coopted fellow American Film Institute alumnus Kagan to the project, claimed to me to have seen a "domed disk" maneuvering over his house near Pasadena, California, in the broad daylight of February 25, 1987. Interviewed on location at the Van Nuys, California, airport in the shadow of a B-29 bomber, Davids went on to say that what attracted him to the Roswell mystery was the fact that many of the UFOs spotted during that summer of 1947, the year the term "flying saucer" was coined, matched his sighting, wobble for wobble.

Neither MacLachlan nor Kim Greist (who plays Marcel's long-suffering wife, Vy) had a close encounter by the start of production. Both actors were, in fact, much more concerned about playing characters who age 30 years in the course of the film—thanks to Manlio Rochetti's latex makeup magic.

Downstairs, in a simulation of the infamous Blue Room, a group of make-believe officers and surgeons was preparing to shoot the scenes in which the Roswell alien blesses them, dies, and is then promptly dissected—revealing a chestful of canned oysters. The silicone creature, courtesy of special-effects master Steve Johnson (who did Uma Thurman's thumbs in *Even Cowgirls Get the Blues*), did indeed look fetuslike, save for four fingers and toes instead of five (maybe that's where Steve got Uma's thumbs) and a lack of visible sex organs.

One theory about the Roswell aliens is that they were actually humans from the distant future and their spacecraft was in reality a time-travel machine. When I asked producer Ilene Kahn if it depressed her to think that the evolution of homo sapiens might include the loss of genitalia, she responded, "It would be sad to think that we're going from more contact to less contact. I would hope that we're not going to spawn by spores!" DG

COMMUNICATIONS

READERS' WRITES:
Beauty in the eye of a storm, defending science, and the length and girth of it all

Don't Mess with Mother Nature
Doesn't hurricane "seeding" [Hurricanes: Reaping the Whirlwind, March 1994] and the technological/scientific investigation surrounding ideas like this merely reflect yet another example of the historically repulsive patriarchal pursuit of science? Hurricanes are indeed "disasters" but what effect do they have on the larger sustentation of the planetary equilibrium? It seems science continues to embrace the man-over-nature mentality, and *Omni* continues to awe-inspiringly cover those topics. Man has a place on the planet that none of us should pretend to comprehend, yet our technologies have placed us in a position to alter the larger network of the planet, and we need to do so responsibly. Much heated debate needs to occur regarding natural phenomenon alteration before we blindly accept its scientific merits.

Kevin Martin
Chicago, IL
AOL: KMART 222

Your Earth column, "Hurricane Omni," March 1994, sent a tremor through my soul. I'm a surfer from Virginia Beach, and for me, a hurricane is a spark of awe, anxiety, and hope. The waves are the final culmination of a hurricane, and being in one of Mother Nature's most awesome spectacles is somehow holy. My heart goes out to those who suffered losses in hurricanes, but I can't help feeling a certain wonder at seeing one of the greatest beauties on Earth. In my opinion, attempting to control or lessen such a storm would be utter folly and criminal. As the old saying goes, "Don't mess with Mother Nature."

Carl Ross
Virginia Beach, VA

Reader to Reader
While Claude Pauly [Communications, February 1994] reminds us about the time when radio waves and bacteria were "declared nonexistent," he forgets that it was science that eventually discovered these wonders. Science does not claim to be "the defender of absolute truth." It claims to have the best, most systematic and rigorous method for bringing us *closer* to the truth. If Pauly or anyone else has an alternative, practical method which has a better record of discovery and invention over the millennia, let's hear about it—but for goodness sake, stop the whining.

Steve Lobley
Sedona, AZ

Where's the Beef?
I read with great disinterest yet another advancement in DNA research and tampering with our chromosomes [Continuum, February 1994]. While I've no problem with this, I feel it misses the fundamental point on which every American male dwells: Where in the DNA is the section that controls the size of the penis, and why aren't they studying it? When most men see a penis larger than their own, they feel inferior. (As a gay man, I know of what I speak.) I suggest scientists conquer length and girth to provide them with an astounding amount of funding.

Ed Stevenson
Baltimore, MD

Men Are Bingers, Too
I was happy to read the piece "Feed Your Head" in the Continuum section of the March edition. However, I stopped at paragraph 3. "Researchers have found that bingers have higher opioid levels than do normal women." The problem is, my binger friend is a man. Eating disorders such as anorexia and bulimia have primarily distressed women, but binging crosses both sexes. Let's not label our binging men with a "woman's disease" by falling prey to old stereotypes.

Leigh Wirth
Rockville, MD

MIND READING AMONG THE MACAQUES

How the brain interprets the intentions of others

By Kathleen Stein

Along with monitoring one's inner life nothing is more central to human thinking than the representation of minds of others. 'We engage automatically and effortlessly in building theories about the inner states of those around us," says neuroscientist Leslie Brothers of the UCLA Brain Research Institute and Sepulveda V.A. Medical Center.

'The complexity of social life demands specific and changing responses to the world of mates, offspring, leaders, rivals, in-group bullies, and allies." Here

All primates, including macaques, have evolved sophisticated and complex ways of figuring out what their peers are up to.

Brothers is not referring to human social exchange, but relationships among macaque monkeys. All primates, she says, have evolved expert systems for decoding the activities and gestures of their fellows. 'You have to be able to remember who's your friend. If you forgot someone wasn't nice to you, you wouldn't survive very long."

How the brain processes social information is a little-researched area. But Brothers and colleague Brian Ring have developed an ingenious method for determining the way neural circuits generate macaque social behavior. The investigators videotaped a troupe of outside-housed monkeys as they ate, groomed, played, copulated and slept. They transferred 50,400 frames of footage showing all manner of body views and movements—closeups of body parts (fur, hands, feet, rear ends, eyes, and ears)—onto a computer-controlled laser disc. They showed these elements of social activity to individual macaques, each of whom had tiny electrodes implanted into single cells—parts of neuron ensembles—in select brain areas.

By recording what neurons fired during what events, Brothers found that images of specific gestures or actions activated specific neurons. In one episode, the observer monkey watched a female holding a piece of fruit as another circled and approached her. A neuron fired strongly as the animal viewed this prelude to a handout. It did not fire at a sequence of two monkeys grooming or of one circling the other who had no fruit. That neuron only responded to the representation of the other's intent to bid for the fruit.

Brothers recorded from electrodes in the amygdala, an area central to processing emotions, having extensive pathways to lower visceral areas, adjacent limbic structures, and cortical regions. Her data indicate that the amygdala is a unifier in a network for social cognition, a sort of Times Square. There, pathways converge from nearby areas, such as the superior temporal sulcus, which may be involved in identity (who is doing what to whom), and the frontal cortex. Others have found specifically socially responsive neurons in these areas.

Social events may have privileged access to both motivational states and memory coding, she says, forging an intimate link between emotions, memory and perception. The emotional component must be present for the social information to have meaning. "I don't want to make a general statement about emotion and cognition," she laughs, "because a lot of people realize it may be an artificial division. But in the anatomy of social cognition, you can make concrete statements about it."

Brothers suggests that paranoia—where one is plagued by the intentions of others of often vague identity—may stem from deficits in this social network. In autism, too, persons have difficulty dealing with emotion-laden information about others. Autistic people don't register the feelings that social situations generate. And individuals with certain temporal-lobe damage can identify faces but can't link identity with the sense of person (a psychological entity), creating a "strangeness" about the familiar face, a conviction that the person is an impostor. Patients with some frontal-lobe lesions don't seem to appreciate social rules or make the right social judgments, misreading others' characters and motivations.

Recently Brothers teamed with UCLA colleagues to study patients set for epilepsy surgery who have electrodes to pinpoint seizures implanted in the same areas she's explored in the monkeys. They watch a movie filled with emotional images and the investigators track neural activity during specific scenes. "Now not only do I have a chance to see how human neurons are firing," says Brothers, a psychiatrist by training, "but I can listen to people telling me what they're feeling at the same time, reflecting on their experiences."

MEDICINE

DAVY JONES' MEDICINE CHEST
Chemists pursue a treasure trove of drugs from the deep

By Michelle Kearns

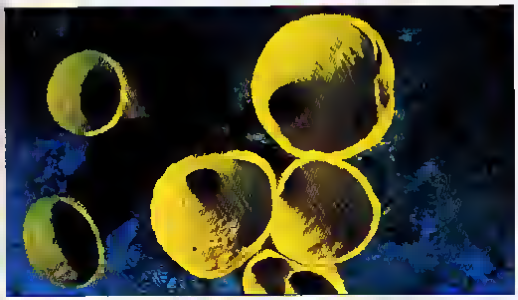
Six years ago in the waters off the Bahamas, a contraband scout from the coast guard stopped Ken Rinehart and his crew. They came away clean: no drugs on board—well, at least not the kind the coast guard is used to finding.

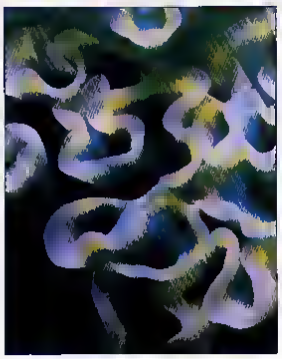
Dr Rinehart's team of chemists at the University of Illinois think they've got some great drugs. They're made by animals, called tunicates or "sea squirts," that grow in grapelike clusters. One species, found by Rinehart in Caribbean mangrove swamps, produces a powerful antitumor agent dubbed *Ecteinascidia turbinata* (Et for short). It's 150 times more potent than today's most commonly used drug. A mere fraction of a nanogram of Et kills tumor cells. Signaling its future potential, the National Cancer Institute recently selected Et for further preclinical testing in animals.

And that's just for starters. For nearly three decades, U.S. scientists have collected and studied algae, seaweed, sponges, and tunicates everywhere from Nova Scotia to the Indian Ocean, from Australia's Great Barrier Reef to the Mediterranean. From a handful of researchers in the late 1960s, the national marine biomedical effort—funded by the federal government's Sea Grant Program and the National Cancer Institute—has grown to at least 12 investigating groups with 200 scientists and students, an assortment of organic and inorganic chemists, molecular and cellular pharmacologists, taxonomists, and marine physiologists. They have found an array of intriguing medicinal compounds: anticancer agents extracted from seafloor bacteria and a mosslike ocean animal, antiinflammatory compounds from seaweed, antibiotics from sea slugs, and anti-HIV chemicals from algae. So far none have made it to pharmacy shelves, but experts are hopeful that some will in due course.

The earliest recorded evidence of extracting medicinal chemicals from marine life dates back to the ancient Phoenicians. However, it was not until the advent of reliable scuba gear in the 1950s and more recent advances in genetic and molecular biology that marine pharmacology offered such rich potential. There's no question that looking to the ocean for cures is worth the trouble. It seems the sea is chock-full of primitive forms of the human immune system. "In the ocean, everybody's in the same bucket of soup," explains Robert Jacobs, Ph.D., a pharmacologist at the University of California at Santa Barbara. "A sponge, like other sea life, is at the mercy of its environment. It has to have a chemical defense system to handle enemies and prey that float in."

Scientists track down chemicals that may be useful in human treatment by looking at the way sea life responds to dangerous invasive substances (such as venom from a sting or an infectious microbe). Jacobs gives the example of manoalide, an antiinflammatory agent extracted from a sponge found in the South Pacific. Humans and sponges use some similar chemical processes to protect themselves. Jacobs believes manoalide may regulate the enzymes in the sponge that destroy intruders, and a similar regulator is found in the human immune system. When an invader shows up, both the human and the sponge immune systems send out chemical signals telling defense cells to accumulate. In humans, one of the results is swelling, the body's way of trapping an invader to prevent it from spreading throughout the system before white cells and enzymes can destroy it. But the sponge's messenger chemicals, such as manoalide, do not initiate swelling and therefore may help in the treatment of ulcers, head-



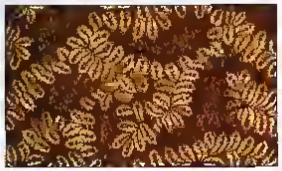


Strange though they may look, sponges like these (top right and left) use some chemical defenses in their immune systems that are similar to ours, and studying them may lead to several practical medical treatments, from antibiotics to anticancer agents and anti-inflammatories.

aches, arthritis, skin rashes, and cancer and could also reduce the inflammation associated with transplanted organ rejection. So impressive is manoalide's activity that it spawned a whole new class of manufactured drugs. Pharmaceutical companies have prepared 300 different versions of manoalide for clinical trials.

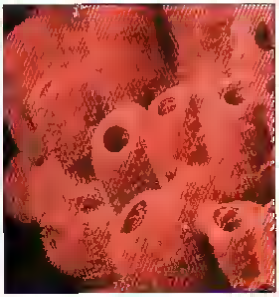
"Mother Nature is a much better chemist than any of us will be," says David Newman at the Natural Products Branch of the National Cancer Institute. "She's had millions of years to produce arcane chemical structures." In fact, if one includes antibiotics, then an estimated 55 to 75 percent of all prescription drugs are based on naturally occurring terrestrial sources.

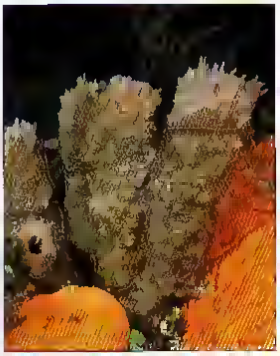
A surprisingly small fraction—perhaps only 1 to 2 percent—of the chemicals from ocean organisms are known. "It's obvious that we need better drugs," says Jon Clardy, Ph.D., a chemist at Cornell University. "We need to look for greater biodiversity. The success rate for finding new drugs from terrestrial organisms is going down. The ocean is a great place to find new things." And the pressure's on. Cure-stumping diseases like AIDS and resurgent tuberculosis bring new urgency to ocean exploration. A survey founded by the National Cancer Institute compared terrestrial and marine microorganisms and found that only 1 to 2 percent of the soil specimens contained never-before-seen compounds. In contrast, 50 percent of marine-derived microorganisms revealed chemical novelties. "These things are spectacular," says Clardy. "When you see them, you almost have to catch your breath." He uses x-ray crystallography to reveal minuscule molecules and unravel the blueprints for the latest chemical discoveries. Then marine extracts, like manoalide, can be synthesized and mass produced.



Thanks to such research and exploration efforts, scuba suits and tunicates soon may edge out pinstripes and missiles in the American economy. "We're leaders in the world," explains Jacobs. "Not only because we find new drugs, but because we develop new methods for designing drugs and for synthesis, determining chemical structure and understanding how it works in the body. Already all of the six major pharmaceutical companies in the country have marine divisions, decades ago there was only one. Other firms are cropping up to start sea farms for growing mass quantities of disease-fighting sea organisms. "Marine science is one of the areas in which the United States has developed the manpower to make progress and show great peacetime leadership," says Jacobs. In this sense, plans for some of the most promising and profitable defense strategies of all may be hidden in the ocean's depths—a greater treasure than any sunken galleon might have carried.

People have long sought sunken treasure in the sea, but few gold seekers would have guessed that the sponges and sea squirts living in the wrecks might prove to be even more valuable in the long run.





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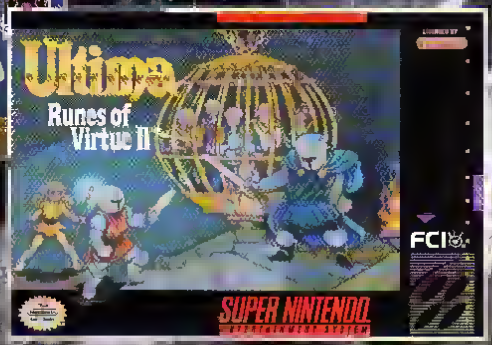


Following the success of the original Runes of Virtue comes this exciting new game based on the previous Ultima® programming and technology. You're back in Britannia where the Black Knight has abducted the mayor, Lord Tholden. Choose your Ultima character: Shamino wields his axe, Iolo the bard fires his long bow, Mariah the mage employs her magical Wand of Fireballs, and the armored knight Dupre carries a sword. Battle bats, rats, goblins, trolls, Cyclopns and skeletons. Build up your strength, dexterity, intelligence and wisdom as you explore Britannia and free Lord Tholden. It's the ultimate challenge in the world of Ultima! Get Ultima Runes of Virtue II for Game Boy or Super NES. Better yet, get them both, you so can bring Ultima adventure with you wherever you go!

FCI
Not Just Kid Stuff

FUNDS

WHEELING AND DEALING
Savvy shoppers are spending less for their new cars

By Linda Marsa

You're ready to replace the faithful bucket of bolts that you nursed through the recession with a sleek new set of wheels. But you hesitate. Worse even than sticker shock is the dread of being hustled by a fast-talking sharpie in the auto showroom. Relax. If you haven't bought a car since Ronald Reagan was president, you're in for a pleasant surprise.

Battered by intense competition, many dealers are trying to attract wary consumers by adopting polite, low-key sales tactics. But no matter how soft the sell, the average consumer is still at a decisive handicap in matching wits with a pro. The wisest way to level this lopsided playing field is to do some legwork beforehand. Do a little reconnoitering and test-drive several vehicles so you know the exact model and options you want before you actually go out shopping—and so you don't get sweet talked into costly additions. Then find out the dealer's invoice price, which is the wholesale cost. Pricing guides such as *Edmund's New Car Prices* or *Edmund's Import Car Prices* have detailed quotes on dealers' costs. Aim to pay 3 to 4 percent over cost for cars priced under $20,000, 5 to 7 percent over cost for higher-priced luxury models.

Armed with this information, skilled hagglers can buy their cars the old-fashioned way by tramping around from dealership to dealership, arm-wrestling salespeople until they find the best deal. Those who want to avoid distasteful showdowns, however, can visit one of the nation's 2,400 no-dicker dealers who move merchandise at a firm price—typically $1,000 to $3,000 below the manufacturer's suggested retail price (MSRP).

You can do one-stop shopping or use this price to leverage other dealers. "Getting a bottom-line price right away," says Doris Ehlers, an account director for J.D. Power and Associates, an automotive-market research firm, "may be more important than getting $100 off by running around to a million places."

If you can't stomach any kind of confrontation, dial a deal car shopping services will negotiate for you. For a $135 fee, CarBargains will solicit competitive bids from at least five dealers in your area who are willing to sell the car of your dreams at a marginal amount above factory invoice. Within about two weeks, you'll receive a printout in the mail containing quote sheets from each dealer so you can compare bids. Depending on the service's connections and the popularity of the model, expect to pay anywhere from $50 to several hundred dollars above the invoice.

You do have to close the deal yourself, but don't worry, the dealer can't suddenly pull a switch and up the price when you set foot in the showroom. In fact, the half-million Americans who used brokers and price clubs last year believe they saved as much as $1,800 over traditional buying methods, according to Ehlers. To find local brokers, try the Yellow Pages.

There are some caveats, though. Automotive brokers might not get you much of a break or have the precise model you want, participating dealers may not be nearby, a few may be in cahoots with the dealers, and some states, such as Texas, outlaw their services.

Before you drive away in your shiny new sedan, there are a few other ways to shave costs. First, sell your old klunker yourself. You'll get a better price, and talk of trade-ins won't muddy up new-car price negotiations. Also, arrange your own financing; shop around so that you don't have to negotiate with the dealer's F&I person—who sells insurance as well as financing.

Careful preparation—researching costs, targeting the model you want, avoiding unnecessary extras—can save as much as $2,000 on a $20,000 car. So by doing your homework you can escape those nagging doubts that someone, somewhere, got a better deal.

Headlights and horsepower aren't the only new options to choose from if you are buying a car. Car brokers and no-dicker dealers can save you time.

ELECTRONIC UNIVERSE

STARRY, STARRY NIGHTS

A look at some of the latest CDs on Mars, the moon, and the stars

By Gregg Keizer

Big things come in small packages, if you take a look at what's new in space CDs. Take a cruise to the final frontier where the sky is really the limit.

Get a CD drive for your game system before you miss out. Multimedia titles may have been a long time coming, but now they're here with a vengeance. Several, in fact, are don't-miss programs you'll want to add to your *Omni*esque science and science-fiction collections.

If you stop channel surfing long enough to watch sci-fi movies with bad lip-syncing, plug a SegaCD player into your Sega Genesis videogame machine; then get Sony Imagesoft's *Ground Zero Texas*. A game of aliens in disguise and Earth under attack, *Ground Zero* plays like a firepower-filled episode of *The Invaders*, a 1960s TV series where normal-looking Janes and Johns were really creatures from outer space. You defend a rustic Texas town with the help of security cameras, zap aliens from the comfort of a control room, and rush to eradicate the menace before the whole place gets nuked. Though strictly a fast-reaction shoot-'em-up, *Ground Zero*'s movie style—it all plays out in grainy video, and the acting is as good as games get—keeps your blood pumping.

A more sedate and cerebral CD is Maris's *RedShift*, a multimedia planetarium for the Macintosh and Windows-capable PCs. Visually stunning, *RedShift* not only shows you the night sky (from any spot in the solar system and at any time during a 15-millennium spread), but it displays detailed maps of the earth, the moon, and Mars. Also, it puts up more than 700 photographs of astronomically interesting sights and takes you on 3-D tours of the planets and their moons. You control *RedShift* with a series of sometimes-frustrating panels that resemble weird TV remote controls. (*RedShift* was created by a team of Russian developers, and their inexperience in interface design shows.) The planetary flybys are the most impressive, for you can circle worlds with a couple of clicks, set everything in motion, and then sit back and watch the sights like an omnipresent space probe. Dim the lights and you'd swear you were watching a monitor at JPL. Highly recommended to anyone with a space-science itch.

