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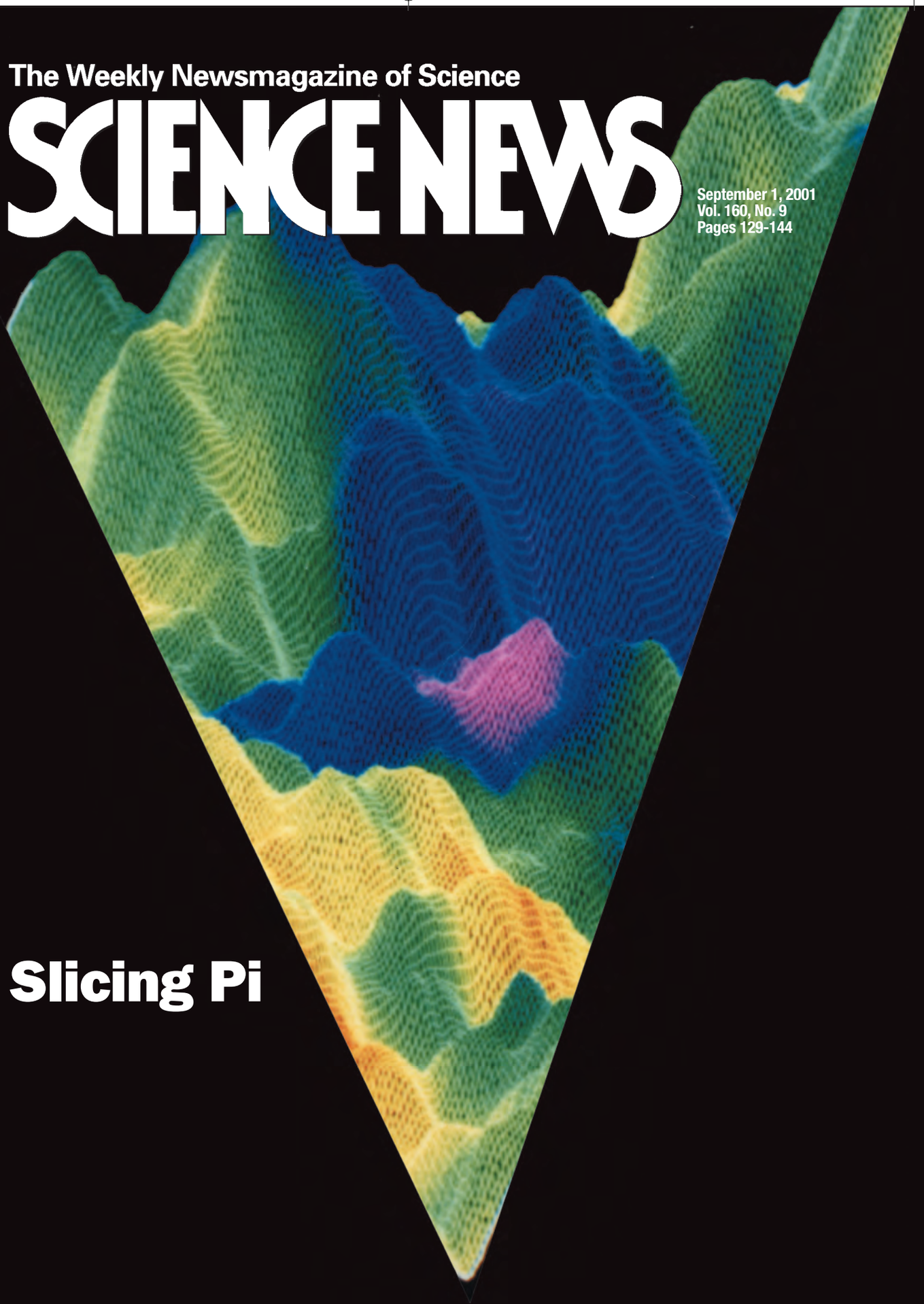

Slicing Pi

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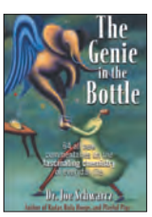
100 Award-Winning Science Fair Projects—Glen Vecchione. This collection of more than 100 projects offers well-organized science experiments designed to inspire understanding scientific concepts. Intended to move students beyond basic procedures to understanding the implications of results, this book invokes critical thinking in a stimulating format. Experiment topics range from discovering how soap removes dirt from your body to conceptualizing the universe by translating astronomical distances into geographic metaphors. Sterling, 2001, 208 p., b&w illus., hardcover, $21.95.

Birds of North America: Eastern Region and **Birds of North America: Western Region**—Fred J. Alsop III. These comprehensive guides are easy to use, even if they are too big to fit into one's pocket. The Eastern Region book features profiles of all 689 documented species of birds known to breed east of the 100th meridian in the United States. The Western Region book includes the 696 documented species that breed west of that line. With the birds arranged in taxonomic order, a full page is devoted to each species. Profiles feature a full-color photograph—both the male and female are shown if the plumage varies between genders—and a written description of the specimen, as well as details of its song, behavior, breeding, nesting, population, conservation, flight pattern, nest identification, size, weight, migration, habitat, and wingspan. A color-coded range map shows where to find the bird at different times during the year, and another information box points out birds of similar appearance and tells how to differentiate them. DK Pub Inc, 2001, color photos/illus., flexibind, $24.95.



The Genie in the Bottle: 64 All New Commentaries on the Fascinating Chemistry of Everyday Life—Joe Schwarcz. In a follow-up to his first book—*Radar, Hula Hoops, and Playful Pigs*—Schwarcz provides a new series of vignettes that explore the positive impact of chemistry in our daily lives. In this collection, he considers the ways that St. John's wort has been used for medicinal purposes, how silicone is used in toys (Silly Putty, for instance) and artificial heart valves, and whether silver can really help curb foot odor. Freeman, 2001, 311 p., hardcover, $23.95.

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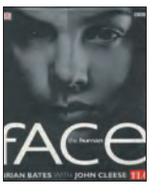
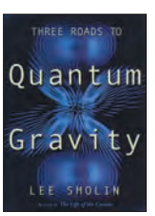


The Human Face—Brian Bates and John Cleese. In an instant, we can pick out a loved one from the strangers around us just by looking at his or her face. Bates and Cleese help us realize why this is so. In this chronicle of the evolutionary origins of the face, they explore the subtle but important differences between the faces of men and women and how anthropologists have discovered universal human expressions that alarm or attract fellow human beings. This book explains some of the physiology and psychology behind these expressions, as well as how to tell a false smile from a genuine one. Readers learn how we judge beauty and how we tend to equate appearance, sometimes unfairly, with personal character. With vivid photography and insightful observations, this book encourages readers to examine with renewed scrutiny their own reflections and the varied faces around them. DK Pub Inc, 2001, 240 p., color photos/illus., hardcover, $29.95.

Mission Jupiter: The Spectacular Journey of the Galileo Spacecraft—Daniel Fischer. It took 6 years for the space probe Galileo to reach Jupiter, but the fruits of this mission have been spectacular. Data generated by Galileo are reinventing our understanding of the giant planet and its many moons. Fischer recalls the history of Galileo's predecessors Pioneer and Voyager and the state of our knowledge of the Jovian system before Galileo. Then, he shifts his focus to the tumultuous launch of the probe and reviews the wealth of data the probe generated during its prolific first 2 years orbiting Jupiter. Completely updated from its original publication in German 3 years ago, *Mission Jupiter* also includes information about some of the more recent findings sent back by the probe. Originally published in Germany in 1998. Copernicus, 2001, 317 p., color plates b&w photos/illus., hardcover, $32.00.



Three Roads to Quantum Gravity—Lee Smolin. What are time and space? Physicists of the 20th century made great strides in answering this question along two fronts: Albert Einstein's theorizing about relativity and the assembly of quantum theory by Niels Bohr, Werner Heisenberg, Erwin Schrödinger, and others. However, due to the incomplete nature of both these ideas, the question still looms, and modern physicists continue to search for a theory that will unite the quantum and cosmic realms. Pennsylvania State University Professor Smolin provides a succinct and remarkably clear glimpse into the nature of this challenge and of the progress being made to meet it. He does so by isolating three of the most promising ideas that make a theory of quantum gravity seem plausible. These are string theory, loop quantum gravity theory, and black hole dynamics. In the process of defining these three possible foundations of quantum gravity theory, Smolin explains how it is that space and time are not continuous. He also introduces the holographic principle, which holds that world is constructed of nothing but the flow of information. Basic, 2001, 230 p., b&w illus., hardcover, $24.00.