Down on the ground—the surface of Mars, that is—Virtual Reality Labs' *Mars Explorer* spreads out the Red Planet on your PC screen. Although it's certainly not an interactive extravaganza, the *Mars Explorer* CD is intriguing, and on a system with SVGA graphics, remarkably detailed. A cylindrical projection of Mars (obtained from originals shot by the Viking probes of the 1970s) awaits a click of the mouse. You then see a section of the surface in gray, red, or false colors. Canyons and craters are everywhere, and labels give you their names. Unfortunately, the two-dimensional view can't provide a sense of Mars' varied terrain, from the incredibly deep Valles Marineris to the incredibly high Olympus Mons. For that, you'll need to turn to Virtual Reality Labs' *Vistapro 3.0*, a PC terrain modeler that lets you direct pretend sweeps past both Earthbound and Martian features. It includes landscapes of Olympus Mons, and you can buy add-on sets that show you other parts of the planet. Make sure you have a powerful PC and plenty of time, though, for *Vistapro* requires a fast machine and makes you work to navigate its commands. Both programs are best buys only if you're a big fan of the fourth planet.

When you get tired of messing around in our solar system, you can head to the frontier with *Outpost*, Sierra's first strategy simulation. This CD sends you on a mission to the stars and puts you in charge of humanity's future. Earth's been pulverized by a renegade asteroid, and what's left of Homo sapiens is aboard a starship. You send probes to several star systems, decide which world to colonize, stock the ship with supplies ranging from weather satellites to a fusion reactor, and then head out. Once you arrive, you begin scraping the ground flat for the various modules that will compose your colony, grow food, make the air breathable, and, if you're *really* lucky, survive. That last one's tough, for the simulation throws all kinds of nasty surprises at you. Some planets are hot, hot, hot, while others sport winds that make something like Hurricane Andrew just a stiff breeze. To beat it all, you've got to contend with rebel colonies that want to hog what resources there are. In many ways, *Outpost* plays like a supersophisticated *SimCity*, with management skills a must and brainpower not far behind. This may not be the way we end up colonizing space (if we ever do), but with some former NASA people behind this simulation, it's a good bet.

CD really stands for *cool dimensions* when it comes to recent science and science-fiction titles. If you don't want to be stranded in this reality, get a CD player for your machine and see what's on the other side. DC

VIRTUAL REALITIES

VARIETIES OF RELIGIOUS EXPERIENCE
The Church of the All Net—a virtual house of worship

By Tom Dworetzky

I really don't want to talk about this teensy problem some of us in 2066 are having in VR. For me it started a few days ago when I was saying how sometimes I feel the weight of the VR monkey on my back—and felt an actual monkey on my back. *Metaphors are as real as reality,* I thought. *in cyberspace.*

That's the damned problem with VR. I try to shut it off, cut myself off from it so I can figure out what is real, and then I can't find anything out there that absolutely *has to be.* The abyss comes with the turn off from the net. Then I'm left with nothingness, wondering if I alone exist. My room is silent and dark. Out on the streets it's the same. Everything that is happening, everyone I could be interactive with, is on the net. All the world is restaurants without tables and chairs, shops without doors or aisles, all nodes on the net. Whatever is outside the net now, no one can know it. I think, therefore I am, blah, blah, blah. So if I'm the only thing that exists without a reference point outside of me, then everything I presume real might just be in my imagination, a metaphor, a symbol in a dream. To shake myself out of this metaphysical funk, I need something that will talk back.

My need led me to the Church of the All Net. Its vaulted ceilings and stained glass illuminate the story of its founding. Marconi, Bell, Von Neumann, Turing, Shannon, Jobs, Gates, Cray. The saints of the net are depicted in their moments of legendary greatness. The gods and saints of all religions and philosophies are there, too: Socrates, Confucius, Lao-tzu, Yahweh, Christ, Mohammed, Krishna and on and on, down endless galleries filled with names and images I could not recognize, whose knowledge I could not possibly fathom. Upon this bedrock of all principles, others as troubled as I am by the basic question of existence have found their answers and peace.

Yet I was not comforted. Although any window could, at a thought, grow animated and play an interactive recounting of the history of a deity's genius in which I could ask questions and receive wisdom in any language or idiom I chose, this total immersion in the religious experience brought me no sense of peace. I needed to pierce this veil.

So I sought the priest and floated into the comfort of the confessional.

"Oh please show me the certainty that I have lost," I begged the shimmering form.

"You wish sensational verification?"

"Yes."

"There are risks. You lack the bandwidth to process omniscience and omnipresence, just for starters, that are part of God's wonder."

"I can't live in doubt any longer."

The priest guided me into the tableau of Adam receiving the touch of God. As we crossed the gateway, he changed into an angel, the flapping of his wings beat in time with my pounding heart. We floated into a blue sky, and I reached for the fingertip that filled my vision. Dread, fear, joy, peace, all filled me as my body expanded and diffused into the heavens. I knew.

Back in my room, curled up on the floor, I became dimly aware of the monotonous voice of my deck. "This is God. Is there anyone you'd like to speak with? Allah, Krishna, Yahweh, Christ, or any other god?"

"I must know you exist. I feel so forsaken."

"Christ, the Son, is good for abandonment. Is He your desire then?"

"Yes, fine."

"That will be 95 dollars a minute."

"Ninety-five dollars?"

"Come, this is the real thing. A full-fledged god experience with a no-questions 30-day money-back guarantee. You owe it to yourself. What will some prerecorded god-line message do for you, considering the metaphysical fix you're in? And, I've only got a few of these full-baud god experiences left before we have to move on to the next item—Rolexes. That's right, circa 1990, they're real collector's items, back when people still kept track of linear time!"

Ninety-five dollars is pretty steep, but I logged in anyway. Faced with this existential bleakness (or is it virtuality?), I guess everyone has to have a god. ∞

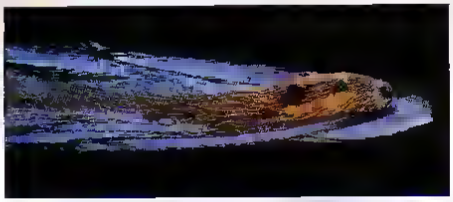
With everyday life virtualized, are electronic gods far behind? Below, artist Petrus Wandrey's *On Air* pays homage to Raphael's *Sistine Madonna.*

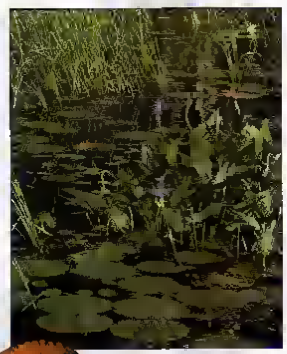
SWAMP OF DREAMS:
The Des Plaines Wetlands Demonstration Project

By Steve Nadis

Traveling west on Grand Avenue in Waukegan, Illinois the pickup truck barrels past the usual array of shopping centers, fast-food joints, and pavement—acres and acres of pavement. "This is what we're trying to reverse," says the driver, Donald Hey.

A mile or so away, in the sleepy northern Illinois town of Wadsworth, Hey and his associates are turning back the hands of time, attempting to revive a defunct marsh that since the mid 1800s has been drained, settled, farmed, mined, and otherwise plundered. The Des Plaines River Wetlands Demonstration Project, managed by Wetlands Research of Chicago, is one of the nation's premier experimental wetlands and perhaps the largest system built strictly for research purposes.





Restoring the wetlands has multiple benefits, including flood control, enhancing water quality, and preserving a habitat for plant life and animals once faced with the possibility of extinction in Illinois.

The restoration began in 1985 on the 550-acre site owned by the Lake County Forest Preserve District. After scientists completed a detailed survey of the area, bulldozers reshaped the land to exacting specifications. In late 1989, water from the adjacent Des Plaines River was pumped in, and then nature took over. Native plants gained footholds as seeds were transported by the wind, river, and waterfowl. Beavers and muskrats moved in, as did a variety of birds, including two on the state's endangered species list: the yellow-headed blackbird and the least bittern. "If you create the habitat, they will come," says Hey.

More than half the nation's wetlands have vanished since precolonial times. In states like Illinois and California, more than 90 percent of the original wetlands are gone. Of the remaining U.S. wetlands, more than 90 percent lie in inland, freshwater regions, which is why the Des Plaines project is so important. "We want to find out how to make a successful wetland," Hey says. "What are the crucial ingredients? How long does it take?" Ultimately, he and his colleagues will draft a design manual that others can use to construct riverine wetlands.

Creating or restoring wetlands is not a new idea. There have been thousands of attempts in this country, though the vast majority have failed. "They were mainly exercises in gardening, trying to get certain plants to grow," notes Ohio State University ecologist William Mitsch.

Unlike typical wetlands-creating ventures, the Des Plaines project is designed for long-term monitoring, offering researchers a rare chance to study a wetland in the making. "You can't just dig a hole, pour water in it, and walk away," says botanist Dan Mason, the team's assistant director of research. "These systems may need some maintenance and fine-tuning."

Wetlands fail when they are not properly integrated into the neighboring landscape. "If you take a wetland and surround it with a shopping center or an airport, there's no access for animals," Hey says. Muskrats, for example, clear out vegetation, preventing the marshes from getting choked on cattails. "If you took the muskrat out of this environment, we wouldn't have yellow-headed blackbirds or the plant diversity you see today."

The crucial ingredient, however, is water, of which most artificial wetlands have too little or too much. That's where the Des Plaines restoration really stands out, with unparalleled control of water flowing into and out of the ecosystem. "If you get the water right, the other things will take care of themselves," Hey notes. Early results appear to substantiate that claim. The experimental wetlands now trap 80 to 90 percent of some key pollutants. In just a few years, the number of waterfowl species visiting the site has jumped 400 percent. Beavers, extinct in Illinois as of 1840, have undergone a population explosion as well, up to the point of being regarded as a nuisance in Lake County.

The biggest surprise, according to Hey, has been "how quickly you can turn things around. Within a couple of years, you can have wetlands that perform many critical functions." The next step, he says, will be to apply the principles learned here throughout the United States. "If we got serious about wetlands restoration, we could change the character of this continent." DQ

CONTINUUM

THE ANDY WARHOL MUSEUM

Celebrating the quintessential artist of his time. Plus, danger lurks at the beauty salon, and the medicinal properties of porcupines

In *blasé* turn-of-the-century Paris, the poet Apollinaire once went to a party leading a lobster on a red silk leash. It was a good little ploy. But when it came to party going, upstaging fellow artists and drawing attention like pigeons to bread, Apollinaire was just a piker compared to our own P. T. Barnum of the arts, Andy Warhol.

Andy's renown has far outlasted the 15 minutes of fame that he predicted everyone would have in the future. In recognition of this success, the Andy Warhol Museum opens May 15 in Pittsburgh, Pennsylvania. In some ways, Warhol is our century's ultimate celebrity. For him, the pursuit of celebrity was a business, a profession—and art, an obsession. And the Andy Warhol Museum is certainly part of his pudding's proof. Created only seven years after his death, it is not just any museum, but an 80,000-square-foot eight-story monument—the largest museum devoted to a single artist.

Andy has survived the public eye a lot longer than 15 minutes.

Housed in a former industrial warehouse (all of Warhol's "Factories" were converted industrial buildings) on the North Side of Pittsburgh, the museum displays every aspect of Warhol's work—as painter, partygoer, sculptor, social anarchist, film director, diarist, photographer, music producer, and magazine publisher.

Warhol's famous paintings, in all their evocative garishness, will be displayed over six floors: *Elvis Eleven Times*, in a painting stretching more than 30 feet; *Double Liz* and *Silver Liz*; *Marilyn Three Times*; orange car crashes; Campbell's Soup cans; pink and yellow flowers; purple jumping suicides; self-portraits; Last Suppers; skulls.

On the top of the building is a kaleidoscope of color and light—55 of Warhol's *Shadows* in 102 different colors, in a skylit installation. There are archives on the third floor and research, reading, and educational rooms on lower floors. There is an Andy Warhol Theatre and a Film Gallery. Scholars can examine everything from his stolen Concorde silverware to Andy's "motionless" movies.

This Museum will certainly help keep the Warhol debate alive. Andy still seems to inspire either outrage or reverence. Was he, for instance, merely a product of his culture or a prophet for our times? Though critics may never agree, one thing is certain: Warhol had an uncanny knack for seeing underneath the surface of our daily lives and showing us what was to come.

He seemed to sense early the coming craze for celebrity and the ubiquitous grip of raging consumerism. At a time when it still seemed peculiar, violence filled Warhol's canvases: car wrecks, suicides, electric chairs, atomic explosions—often in brightly colored series—as though anything, even horrible mayhem, could be made the stuff of mass production and entertainment—which it has. His movies too, in retrospect, look like nothing so much as the precursors of public-access television, home videos, and talk shows. And Warhol's *Interview Magazine* was a herald of the "style" and "people" publications which currently fill up the newsstands.

What about the value of the artistic legacy? In their time, his giant paintings of Coca-Cola bottles, his Brillo box sculptures, and his celebrity silkscreen portraits transformed modern art. His underground movies and multimedia happenings were the first word in controversial chic. Art critic Robert Hughes concedes that Warhol "opened the door" for many artists, mostly of dubious ability. But, Hughes scoffs, "even a butler could do that."

Art historian Calvin Tomkins sees Warhol in a more intriguing light. "The key word," he writes, "is *resonance*. From time to time, an individual appears, often but not necessarily an artist, who seems to be in phase with certain vibrations—signals not yet receivable by standard equipment. . . . Always somewhat unearthly, Warhol became a speechless and rather terrifying oracle. He made visible what was happening in some part of us all."

Where Warhol and his art are concerned, there still seems to be neither any certain ground nor any middle ground. As even his closest friends say, Warhol was one of those truly rare people. The more you knew about him and of him, the less certain you became about what he was or what he was like. He remains an enigma. Perhaps because Andy Warhol was as much a puzzle and a mystery as is the future, the future will keep coming back to Andy and now to his museum. —*MARION LONG*

CONTINUUM

If you listen carefully with this new supersensitive sensor, you can hear larvae eating the precious grain.

SNAP, CRACKLE, POP

Do you have a bee in your bonnet? How about bugs in your barley?

Pest larvae chew their way through 10 percent of stored grains annually in the United States. In tropical climates, moist environments and storage conditions actually incubate the insects, driving the spoilage figures toward 50 percent. But now farmers may have a way to thwart the pesky critters' sabotage. Engineers at the University of Mississippi have invented a small, supersensitive sound sensor that can detect tiny insect larvae lurking inside harvested grains. Composed essentially of a sensitive microphone in the head of a stethoscope, the inexpensive sensor can be distributed throughout a granary to listen and detect an infestation early on.

Two major bug activities generate the detectable sounds, according to researcher Robert Hickling. First, the larvae create a slithering, rubbing noise as they prowl around inside the skin of their home-cum-smorgasbord, looking for something to devour. Then comes the "surprisingly loud" crunching, gnawing sound when they actually start to eat. "It sounds like a horse in a barn chewing away at oats," Hickling says.

Testing the crunch-o meter on grain, the researchers found its range to be 20 centimeters or so. They'd like to achieve a range of one to two meters to better ferret out the weevils, potato bugs, and other creepy-crawlies that bedevil farmers. At the shorter distances, the device has proven very effective. In trials at a Florida airport where customs officials routinely confiscate exotic fruits from Guatemala and Peru to prevent unlawful entry of alien insects, the sensors found every last fruit fly. Each piece of fruit that sounded clean contained no bugs, while all of the suspicious-sounding ones did, in fact, harbor insect larvae.

—Pat Janowski

DARWIN AND NECKING GIRAFFES

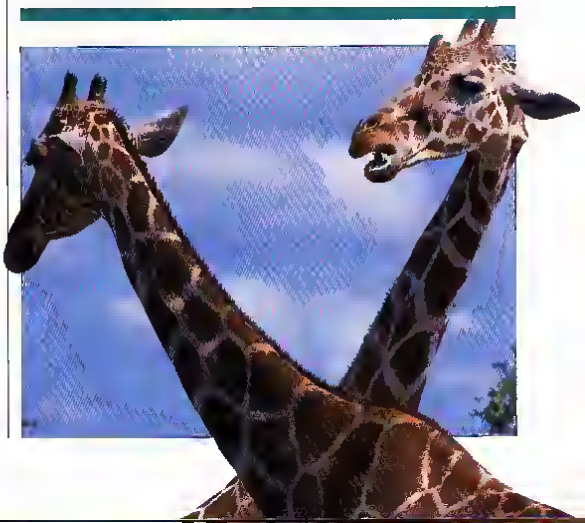
Why does the giraffe have a long neck? To feed on leaves out of other browsing beasts' reach, posited Charles Darwin. The answer seemed obvious. But now Rob Simmons, a senior conservation officer in Namibia's Wildlife Ministry, has come up with an alternate explanation. The necks are weapons—used by males to fight one another to win mates.

When male giraffes compete for a female, they stand side by side and violently swing necks and heads at each other. Each blow's momentum is crucial, especially when the animal concentrates the force behind its small horns, using them to puncture an opponent's neck and spinal column. By "necking," one giraffe can knock out another.

The male's neck, larger and thicker than the female's, is better designed for these sorts of battles. Its size, however, drags the male giraffe's maximum speed down to 34 miles per hour, unusually slow for such a long-legged creature.

Fossil evidence, Simmons believes, fails to support Darwin's hypothesis. The largest extinct giraffe, *Samotherium*, had legs nearly as long as its present descendants but a much shorter neck. If growing taller to get access to more

BOTH DIAMOND AND GRAPHITE ARE COMPOSED OF ONLY CARBON ATOMS, BUT BECAUSE OF DIFFERENT BONDING PATTERNS, DIAMOND IS THE HARDEST SUBSTANCE KNOWN AND GRAPHITE IS ONE OF THE SOFTEST.



food played the crucial role in giraffe evolution, then the animal would have evolved longer legs, too. In addition, studies reveal that the giraffe's neck vertebrae have elongated by 130 percent over vertebrae farther down the spine. "Only in the giraffe," Simmons says, "do we see this rather sudden and disproportionate growth in neck length and the appearance of relatively short, stout horns."

—Ivor Smullen

Scientists developed an improved version of the conventional canine distemper vaccine by using whole viral proteins rather than a modified live virus, which can sometimes cause the disease itself

PROTEINS BEAT VIRUSES—AND DISTEMPER

In the veterinary war against canine distemper, which afflicts animals ranging from dogs to foxes to raccoons, the Parhelion Corporation in Columbus, Ohio, has used techniques derived from molecular biology to develop a safer, more effective vaccine from protein rather than from the virus itself.

By shunning the modified live viruses usually used to fashion vaccines, the Parhelion scientists eliminate the possibility of causing the disease. Instead, they isolate whole viral proteins on the cell membranes of infected cells, where the virus is assembled. They use those proteins to fashion the vaccine, according to Richard G. Olsen, a retired virologist at Ohio State University who founded Parhelion.

"Because the immune system actually attacks infected cells rather than the virus itself, proteins from those cells stimulate a more effective response to canine distemper," Olsen says. Several years ago, Olsen pioneered this procedure, producing the first feline leukemia vaccine from proteins rather than from the leukemia virus.

Canine distemper is a paramfluenza akin to measles in humans, according to Olsen. Outbreaks can devastate dog kennels and commercial wild-animal farms alike. Once approved by the Department of Agriculture, Parhelion's distemper vaccine could reach vets as soon as next year.

—George Nobbe

A SIZABLE OAK TREE, DURING THE GROWING SEASON, GIVES OFF 28,000 GALLONS OF MOISTURE.

CAMEROON VINE TESTED AS AIDS TREATMENT

The leaves of a thick-stemmed vine that climbs to the canopy of a remote rain forest in Cameroon look promising as a source of a potential treatment for AIDS. An alkaloid isolated from the leaves is currently undergoing tests at the National Cancer Institute's drug-development labs.

No one at NCI is yet claiming that the vine leaves—tentatively named *ancistrocladus korupensis* after the national park in which they were found—will provide a treatment, but the researchers are hopeful because the alkaloid inhibits replication of the AIDS virus.

"It is, at present, in preclinical development, and some limited testing in animals is being done to see if the concentrations required for activity against the virus can be attained without it being too toxic," says Gordon Cragg, chief of NCI's natural-products branch in Frederick, Maryland. NCI's labs routinely test everything they can get their hands on—some 20,000 plant samples from 25 countries since 1986—but the vine from the Korup National Park has come farther along in the process than three other plants from Malaysia, Samoa, and Australia, the only ones that have shown some activity against AIDS so far.

The vine grows well in sandy soil and is fairly common in a section of the rain forest that borders Nigeria, according to Cragg. Cameroon natives don't use the vine for any medical purposes, a rarity in rain-forest plant harvesting. The vine was discovered by British botanists working in conjunction with the Missouri Botanical Garden, which collects plant specimens in Africa for NCI to test against both cancer and AIDS. Clinical AIDS tests, still several years off, would be done by the National Institute of Allergies and Infectious Diseases.

—George Nobbe

CONTINUUM

ELECTRIC TOMATOES

When a caterpillar feeds on a tomato leaf the plant moves swiftly to protect itself, systematically releasing "proteinase inhibitors"—proteins that interfere with the caterpillar's digestion—throughout the plant, especially in the leaves. But how does the message get from the wounded leaf to the rest of the plant?

Most scientists believed the alarm was spread by chemical messengers until a team of researchers headed by David Wildon—a biologist at the University of East Anglia in Norwich, England—made a shocking discovery. An injured leaf, the researchers found, sends an electrical signal to warn neighboring leaves of imminent danger. It's a "terribly tiny current" driven by an electrical potential difference of only 20 millivolts, says Wildon, who measured the voltage with electrodes attached to the plant's surface.