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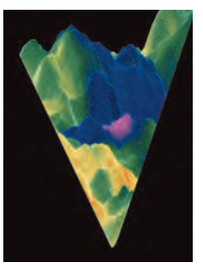

Cover: The apparent randomness of pi's digits, as represented by this random-walk landscape, has long intrigued and puzzled mathematicians. Researchers have now identified a possible route to a proof that each digit occurs with the same frequency. **Page 136** (Illustration: David V. Chudnovsky and Gregory V. Chudnovsky)

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Letters

Know what amine?

Your story on trace amines in the brain ("Obscure brain chemicals draw new attention," SN: 7/21/01, p. 37) neglected to mention the most interesting and well-studied of these, the powerful endogenous hallucinogen *N,N*-dimethyltryptamine (DMT). DMT's role in endogenous psychosis was studied intensively in the 1960s, before research with these drugs became so controversial. We recently subjected DMT to intensive study in a group of normal volunteers. Our inability to invoke tolerance, as well as others' findings that DMT crosses the blood-brain barrier, continues making DMT the most likely candidate for a trace amine of great physiological significance.

Rick J. Strassman
University of New Mexico School of Medicine
Taos, N.M.

Reinventing the wing?

In your article on powered exoskeleton development ("Dances with robots," SN: 6/30/01, p. 407), you mention the one-person flying machine being developed by Millennium Jet to fly at more than 70 miles per hour, at altitudes of 2,400 meters (7,900 feet), and for a "maximum load of 200 kilograms" (440 pounds). This project is an attempt to recreate a solution provided more elegantly 20 years ago by Williams Research Corp. with their demonstrated flight capability of the Williams Aerial Systems Platform (WASP) II, which was capable of 65-miles-per-hour level flight, altitude of 10,000 feet, and a combined load of pilot, fuel, and payload of 518 pounds. Why are the taxpayers paying good money to reinvent the wheel?

Michael J. Dunn
Auburn, Wash.

The jet-engine–powered WASP could fly only for a few minutes on a tank of fuel, had control problems, and was as noisy as a jet plane, according to Michael Moshier, who heads Millenium Jet in Sunnyvale, Calif. In contrast, the flying platform his company has been developing is expected to cruise stably for hours per tank using relatively quiet fan engines, he says. —P.W.

CORRECTION

In the radar image of asteroid 1999 KW4 that accompanies "Bow-wowing them with radar" (SN: 7/28/01, p. 57), it's the smaller of the two orbiting bodies, not the larger one, that measures 400 meters in diameter.

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Human Brains May Take Unique Turn

Two neuroscientists have tapped into what may represent a fundamental difference in brain development between people and other mammals.

If the findings hold up, they'll offer insight into how humans evolved an enlarged frontal cortex capable of supporting symbolic thought and language use, conclude Kresimir Letinic and Pasko Rakic of Yale University School of Medicine.

Researchers have identified many commonalties in how brains of various animal species develop. In contrast, facets of brain growth unique to any one species, including humans, have been elusive.

"There must be small differences between brain development in humans and in other animals," Rakic says. "These small differences can have a big functional impact on how the brain works."

In 1969, Rakic and his coworkers first used brain slices from human fetuses—obtained following second-trimester death—to identify remnants of a stream of neurons that traveled from the telencephalon to the thalamus. The telencephalon is a structure that gives rise to the cortex, and the thalamus is a relay center for messages to and from the cortex.

In the new study, Letinic and Rakic injected a dye into the telencephalon of living tissue slices taken from the brains of 15-to-26-week-old human fetuses, as well as from monkey and mouse fetuses of comparable development. Over a period of 36 to 48 hours, the dye unveiled a contingent of human neurons that were migrating from a spot on the telencephalon to a destination on the thalamus. This activity was absent from the other creatures' brains, the researchers report in the September NATURE NEUROSCIENCE.

In further tests on human and mouse brain tissue, Letinic and Rakic found that only in people did thalamic neurons at the end of the migratory stream attract telencephalic neurons taken from its source. In mice, neurons located along the migratory path chemically repelled telencephalic neurons, the scientists report.

Although other scientists need to confirm that this neural migration occurs only in people, the new data suggest that specific developmental innovations fostered human brain evolution, says Stewart A. Anderson of the Weill Medical College of Cornell University in New York City. Since the migrating neurons head to a part of the thalamus that connects to the frontal cortex, this link "may provide one mechanism for the remarkable flexibility of human cognition," he says. It also supports a theory that disturbed thalamic development contributes to thought disorders such as schizophrenia, he holds.

Barbara L. Finlay of Cornell University in Ithaca, N.Y., regards the new data as intriguing evidence for an evolutionary change in brain development. However, the same neural migration that Letinic and Rakic observed in human tissue may also occur in apes, which the researchers didn't test, she notes.

Moreover, there are few examples of evolution molding specific brain areas independently, Finlay notes. In a controversial analysis of data from 131 mammalian species's evolution, her team finds that within a species, most brain areas grow or shrink in unison according to overall changes in brain size. *—B. Bower*

It's a snake! No, a fish. An octopus?

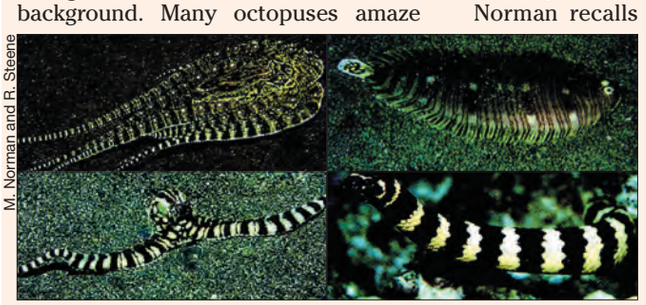
Whether the so-called mimic octopus could impersonate Madonna or President Bush remains unclear, but researchers say the long-armed wonder does a great sea snake and lionfish.

The octopus, too recent a discovery to have a scientific name, prowls the silty stretches where rivers spill into the sea in Indonesia, explains Mark D. Norman of Museum Victoria in Melbourne, Australia. Even with few hiding places, the octopus forages in daylight. Such boldness may come from its ability to change posture, color, and motion in impersonations of venomous animals, say Norman and his colleagues in the first scientific report of the behavior.

Plenty of animals play mimic, perhaps taking on the color of bark or sand in the background. Many octopuses amaze divers by matching a background so perfectly that the animals seem to vanish.

Other animals mimic a less tasty or more dangerous neighbor. However, shifting impersonations among very different species is new, according to coauthor Tom Tregenza of the University of Leeds in England. "The main dramatic thing about this is that it's orders of magnitude more dynamic than what's been observed in other animals," he says.

"It sounds terrific to me," comments longtime cephalopod specialist Richard E. Young of the University of Hawaii in Honolulu. Although Young cautions that the differences in the way people and other animals see things can make mimicry very hard to prove, he says he was amazed by videos of the mimic octopus.



M. Norman and R. Steene

Indonesian octopus (left column) mimics a banded sole (top right) and a banded sea snake (bottom right).

Norman recalls that he first heard about this octopus from some underwater photographers, whose still pictures remained open to many interpretations. "At first we joked, 'This one's doing a piano and this one's doing a sofa bed,'" he says.

In 1999 and 2000, British and Japanese networks sent Norman out with TV crews. He became convinced that the animals were indeed mimics. "When you follow one around, you see it doing very un-octopus-like things," he says.

Sometimes, the octopus fled with its arms aligned in a flattened, striped oval, looking much like a common poisonous flatfish. On four occasions when damselfish pestered an octopus, Norman saw it poke six of its legs down a burrow and spread the other two. They sported bands and waved gently, resembling the sea snakes that prey on damselfish.

When Norman saw a mimic octopus chugging along well above the seafloor, extended arms colored in stripes, he thought of the sunburst of striped, poisonous spines that lionfish flare.

Norman and his colleagues propose these mimicries in the Sept. 7 PROCEEDINGS OF THE ROYAL SOCIETY OF LONDON B, but Norman suggests the octopus' repertoire probably extends much further. "The more we watched it, the more weird behavior we saw," he says.

Tregenza suggests that the octopuses may be responding to menaces with particularly appropriate kinds of threats.