"Right now, all we can say is that there is a correlation," Wildon notes. "If you wound the plant, you'll see an electrical signal accompanied by a biochemical response." To learn more about the reaction, Wildon's team plans to insert electrodes within the plant tissue (rather than on the surface) to determine what's going on at the cellular level.

The findings may help explain other mysteries surrounding plants. For example, many plants start to flower in springtime, as days grow longer, but plants sense the change in the day length through their leaves, while flowers begin to bloom at the buds. "There must be a signal from the leaf to the growing points," Wildon says. "So far no one has come up with a convincing chemical mechanism. Maybe an electrical signal is involved."—Steve Nadis

SALON STROKE

One of the nicest things about going to the hairdresser is that long, relaxing shampoo. Well, sorry, but a New York neurologist says it can actually endanger some customers' health.

Michael L. Weintraub, a professor of neurology at New York Medical College in New York City and chief of neurology at Phelps Memorial Hospital, heard reports of two elderly women who had experienced strokes after beauty-salon shampoos. He then surveyed 25 older women who had histories of transient ischemic attacks, the ministrokes that sometimes precede stronger strokes. Eighteen of the women reported blurred vision, dizziness, or loss of balance—all symptoms of ministrokes—while having salon shampoos.

The neck position during shampooing causes the problem, Weintraub explains. Rotating the neck to one side can alter the flow of blood in the opposite vertebral artery, a type of blood vessel that supplies blood to parts of the brain. If the neck is rotated for as long as eight to ten minutes, blood flow is compromised and a stroke can result.

Weintraub's advice for hairdressers with elderly clients: "Don't hang the head backward in the sink," he says. "Have clients face the sink with their heads flexed forward. It's much safer that way."—Bill Lawren

PLANTS STAND ERECT

Thanks to fossilized spores, scientists have long known that close-to-the-ground mosslike plants flourished on Earth hundreds of millions of years ago. But when did plants start growing skyward? Scientists at the University of Wales College of Cardiff in Great Britain recently found fossil evidence that the earliest known common ancestor of all upright land plants was *Cooksonia pertoni*, a relative of ferns that lived around 420 to 395 million years ago.

The coalified fossils, found in sandstone sediments in Shropshire, England, contain remarkably well-preserved cells, according to University of Wales paleobotanist Dianne Edwards, who headed the research. A scan with an electron microscope revealed specialized tubular cells, called tracheids, that enable land plants to grow upright by conducting water up their stems.

What did the earliest upright land plants look like as they began growing among ground-hugging mosses and liverworts some 200 million years before dinosaurs ruled the planet? "The *Cooksonia* was only a few centimeters high," Edwards reveals. "It had smooth branching stems with terminal sporangia—capsules containing spores. It was quite unlike anything living today."—Sherry Baker

CONTINUUM

PORCUPINE ANTIBIOTICS

A porcupine's quills certainly make for an intimidating weapon, particularly to the animal's natural enemies. But those sharp stalks have another, less obvious, property. They're coated with antibiotically active chemicals, according to a New York City biology professor.

Despite their impressive armor, porcupines are far from invulnerable. Besides occasionally impaling themselves on their own quills, they also break bones and suffer internal injuries when they fall out of trees, where their preferred food dwells. They may have evolved their in-house antibiotic factories as a defense against such self-inflicted wounds, speculates Uldis Roze, a mammalogist at Queens College in New York.

He found out about quill antibiotic properties the hard way. While in a tree catching a porcupine to be radio-collared, Roze took a quill in his upper arm that burrowed beneath the skin and left the arm "paralyzed from pain."

Unable to remove the quill, Roze had to wait for it to exit by itself, a process that took two days. Surprisingly, the puncture wound remained clean. A wood splinter traveling the same path would almost certainly have produced massive infection, Roze says. He theorized that the quills must possess some antibiotic properties, probably in their greasy coating.

> UP TO 150 TONS OF METEORITE FRAGMENTS SLAM INTO THE EARTH EVERY YEAR.

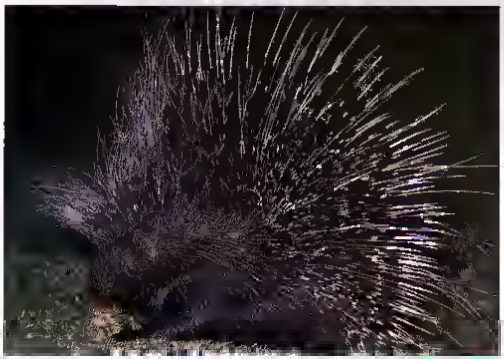
When his team analyzed porcupine-quill lipids, they found a group of fatty acids that can kill six gram-positive types of bacteria—the same kind penicillin kills—including *Streptococcus faecalis* and *Staphylococcus aureus*.

But don't look for porcupine ointment on pharmacy shelves. Roze tried to interest one manufacturer in his discovery but was told the company had no interest because the fatty acids are "not exotic and they can't be used internally," he says.

—Peggy Noonan

"Aesthetics is for the Artists like Ornithology is for the birds."

—Barnett Newman



MAN, THAT'S A COOL VEST

It's not the humidity that bothers most people with multiple sclerosis—it's the heat. The slightest rise in body temperature can exacerbate fatigue, poor coordination, and a host of other ailments that often make life hell for MS sufferers. But many of them have reason to rejoice: Tests indicate that a new cooling vest originally designed for NASA astronauts alleviates symptoms in some MS sufferers.

"The fact that this is like a piece of clothing is an important step forward," says Wallace Tourtellotte, chief of neurology service at the Veterans Administration's Wadsworth Center in Los Angeles and vice-chairman of the department of neurology at the University of California at Los Angeles. He's currently studying how the vest affects the wearer's mobility.

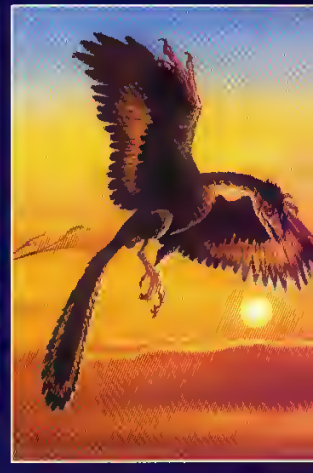
Donning the vest and accompanying cap for up to an hour can decrease an MS patient's temperature by nearly one degree—providing relief for a few hours and allowing the patient to pursue activities that may have proved too difficult in the past.

Dubbed the Mark VII by its manufacturers, Life Support Systems of Mountain View, California, the system comes in two versions: one for clinic use, and a portable model for home use that comes with the vest and an "umbilical cord" attached to a battery operated unit similar to a picnic cooler.

Users have reported no side effects. In fact, the biggest drawback appears to be the cost: $1,995 for the portable unit and $2,995 for the clinic model. Some insurance companies have begun to foot the bill, and as an alternative, patients can join research studies funded by the MS Association of America and receive the system on loan. In addition, the MSAA has instituted a limited funding program for poor patients.—Peter Callahan





These hypothetical illustrations trace the 110-million-year evolution of the mesendosaurus into early modern birds capable of flight. *Article by George Olshevsky • Illustrations by Luis Rey*

THE BIRDS FIRST? A THEORY TO FIT THE FACTS

Okay, you've seen *Jurassic Park*, and you've seen those dinosaurs running around like giant birds a flock of *Gallimimus* wheeling and turning like sparrows in the noonday sun, sinister *Velociraptors* stalking kids like 500-pound vultures and that humongous *Tyrannosaurus rex* sprinting after a car like a giant, five-ton chicken. Suddenly the notion that today's birds, from parakeets to turkeys to eagles, are the actual descendants of dinosaurs such as the ones in the movie doesn't seem so strange. Unfortunately, the notion that birds are dinosaur descendants—or the BADD theory, is wrong. Here's why.

First there's the time problem. The most birdlike dinosaurs always occur later in the fossil record than *Archaeopteryx*, the earliest known 'true bird.' The dinosaurs that came before *Archaeopteryx* were all much less birdlike than ones that came after. If the BADD theory were correct, we would see plenty of very birdlike dinosaurs—*Velociraptors* and such—in the fossil record earlier than *Archaeopteryx*. Where are they?

Second is the size problem. The known birdlike dinosaurs were all much larger than *Archaeopteryx*. *Archaeopteryx* fossils are tiny even when compared to those of *Velociraptor* and *Gallimimus*, let alone a dragon such as *Tyrannosaurus rex*. Edward Cope's Rule of evolution, numerous instances of which include the evolution of horses, elephants, and even people, states that large forms evolve from small forms, not vice versa. This doesn't mean it's impossible for small animals to evolve from large ones, only that it takes some pretty restrictive circumstances—such as complete isolation on an island for thousands of years—to force this to happen. What extraordinary environmental conditions could have persisted long enough to cause behemoths like *Tyrannosaurus rex* and its giant relatives to evolve into small, pigeon-sized birds?

Third is the wing problem. How could the tiny, nearly useless arms of a dinosaur such as *Tyrannosaurus rex* have possibly evolved into the relatively huge and powerful arms—the wings—of a bird such as *Archaeopteryx*? Maybe *T. rex* isn't the best example, but even the bigger, more serviceable arms of *Velociraptor* and its rapacious relatives were too far removed in size and function from the wings of *Archaeopteryx*. All the birdlike dinosaurs, regardless of their geological age, had arms and shoulders that, although fine for holding and tearing prey, would have been completely inadequate for gliding or flying.

There are many other problems with the BADD theory besides those three. But don't get me wrong; the bird-dinosaur connection is real. There is no doubt that birds and dinosaurs are very closely related to each other. That message from *Jurassic Park* is quite correct. Birds and birdlike dinosaurs, which scientists call *theropods*, are too much alike for their resemblances to have arisen just by coincidence. The problem is with the nature of the connection. Did birds and theropods inherit their similarities from a common ancestor, like sister groups on the dinosaur family tree? Did birds inherit their features from theropods, à la the BADD theory? Or is the third possibility, that theropods inherited their features from birds, closest to the truth? If so, birds are not small flying dinosaurs instead, dinosaurs were giant flightless birds. Strange as it may at first seem, this third alternative—what I call the "birds came first," or BCF, theory—provides the best description of the bird-dinosaur connection.

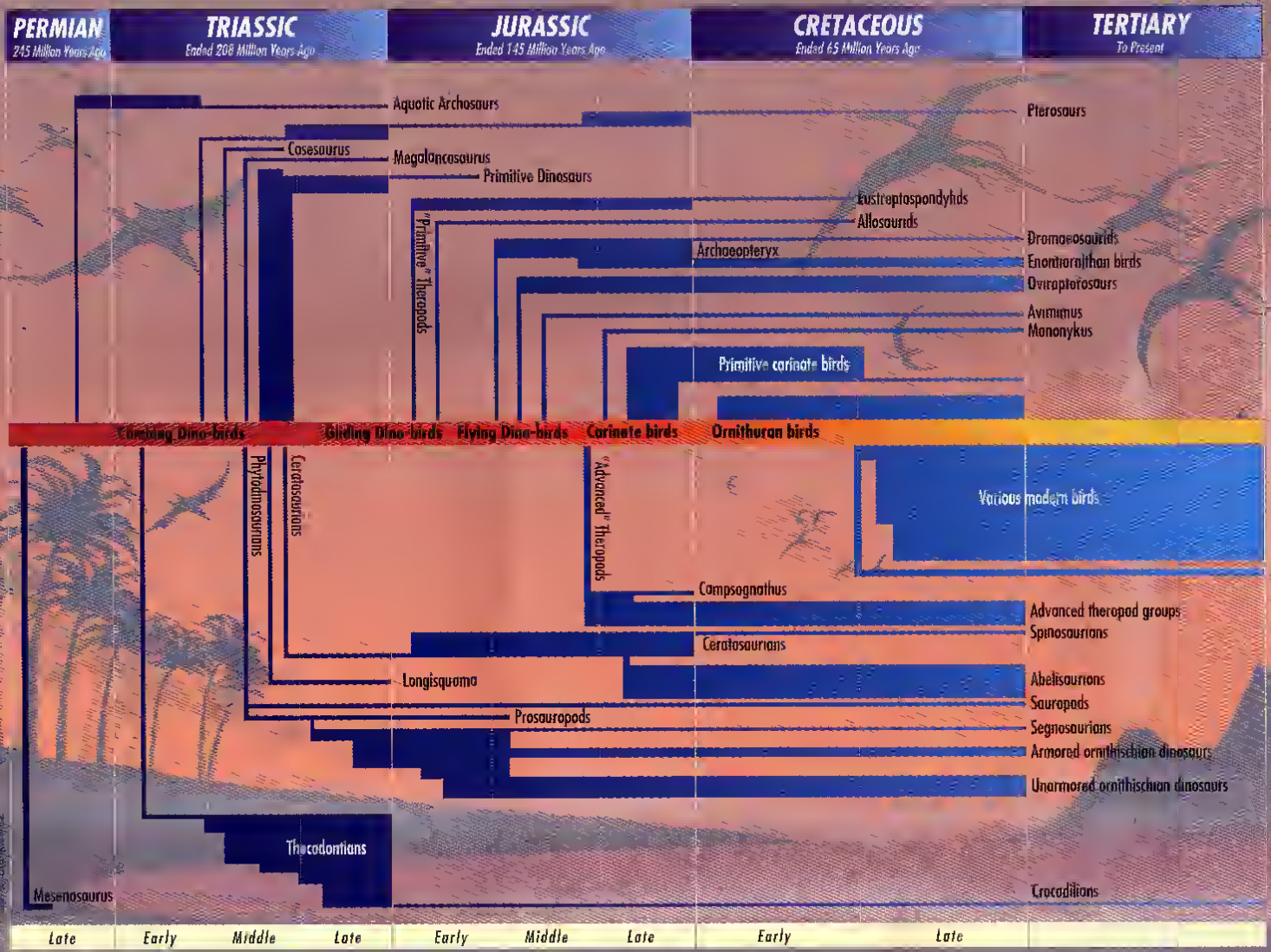
> ON THE WAY TO PERFECTING FLIGHT, THE LINEAGE LEADING FROM REPTILES TO BIRDS INCLUDED A NUMBER OF SMALL, TRANSITIONAL, TREE-DWELLING ANIMALS UNLIKE ANY OTHER ANIMALS WE HAVE EVER SEEN.

Dinosaurologists have known about the bird-dinosaur connection since the middle of the nineteenth century. That's when legendary paleontologists Joseph Leidy and Edward Drinker Cope (of Cope's Rule) dug up the first fossils which showed that dinosaurs, particularly the theropods, walked around on their hind legs. Cope in particular visualized his 1866 dinosaur *Laelaps aquilunguis* ("eagle-clawed hurricane") as running down its prey like a gigantic predatory cassowary. The word spread to England, where dinosaurological doyen Richard Owen had just finished supervising a set of life-sized dino models for the incomparable Crystal Palace, all in four-footed poses (oops!). (They're still on display if you happen to visit London and need something to do.) Iconoclastic Thomas Henry Huxley, Owen's rival, wrote extensively on the bird-dinosaur connection in the 1860s. But partly because of those three problems described earlier and an irritating lack of good fossils, dinosaurologists had concluded by the early years of the twentieth century that birds and theropods were merely sister groups, that neither group was descended from the other.

In the early 1960s, a hundred years after Leidy, Cope, and Huxley, this picture was shattered beyond repair by John H. Ostrom's discovery in Montana of fossil skeletons of the man-sized theropod *Deinonychus*, a close earlier relative of *Velociraptor*. *Deinonychus* had so many features in common with *Archaeopteryx* that only a near-lineal relationship between the two fossils could explain them. Spurred on by the discovery of *Deinonychus*, dinosaurologists reexamined other theropod fossils and came to a similar conclusion. They ruled out a sister-group relationship between birds and theropods, and almost everyone rallied to the BADD theory, the idea that birds are dinosaur descendants. This is quite understandable since, after all, modern birds are more advanced than dinosaurs, and birds are still here and dinosaurs are extinct. But as outlined earlier, the BADD theory doesn't solve the problems involving time, size, and wings. Far worse. It ignores them by saying that we simply haven't yet found the fossils that will solve those problems.

As you'll see, we have indeed found such fossils, but we don't even need them to understand that something's wrong with the BADD theory. All too often when a new birdlike fossil is discovered, it is hailed as overturning established ideas about dinosaur-bird evolution or viewed with surprise and dismay as some kind of paleontological paradox or, worst of all, just plain disregarded. If the BADD theory were substantially correct, such new discoveries would fit satisfyingly into the overall picture, like long-sought jigsaw puzzle pieces, much more often than they do.

The BADD theory views the birdlike features of theropods as having come together by chance and coincidence in the same group of animals, who were then able to use those features for flight. But flight requires so many niggling, highly specific changes to the basic theropod body plan that they couldn't possibly have "just happened." No, the theropod features associated with flight in birds must have


PERMIAN
245 Million Years Ago
TRIASSIC
Ended 208 Million Years Ago
JURASSIC
Ended 145 Million Years Ago
CRETACEOUS
Ended 65 Million Years Ago
TERTIARY
To Present
Aquatic Archosaurs
Pterosaurs
Cosesaurus
Megalancosaurus
Primitive Dinosaurs
Eustreptospondylids
Allosaurids
"Primitive" Theropods
Archaeopteryx
Dromaeosaurids
Enantiornithan birds
Ovaraptorosaurs
Avimimus
Mononykus
Primitive carinate birds
Climbing Dino-birds
Gliding Dino-birds
Flying Dino-birds
Carinate birds
Ornithuran birds
Phytodinosaurians
Ceratosaurians
"Advanced" Theropods
Various modern birds
Compsognathus
Advanced theropod groups
Spinosaurians
Ceratosaurians
Longisquama
Abelisaurians
Sauropods
Prosauropods
Segnosaurians
Armored ornithischian dinosaurs
Unarmored ornithischian dinosaurs
Thecodontians
Mesenosaurus
Crocodilians
Late
Early
Middle
Late
Early
Middle
Late
Early
Late

originated serially as improvements and adaptations to a very definite lifestyle—beyond doubt, a tree-climbing and even tree-dwelling lifestyle. On the way toward perfecting flight, the lineage leading from reptiles to birds included a number of small, transitional, tree-dwelling animals unlike any other animals we have ever seen. For want of a better term, we can call them *dinobirds*. In my BCF theory, these are the "birds" that came first.

That dinosaurs evolved from small dino-birds who climbed trees, leaped among branches, glided, and even flew in a rudimentary way is perhaps the most surprising conclusion of my BCF theory. Yet there is hard evidence to support it in the form of actual dino-bird specimens—rare, but by no means nonexistent, and largely unrecognized for what they are by BADD paleontologists. Also, a surprising number of dinosaurian features that have baffled or been ignored by BADD dinosaurologists acquire quite simple and reasonable explanations in my BCF theory. But rather than bore you with long, droning accounts of dinosaur anatomy, let me simply tell you the story of how dinosaurs, birds, and some of their lesser-known relatives came to be as seen through BCF eyes. I'll cheerfully point out the BADD inadequacies as we come to them. And in the end, you'll see how those three problems I outlined earlier practically solve themselves when the bird-dinosaur relationship is looked at in the BCF way.

Two hundred sixty million years ago, just before the end of the Paleozoic Era, the earth was inhabited by several groups of primitive reptiles, some quite odd looking. Although they're often pictured in dinosaur books, none of them were dinosaurs, that long ago, dinosaurs hadn't yet evolved. Many, including the largest, which were dumpy, ungainly vegetarians about the size of cattle, are called *therapsids*. Among the therapsids were also dog-sized meat eaters and small, ratlike insectivores. Some of the other reptiles of the time, generally smaller and much more lizardlike than the therapsids, are called *diapsids*. The diapsids tried to keep out of the way of the therapsids, particularly the meat eaters, which gladly dined on diapsids whenever they could catch them.

One little lizardlike diapsid, outwardly similar to its immediate ancestors, differed from them in having an extra, slitlike hole in its skull in front of each eye. If naturalists had been alive at the time, none would have dreamed that this little reptile would give rise to hundreds of thousands of species over the next 260 million years—almost 10,000 still live today. All of its descendants had that extra hole in the skull, often very wide and prominent (Cope once mistook it for a dinosaur's eye socket), although in some it became secondarily covered over or shrank away to nonexistence.

The descendants of that hypothetical little reptile are collectively called *archosaurs*, or "ruling reptiles." Their time to rule came up soon after the therapsids were decimated by the great mass extinction that ended the Paleozoic Era 245 million years ago. Amazingly enough, a small foot-long fossil exists that very closely fits our picture of that hypothetical first archosaur. Called *Mesenosaurus*, it was originally described in 1940 by a Russian paleontologist. No one could pigeonhole it into any reptilian category until 1978, when two other Russian paleontologists reexamined it and found the narrow slit in front of its eye. Although a few paleontologists still dispute the findings of the Russians, for all practical purposes *Mesenosaurus* is the earliest known archosaur, about 10 million years older than the next earliest known archesaur.

The first few million years after the Paleozoic ended and the Mesozoic Era began witnessed an evolutionary free-for-all, as the surviving reptile groups competed and diversified to fill the vacant large-animal niches. From the standpoint of the archosaurs, the important thing was that those disagreeable therapsid predators were gone. The archosaurs eventually won the competition, and, in the form of dinosaurs, they ruled until another extinction ended the Mesozoic Era, a mere 65 million years ago. Then the tables were turned: therapsids, in the form of mammals, came out on top again.