That would be pretty fancy footwork for an invertebrate, but Norman notes, "We're just getting glimpses of this amazing hidden fauna lurking out there." *—S. Milius*

Hindering glutamate slows rat brain cancer

Drugs that thwart the effect of a chemical secreted by certain cancerous brain cells could slow the growth of deadly brain tumors, a new study suggests.

The chemical, an amino acid called glutamate, normally acts as a neurotransmitter that brain cells use to signal each other. To serve this purpose, glutamate must move cleanly between cells. However, excess glutamate spilled into the space between cells can cause neurons, the information-carrying brain cells, to fire out of control and die.

In a healthy person, any excess glutamate is promptly gobbled up by glial cells, which are brain cells that support neurons. But in many glial-cell cancers, or gliomas, the tumor cells instead secrete glutamate. The resulting abundance of the neurotransmitter appears to kill neurons and create room for the cancerous glial cells to grow in the limited space within the skull. Moreover, glutamate secreted by glioma cells may cause surviving neurons to misfire and initiate epileptic seizures.

Scientists in Europe reported earlier this year that glutamate enhances the growth of various cancerous cell lines in lab dishes, whereas glutamate blockers thwart such growth. Wojciech Rzeski of Humboldt University in Berlin and his colleagues reported these findings in the May 22 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

In the September NATURE MEDICINE, New York scientists now report that two compounds that impede excess glutamate's effect on neurons can salvage some of these cells in rats. In so doing, the drugs inhibit glioma's spread.

The researchers examined brains of rats with gliomas that naturally did or didn't secrete excess glutamate. Tumors releasing abundant glutamate were significantly larger than the rest, says study coauthor Takahiro Takano, a neuroscientist at New York Medical College in Valhalla.

Takano and his colleagues also found that two chemicals—dubbed MK801 and memantine—slow the growth of some glioma cells in lab dishes. When the researchers injected the compounds into rats with glutamate-releasing gliomas, both slowed tumor growth.

The study "provides compelling evidence that [glutamate] gives the tumor cells a growth advantage," says Harald Sontheimer, a neurobiologist at the University of Alabama in Birmingham.

How some tumor cells produce excess glutamate is unclear, Takano says. In healthy people, glial cells draw small amounts of glutamate from the blood and pass it to neurons for its controlled use as a neurotransmitter.

Besides destroying neurons, glioma cells engender inflammation. This attracts the brain's housekeeping cells, which haul away remains of the dead neurons, Takano says. Inflammation may also spur angiogenesis—the process of building new blood vessels—which nourishes a growing tumor, he says.

MK801 and memantine work by binding to receptor molecules on the surface of neurons. This leaves fewer docking sites for glutamate, which prevents it from overstimulating the cells, Sontheimer says. With no place to grow and little angiogenesis, the tumor is stifled.

However, occupying a receptor on neurons can keep them from firing normally and thus may disrupt brain function. Memantine seems to block receptors enough to ward off excess glutamate but still permits neurons to function, Takano says. Already prescribed in Europe for some brain disorders, it shows few side effects. But MK801 occupies more glutamate receptors, preventing the neurons from firing, and would be too strong for use in people, Takano suggests.

These and other recent studies "open up an entirely new treatment approach to fatal central nervous system tumors," Jeffrey D. Rothstein and Henry Brem of Johns Hopkins University Medical Institutions in Baltimore say in the September NATURE MEDICINE. *—N. Seppa*

New fossil sheds light on dinosaurs' diet

Vestiges of soft tissue preserved in a 70-million-year-old Mongolian fossil suggest that some dinosaurs strained small bits of food from the water and mud of streams and ponds, just as modern ducks, geese, and flamingos do.

The remnants of a comblike plate appear inside the beak on the fossil's upper and lower jaw. Individual strands of material, about 5.6 millimeters long, sit about 0.5 mm apart. This type of structure, never before seen on a dinosaur, suggests that the ancient animals had a wider variety of feeding strategies than previously recognized, says Peter J. Makovicky, a vertebrate paleontologist at the Field Museum in Chicago. He and his colleagues describe their find in the Aug. 30 NATURE.