In order to organize the multitude of lineages that originated with *Mesenosaurus*, let me focus first on just the one that led to today's birds. This lineage is particularly important. First, it is not yet extinct, making it one of the longest possible archosaur lineages. Second, it encompasses the largest number of important body changes to the archosaurs themselves. And third, it is the lineage along which all the "famous first" archosaurs can be found: the first archosaur with a four-chambered heart, the first archosaur with feathers, the first archosaur to glide, the first archosaur to perch, the first truly hot-blooded archosaur, the first archosaur to fly, and so forth. Let us call

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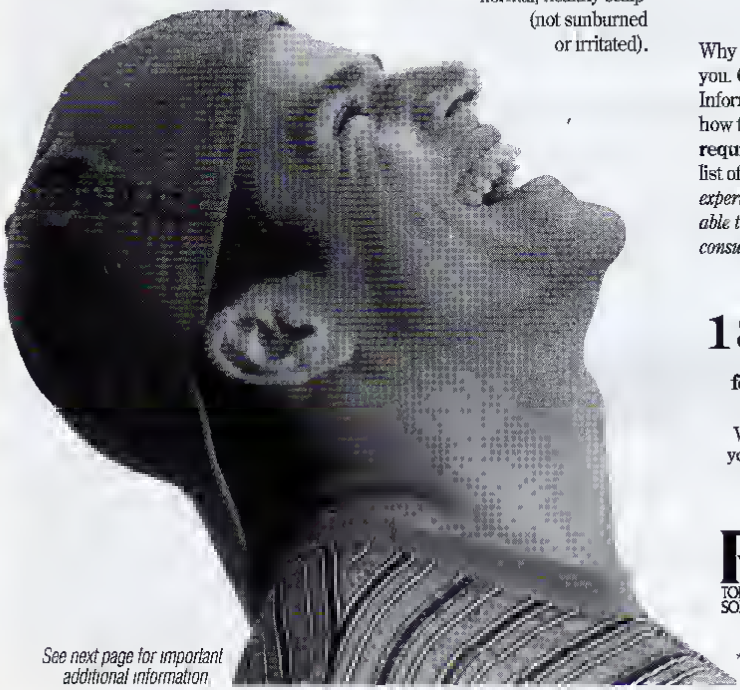

See next page for important additional information.

*Not available in all areas

it the dino-bird lineage.

Singling out a central lineage gives the family tree a Christmas-tree appearance with a central trunk and lots of branches sticking out sideways. Each side branch represents a population of animals that at some time for one reason or another began to evolve differently from the central population. Side-branch animals had all the features of the central-lineage animals up to the divergence point because up to that point they were the *same* animals. Thereafter, they started acquiring different features. So the later a side branch diverged from the dino-bird lineage, the more birdlike were the archosaurs on it. However, because it was a side branch, it never led to birds. In the archosaur "Christmas tree" that forms the framework of the BCF theory, mesenosaurs are at the root, birds are at the pinnacle, dino-birds are on the trunk of the tree connecting the root with the pinnacle and on a multitude of short, pine-needle-like side branches off it, and the dinosaurs and other archosaurs are on the larger, more extensive side branches.

The dino-bird lineage itself probably passed through only a couple of hundred species to get from mesenosaurs to birds; the rest of the hundreds of thousands of archosaur species, including all the dinosaurs, evolved along the side branches. Consequently, most of the Mesozoic archosaur fossils in our museums are side-branch fossils. But by studying them and figuring out which of their features were inherited from the dino-bird lineage and which appeared independently later, we can make a good, scientific attempt at reconstructing the dino-bird lineage itself. A little bit of common sense doesn't hurt either.

Anyway, a few million years into the Mesozoic, dino-birds evolved their most dramatic and profound innovation: the four-chambered heart. This had two *major* advantages over the more primitive diapsid circulatory system which is driven by a simpler three-chambered heart. First, all the blood is fully oxygenated before being pumped around the body; second, the blood pressure in the body can be a lot higher than in the lungs.

Owing mainly to incomplete oxygenation, the lifestyles of today's reptiles, which have three-chambered hearts, consist of "sit and wait" periods of motionlessness punctuated by bursts of activity, or of slow, plodding movement with frequent intervals of rest. The more efficient, four-chambered hearts of birds and mammals allow them to be active longer and to

recuperate more quickly from bursts of strenuous activity

Just as important as complete blood oxygenation is having two separate blood pressures, one at lower pressure for the lungs and one at higher pressure for the body. Tall, erect animals—such as today's birds and mammals and yesterday's dinosaurs—with long legs and heads held well above the general body level, need high blood pressure to pull the blood up from the legs and to push the blood up to the head. But if the blood pressure is too high, blood will flood the lungs and drown the animal. The trick to keeping the blood pressure in the lungs nice and low but the blood pressure in the body high is to separate the pumps for the two circulatory systems. The four-chambered heart accomplishes this at the same time it keeps stale blood destined for the lungs from mixing with fresh blood destined for the rest of the body.

Developing a tall stance with the legs vertical is thus impossible without having those two parallel circulatory systems. Three-chambered hearts compel animals to be sprawlers, but four-chambered hearts are like turbochargers that allow animals to stand tall and to cruise around tirelessly. Some scientists try to tie an animal's erect stance and activity level to being hot-blooded, but having a constant body temperature is not as important as having a rich oxygen supply and an even blood pressure.

In climbing a tree, a sprawling horizontal archosaur becomes a de facto tall animal when its body goes vertical. As the body tilts up, the blood pressure in the head falls, inducing dizziness or a momentary faint, and precious split seconds are wasted until the low blood pressure can accommodate to the body's new position. You can see how a tree climbing archosaur with a higher blood pressure could better cope with the changes in body orientation associated with rapid up-and-down tree climbing. Among other things, four-chambered hearts helped to ensure that the earliest dino-birds were splendid tree climbers.

The appearance of the four-chambered heart fostered an evolutionary explosion of tall, turbocharged archosaurs. All of a sudden, the fossil record fills with large archosaurs with high skulls, long, upwardly flexible necks, and semierect legs—legs held at an angle to the ground, no longer sprawling horizontal but not yet vertical, either. Collectively called *Thecodontians*, they ruled the earth for the first two-thirds of the Triassic Period (208 to 245 million years ago). There were many different kinds, small and large, including heavily armored plant eaters, lightly built predators, ponderous meat eaters, and giant 30-foot-long river-dwelling fish eaters. Except for the crocodilians, which are the last surviving Thecodontians—and today's only reptiles possessing four-chambered hearts—they vanished in a series of minor mass extinctions during the final third of the Triassic.

The dino-birds, meanwhile, remained in the trees and continued to evolve into ever better tree dwellers. Their hands and feet acquired sharp, hooklike little claws for climbing tree limbs and fronds. Hollow bones lightened their skeletons, helping to reduce impact injuries from falls and allowing dino-birds to become as agile as modern squirrels in leaping among the treetops. Hundreds of different species must have scampered through trees and underbrush. Most of those creatures, however, because of their small size, tree-dwelling lifestyle, and delicate skeletal structure, did not survive as fossils. But the pterosaurs, which branched off sometime in the Middle Triassic, did leave behind an excellent fossil record.

Pterosaurs, the leathery-winged "flying reptiles," lasted through the end of the Mesozoic and perished in the great extinction with the dinosaurs. They were the first vertebrates to achieve true powered flight, not just the ability to glide. Small, sparrow-sized pterosaurs were most numerous during the Jurassic Period (145 to 208 million years ago), but they seem to have diminished in diversity during the Cretaceous Period (65 to 145 million years ago), perhaps because of competition from true birds. Giant pterosaurs with wingspans 6 to 30 feet wide arose at the beginning of the Cretaceous and controlled the skies until its end. Even BADD paleontologists agree that pterosaurs originated as small tree dwellers, evolved into gliding animals that looked something like reptilian flying squirrels, and culminated as fully powered fliers.

The wings of pterosaurs differed greatly from those of birds and show that birds are not pterosaur descendants, as some people might think. Pterosaurs had wings made of a leathery skin, supported by a single, very large "wing finger." Birds, however, have wings made of feathers, supported by three fingers fused into a single unit. Feathers arise from the same parts of the skin as scales, so paleon-

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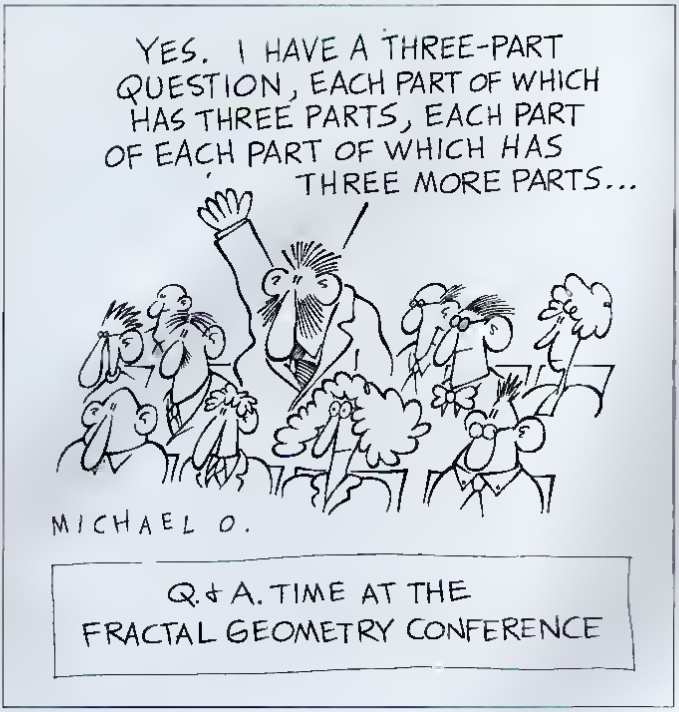


Is Science Rational?

Article By George Zebrowski

Is science rational?
Of course it is—under the circumstances
The dream of a cerebral cortex freed from the lower regions
of mind and body, or at least in control
of the lower regions, was first expressed in religions
mythologies, and philosophies as a yearning
for the angelic, for a sinless state aspiring to godhood With
the growth of science, this wish for
rational self-possession began to do more effective battle
with human error and irrationality
The very aim of science is to get around human error and
irrationality, not to mention the
preconceptions of "common sense" and "mythic traditions"
Science does this through repeatable
forms of experience, called experiments, that strive to
establish assemblies of facts, called theories,
that will resist disproof through continuing experimental

Painting By Michael Parkes

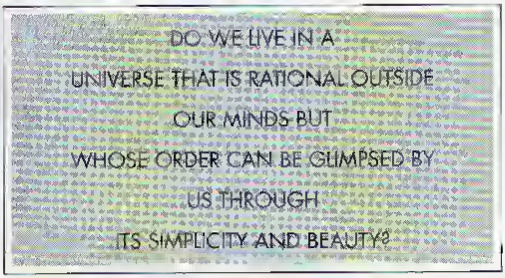
tests These provisional truths may stand indefinitely or be toppled by an experimenf or be subsumed into some broader theoretical structure, but fhey can always, in principle, be exposed as false or incomplete That is, we always know what it would take for them to be undermined This vulnerability to doubt and disproof through physical experimenf and observation is what makes them scientific Theirs is an essential modesty as opposed to dogmatisms that are consistent with any and all facts and that can never, in principle, be refufed

Rationality in science means that whaf we think is true must agree with what we can experience through observation and experiment, so that what is in our heads agrees with allowances for error, with what's outside This modest rafionality has built for us an island of the provisionally known that remains surrounded by an ocean of the unknown. As the island grows larger, it expands into the unknown

What kind of science are we describing by fhe above? This is the science of a rationalizing, not fully rational species which must come at nature's mysteries through essentially fallible means, with fallible, finite minds Given this, it's remarkable fhat we have invented an inductive method that enlists reason, intuition imagination and guessing, observation and experiment in an attempt to get around ourselves, around our own limits and capacities for error and failure, as much as it strives fo penetrate fhe unknown. Nevertheless, despite science's successes, the philosopher Wilhelm Dilthey, in disfinguishing between explanation and undersfanding, reminds us that the human scientist must inevitably attempt to explain more than he can understand, always carrying within himself, in the words of the French scholar Jean Wahl, both "the inexpressible and the need for knowledge" with "no contradiction between them," since "one calls for the other"

What kind of universe is it that makes this kind of science necessary for us? Do we live in a universe that is rational outside our minds but whose order can only be glimpsed by us through its simplicify and beauty? Do we live in a transcendent rational order which our fallible, rationalizing minds can only approach by putting erasers on fhe ends of our scientific pencils? The way in which we conduct our sciences may tell us as much about ourselves as it does about nature

Science confronts two kinds of irrationality—the human, in the error-prone conduct of scientific research and its applications, and the natural, in the seeming irrationality of fhe physical universe Againsf human irrationality, science has only the authority of organized experience—the merits of observafions and experiments patterned into descnptive and explanafory theoretical structures that yield successful predictions and raise new technologies. Besides having economic value science attempts to persuade us that its candidates for truth and practical application are valid, buf it is slowed, as are all human enterprises, by a biologically and socially limited human psychology that seems at odds with itself and nature But despite the fact thaf it is our humanify fhat consfrains the science we have—fallible, in constant need of correction, and sometimes irrational—we imagine that we can glimpse a science beyond our natural bias, a way out of ourselves.



The dream of reason is to step outside the human skin and see reality plain, free from social and adaptive biological prejudices. to glimpse the "thingness" of all the "otherness" outside our minds that is not us We can talk abouf it but have we ever been "outside," even for a momenf? I would say that we have looked outside in two ways—the first imaginative, the second experimental Whenever we feel disillusioned, strange under the stars, alien to ourselves and to each other, and realize that we have given ourselves what seem to be arbitrary identities, we know that we are much more than we can say—and that realizafion is a kind of inhuman objecfivity thaf invades our conventional way of seeing ourselves. The second, experimental way yields what scientisfs call "nonintuitive" theories, especially in physics, where we know that the conclusions, experimentally confirmed and convincing, violate our everyday expectations Physicists have slowly built up a map of what philosophers once called the noumenal world of things-in-themselves behind phenomena, the underpinnings of the world we see

Despite Schopenhauer's famous statement that "The world is my representation," that we "do not know a sun and an earth, but only an eye thaf sees a sun, a hand thaf feels an earth," we have glimpsed, through mathematical reasoning confirmed by experimenf, the universe that exists outside the shaping effect of our senses

But what if our science rests on irrational impulses thaf we cannot measure? What if our mind is a ruler that cannof measure itself withouf always getting the same answer? We know that the clouded mind continues to see itself as normal. Human reason cannot help but define itself as normal, whatever ifs limits Is all our knowledge ephemeral, serving only our limited biological and social context? Or is more possible? Perhaps if we can do as much as we have, and even see the circular nature of being ourselves embedded in the problem, fhen we might be able to break into a greater objectivity, stepping out from one frame into the next, seeing clearly what is in the prior frame but unable to understand the frame we have sfepped into—unfil we step into the one beyond it

Many scienfists believe that the process of uncovering new knowledge may never end, even though some, including Stephen Hawking, seem reluctant to rule out the possibility of getting to the botfom of physics If does seem possible to widen the scope of what science is doing, in further relative ways, and even to take a few steps outside the present limits of our minds.

Two ways seem at hand. The developmenf of artificial intelligence, which is also a way of trying to understand the human mind, may give us perspectives on human intelligence and (ir)rationality. Contact with an alien race, assuming even a modicum of lucid communication, would give us another view of ourselves, although we may not like what we might hear from them Both of these possibilities might give us fresh vantages from which to look back at ourselves, thus increasing our relative objectivity. "Give me a firm place to stand," said Archimedes, "and I will move the earth." We mighf change his words and say, 'Give me a place from which to see and I will explain both myself and the universe.'

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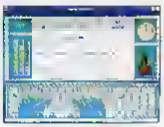

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Of course, an alien science would have alien biological limits and irrationalities to overcome, which we might not even be able to guess at. Everything we can say about the limits of human science should also apply to an alien science—in an alien way. Perhaps an alien civilization might consider its science both rational and complete and ours hopelessly biased, fragmented by too timid an approach to truth. Would we confront these aliens with Gödel's Proof and insist that the universe is bottomless while they claimed to have already learned everything? It might turn out that what they mean by having learned "everything" is that they know enough to do everything they want to do, and the fulfillment of curiosity beyond that point would be to them pointless, even irrational. There can be no science that will not be affected, to some degree, by the species practicing it. Yet we have won a vision from the traditions of our human sciences that has enabled us to glimpse a broader ideal of scientific honesty and enterprise that might be universal—the conception of mind in nature—growing beyond the origins of species to a greater objectivity that might be further enhanced when two or more intelligent species meet and compare notes.

Einstein said, "God does not play dice with the universe." In time, we would find the missing pieces of the theory, and the seemingly irrational aspects would vanish. More recently, Stephen Hawking has suggested that "God not only plays dice, but He also sometimes throws the dice where they cannot be seen."

Infinities, when they turn up in physical theories, are considered irrational, a sign of a problem with the work, something to be eliminated. The notions of an eternally existing, spatially infinite universe, or an eternal God, or the square root of 2, seem to be irrational because actual infinities appear inexplicable. But our resistance to the irrationality of infinity reveals that our intuition of what is rational requires limits, distinctions and a finite perspective—the view from discrete angles. We're always cutting things into manageable bits: this is what we mean by analysis. Perhaps what we know as human reason may not be all of reason.

Is the universe rational outside our minds? Many scientists would say yes, but it is its vast diversity, according to William Poundstone in *The Labyrinths of Reason*, that forces us to "compress" its features into our finite brains as inductive generalizations that leave out what is not essential. In a perfectly rational universe, infinities turn back on themselves; others are complex systems that only appear to be infinities. A universe may appear irrational to us because it isn't simple-mindedly rational. The rationality of our universe is best suggested by the fact that we can discover more about it from any starting point, as if it were a fabric that will unravel from any thread. Why can we do this? Richard Feynman answered by saying, "I think it is because nature has a simplicity and therefore a great beauty." All irrationality may be ours.

The sudden leap to a new scientific insight is not easily explained and itself seems irrational. In his book *Genius: The Life and Science of Richard Feynman*, James Gleick quotes mathematician Mark Kac: "There are two kinds of geniuses, the 'ordinary' and the 'magicians.' An ordinary genius is a fellow that you and I would be just as good as, if we were only many times better. There is no mystery as to how his mind works. Once we understand what he has done, we feel certain that we, too, could have done it. It is different with the magicians—the workings of their minds are for all intents and purposes incomprehensible. Even after we understand what they have done, the process by which they have done it is completely dark." Gleick playfully presents Murray Gell-Mann's description of magician Richard Feynman's method: "You write down the problem. You think very hard. (He shuts his eyes and presses his knuckles parodically to his forehead.) Then you write down the answer."

This is not as silly as it may seem. To write down the problem presupposes a background and experience in science, making possible the framing of a useful question that might be answered through experiment and mathematical manipulation. And such a question may have considerable grounding in earlier experiments and calculations before it reaches this stage, it may even be possible to guess consequences and from those consequences new principles, even new laws—which then have to be established through further experiment. There does seem to be a kind of heuristic irrationality in the activity which enables one to make discoveries that could not be mechanically deduced. Completely rational would be mechanically deducible—as certain as addition—and that is not how scientists always proceed.

An imaginative jump seems to occur when important new discoveries are made, despite the fact that scien-

"Personnel."

tists freely admit that they have to stand on the shoulders of previous scientists in order to see beyond. But 'our imagination is stretched to the utmost,' Feynman said, 'not as in fiction, to imagine things which are not really there, but just to comprehend those things which *are* there.' Gleick recognizes that scientists are constrained by the 'ever more intricate assemblage of theorems, technologies, laboratory results, and mathematical formalisms that make up the body of known science.' but it is these very constraints that produce what may be called the "imaginative crunch"—a sudden act of unconscious deduction and creative guessing, coming out of a rich synergistic critical mass that took much effort to bring together. In effect, one way or another, quite a bit of work has preceded what appears to be a discontinuous leap.

But the seeming irrationality of the above description persists when we ask why we can't discover anything except through tortuous effort and ingenuity. Is our life some kind of game, with hidden prizes? The naivete of such a question is only superficial because it does ask a profound, though probably unanswerable, question. The fact that most people will smile at it points up the degree to which we have domesticated fundamental enigmas. It may be said that if one were to design a universe that would be interesting to live in, it would be one that does not give us anything on a silver platter, but requires imagination and a great "interplay of induction and deduction, of ambiguity and certainty,' in Poundstone's words. What kind of existence would it be to live without difficulties? One is tempted to say that such an existence would make no rational sense. Or would it be as Nietzsche and Rimbaud sometimes imagined, "the rational song of the angels," free of the raucous race for goals?

One may wonder again if any of our human conceptions of reason have anything to do with the reality outside our bodies' selective restrictions. Furthermore, as Gleick points out, "The forms and constraints of scientific practice are held in place not just by the grounding in experiment but by the customs of a community more homogeneous and rulebound than any community of artists. Scientists still speak unashamedly of reality, even in the quantum era, of objective truth, of a world independent of human construction, and they sometimes seem the last members of the intellectual universe to do so." Yet, Gleick emphasizes, "reality hobbles their imaginations. New dis-


ATTOE.

coveries and novelties can either come by building on the past or by breaking with it, at least to some degree. One must say then that the mass of seeming irrationalities, anomalies, contradictions, proliferating infinities may be the most important parts of any science. They drive the accumulation of new knowledge.

If a fundamental science like physics is ever completed—that is, if all of its laws are ever enumerated—the achievement will throw a great finality over human life, diminishing and perhaps destroying the goal-oriented philosophy of inquiry that was born when human curiosity became aware of itself. We will then always have to live with the suspicion that every question may in time be answered, that everything will in time be exhausted, and we may then develop a nostalgia for the mysterious, ultimately unknowable universe of seemingly irrational infinities in which we once imagined that we lived. And we may conclude that taking the blinders off our minds was not an aesthetically reasonable or pleasant accomplishment, as we realize that less was infinitely more, that ignorance was at least sometimes blissful, and that the apples that grew from the tree of knowledge turned out to be poisonous in an unexpected way.

Even if one denies that the disappointment of the above described undesirable cul-de-sac is possible, one may still conclude that openness seems to be just as irrational a state as closure. Perfect knowledge seems just as irrational a state as no knowledge.

Science is rational enough—under the circumstances of our finite existence—because it avoids each extreme and is content to learn a lot, short of everything, by matching up theories to observations and experiments while keeping an open, but not credulous, mind. We live in an ocean of truth, in which, as Gödel proved, complex "truth" can have no finite, rational form—for us.

Still, one may persist in wondering whether finitude is not somehow an irrational state to be in, and how strange it is that limits, definitions, and the drawing of finite boundaries are the very core of our conceptions of reason, according to which we can be rational, even superrational. Yet we sometimes continue to delude ourselves by imagining that we hear the "rational song of the angels," the higher reason beyond our reason, haunting us with a memory of completeness, as if we were fragments broken off from something vast and eternal, seeking to regain that being. ∞

ILLUSTRATION BY CHRIS MOORE

ARTICLE BY DENNIS STACY

COSMIC CONSPIRACY: SIX DECADES OF GOVERNMENT UFO COVER-UPS

PART THREE

The third in a six-part series on government suppression of UFO-related material, this article examines the 1960s.

The Sixties were marked by upheaval: street riots outside the Democratic National Convention in Chicago, demonstrations against the war in Vietnam, "free love," and psychedelic drugs. And according to pundits, a "Big Brother" government intent on suppressing the winds of change had extended its reach beyond the merely social or political to the realm of UFOs. The result of this saucer suppression? Angry congressional hearings and the closure of Project Blue Book, the Air Force agency responsible for investigating UFOs.

The Sixties' "Saucergate" was triggered on March 20, 1966, when a glowing, football-shaped UFO was reported hovering above a swampy area near the women's dormitory of a small college in Hillsdale, Michigan. Witnesses included 87 female students and the local civil-defense director. The following night in Dexter, 63 miles away, another UFO was spotted by five people, including two police officers.

The Michigan sightings provoked a national outcry; in short, the public wanted an explanation. Addressing the largest media gathering in the history of the Detroit Free Press Club, Project Blue Book spokesman J. Allen Hynek, an astronomer

with Ohio State University, finally ventured an opinion. He said the sightings might be due to "swamp gas"—methane gas from rotting vegetation that had somehow spontaneously ignited. The explanation didn't wash, and both Hynek and the Air Force found themselves the brunt of immediate and almost universal ridicule. Newspapers had a field day as cartoonists, columnists, and editorial writers nationwide lampooned the Air Force suggestion.

In a letter to the House Armed Services Committee, then–Michigan congressman and House Republican minority leader (and later president) Gerald R. Ford called for congressional hearings on the subject, arguing that "the American public deserves a better explanation than that thus far given by the Air Force." The subcommittee subsequently held its hearing on April 5, 1966, but only three individuals, all with Air Force connections, were invited to testify: Hynek, then–Blue Book chief Hector Quintanilla, and Harold D. Brown, secretary of the Air Force. Brown told the committee, chaired by L. Mendel Rivers, that they had no evidence of an extraterrestrial origin of UFOs, nor was there any indication that UFOs constituted a threat to national security.

Under scrutiny, however, the Air Force eventually agreed to an outside review of Blue Book's files. Toward that end, the Air Force awarded $500,000 to the University of Colorado at Boulder. The major-domo of this extensive review was physicist Edward U. Condon, former director of the National Bureau of Standards. His second in command was the assistant dean of the graduate school, Robert Low.

Initially, critics of the government's UFO policy were happy to see the matter out of Air Force hands. But it didn't take long for their faith in the Condon effort to fade. If the Air Force had tried to gloss over the UFO issue, said retired Marine major Donald E. Keyhoe, director of the civilian National Investigation Committee on Aerial Phenomena (NICAP), the Condon Commission was even worse.

The day after his appointment, for instance, Condon was quoted in the *Denver Rocky Mountain News*. He saw "no evidence," he said, for "advanced life on other planets." Moreover, he explained, the study would give the public a "better understanding of ordinary phenomena, which, if recognized at once, would reduce the number of UFO reports."

Low, Condon's chief administrator, seems to have prejudged the reality of UFOs, too. In a telling memo written to University administrators, Low noted that "the trick would be, I think, to describe the project so that to the public it would appear a totally objective study but to the scientific community would present the image of a group of nonbelievers trying their best to be objective but having an almost zero expectation of finding a saucer."

Condon soon fired the two senior staffers he blamed for leaking the memo to the press. Two weeks later, Mary Lou Armstrong, his own administrative assistant, resigned, citing low morale within the project as a whole. "Low's attitude from the beginning," she wrote, "has been one of negativism. [He] showed little interest in keeping current on sightings, either by reading or talking with those who did." At one point, Low left for a month, ostensibly to represent the Condon Committee at the International Astronomical Union in Prague. Staff members suggested he use the opportunity to meet with veteran UFO researchers in England and France. Instead, Low went to Loch Ness, claiming that sea monsters and UFOs might share some similarities since neither existed. Even so, there is no record that he filed any written notes on his investigations.

> THE SCIENTIFIC COMMUNITY WOULD PERCEIVE A GROUP OF NONBELIEVERS TRYING THEIR BEST TO BE OBJECTIVE BUT HAVING AN ALMOST ZERO EXPECTATION OF FINDING A SAUCER.

The Condon Report was published in August of 1968 as the *Scientific Study of Unidentified Flying Objects*. In all, 30 of the 91 cases analyzed remained unidentified. Examining the famous McMinnville, Oregon, UFO photos, for example, project investigators opined that this was "one of the few UFO reports in which all factors investigated, geometric, psychological, and physical, appear to be consistent with the assertion that an extraordinary flying object, silvery, metallic, disc shaped, flew within sight of two witnesses." Of a radar/visual UFO sighting that occurred over Lakenheath, England, in August of 1965, the study concluded that "the probability that at least one genuine UFO was involved appeared to be fairly high."

Yet these suggestions that an unidentified phenomenon might indeed be afoot were buried in a bulky 1,500-page report. More readily accessible to the media was Condon's conclusion, published at the beginning of the study rather than at the end, as was standard scientific procedure. Essentially, Condon concluded, "further extensive study of UFOs probably cannot be justified in the expectation that science will be advanced thereby."

The Air Force seized the opportunity to withdraw from the minefield of UFOs, and on December 17, 1969, called a press conference to announce the closing of Project Blue Book. Citing the Condon report, acting secretary of the Air Force, Robert C. Seamans Jr., told reporters that Blue Book's continuation could no longer "be justified on grounds of national security or in the interest of science."

Critics contend that Blue Book never mounted a thorough scientific investigation of the UFO phenomenon to begin with, and that during its 22-year involvement with the issue, it had functioned as little more than a public-relations program. The charge, it turns out, was made by Hynek himself. In his last interview, granted this reporter shortly before his death from a brain tumor, Hynek avowed that while the Air Force always said it was interested in the study of UFOs, officials regularly "turned handsprings to keep a good case from getting to the attention of the media. Any case they solved," Hynek added, "they had no trouble talking about. It was really sad."

As the Sixties came to a close, the Air Force finally got what it wanted. It officially washed its hands of UFOs. Condon continued to deny the subject was "shrouded in secrecy." Overall, he said, the Air Force had done a commendable job.

Hynek agreed, though for reasons of his own. "The Air Force regarded UFOs as an intelligence matter, and it became increasingly more and more embarrassing to them," he said. "After all, we paid good tax dollars to have the Air Force guard our skies, and it would have been bad public relations for them to say, 'Yes, there's something up there, but we're helpless.' They just couldn't do that, so they took the very human action of protecting their own interests."

8 July

The june bug Jackson Pollocked my windshield. And as I looked at its innards, I saw substance. Which made me think. Is there still room in a society of disposable razors, disposable cars and disposable marriages for anything with substance? Or is the American mind so completely closed that it can no longer digest anything but cerebral cupcakes? Mental junk food filled with a lot of air. And as another june bug adds to the painting on the windshield, I glance at the radio dial and think, Yes. there are a few places where substance still matters.

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B L O O D L E T T I N G

am sitting in my car, and

A PERSON CAN

nothing is visible, just the black night out there, the black night

BECOME OLD IN

inside, the only sound is of the sea, the waves crashing against the

A DAY. MIKEY

cliff with fierce regularity. I remember the one time my grandmother

TURNED FIVE,

came out here; she did not like the constant sea noise. She

AND WARREN,

complained, "Don't it ever shut up?" She did not like the constant

A HUNDRED.

wind, either, worse than Kansas, she said on that trip. On my first visit to her farm in Kansas I marveled at the stars, and she took that to be a sign of a simple mind. But I knew then, and I think I still know, that they have more stars in Kansas than they do at the Oregon coast. Grandmother also said Warren was simple. But that was later, ten years ago.

The impenetrable darkness has made me think of her, I suppose. She talked about growing up on the prairies that were virtually uninhabited, of being out late when there wasn't a light to be seen, of her fear of the dark then and forever after. When I said I wasn't afraid of the dark, she muttered, "You don't know dark, child. You don't know." I do now.

She came out of the kitchen muttering the day I took Warren home to meet my family. "That man ain't as smart as he thinks," she said. "He don't know enough to open a can. Simple, that's what he is." I went to the kitchen to find Aunt Jewel showing Warren how to use an old can opener. He had never seen one like it. Simple. He was thirty, with a Ph.D., tenure at the University of Oregon, working with Gregory Oldhams. He had turned down other better-paid positions for the chance to work with Greg, he could have gone to Harvard, Stanford, almost anywhere he wanted.

It has started to rain, a soothing monotonous patter on the roof of the car, and now a wind has come up, rustling in the firs, in the vine maples, the broom that grows down the face of the cliff where nothing else can find enough dirt to sink roots. I am very tired.

I brought Warren up here before we were married; he was envious. "You grew up in a wilderness!" he said. He had grown up in Brooklyn.

"Well, you're here now," I said. "So it doesn't really matter so much, does it?"

"It matters," he said, gazing down at the ocean, then turning to look at the trees and finally at the A-frame house below us and across a shallow ravine. I had lived in that house for the first twelve years of my life. "It matters," he repeated. "You have things in your eyes I'll never get. I have people and traffic and buildings, and people, more people, always more people, always more cars, more exhaust, more noise . . . ." He stopped and I was glad. There was anguish in his voice, bitterness—I didn't know what it was, I didn't want to know it.

Greg Oldhams is the foremost researcher in hematology, the study of blood. He already was famous when Warren started working with him, and since then his research, and Warren's, has become what the articles call legendary. At first, after I met Warren, I felt almost ashamed of my own field—medieval literature. What was the point in that, I wondered, compared to the importance of what they were doing? At first Warren talked about his work with excitement, passion even, but then he stopped. I know to the day when it changed. On Mikey's fifth birthday, five years ago. Warren didn't come home in time for the party, and when he did get home, he was old.

A person can become old in a day, I learned then. Mikey turned five, Warren turned a hundred.

The wind is increasing, there may be a gale moving in. I had to roll up the window on my side when the rain started, and when I reached over to open the passenger side window, I realized I still had the seat belt fastened

> A GALE HAS ARRIVED FINALLY. NOW THE TREES ARE THRASHING, AND THE BROOM IS WHIPPING ABOUT FURIOUSLY, SHRIEKING EERILY

and then it seemed too hard to work the clasp and free myself. I began to laugh, and then I was crying and laughing. I don't care if rain comes in the passenger side, but the wind makes a harsh whistling sound through the narrow opening near my head, and I have to decide: open the window more and get wet, or close it. I can't bear the whistling noise. Finally I make the effort to undo the seat belt, reach over and open the other window and close the driver-side one. Now I can hear the ocean, and the rain, and even the wind in the trees. So much exertion, I mock myself, but I have to lean back and rest.

This is where I told Warren yes, I would marry him, up here overlooking the sea. "No children," he said. "The world has enough children."

I backed away from him and we regarded each other. "But I want a family," I said after a moment. "At least one child of ours, our genes. We can adopt another one or two."

Nothing was settled that day. We went back to the A-frame and banged pots and pans and argued and I told him to get lost, to get out of my life, and he said it would be criminal to bring another child into the world and I was being selfish, and the much-touted maternal urge was cultural, and I said people like us owed it to children to give them the same advantages we had, education, love, care. . . . It went on into the night, when I told him to sleep on the couch, and the next day until I stomped out of the house and came up here to glare at the ocean and its incessant racket. He came after me. "Christ," he said. "Jesus. One." Two months later we were married and I was pregnant.

When Mikey was two he got a big sister, Sandra, who was three and a half, and a year later he got a bigger brother, Chris, who was five. Our family.

Mikey was four when they all had chicken pox at the same time. One night Warren was keeping them entertained, coloring with them at the table while I made dinner.

"Why did you make him green?" Chris demanded.

"Because he has artificial blood," Warren said.

"Why?"

"Because something went wrong with his blood and they had to take it out and put in artificial blood."

Mikey began to cry. "Is that what they'll do to us?"

"Nope. You're not sick enough. You've just got spots on your face. You call that sick? I call it kvetching."

"What's that?" Sandra asked. She had fallen in love with Warren the day we met her, and he loved all three children.

"That's when you grow spots on your face and itch, and pretend you're sick so your mother will let you eat ice cream all day if you want. And your dad plays silly games with you when he should be at work. That's kvetching."

They liked kvetching. Later they got into my lipstick and tried to make it all happen again, spots, whining for ice cream, laughing.

Later it was funny, but that night with my sick children at the table, itching, feverish, it was not funny. I froze at the sink with water running over lettuce. Artificial blood? We were still in the cold war, atomic war was still possible, anything was possible. Even artificial blood.

"Why?" I asked, after the children were in bed.

He had to start way back. "Remem-

ber in the movie *Dracula* how the good doctor transfused one of the women over and over with whole blood, and it took? Pure luck. Lucy was probably an A-group type, and so was the guy. If he had put blood from an O group in her, she probably would have died on him. That's how it was. One took, another one, then bingo: it didn't. Then they found out about the blood groups, and later on about how the agglutinogens combine with certain agglutinins, and not others. And we've been learning ever since. The body treats the wrong blood type just like any other invading organism, bacterium, virus, whatever, and rejects it. But in the case of a major catastrophe you can't count on the lab facilities to handle the typing, the storage, all the mechanics of transfusions. The labs might not be there. We've got artificial blood now, you know, but it's pretty high-tech stuff."

I hadn't known until then. I shuddered, and he grinned. "So what's wrong with being green? Don't worry, it's still experimental, and very, very temporary. Anyway, if we could get away from some of the really high-tech stuff and simply transfuse from any healthy person to one who is ill . . . see?"

"But wouldn't that be just as high tech?"

He shrugged. "Maybe. Maybe not. There are genetic blood characteristics that get passed on from parent to child, you know. Sickle cell anemia, which, by the way, comes in a package that includes resistance to malaria. Hemophilia gets passed on . . . ." Whatever expression my face was registering made him stop. "Hey," he said softly, "I'm just spitballing."

I jerked upright so fast, I bumped into the steering wheel. I must have been dozing, dreaming. How clear Warren was, his hair thinning just a touch, a little too long, the color of wet sand, that day he had a suntan and looked almost ruddy. A big-faced ruddy man who looked as if he should be out plowing, or putting a roof on a building, or something else physically demanding. A sailor, he would have made a fine sailor. I can't see him now, my imagination is faulty in that I can't see images with any sharp detail. Only my dreams re-create with exactitude the people I have loved. My parents live on in my dreams, Warren is there, the children, but they won't show themselves to my waking mind. I have only feelings, impressions, nuances that have no names. Warren is a loving presence, a comforting presence, bigger in my mind than ever in person, stronger, more reassuring, strangely more vulnerable so that I feel I have to protect him. From what is as unclear as the visual image.

When I drove down here from the Portland airport, it was my intention to turn into the driveway to the house where I played out my childhood, instead I kept driving, followed the road that became a track up to this lookout point. The end of the road. The place where the world disappears.

We came out here with Greg two years ago. His wife was gone by then, back to Indiana or somewhere with their two children, and he was lonely. Or so Warren said. I didn't believe it, and still don't believe Greg ever knew loneliness. His work was world enough. We built a fire on the beach and the children played in the surf and came near to get warm, then raced back to the frigid water.

"Tell Greg about the meals," Warren said, grinning, contented that day, even though he was a hundred years old.

I had told him and the children about a typical meal during the time of Abelard and Heloise. Our children wanted to eat that way, too. A long board against the wall, food within reach of everyone, people sharing the same bowls, the same cups, eating with spoons or fingers. The beggars crowding about, and the dogs crowding everyone, snapping at each other, at the beggars, at the diners and the servers.

Greg laughed when I described it. He was lazy looking, relaxed, but if Warren had turned a hundred, Greg had turned two hundred. An old worried man, I thought. He was only forty-five according to the official records, but I knew he was ancient.

"Was that during the plague years?" he asked. He was leaning against a forty-foot-long tree that had crashed ashore, riding the waves to be stranded here, a memento of the power of the sea during a storm. The tree trunk was eight feet thick. It might have been alive in Abelard's time.

"Not much plague yet, not in epidemic form in Europe at least, although plague was recorded back in the sixth century, you understand, and continued intermittently until it struck in pandemic force later, about the fifteenth century. This period was eleven hundred or so. Why?"

"The beggars were inside at the table?" he asked, bemused.

"They were kicked out shortly after that, the beggars had to stay beyond the door, but the dogs weren't banished."

The conversation ended there, the children found a starfish which we all went to examine, and the sun was going down by then.

Late that night we discussed when we would leave for home the following day. Traffic had been bumper to bumper coming out and it would be worse on Sunday.

"I may stay on a few days with the kids," I said. Warren could go back with Greg early, what they were both inclined to do, but I knew the children would be disappointed at the short stay, as I was. It was summer, I had no classes, and this was the only kind of vacation we would have: a day now and then, two, three days at the coast.

"I wonder what it was like during the plague years," Greg mused, reviving the subject we had left hours before. "Anywhere from one-third to half the people gone, just gone."

"It wasn't exactly like that," I said. "It took three hundred years before it stopped sweeping the continent in epidemic form, and during that period the church became the power it is now. Superstition, heresies, empowerment for the church and state, fear for the public, that's what was going on. Life was hell for most survivors."

"And the Renaissance came about," Greg said thoughtfully. "Would it have happened without the plague? No one really knows, do they?"

"That's the romantic version," I said, not quite snapping at him. "The silver-lining theory. Out of every evil thing comes something good. You believe that?"

Warren had been brooding, gazing at the fire in the fireplace, snapping and cracking, a many-hued fire burning off salts and minerals of dried wood scavenged from the beach. He sound-

THERE'S A VAGUE MEMORY OF SOMEONE ELSE PUNCHING NUMBERS FROM MY CREDIT CARD. I MUST HAVE ASKED FOR HELP.

ed very tired when he spoke now. 'The Renaissance came about because people had used up all the resources they had available to them: they were desperate for better ways to farm, to make clothing, to warm themselves. Better ways to survive. They had to invent the Renaissance. It had nothing to do with plague."

I realized that they had had this conversation before: neither was saying anything the other had not already heard. I stood up.

"Are you going to tell me what you're doing in your lab?"

Greg looked blank, and Warren shook his head. "Same old stuff," he said after a long pause. "Just the same old stuff."

If it was just the same old stuff—artificial blood, whole blood transfusions, work they had been publishing for years—why had they both become so old? Why were they both terrified? Why had Warren stopped talking about his work altogether, and refused to talk about it when I brought it up?

Greg got up abruptly and went to bed, and Warren shook his head when I asked him again what they were doing. "Go on to bed," he said. "I'll just be a few minutes."

What do you do if your husband holds the agent to destroy half the human race? You try not to know it: you don't demand answers, you go to bed.

A gale has arrived finally. Now the trees are thrashing, and the broom is whipping about furiously, making its own eerie shrieking sound, and the rain is so hard it's as if the sea has come up here and is raging against the car, pushing, pushing. I am getting very cold and think how strange that I was so reluctant to turn on the motor, use the heater. I can hardly even hear the engine when it starts, and as soon as I lift my foot from the accelerator, I can't hear it at all.

Greg's wife took her two children and ran when she learned. I wonder if that is why Warren refused to tell me anything for so long.

In the past two years Warren became a stranger to us, his family. We saw him rarely, and only when he was so fatigued he could hardly stay awake long enough to eat, to bathe. I didn't see Greg at all after that day at the coast, not until two weeks ago.

Warren came home late. I was already undressed for bed, in my robe. He was so pale he looked very ill. "I blew the whistle," he said, standing just inside the door, water running off his jacket, down his hands, down his face. I went to him and pulled the jacket off his shoulders. "It's going to be out of our hands by tomorrow," he said, and walked stiffly into the living room to sit on the sofa.

I hurried to the bathroom and came back with a towel, sat beside him, and began to dry his hair, his face.

"Will you tell me about it now?"

He told me. They had found a viroid that had an affinity for some blood groups, he said. Not even a whole virus, not a killed virus, a piece of a virus. They had combined it with the O group first and nothing happened, but when they then combined the O blood with A blood, the viroid changed: it became whole, replicative, and the A blood was destroyed, consumed. He said it in a monotone, almost absently, as if it were of no real consequence, after all. And then he buried his face in his hands and cried.

Forty-five percent of Caucasians have A group blood, five percent have AB. Thirty percent of Blacks have A or AB. Thirty percent of Amerinds have A or AB. And the virus they created could destroy all of them.

I held him as he wept and the words tumbled incoherently. They would both go to Atlanta, he said that night, he and Greg, and someone would come to

oversee the packing of the material, the decontamination of the lab.