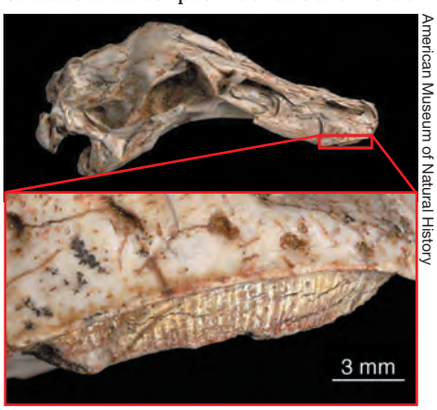
Makovicky discovered the almost-complete fossil in the Gobi Desert last summer. The ancient bones belong to *Gallimimus bullatus,* a species of bipedal dinosaurs in the group ornithomimids, or bird mimics. Ornithomimids had long, flexible necks, small heads, and prominent beaks. They looked something like ostriches with long tails.

Gallimimus' forelimbs probably couldn't grasp well, but the dinosaurs' long legs and sleek build suggest they were fast runners. Adults were about 2.1 meters tall and weighed about 320 kilograms.

Primitive ornithomimids, which appeared about 130 million years ago, had teeth, says Makovicky. All later members of the group, including *Gallimimus,* sported toothless beaks. Because fossils indicate that the animals had weak jaw muscles, paleontologists previously suspected that these later ornithomimids pursued small prey or ate eggs. However, the newly discovered sieve-like structure suggests that *Gallimimus* should be crowned as the all-time largest known terrestrial filter feeder.

Such a feeding strategy would help explain why paleontologists have found most ornithomimid remains in sediments deposited in lakes, rivers, and other wet environments, Makovicky notes. Modern birds with similar filters in their beaks glean plant material and small crustaceans from shallow water or mud.

It's unlikely that *Gallimimus* pursued prey that required cutting, ripping, or tearing—such actions probably would have damaged the beak's delicate structures. The gastroliths, or stomach stones, that have been found in some ornithomimids provide another clue



American Museum of Natural History

Fossil skull (top) bears a sieve-like plate (seen in detail at bottom), suggesting that the dinosaur Gallimimus *and its close kin were filter feeders.*

that the creatures didn't consume large animals, says Makovicky. Gastroliths are similar to modern birds' gizzard stones, which help grind vegetation and hard-shelled invertebrates into a more easily digested pulp.

Furthermore, ornithomimids couldn't have gotten their nourishment from fleshy fruits because plants that bore them hadn't yet evolved, says Dale A. Russell, a vertebrate paleontologist at North Carolina State University in Raleigh.

Russell suspects that all of the toothless ornithomimids may have been filter feeders, foreshadowing a feeding strategy employed by a wide variety of modern aquatic birds.

"I'd never considered that if one were to design a Mesozoic duck, it would look like an ornithomimid," says Russell. *—S. Perkins*

Crystal listens for telltale sounds of virus

After successfully testing a device that can hear the movement of a single virus from a drop of fluid, researchers envision a handheld instrument that could detect viral illnesses such as foot-and-mouth disease and Ebola.

The investigators suggest that their acoustic detector could be quicker and more economical than current assays used to identify viruses in blood, saliva, and other bodily fluids. Many of those tests employ expensive enzymes and take days to perform.

The new device depends upon a small piece of quartz crystal similar to the billions of crystals used every year in televisions, VCRs, computers, and phones. The researchers coat one surface of their coin-size quartz disk with antibodies specific to whatever virus they want to detect.

To find viruses in a fluid, the investigators place a drop onto the crystal and allow about 40 minutes for the antibodies to snag any viruses present. They then shoot electricity through the crystal, causing it to vibrate back and forth horizontally and repeatedly shift the position of any virus attached to an antibody.

As the voltage applied to the crystal increases, its vibrations speed up, and the viruses shift up to 10 million times a second. This exposes them to forces of up to about 10 million times that of gravity, says Matthew A. Cooper of the University of Cambridge in England.

When the forces become too strong for the bonds that join a virus and an antibody molecule, the virus breaks free and releases energy, some of it as a high-pitched sound. Cooper compares the sound to the snap heard when a twig breaks after being bent.

The quartz crystal also serves as a microphone that picks up the viral snap. "We use the crystal to both shake and detect" the virus, says Cooper.

Moreover, since all the individual viruses pop off at the same vibrational frequency, the strength, or loudness, of that acoustic signal provides a direct measure of the number of viral particles in the tested sample, the researchers report in the September NATURE BIOTECHNOLOGY.

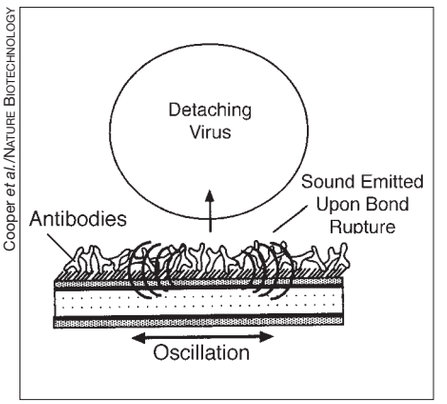
The scientists tested their device on herpes simplex virus, a relatively innocuous pathogen that can infect the mouth, eyes, and genital tract. "It's a surrogate for more pernicious viruses such as HIV or hepatitis B," says Cooper.

In a series of trials, the investigators confirmed that they could detect the virus in a water solution and in serum, the cellfree portion of blood.

Frances S. Ligler, who studies biosensors at the Naval Research Laboratory in Washington, D.C., notes that the crystal's sensitivity dropped significantly when the investigators tested serum. "It remains to be determined whether the detection method will be very sensitive or quantitative in the presence of highly variable patient sera," she says.

"It's always a big jump going from a lab situation to a real clinical sample," agrees Cooper, who notes that his group plans to work soon with a local hospital to test patients' blood samples for a variety of viruses.

The researchers have also set up a company to commercialize their invention. Since the device's electronics can be miniaturized easily, the researchers would like to build a portable unit for detecting pathogens outside of a laboratory setting.



Cooper *et al.*/NATURE BIOTECHNOLOGY

A vibrating quartz crystal can hear a virus popping off the crystal's surface.

Such an instrument would help veterinarians and physicians monitor outbreaks, suggests Cooper. It would have been useful, he notes, to public health officials in England who recently sought to stem the spread of the virus that causes foot-and-mouth disease in animals. *—J. Travis*

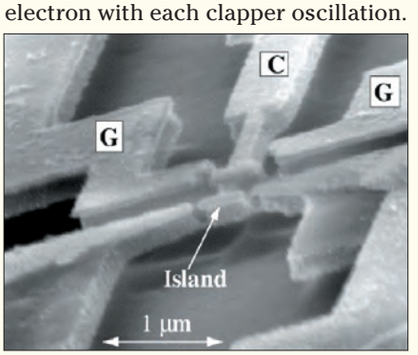
Quantum bell rings to electron beat

Before the invention of the transistor, telephone switching stations clicked with the sound of small metal arms gating the flow of electricity. A new invention revives mechanical systems, but on a far smaller scale.

German researchers have come up with a device that takes control of electricity by shuttling electrons across a gap with metronome-like regularity. The mechanism has potential uses in electronic odor detectors and extremely accurate current gauges. A team including Artur Erbe and Robert H. Blick of the Ludwig-Maximilians University in Munich reports its findings in the Aug. 27 PHYSICAL REVIEW LETTERS.

The researchers gave the silicon-containing device an apt name: the quantum bell. Its centerpiece is a clapper that oscillates at 100 megahertz when voltage is applied to either side. Attached to its tip is an island of metal electrically isolated from the clapper. As the island bounces back and forth, it transfers electrons between two plates.

"They use the mechanical motion of the clapper sort of like an [electron] turnstile," explains Andrew Cleland at University of California, Santa Barbara. By cooling the apparatus to 4.2 kelvins, the researchers came close to their goal of reproducibly moving one electron with each clapper oscillation.



Erbe *et al.*/PRL

The quantum bell: A clapper (C) is set in motion by voltage applied across gates (G) on either side. The clapper is mechanically connected to an island that shuttles electrons between two plates.

If such one-electron precision is attained, it could lead to an extremely accurate way to tally an electron flow, Cleland speculates.

By cooling the device further or changing its blueprint, the researchers will reach that goal, they predict. "This paper describes probably the most difficult steps toward achieving that," says Cleland. He says it remains to be seen whether this approach can ultimately perform better than the transistors presently used to measure current and calibrate electronic circuits.

Erbe imagines that the quantum bell could have practical applications at room temperature. For example, if airborne molecules stick to the clapper, they may slow down the oscillation frequency and thus the flow of electrons. That could form the basis for a mechanical nose, he says.