Greg came in while I was on the phone," he said at some point. "He tried to stop me. I hit him. God, I hit him, knocked him down! I took him home and we talked it over."

"Does he agree, then?"

"Yes," he said tiredly. "It was like hitting your father, your god."

"Why didn't you stop when you knew what it was?"

"We couldn't," he said. He was as pale as death, with red-rimmed eyes, a haunted look. "If we did it, then so will someone else if they haven't already. We kept trying to find an out, an antidote, a cure, something."

We were still on the sofa side by side. He drew away from me and got to his feet, an old man laboriously rising, he staggered when he started to walk. "I need a drink."

I followed him to the kitchen and watched him pour bourbon into a glass and drink it down. If he and Greg couldn't find the cure, I was thinking, then who could? They were the best in the field.

I keep thinking of what Greg said that day on the coast. The plague killed off one-third to half the population of Europe, the same numbers that make up the A, the AB, the AO blood groups. And out of that horror, he thought, had come the Renaissance.

I know so much more about blood groups and complexes now than I did two weeks ago. I put in a period of cramming, as if for an examination. I am in the A group. Mikey is AO. Warren is O. Sandra is A, and Chris is O.

I drove Warren to the lab the next morning, where we were met by a middle-aged man who introduced himself to Warren and ignored me. They went inside without a backward glance. When they were out of sight, Greg appeared, coming from the corner of the brick building, walking toward me. He had a Band-Aid on his jaw, Warren had one on his middle knuckle.

"At the last minute," Greg said, "I found I didn't want to see anyone, not Warren, not the hot-shot epidemiologist. Just tell Warren I'm taking off for a few days' rest, will you?"

I nodded, and he turned and walked away, old, old, defeated, sagging shoulders, slouching walk, his hair down over the collar of a faded gray ski jacket that gleamed with rain, sneakers squishing through puddles.

Such a clear picture of him. I marvel, coming wide awake again. The car is much too warm now, it has a very efficient heater. I want to sink back down into dreams, but instead I force myself up straighter in order to reach the key to turn off the ignition. My hand feels encased in lead.

I packed for Warren and later that day he dashed in, brushed my cheek with his lips, snatched up his bag, and ran out again. He would call, he said, and he did several times, but never with anything real to say. I was as guarded on the phone as he was. Anything new? I asked, and he said no, same old stuff. I clutched the phone harder and talked about the children, about the rain, about nothing.

I did the things I always did. I braided Sandra's hair, and made Mikey do his homework. I talked to my own class about *The Canterbury Tales*. I shopped and made dinners. I washed my hair and shaved my legs. . . . Mikey had a cold and Chris caught it, and I was headachy and dull feeling. Late fall things. I told Warren over the phone. He said it was rather warm in Atlanta and sunny. And, he said tiredly, he would be on the seven-o'clock flight due in Portland on Friday. We made soft thankful noises at each other. I had tears in my eyes when I hung up.

Trish Oldhams called the following evening. She wanted Warren, and when I said he was out of town, there was a long pause.

"What is it, Trish? Anything I can do?" I hoped it was nothing, my headache was worse and now I was afraid it was flu, not simply a cold.

"It's Greg," she said at last. "I was going to ask Warren to go check on him. He called, and he sounded . . . I don't know, just strange."

"What do you mean, strange?"

"He said he wanted to tell me goodbye," she said in a low voice. "Is he sick?"

"Not that I know. I'll drop in on him and call you back. Okay?"

Time is a muddle for me now. I can't remember when Trish called, but I didn't call her back. I found Greg loading boxes into his truck that he had backed up partway into the garage. His house was surrounded by unkempt gardens and bushes and a lot of trees, two or three acres that he ignored. Trish used to maintain it all. I remember thinking what a wilderness he had let it become.

"What are you doing here?" he demanded, when I stopped behind his truck and got out of my car.

"Trish called. She's worried about you."

"You're shivering. Come on inside."

The inside was a shambles, things strewn about, drawers open, boxes

"How thoughtful. Mr. Kessler sent a dozen roses."

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everywhere. He led me to the kitchen where it was more of the same. The table was piled high with books and notebooks, others were on the floor, on chairs.

"Sit down," he said. "You're shaking, you're so cold." He poured us both whiskey with a drop of water, and he sat opposite me, with the piles of stuff between us. 'Trish,' he said after a moment. 'I shouldn't have called her, I guess. She was surprised. I made her leave, you know."

I shook my head. "Why?"

"Because I was dangerous for her and the boys," he said, gazing past me. "A menace to her. I told her that and she would have hung on, but I told her I was a menace to the boys, too, and she left, just like I knew she would."

"I don't understand what you're saying." My glass rattled against the table when I tried to put it down. He took it and refilled it.

"I'm contaminated," he said. "Four, five years ago I nicked myself in the lab and got some of the viroid material in the cut. We thought I would die. Warren and I thought that, but as you can see—" He drained his glass and put it down hard. "But it's there, the viroid waiting to meet up with A-type blood, fulfill its destiny. Trish is A, and the boys are AO. It was just a matter of time before something happened, no matter how careful I was. I sent her away."

It is all muddled. He said he would not be a guinea pig, live in quarantine. No one knew about him yet, but he would tell them soon. He had made Warren promise to let him tell them in his own time, his own way. I was drinking his liquor and having trouble following his words, but I finally had become warm, and even drowsy as he talked on. He couldn't infect me, he said, driving me home, and Warren was all right. I was safe. He insisted that I couldn't drive, and he called a cab to return home afterward. Blood contact was necessary, he said, between a contaminated O and anyone else. Alone, the viroid was inert. And the virus? I asked. "Oh, that," he said grimly. "That's one of the things they'll be finding out in Atlanta. We, Warren and I, think it might be passed by any contact, or it could be airborne. They'll find out."

Today, Friday, I braided Sandra's hair and made Mikey brush his teeth, and told Chris that he couldn't go to a football game after school, not with his cold. Sandra was sneezing. I dragged into my one class, and then a committee meeting, and a late lunch with my friend Dora who told me to go home and to bed because I looked like hell. I felt like hell, I admitted, but I had to go to Portland to meet Warren. I wanted to go early enough to miss the traffic rush. I would have a snack in the restaurant and read and wait for his plane.

I heard the news bulletin on the car radio. Dr. Gregory Oldhams had died in a fire at his house. There were no details. I pulled off the road onto the shoulder and stared ahead through tears. He had called Trish to tell her goodbye. He had packed up things he couldn't bear to have burned. A guinea pig, live in quarantine, in isolation, his own time, his own way.

Lights have come on in the house across the ravine. They are looking for me. Warren must have told them this is where I would come. Home. I wonder if he is with them, if he is, he may think to come up here. I rather imagine that they have him in a high-security lab somewhere, drawing blood, testing it, or packaging it to send to Atlanta.

They may send him back. He will be so tired. Would I scream at him if we met now? Probably, and he doesn't need it, he knows, and he will know for the rest of his life. If we met, and if I had a gun, would I shoot him? I can imagine doing it, and I would want to do it, but would I?

Warren's plane was going to be an hour late. It was five when I got inside the terminal; three hours stretched like eternity. I was too tired to do more than buy a book and a newspaper and then find a place where I could sit in peace. No food. I thought, shivering again. Orange juice. I sat in the restaurant thinking about Greg, about yesterday, how he had driven me home. What he had said. Blood contact between an O and anyone else, airborne possibly after an A became infected. I remembered the Band-Aid on his chin, another Band-Aid on Warren's knuckle. How Warren had wept, not because of the work, but because he had struck Greg, his mentor, his father, his god.

I knocked over my orange juice when I attempted to lift the glass, and I stared at the spreading pool until the waitress's voice made me start. "You want another one?" she asked.

I fled to the restroom and studied my face in the mirror. Bloodless. It's the flu. I told myself. Just the flu. My fingers were tinged with blue under my fingernails, my palms were drained of color.

I know I talked to someone in Atlanta, but I can't remember how it came about. There's a vague memory of someone else punching numbers from my credit card. I must have asked

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for help. I had to go through so many people, wait so long before someone who knew something came on the line. 'Is it airborne?' I asked, and he had many questions, which I must have answered. He kept asking, "Are you there? Are you all right? Can you hear me?" I know he said, "Stay right where you are. Don't move from the phone. We'll send someone to help you."

Why didn't I wait for Warren? I should have waited for him, but I didn't and then I remember, they would have come for me, and someone else would have met him and taken him somewhere. I think of all the people I was with in the restaurant, in the lounge, in the vast waiting room, buying a newspaper, a book, the shop where I bought the tape recorder I'm using, just walking around in the parking lot . . . I forgot to tell the voice on the phone that I had stopped to buy gas, another contact.

I had to leave the phone because someone else wanted to use it, an angry man who told me to move my ass. I walked away from the phone and I stopped to buy the tape recorder, and then I kept walking, out to the lot, to my car, and I drove here. That much is clear in my head. As long as I don't try to move, or lift anything, I don't even feel too bad, just so tired, and so heavy. The oddest thing is the lack of coordination in my hands. I fumble with things, drop them. I can't even manage the key in the ignition any longer.

I told the man how it happened. Warren got the vibroid when he hit Greg. He used my razor the next morning, and I used it later, we both always nick ourselves shaving. So simple.

They will spread their nets and try to catch everyone who was in the airport this evening, people flying off to Denver, Chicago, England, Hawaii . . . They will scoop up everyone at school, all my classes, my friends, committee members. My children.

I can't weep now. I must be dehydrating too much. At first I thought Greg's way would be mine. I would drive to my old house and arrange a great fire and at the last minute set it off, but I won't burn myself. They'll want to know what damage was done, they may even find a clue to help someone. Or maybe, without even thinking it through, I realized they would come to the house. The house lights appear to be dancing through waves of water. The storm is so intense now, my voice sounds faint to my own ears. I don't even know how much I've said for the tape recorder, how much I have dreamed. The dreams are more real than reality. The car rocks, and the trees thrash about. I wish I could see them, but it's enough to know they've seen this before many times. Maybe they like it as much as I do.

"Can we sleep in the loft, Mom?" Mikey yelled, racing to the stairs.

"Well, sure. That's where I slept. Good enough for me, good enough for you."

I shooed them all ahead of me and lay down on the built-in bed. "Look, if you put your head right here, as soon as the moon reaches that tallest fir tree, the shadow of the tree will come in and kiss you good night."

Chris snorted in disbelief, but Sandra and Mikey lunged for the right spot, which I quickly vacated. Reluctantly Chris stayed close enough to see if it would really happen.

Later, Warren and I listened to them giggling and playing overhead. "Remember?" I asked. "You gave in and said okay to one."

There was a thump and silence and we both tensed, then renewed giggling floated down, and we relaxed. My legs were cramping from the position we were in, but I didn't tell him. I closed my eyes and listened to the laughing children. ∞

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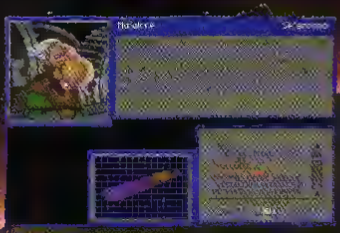

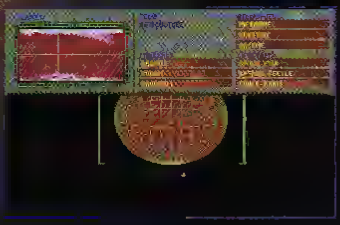

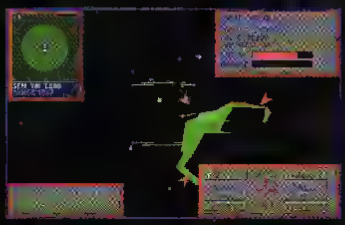

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INTERVIEW

"I'M NOT CLAIMING ANY MAGIC FOR MACHINES," SAYS THE GRANDDADDY OF AI. "ALL I CLAIM IS THAT THEY CAN THINK."

HERBERT A. SIMON

January 1958. Social scientist, cognitive psychologist, and philosopher. To Edward Feigenbaum, an AI pioneer at Stanford University, "Herb Simon is first and foremost a behavioral scientist. His genius lies in cutting through the immense complexities of human behavior to build elegantly simple models that work, that explain the data. He might well be the greatest behavioral scientist of the twentieth century."

Fast talking and combative at 77, Simon remains an unapologetic "left winger" in the AI world he helped found. Brusque to the point of arrogance, he insists that everything a brain does can be adequately explained in terms of information processing. A computer, he argues (and Simon argues a lot), could do these things just as well.

Herb Simon has always argued. His first

PHOTOGRAPHS BY ROB CLARK

publication, in grade school, was a letter to the editor in the *Milwaukee Journal* defending atheism. A civil libertarian and New Deal Democrat, he's been known to dampen conversations at dinner parties by asking guests whether they'd prefer having real children or disease-resistant AI programs that were otherwise identical. He doesn't take criticism well, he confesses, nor is he gracious in defeat—the sort of chess player who'll lose a game, then tell his opponent the next day he'd have won but for a single move.

Until the mid Fifties, Simon was an economist and political scientist. His 1978 Nobel Prize was in economics. He helped push conventional economics beyond neat (and accurate) supply and demand charts and toward the real-world complexity of psychology and behavioral science. His theory of "bounded rationality" subverted the classical view that organizations always make decisions that maximize profits and that, more broadly, individuals always pick the best choice among numerous alternatives. Instead, he observed, people are saddled with too much information and not enough brain power. As a result, whether setting prices or playing chess, they settle for the first choice that's "good enough." In Darwinian terms, it's survival of the fitter.

Despite Simon's nominal shift to AI and cognitive science 40 years ago, the central question underlying all of his research has never changed: How do people make decisions? His explorations of how people wade through a mass of information by making a series of split-second decisions, like a person playing Twenty Questions, led him logically to computers. What tool could better test his theories than programs that mimicked a human's search-and-select strategies?

Unlike many of his peers, Simon isn't interested in electronic superbrains. The human brain is obviously limited in how fast and how capably it can handle information. So Simon scrupulously builds into his artificial systems those same limitations. Computers for him are merely means to an end—understanding how a brain can think.

For his first interview with *Omni*'s Doug Stewart, Simon wore a crisp blue Mao jacket, a souvenir of a trip to China. A self-confident man, he is voluble and unrepentant about his many past pronouncements. To anyone who would challenge his assertion that creativity can be automated, he points to his office walls, which are dressed up with computer-made figure drawings. Although he evidently admires the drawings, he also finds them useful as exhibits A, B, and C when making his case to skeptical visitors.

Omni: So you believe computers think?

Simon: My computers think all the time. They've been thinking since 1955, when we wrote the first program to get a computer to solve a problem by searching selectively through a mass of possibilities, which we think is the basis for human thinking. This program, called the Logic Theorist, would discover proofs for a theorem. We picked theorems from Whitehead and Russell's foundation work in logic, *Principia Mathematica*, because it happened to be on my shelf. To prove a theorem, a human mathematician will start with axioms and use them to search for a proof. The Logic Theorist did quite a similar search, we think, to end up with a proof—when it was lucky. There were no guarantees it would find one, but there are none for the human logician either.

A year or two later, we embodied these ideas in the General Problem Solver, which wasn't limited to logic. Given a problem like, "How do I get to the airport?" it starts with, "What's the difference between where I want to be and where I am now? That's a difference in location, one of 20 miles. What tools do I know that reduce differences like that? You can ride a bike, take a helicopter or taxi. If I pick a taxi, how do I find one?" Again, GPS asks, "How do you get taxis? You telephone them." And so on.

VOCATION:
Cognitive psychologist, computer scientist, sociologist, philosopher

HIGHEST HONOR:
Nobel Prize in economics, 1978

RECENTLY WRITTEN:
Sciences of the Artificial, *Models of My Life*

MOST DISDAINED ADVERSARIES:
Armchair theorists

BEST-KNOWN CREATIONS:
Theory of bounded rationality and computer chess

ON COMPUTERS:
The machines that taught us how a mind could be housed in a material body

ON ARTIFICIAL MINDS:
It's going to be easier to simulate professors than bulldozer drivers.

Every time you set up a problem it thinks of some method or tool already stored in memory that can remove the difference between where it is and where it wants to be. Each tool requires that certain conditions be met before that tool can be applied, so it then searches its memory for a tool for doing that. Eventually, it finds one it can apply. You call the taxi, it comes, you get in it, and the first thing you know you're delivered to the airport. Notice GPS doesn't try everything—not walking or a helicopter. It knows all sorts of things about walking or helicopters that help it decide they don't work in this situation.

Omni Did you tell Bertrand Russell, *Principia*'s surviving author, what you had done with Logic Theorist?

Simon Yes, and he wrote back that if we'd told him this earlier, he and Whitehead could have saved ten years of their lives. He seemed amused and, I think, pleased.

Omni Wouldn't most people feel demeaned that a computer—a primitive one by today's standards—could do what they'd devoted ten years of their lives to?

Simon You know, sometimes I feel terribly demeaned that a horse can run so much faster than I can. But we've known for a long time that there are creatures bigger, stronger, and faster than we are.

Omni But *Principia Mathematica* was a celebrated cerebral accomplishment.

nothing like an animal's brawn!

Simon It's true that thinking seems a peculiarly human capability, one we're proud of. Cats and dogs think, but they think little thoughts. Why should it be demeaning to us to try to understand how we do something? That's what we're really after. How's thinking done? The farther we go in understanding ourselves, the better off we are.

Still, people feel threatened whenever the uniqueness of the human species is challenged. These kinds of people made trouble for Copernicus and Galileo when they said the earth wasn't the center of the universe, for Darwin when he said maybe various species descended from a few ancestors. I don't know that anybody's been hurt by our not being in the center of the universe, although there are some who continue to lose sleep about Darwin. We'll get used to the fact that thinking is explainable in natural terms, just like the rest of our abilities.

Omni A program you worked on in the Seventies rediscovered Kepler's third law of motion. How?

Simon We called it BACON, in honor of Sir Francis, because it's inductive. Kepler in the seventeenth century knew the distances of the planets from the sun and their periods of revolution. He thought there ought to be a pattern to these numbers, and after ten years he found it. We gave BACON the same data and said look for the pattern. It saw that when the period got bigger, the distance got bigger. So it divided the two to see if the ratio might be constant. That didn't work, so it tried dividing the distance again. That didn't work either. But now it had two ratios and found that as one got larger, the other got smaller. So it tried multiplying these—maybe their product was a constant. And by golly, it was. In three tries, BACON got the answer.

Omni A lucky guess!

Simon It wasn't luck at all. BACON was very selective in what it looked at. If two quantities varied together, it looked at their ratio. If they varied in opposite directions, it looked at their product. Using these simple heuristics, or rules of thumb, it found that the square of a planet's period over the cube of its distance is a constant. Kepler's third law. Using those same tricks, BACON found Ohm's law of electrical resistance. It will invent concepts like voltage, index of refraction, specific heat, and other key new ideas of eighteenth- and nineteenth-century physics and chemistry, although, of course, it doesn't know what to call them.

This tells you that using a fairly simple set of rules of thumb allows you to

replicate many first-rank discoveries in physics and chemistry. It thereby gives us an explanation, one that gets more convincing every time BACON gives us another example, of how people ever made these discoveries. It gets rid of these genius theories and tells us this is a normal process. People have to be intelligent, but their discoveries are not bolts from the blue.

Omni: Why are rules of thumb so important for computers and humans?

Simon: Take something limited like a chessboard. Every time you make a move, you're choosing from maybe 20 possibilities. If your opponent can make 20 replies, that's 400 possibilities. The 20 replies you can then make gets you 8,000 possible positions. Searching through 8,000 things is already way beyond a human's limits, so you limit your search. You need rules to select which possibilities are good ones. To exhaust all the possibilities on a chessboard, a player would have to look at more positions than there are molecules in the universe. We have good evidence that grand masters seldom consider more than 100 possibilities at once.

Omni: You and Allen Newell wrote the world's first chess program in the Fifties. How well did it play?

Simon: Not well. Hubert Dreyfus, in his book *What Computers Can't Do*, seemed pleased that it was beaten by a ten-year-old kid. A pretty bright one. I should add. Shortly after Dreyfus observed that, he was beaten by Greenblatt's machine at MIT, but that's a different story. Later in the Sixties, George Baylor and I built MATER, a program specializing in mating situations, going in for the kill. Its criteria tested whether a given move was powerful and explored only those, never looking at more than 100 choices. Chess books report celebrated games where brilliant players made seemingly impossible mating combinations looking eight or so moves deep. MATER found most of the same combinations.

Omni: It had the same insight as the human champion, so to speak?

Simon: You don't have to say 'so to speak'! It had the same insight as a human player. We were testing whether we had a good understanding of how human grand masters select their moves in those situations. And we did.

Omni: You talk about a string of serial decisions. Don't grand masters get a chessboard's gestalt by seeing its overall pattern?

Simon: A Russian psychologist studying the eye movements of good chess players found that grand masters looked at all the important squares in the first five seconds and almost none of the unimportant ones. That's "getting a gestalt of a position." We wrote a little computer program that did this by following a simple rule: For starters, it picked the biggest piece near the center of the chessboard; then the program found another piece it either attacked or defended. Then the program would focus on the second piece and repeat the process. Lo and behold, it quickly looked at all the important squares and none of the unimportant ones. Show me a situation where ordinary cue response mechanisms—call them intuitions if you like—can't reproduce those gestalt phenomena!

Omni: But can't good players see several pieces at a glance?

Simon: Experiments on perception show we take in all our visual information in a very narrow area. And there's something else. A colleague, Bill Chase, and I did experiments where we took the board of a well-played game after the twentieth move, say, and let chess players look at it for five seconds. A grand master will reproduce the board almost perfectly, maybe 24 or 25 pieces correct. A weekend player will get six or seven correct. You say, "Grand masters have great vision, don't they?"

Now put the same 25 pieces on the board but completely at random, with no regard for the rules of chess. Again, the ordinary player puts six or seven pieces back. This time, the grand master puts six or seven pieces back, maybe one more. Clearly, what the grand master is seeing isn't pieces but familiar patterns of pieces—Fianchetto's castled-king position or whatever. It's an act of recognition, just as you'd recognize your mother coming down the street. And with that recognition comes all sorts of information.

A grand master can play chess with 50 patzers, moving from board to board every few seconds, and at the end of the evening, he's won 48 of the games. How? He doesn't have time to look ahead, so he looks for cues. He plays ordinary opening moves, hardly looking at the board until he notices an opponent has created a situation he knows is an error. He recognizes it as a feature on the chessboard, just as a doctor sees a symptom and says, "Oh, you've got the measles." The grand master says, "A doubled pawn! He's in bad trouble."

Omni: You've argued that empirical knowledge, not theoretical postulates, must guide computer-system design.

CONTINUED ON PAGE 87

ANTIMATTER

UFO UPDATE:
To follow their stars, SETI researchers have found that they must seek a pot of gold

In the Search for Extraterrestrial Intelligence (SETI), scientists train radio telescopes on the cosmos, hoping to pick up signals from civilizations light-years away. But in October 1993, Congress pulled the plug on SETI funding, sending some of the most prominent projects back to square one. NASA's SETI program has recently had an infusion of cash from prominent private donors, giving agency researchers hope that at least some of their programs will survive. Other SETI researchers have had no such luck, however, and are scrambling for money so their projects can go on.

The NASA program, saved just recently from oblivion, includes a targeted search for signals from the nearest 1,000 sunlike stars. According to Seth Shostak of the SETI Institute, a nonprofit organization devoted to the search for signals from intelligent civilizations in space, his group has recently raised some $4.4 million to continue the NASA project. The funds, adds Shostak, were donated by William R. Hewlett and David Packard of the Hewlett-Packard Corporation; Gordon Moore, cofounder and chairman of the Intel Corporation; and Paul Allen, co-founder of Microsoft Corporation, among a number of others.

The NASA program, renamed Phoenix because it has risen from the ashes, will use Australia's 210-foot Parkes radio antenna to search for intelligent signals from specific stars found in the Southern sky. It will also rely on the 1,000-foot radio telescope in Arecibo, Puerto Rico, now being upgraded. Even so, says Kent Cullers, a NASA Ames project scientist who developed the signal-detection equipment for the thousand-star search, the new program will be able to search just about half as many stars as had previously been planned by scientists behind the effort.

For other groups, the news is worse. Once considered the world's premiere SETI effort, for instance, the High Resolution Microwave Survey operated out of two facilities—the Jet Propulsion Lab (JPL) in Pasadena, California, and the NASA Ames Research Center near Mountain View, California—and allocated $58 million over the last 20 years largely to build and test hardware designed to pick up messages from E.T. Before Congress withdrew federal funds earmarked for the program, SETI scientists at JPL had been all set to launch the largest "all sky" search ever conducted.

"But now SETI is dead at JPL," says Mike Klein, program manager for the Sky Survey, an attempt to survey the sky on millions of radio channels. Long viewed as a crucial complement to the highly targeted NASA efforts, the broad and wide-ranging JPL program, Klein laments, has been stopped in its tracks.

Smaller players have been crippled by the cuts as well. Project SERENDIP, run by Stuart Bowyer at Berkeley's Space Sciences Lab, for instance, requires just $60,000 a year, an extremely small sum by SETI standards; at one point, Bowyer even ran SERENDIP on a $20,000 gift from his mother. But if Project SERENDIP doesn't find some funding soon, it may be benched for good.

Bowyer is clearly worried. He could get by on less than $60,000 a year, of course, and has already launched a mailing that puts the touch on prospective donors. "If you have a Christmas card list," he says, "send it to me."

For these groups and others, says Shostak, it's just a shame. "It's analogous to Isabella and Ferdinand financing the *Niña*, *Pinta*, and *Santa María*," he says, "and then once the ships were built, telling Columbus that times were tight and they were going to mothball the fleet."—*PAUL McCARTHY*

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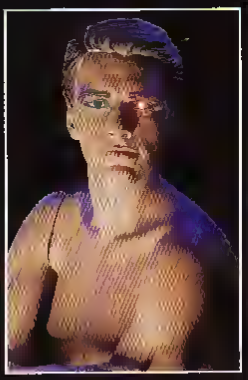


SPY DUMMIES

Did you ever look into a mannequin's eyes? Well, it may be looking right back at you— with closed-circuit TV.

Anne Droid mannequins, manufactured by F. Jerry Gutierrez of Denver, are made to keep an eye on customers and employees. Whatever a mannequin's eye-mounted, half-inch camera sees is relayed by cable to a monitor for store security to watch or tape. The spy dummies can be equipped to pick up sound with a microphone installed in the nose.

Most are placed in stores to catch shoplifters, but Gutierrez says some clients install them at conventions to find out what the customers think.

Human figures are the ideal, he adds, but the surveillance systems can also be fitted into mannequin dogs, cats, or other objects "as long as it has an eyeball" with a half-inch iris.

What if you can't afford the $2,400 to $5,000 price tag for a new Anne Droid surveillance mannequin? Gutierrez will fit the spy equipment into the buyer's mannequin for about $1,800. Moreover, customers who can't afford the system at all but want to look as if they have Anne Droid can buy "blind installation"—fake look-alike eyes for about $60. Put these lenses on non-spy dummies next to the real thing and you can't tell them apart without looking inside.

THE SURVEILLANCE SYSTEMS CAN BE FITTED INTO MANNEQUINS OF PEOPLE, CATS, DOGS

University of Colorado psychiatrist Gordon Neligh thinks surveillance mannequins are "the latest in a long line of things that are, for the average person, somewhat dehumanizing." He says people who are already paranoid will have their worst fears confirmed.

But, according to Gutierrez, "if you're honest, you don't have a thing to worry about."

—Peggy Noonan

STAR-STRUCK STOCKS

Want to make a killing on Wall Street? Try looking to the stars, suggests New York commodity trader Henry Weingarten.

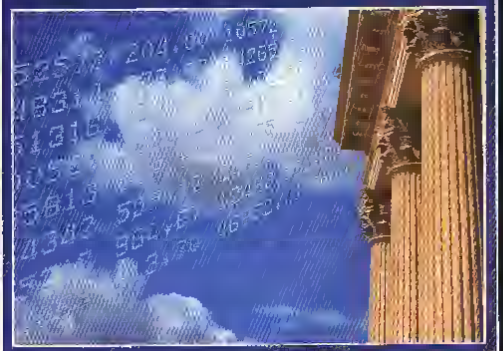
To pick financial winners, Weingarten studies the stock market's horoscope every day and checks what the stars portend for the nation. He sometimes charts the astrology of an individual stock, along with the CEO's horoscope. Although he won't release specific figures, Weingarten insists this star gazing has produced resounding successes for his six-year-old Astrologer's Fund.

"Using astrology, we can make predictions," says Weingarten. In 1992 he warned of upcoming natural disasters that would affect the stock market. He also correctly forecast, in July of 1993, that gold prices would soar within days.

Few Wall Street insiders will publicly admit that they take astrological predictions seriously, Weingarten says. But that may change: According to Weingarten, last year's Astrologer's Fund conference held in New York attracted financial managers who control more than 3 billion dollars.

"I don't believe in astrology," notes Gary Meyers, first vice president of investments at Robinson-Humphrey in Atlanta, "but there are so many cyclical indicators for the market. It's inevitable some people in this business think astrology is another cycle to consider."

—Sherry Baker



BIRDS FIRST?

CONTINUED FROM PAGE 43

tologists believe feathers originated as scales that elongated and acquired their fluffy structure gradually. But because feathers fossilize so rarely we have very little hard evidence of how they might have evolved. The earliest unquestioned feather traces of any kind are found with *Archaeopteryx*, and they're already perfectly formed, modern-looking feathers. There was nothing primitive about them. We can guess that early dino-birds acquired long, thin, flat scales—the hypothetical first stage of feather evolution that I call 'prefeathers'—shortly after the pterosaurs branched off, since pterosaurs didn't have such structures.

Prefeathers would have had many uses to a small, agile tree dweller. They would have helped to break falls, like little parachutes, and they could have carried colorful patterns that might have been used for signaling during courtship and mating, species "identification badges," like the wing and tail feathers of today's birds. Like the fletching on the rear of an arrow, these feathers would have been particularly effective arranged along the tail, the best place to provide balance, direction, and a slight amount of lift for a small, wingless dino-bird taking long leaps between trees. *Archaeopteryx* had a beautiful series of such feathers on its tail, still useful more than 50 million years after it first evolved. We can call a hypothetical dino-bird equipped with such a fringe of tail prefeathers a 'tail glider.'

One fossil of what may have been a tail glider has already been discovered. From the Middle Triassic of Spain, *Cosesaurus* was a lightly built, birdlike, perhaps semierect animal about seven inches long, with short arms but long hind legs. It probably had a set of prefeathers arranged horizontally along its long tail. Unfortunately their traces are very faint, and many skeptics consider them to be artifacts of fossilization or the describer's imagination, not real features. Nevertheless, I believe that minute examination of the *Cosesaurus* specimen, of the kind lavished by BADD paleontologists on the *Archaeopteryx* specimens, will confirm it as a dino-bird.

Megalancosaurus, a more advanced dino-bird, was briefly described in 1980 from the Late Triassic of Italy. Like *Cosesaurus* it was a small animal 7 to 15 inches long. Its arms were long, with huge five-digit hands endowed with prominent claws, perfect for tree climbing. The first two digits pointed opposite to the other three, a clear adaptation for grasping. *Megalancosaurus* likely climbed along branches with all four limbs vertical, like a monkey. Indeed, new *Megalancosaurus* specimens just described show that it and related dino-birds even had ribbonlike prehensile tails that ended in a little hook.

No feather or prefeather impressions were preserved with the *Megalancosaurus* specimens, but another similar-sized archosaur, *Longisquama* from the Late Triassic of Russia, shows wonderful impressions of very long prefeathers, which had a thickened central ridge like the spine of a modern feather. *Longisquama* even had a wishbone like that of *Archaeopteryx*! Its longest prefeathers were arranged elegantly in a double row along the back, and some paleontologists suggest that it could have lowered them horizontally to serve as gliding wings.

None of these three archosaurs fits into the BADD theory. BADD dinosaurologists view them as curiosities or archosaurian side branches, having little to do with avian ancestry or with dinosaurs. But in my BCF theory, they as-

sume paramount importance. Their very existence calls the entire BADD theory into question, so we should study them in great detail, and we should also try to find more specimens like them from the Triassic Period. In the BCF theory, *Cosesaurus Megalancosaurus* and *Longisquama* are all dino-birds on little side branches very close to the central dino-bird lineage.

Although most dino-birds were insectivores, like numerous present-day birds, at least one lineage discovered plant food: perhaps the seed cones of the coniferous trees they lived in. Plant-eating represents a major lifestyle change for predatory or insectivorous vertebrates, radically altering their teeth and jaw mechanics, digestive systems, and behavior patterns. Plants, however, are easier to catch than animals, which may be why a not particularly well-adapted predator might start to consume them. Plant-eating did not often evolve among predators and insectivores, but when it did, it opened up a wide range of previously unavailable lifestyles. Since plants exist virtually everywhere, there are many more ways to be a plant eater than to be a predator, and many different groups of plant eaters can evolve from a single common ancestor.

The first plant-eating dino-bird, a long-necked, large-eyed, lemur-like archosaur with a body a couple of feet long, developed grasping hands with big thumbs specialized for climbing trees and plucking plant matter to eat. It was probably covered with prefeathers along the neck, flanks, back, and tail. Its arms were mobile and muscular. When forced to travel on the ground, these plant eaters could have used their forelimbs for walking—something that today's tree-dwelling great apes do—but it would have tended to rely more on its longer, stronger, more vertical hind limbs.

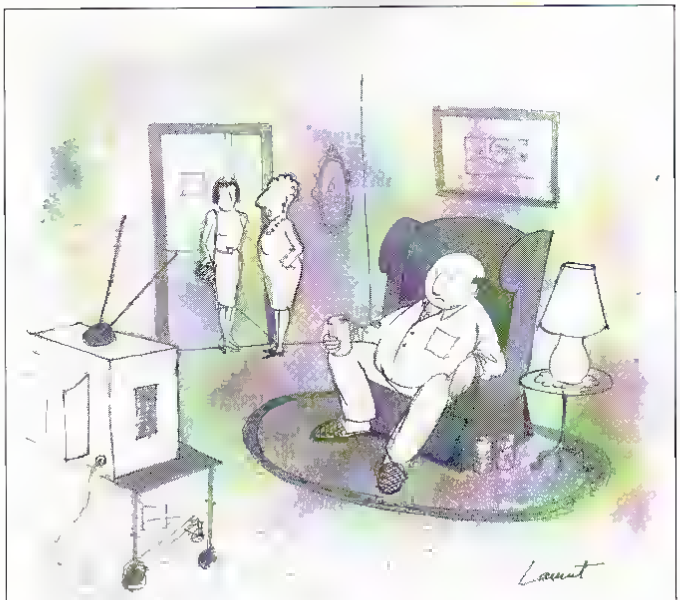
This hypothetical plant eater branched off from the dino-bird lineage sometime during the Middle Triassic. Its ground-dwelling descendants were the plant-eating dinosaurs known as brontosaurs and ornithischians. The very long-necked brontosaurs stayed on all four legs and, as an extreme instance of Cope's Rule, evolved into the largest animals that ever walked the earth. The *Brachiosaurus* of *Jurassic Park* was one such gentle giant. The ornithischians evolved into a more diverse array of small to large dinosaurs, including the duck-billed dinosaurs, the horned dinosaurs (such as the sick *Triceratops* of *Jurassic Park*), the tank-like ankylosaurians, and the bizarre, spiny-backed stegosaurians. Many ornithischians walked and ran on just their hind legs; their forelimbs had become too specialized for walking.

Indeed, that was the most peculiar thing about those particular ornithischians as well as the theropod dinosaurs that evolved from the later dino-birds. They walked and ran on just two legs. Recall that *Mesenosaurus* was a small, lizardlike, sprawling quadrupedal animal. What would have compelled its descendants to stay up permanently on their hind legs when bipedality is so hazardous? How long, for example, could a bipedal animal get around with a broken leg? The BADD theory provides no explanation. It would have us believe that bipedality just happened quite naturally to dinosaurs somewhere along the line.

In the BCF theory, however, bipedality becomes in and of itself a compelling piece of evidence that the ancestors of dinosaurs must have spent a long time living in trees. Otherwise dinosaurs, like most of today's land mammals, would have all remained quadrupedal, and the holding and tearing functions of their forelimbs would have been fulfilled by other body parts, such as their jaws. *Bipedal dinosaurs became bipedal because their forelimbs were already modified for doing something other than walking*—namely, climbing in trees, plucking cones and leaves, and even gliding through the air. This, by the way, is why we humans are bipedal. We, too, descended from tree-dwelling ancestors with grasping forelimbs too specialized for ordinary walking.

As the dino-birds became better and better climbers and leapers, and their prefeathers became more and more featherlike in structure, their eyesight, sense of balance, and hand-eye coordination greatly improved. Their leaps, propelled by long, strong hind legs, lengthened into glides, and midair control of the trajectory became ever more important. So the tail, with its stabilizing fringe of prefeathers, became more flexible at the base but stiffened toward the tip to act like a rudder. The prefeathers along the tail, thighs, and especially the forelimbs elongated, and the first short wings appeared.

At this point in their evolution, the dino-birds, strong, erect hind legs, their light weight, their relatively huge, increasingly specialized hands and forelimbs, and their improved sense of balance allowed them, when grounded, to avoid danger by sprinting bipedally to the nearest tree and scaling it using all four limbs. As their forelimbs



Richard's monitoring the culture."

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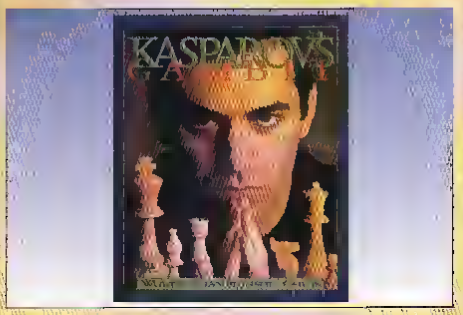

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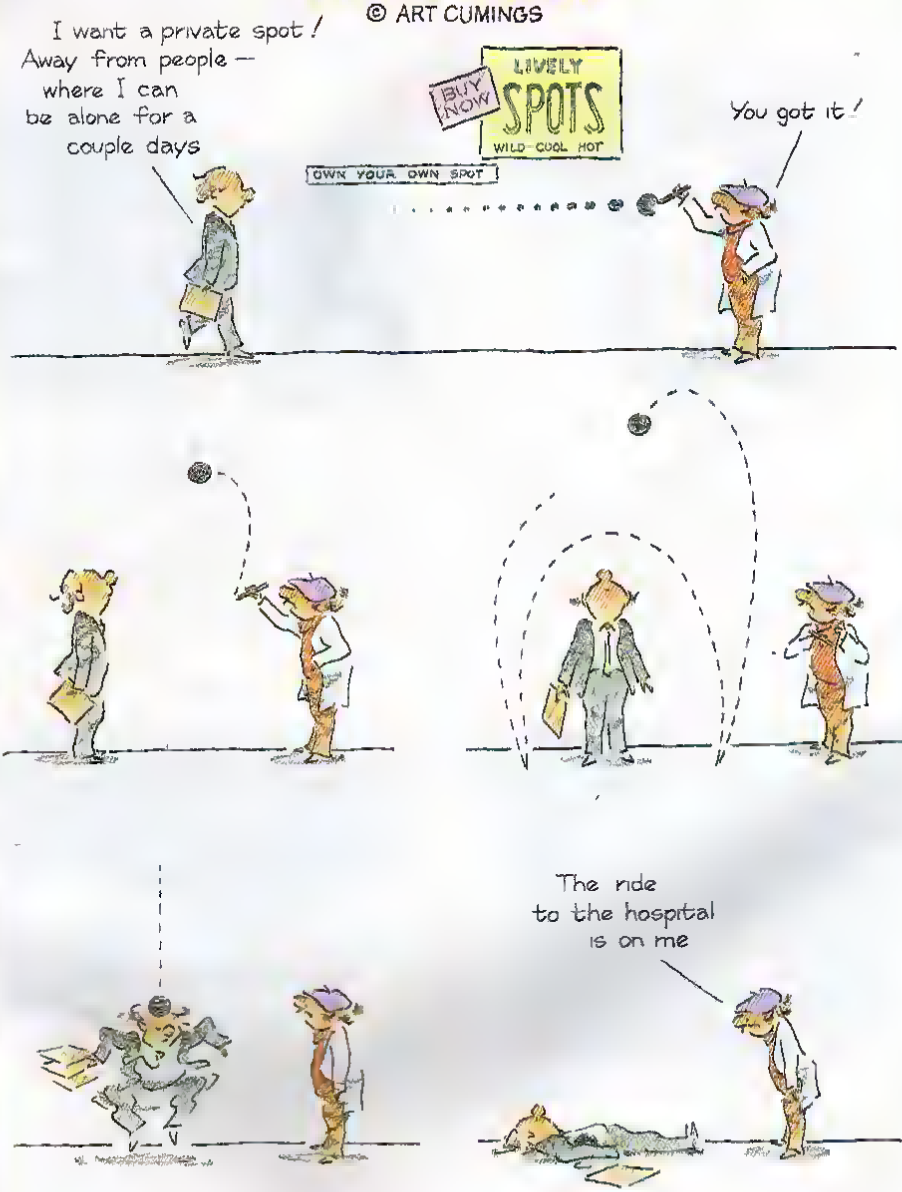

became better adapted for gliding, their hands lost the fifth, outermost finger, and the fourth finger shrank. These seemingly minor adaptations permitted the hand's long prefeathers to fan out into a true wing and also helped to define and steady the evolving wing's leading edge.

What we presently call theropods are the large, long-tailed, flightless, ground-dwelling archosaurs that arose on side branches at or above this point along the dino-bird lineage. They all looked a lot alike, making them difficult to sort into groups, of which paleontologists now recognize no less than ten. This we might expect, because many of the changes that took place at this point in dino-bird evolution were no longer major body changes but fine-tuning of gliding and flying abilities. For example, in later gliding dino-birds the first toe swung around to the back of the hind foot for grasping tree branches and perching. Another finger was lost, leaving only three in the hand. The joints in the arm altered, allowing the wing to fold up alongside the body out of the way when not in use. The breast bone enlarged, to support powerful wing muscles. These changes are clearly improvements for flying, not for running or hunting. Yet all also are found among ground-dwelling theropods that could not possibly have been fliers.

The earliest theropods, of the Middle to Late Triassic, were the size of roadrunners and even looked a bit like them, covered with colorful prefeathers or perhaps even fluffy feathers, and with stiffened tails sticking straight out as they chased down their prey. Too heavy for gliding, they would have used their four-fingered hands, equipped with sharply curved tree-climbing claws, to catch and tear up their kills; their arms were no longer useful as primitive wings. Following Cope's Rule, they evolved over time into larger forms, eventually replacing their less-advanced Thecodontian predecessors as the world's large predators. *Jurassic Park*'s overly fancy poison-spitting *Dilophosaurus* was actually one of those big, early, four-fingered theropods. And now, at last, you can see how the BCF theory solves the wing problem described at the beginning of this article. The small arms of the large theropods evolved *from* wings, not *into* wings.

As dino-birds perfected their flying abilities, they also improved their metabolism. They changed by stages from primitively hot-blooded animals into advanced hot-blooded animals. Each quantum-jump metabolic im-

provement in the little dino-birds generated a whole new set of theropod side branches, with their own giants, that replaced the more primitive giant theropods that had evolved before. This is why the giant theropods of one period do not seem to be directly descended from the giant theropods of earlier periods. Such a pattern of theropod dynasties signals that most of their evolution was taking place among small, rapidly evolving forms rather than among larger, more slowly evolving animals. And now you can see how the BCF theory solves the size problem. Small birds never evolved from large theropods, it happened the other way around.

By the end of the Jurassic Period, the dino-birds had evolved into flying animals that resembled *Archaeopteryx*. The large theropods of that time, such as the well-known *Ceratosaurus* and *Allosaurus*, were descended from earlier, more primitive dino-birds. "Advanced" theropods, such as *Gallimimus*, *Tyrannosaurus rex*, and *Velociraptor*, were still millions of years in the future, although their individual ancestral dino-birds had probably already branched away from the central lineage by the time *Archaeopteryx* had appeared. And this is the answer to the time problem, why the most birdlike theropods occur later in the fossil record than *Archaeopteryx*: it took as many as 60 or 70 million years for the descendants of *Archaeopteryx*-like dino-birds to evolve into giant, advanced theropods such as *T. rex*.

The original nineteenth-century sister-group theory of dinosaur-bird relationships posited that birds evolved independently of dinosaurs along a lineage of small, unknown reptiles that shared only a remote common ancestor with them. The BADD theory acknowledges that birds and dinosaurs are much more closely related than that, but it fails to provide convincing arguments to support its central idea that birds are dinosaur descendants. My BCF theory turns this notion around and asserts that the animals we know as dinosaurs were the flightless descendants of various kinds of dino-birds, among which were also the precursors of modern, flying birds. Looking at the relationship between birds and dinosaurs this way solves, in a clear and understandable way, puzzling problems that the BADD theory ignores or overlooks. Although BCF is not yet a finished theory, it is comprehensive, clean, and streamlined, and it is the closest we have yet come to correctly describing the pattern in which archosaurs evolved.

INTERVIEW

CONTINUED FROM PAGE 75

Why? What's the matter with theory?

Simon It's claimed that you can't have an empirical computer science because these are artificial objects, therefore they're whatever you make them. That's not so. They're whatever you can make them. You build a system you hope has a certain behavior and see if it behaves that way. In computer science, the only way we'll know what assumptions to start with is through experience with many systems. Humans are at their best when they interact with the real world and draw lessons from the bumps and bruises they get.

Omni Is this analogous to objections you voiced to classical economics early in your career?

Simon It certainly is. Economists have become so impressed with what mathematics has done for physicists that they spend much of their time building big mathematical models and worrying about their rigor. This work usually proves fruitless because they're allowed to sit down in an armchair and put any kind of crazy assumptions they want into those models.

Not inconsequentially, I started out in political science, not economics. Political scientists have a deep respect for facts—going out and observing, which I did a lot of. When I was 19, I did a study of how people working for the Milwaukee city government made budget decisions—how they chose between planting trees and hiring a recreation director. That work led to my Ph.D. thesis and first book, *Administrative Behavior*, in the late Forties.

Classical economic theory assumes that decision makers, whether groups or individuals, know everything about the world and use it all to calculate the optimal way to behave. Well, in the case of a firm, there are a zillion things that firm doesn't know about its environment, two zillion things it doesn't know about possible products or marketing methods that nobody's ever thought of, and more zillions of calculations it can't make even if it had all the facts needed to dump into the calculations. This is a ridiculous view of what goes on.

To go into a firm and evaluate the actual decision-making process, you must find out what information they have, choose to focus on, and how they actually process that information. That's what I've been doing all these years. That's why my AI work is a natural continuation of what I did earlier in

economics. It's all an attempt to see how decision making works: first at the individual level—how is it possible to solve problems with an instrument like a human brain?—and at the group level, although I've never gotten back to that level.

Omni: You've said human decision makers, instead of making the "best choice," always settle for "what's good enough." Even in choosing a spouse?

Simon: Certainly. There are hundreds of millions of eligible women in the world at any given time. I don't know anybody who's gone the rounds before making the choice. As a result of experience, you get an idea of which women will tolerate you and which women you will tolerate. I don't know how many women I looked at before I met my wife. I doubt it was even 1,000. By the way, I've stayed married for 56 years.

Omni: Congratulations. Why did you shift from economics to AI and cognitive psychology?

Simon: When I looked at the social sciences as fresh territory. They needed a good deal more rigor, so I studied applied mathematics and continued to study it even after I left the university. In economics, you can always turn prices and quantities into numbers, but how do you add rigor to concepts in political science like political power and natural language?

I saw the limits of using tools like differential equations to describe human behavior. By chance, I'd had contact with computers almost from the time they were invented in the Forties, and they fascinated me. At a think tank on the West Coast called the Rand Corporation in the early Fifties, I'd seen Allen Newell and Cliff Shaw using a computer to superimpose pictures of planes flying over a map. Here was a computer doing much more than cranking out numbers: it was manipulating symbols. To me, that sounded a lot like thinking. The idea that computers could be general-purpose problem solvers was a thunderclap for me. I could use them to deal with phenomena I wanted to talk about without turning to numbers. After that, there was no turning back.

Omni: But beneath these symbolic representations, isn't a computer just crunching numbers?

Simon: [loudly] No, of course the computer isn't! Open up the box of a computer, and you won't find any numbers in there. You'll find electromagnetic fields. Just as if you open up a person's brain case, you won't find symbols; you'll find neurons. You can use those things, either neurons or electromagnetic fields, to represent any patterns you like. A computer could care less whether those patterns denote words, numbers, or pictures. Sure, in one sense, there are bits inside a computer, but what's important is not that they can do fast arithmetic but that they can manipulate symbols. That's how humans can think, and that's the basic hypothesis I operate from.

Omni: Are there decisions you'd never leave to a computer, even an advanced future machine?

Simon: Provided I know how the computer is programmed, the answer is no. Years ago, when I flew a great deal, and particularly if I were landing at La Guardia on a bad day, I'd think, *I hope there's a human pilot on board*. Now, in similar weather, I say, "I hope this is being landed by a computer." Is that a switch of loyalty? No, just an estimate that computers today have advanced to the point where they can land planes more reliably than humans.

> HUMAN BEINGS KNOW A LOT OF THINGS, SOME OF WHICH ARE TRUE, AND APPLY THEM WHEN WE LIKE THE RESULTS, WE CALL IT WISDOM.

Omni: Would you let a computer be the jury in a criminal trial?

Simon: Again, I'd want to know what that computer knew about the world, what kinds of things it was letting enter into its judgment, and how it was weighing evidence. As to whether a computer could be more accurate in judging a person's guilt, I don't lack confidence that it could be done. Standardized tests like the Minnesota Multiphasic [Personality] Inventory can already make better predictions about people than humans can. We predict how well students will do at Carnegie-Mellon using their high-school test scores and grade-point averages. When you compare those predictions with the judgments after an interview, the tests win every time.

Omni: Is creativity anything more than problem-solving?

Simon: I don't think so. What's involved in being creative? The ability to make selective searches. For that, you first need knowledge and then the ability to recognize cues indexed to that knowledge. In particular situations. That lets you pull out the right knowledge at the right time. The systems we built to simulate scientific or any kind of creativity are based on those principles.

Omni: What about an artist's ability to create something beautiful?

Simon: Like a painting? Harold Cohen, an English painter at the University of California at San Diego, wanted to understand how he painted, so he tried writing a computer program that could paint in an aesthetically acceptable fashion. This program, called AARON, has gone through generations now. AARON today makes really smashing drawings. I've got a number of them around my house. It's now doing landscapes in color with human figures in them [pulling a book from his shelf].

These were all done on the same day, a half hour apart. These figures seem to be interacting with each other. Aren't they amazing? There's a small random element in the program; otherwise, it would just keep reproducing the same drawing. Clearly, Cohen has fed AARON a lot of information about how to draw—don't leave too much open space, don't distribute objects too evenly, and so forth—whereas human artists have to learn these things on their own. The interesting question is, what does a computer have to know in order to create drawings that evoke the same responses from viewers that drawings by human artists evoke? What cues have to be in the picture?

Omni: Why does this strike me as rather unethical?

Simon: I don't know. You'll have to explain it to me because it doesn't strike me as unethical.

Omni: Vincent Van Gogh's great creativity supposedly sprang from his tortured soul. A computer couldn't have a soul; could it?

Simon: I question whether we need that hypothesis. I wouldn't claim AARON has created great art. That doesn't make AARON subhuman. One trap people fall into in this "creative genius" game is to say, "Yes, but can you do Mozart?" That isn't the right test. There are degrees of creativity. If Mozart had never lived, we would regard lesser composers as creative geniuses because we wouldn't be using Mozart as a comparison.

As to whether a human being has to be tortured to make great art, I don't know of any evidence that Picasso was

tortured. I do know he had a father who taught him great technique. The technique he used as a kid just knocks your eyes out; it helped make his Blue Period possible a few years later in Paris. I don't know what that last little bit of juice is—yet. I always suspect these "soul" theories because nobody will tell me what the soul is. And if they do, we'll program one. [laughs]

Here's our friend van Gogh with his ear missing [opens another book]. I don't know whether you need a soul to paint that. The colors of these sunflowers are intense, certainly. There's a forsythia hedge I pass every morning when I walk to my office. When it blooms in the spring, especially if there's a gray sky behind it, the flowers just knock me out. I don't think that hedge has a soul. It has intensity of color, and I'm responding to that.

Omni: Van Gogh shot himself soon after he painted *Wheat Field with Crows*, so my emotional response to seeing it is inseparable from that knowledge. AARON's at a disadvantage in that sense.

Simon: Well, Cohen could invent a history for AARON. It could shoot its ear off.

Omni: Can a machine automate creativity then?

Simon: I think AARON has. I think BACON has.

Omni: Could a computer program have come up with your theory of bounded rationality?

Simon: [testily] In principle, yes. If you ask me if I know how to write that program this month, the answer is no.

Omni: You say people never have correct intuitions in areas where they lack experience. What about child prodigies? How can a 12-year-old violin virtuoso pack so much practice into so few years?

Simon: They do. But when a kid 12 years old makes it on the concert circuit, it's because he or she is a kid. Was Yehudi Menuhin ever really an adult artist? We have data on this; we don't have to speculate. Either out of conviction or a desire to earn money, the teacher says, "Gee, your kid is doing well at the piano." The kid gets gratification from being complimented and from not having to do other things because they have to practice instead.

Then the teacher says, "I've brought this kid along as far as I can. You'd better find a more experienced teacher." So they find the best teacher in town. Then they go national. It goes that way without exception. A study comparing top solo musicians with people good enough to teach or play in orchestras found an enormous difference in the numbers of hours each group puts in. Does that mean you can make people into geniuses by beating them into working 80 hours a week? No. But a large percentage of the difference between human beings at these high levels is just differences in what they know and how they've practiced.

Omni: So Albert Einstein didn't invent the theory of relativity in a blaze of insight, but rather prepared himself by amassing experience and learning to recognize patterns?

Simon: Einstein was only 26 when he invented spatial relativity in 1905, but do you know how old he was when he wrote his first paper on the speed of light?—15 or 16. That's the magic ten years. It turns out that the time separating people's first in-depth exposure to a field and their first world-class achievement in that field is ten years, neither more nor less by much. Einstein knew a hell of a lot about light rays and all sorts of odd information related to them by the time he turned 26.

Omni: You talk about machines thinking and humans thinking as interchangeable, but could a machine simulate human emotion?

Simon: Some of that's already been done. Psychiatrist Kenneth Colby built a model of a paranoid patient called PARRY. Attached to some of the things in its memory are symbols that arouse fear or anger, which is the way we think emotions are triggered in humans. You hear the word *father*, and that stirs up fear or whatever fathers are supposed to stir up. When you talk to PARRY, the first thing you know it's getting angry at you or refusing to talk. PARRY is very hard to calm down once it gets upset.

Omni: Some say AI has had a disappointing record of progress. What about all the rosy predictions from AI researchers?

Simon: Starting with mine. In 1957, I predicted four things would happen within ten years. First, music of aesthetic interest would be composed by a computer. Second, most psychological theories would take the form of computer programs. Third, a significant mathematical theorem would be proved by a computer. Fourth, a computer would be chess champion of the world. We could quibble about the word *most* in the psychological-theory predictions—our GPS program is widely accepted as are a number of others—otherwise, all but my chess prediction actually took place in the following ten years.

Omni: Hmm. Isn't the music verdict pretty subjective?

Simon: Not at all. Hiller and Isaacson at the University of Illinois used a computer to compose the ILIAC Suite and the Computer Cantata. Without identifying the music, I played records of these for several professional musicians, and they told me they found it aesthetically interesting—I didn't say it had to be great music—so that passed my test. So what's subjective?

Omni: You don't back down at all on your predictions?

Simon: No. And on my chess prediction, I was off by a factor of four. It'll take 40 years, not 10, for a computer to be world champion. My alibi is that I thought the field was so exciting that there would be a huge increase in effort on computer chess, and there wasn't.

Omni: Do you ever admit you're wrong?

Simon: Oh sure, I do it all the time. My wife couldn't live with me if I didn't. But on these things I wasn't wrong.

Omni: Except the chess.

Simon: Except the chess ... by a factor of four. ◻◻

WHEN YOU TALK TO
THE PARANOID COMPUTER PROGRAM, PARRY,
YOU'LL SOON NOTICE
IT'S GETTING ANGRY AT YOU OR REFUSING
TO TALK. PARRY IS
HARD TO CALM DOWN ONCE IT'S UPSET

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GAMES

THE CASE OF THE MYSTERIOUS NUMBERS: Scot reveals the *real* secret of *The Cuckoo's Egg*

By Scot Morris

In his best-selling tale of computer espionage *The Cuckoo's Egg* Cliff Stoll tells how he tracked an international spy through the maze of electronic networks.

Late in the book Stoll relates how the National Security Agency invited him to address its top-secret Department X-1. Before the talk, he spent a few minutes writing puzzles on a chalk-board with Bob Morris, the head of the agency (chapter 48).

Bob hit me with an easy number problem. OTTFFSS "What's the next number, Cliff?"

That was an oldie. One, two, three, four, five, six, seven. 'The next letter is E for eight,' I announced.

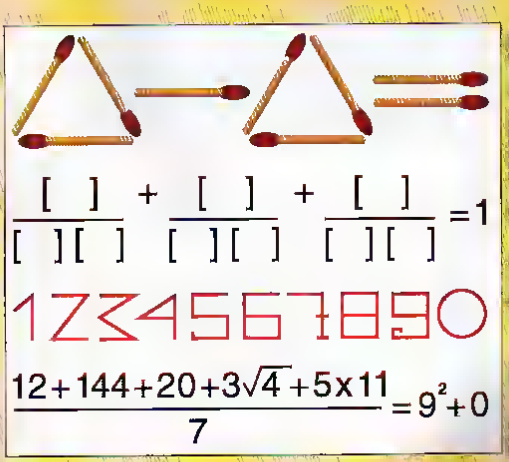
Well, we fooled around with puzzles and palindromes for a while, until he wrote out this series of numbers: 1, 11, 21, 1211, 111221.

'Complete that series, Cliff.'

I looked at it for five minutes and gave up. I'm sure it's easy, but to this day, I still haven't solved it.

Stoll tells me that he has received thousands of letters since the book came out, including perhaps 600 mentioning this puzzle. "I haven't kept track, but probably most are wrong guesses," he says.

Stoll has since learned the answer. The next term is 312211. But why? And what's the *next* term? (Answer below.)



OLD BUSINESS

Above is the solution to the matchstick triangle problem presented in April's column. Nob Yoshigahara created this puzzle and the three fractions below it, another puzzle posed in April. I challenged readers to distribute the nine digits 1 through 9 into the nine positions so that the equation is correct. There's only one way to do it. The answer appears below.

Last month I asked readers to determine the logic of a list that began *schwa, splat, three, grist, chore*. This isn't an alphabet list; it's a number list, originated by David Shukan. The third term, *three*, stands for "3" rather than "C." Convert every vowel (v) to the digit 1 and every consonant (c) to 0, and the list becomes the numbers 1 to 26 written in binary notation: *schwa* = cccvc = 00001 = 1, *splat* = ccccvc = 00010 = 2, *three* = cccvv = 00011 = 3, and so on down to *oiled* = vvcvc = 11010 = 26.

QUICKIES

1. What's special about the numbers shown above, third from top?
2. John Kirkland sent the equation at the bottom of the box above. Can you read it as a limerick?
3. David Fields asks you to imagine you're trapped on an island and there's only one way to escape—but you can't see it. Monsters are closing in on you to eat you alive. What should you do?
4. Nick Baxter asks how many times the phrase "The United States of America" appears on the front of a $100 bill. Most people see only one, but the correct answer is 11. Explain.

ANSWERS

Stoll number series: 1, 11, 21, 1211, 111221, 312211. The next term is 13112221. Each number is generated by an English description of the previous number. The sequence starts with "one one," so the second term is 11. That can be described as "two ones," generating 21. That's "one two, one one." Recursion does the rest.

The strange sequence was described by John Horton Conway, the legendary Princeton mathematician, as an example of "audioactive decay"—progressions that depend on how numbers are pronounced.

Another audioactive sequence *counts* the total numbers of each digit and describes them, starting with the largest digit. The first four terms are the same as Conway's sequence: 1, 11, 21, 1211, but then it becomes "one two, three ones," or 1231. What is remarkable about the thirteenth term in this sequence: 14233221?

Yoshigahara's fractions: The three fractions are 5/34, 7/68, and 9/12.

Quickies:
1. The number of angles (90° or less) in each digit equals the number itself.
2. A dozen, a gross, and a score/Plus three times the square root of four/Plus five times eleven/Divided by seven/Is nine squared and not a bit more.
3. Stop imagining.
4. The phrase is repeated ten times in a tiny frame around the image of Benjamin Franklin. The minute text is designed to deter counterfeiters.

Finally, 14233221 describes itself, and the sequence repeats endlessly from then on. DO

LAST WORD

UFOs IN NEW YORK
Roll out the red carpet and come on down!

By Peter Callahan

Forget the nasty little green men; these aliens are really hip and they certainly know how to play the Big Apple for more than fear and sympathy.

It was a big story when the UFO landed in New York, some even called it the biggest story of the twentieth century. Two aliens in a spaceship touched down in Times Square amidst the hustle and bustle of a Saturday night—and were promptly robbed and beaten by a group of thugs. "UFO a Flop on Broadway!" the *New York Post*'s headline screamed. "Martians Mugged!" the *Daily News* blared.

The story may have died there, a one-day sensation in the tabloids, if a videotape of the incident hadn't emerged the next day. Shot from the sixth-floor window of an X-rated book depository, the tape set off a worldwide media frenzy. Even the *New York Times* discreetly reported the event on a back page of the Metro section, elevating the story above suspicion.

The aliens, identified as Quisp and Quake, received an outpouring of sympathy and donations from thousands of people shocked by the incident. At City Hall, the mayor offered a public apology and keys to the city. After the ceremony, the aliens told a packed press conference, "We mean no harm to you or your planet. We just wanted to see New York."

Quisp and Quake quickly became the toast of the town. The Plaza Hotel set them up in an elegant suite while restaurants and nightclubs welcomed them with open arms. Their every appearance, from a taping of *Donahue* to the opening of a trendy disco, attracted hoards of adoring fans eager to glimpse the city's newest celebrities.

Quisp's rap version of the Byrds' *Mr. Spaceman* quickly topped the charts, and *Cosmopolitan* named Quake the Bachelor of the Month. It was a heady time for both the aliens and the city. But then, unexpectedly, it was over. Quisp and Quake disappeared one night, apparently returning from whence they came, and everyone mourned the loss of the aliens.

Until the scandal broke.

It started small, as most scandals do, when a maid entered the aliens' suite at the Plaza and found it in shambles: champagne bottles strewn everywhere, cigarettes stubbed out on priceless antiques. It was time to call in the police.

"We started hearing things about these guys all over town," says Detective Clifton Leaf of the Police Department's Fraud Investigations Unit. "Unpaid restaurant bills, totaled rental cars—and a lot of broken hearts. Turns out these guys liked to play the field, and at least a dozen women have already filed paternity suits. The whole thing makes me sick."

The city rocked and reacted with each new revelation. A major publishing house, after signing a million-dollar book advance with the aliens for an exclusive story, received a "manuscript" consisting entirely of newspaper clippings about the night of the incident in Times Square. A company the two founded, Spacial Relations, turned out to be nothing more than a glorified pyramid scheme. Investors lost millions.

The Martians even found time for small-time scams, according to Detective Leaf. "They were cleaning up on three-card monte games outside their hotel. People were looking at their funny heads instead of watching what they did with the cards." And they hit the transit system. "Because of their physiology," explains Leaf, "they were whizzes at sucking subway tokens out of turnstiles. Hell, they could suck a token out of your pocket and you wouldn't feel a thing."

The greatest shock came when experts determined that the video of the beating was a fake. According to Detective Leaf, Quisp and Quake staged the whole thing.

"We've arrested a group of unemployed actors who've admitted they were hired by these guys to play the muggers. In fact, if you enhance the tape you can even see Quisp, when he's supposedly being beaten, *laughing* at one point. It just makes me sick," Leaf sighs.

In the wake of what the press now calls "Martiangate," many people are wondering how two little aliens could have conned so many sophisticated New Yorkers. "I guess in the end," says Leaf, "they were just a lot smarter than us. The way I see it, they must have been casing us for a long time, because they sure figured out how things work down here." ∞