Erbe adds that devices based on the quantum bell, with its high-frequency clapper, could ultimately be used to miniaturize communication tools, including cell phones and radios. Such devices use filters to convert the low frequency of the human voice into high-frequency waves. A quantum-bell–based device would be smaller than current filters and would use less electricity. *—C. Schubert*

Milk seems to guard against breast cancer

Milk isn't just a boon to a woman's bones. A new study finds that it might also protect her breasts. Norwegian scientists have linked high milk consumption to low incidence of breast cancer.

A decade ago, researchers launched the still ongoing Norwegian Women and Cancer (NOWAC) study. They recruited 100,000 participants, all 35 or older, from throughout the nation. Though the thrust of the study was to evaluate factors that affect hormones and cancer, the researchers also initially administered a rudimentary dietary survey to some 53,000 women. It surveyed current eating habits and recorded estimates of childhood milk and vegetable intake.

In 1995, Anette Hjartåker, a nutritional epidemiologist at the University of Oslo, decided to consider milk consumption among the NOWAC participants. Another Norwegian study that year had reported that drinking five or more glasses of milk per day appeared to increase a woman's risk of breast cancer. Confusing the issue, a few other studies around that time showed hints of an anticancer role for milk.

Hjartåker recognized that the NOWAC data might be able to resolve the issue. They represent a big population where milk drinking is common. Half of the study's women downed at least a glass of milk per day; fully 10 percent consumed at least three times that much. In contrast, U.S. women average just a half-glass per day. However, most volunteers for whom dietary data were available were still premenopausal, below the age when breast cancer incidence escalates, so any effect would have to be large to show up. "I didn't really expect to find any effect of milk," Hjartåker says.

In their analysis, Hjartåker and her colleagues focused on the almost 50,000 premenopausal women. Through 1997, 317 of the women developed breast cancer. Those who drank at least three glasses of milk per day in adulthood "had a 44 percent lower incidence rate of breast cancer than women not drinking milk at all," Hjartåker's group reports.

When the researchers factored in women's childhood consumption, milk's apparent benefit increased slightly. Cancer incidence in the women who reported downing three or more glasses daily throughout life was about half that in the participants who had always shunned milk.

These associations held even after adjusting for other major factors influencing cancer risk, such as current age, age at first pregnancy, and total number of pregnancies, the team notes in the Sept. 15 INTERNATIONAL JOURNAL OF CANCER. Moreover, whole, reduced-fat, and skim milk appeared equally beneficial.

Robert P. Heaney of Creighton University in Omaha, Neb., isn't surprised by the new report. He observes that "there is a modest body of literature supporting this trend." Some studies even suggest components that might underlie milk's benefits, he notes, such as conjugated linoleic acid (SN: 3/3/01, p. 136). This fat, present in most dairy products, nearly halved the risk of mammary cancer in one rodent study (SN: 12/11/99, p. 375).

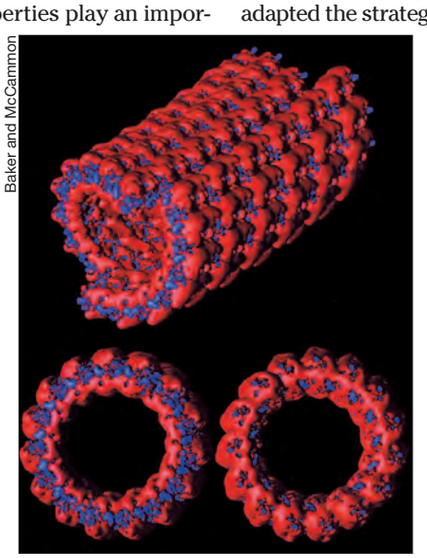
In a 1999 review, Martin Lipkin of the Rockefeller University in New York and Harold L. Newmark of Rutgers University in Piscataway, N.J., made a pitch for two additional milk constituents. The researchers cited a host of studies, including many of their own, showing anticancer benefits from vitamin D and calcium. For instance, data show that animals eating chow as high in fat as the typical U.S. diet often exhibit high rates of mammary cancer—unless the chow is fortified with extra vitamin D and calcium.

Lipkin and Newmark also noted that breast cancer incidence and mortality tend to be high where sunlight exposures—necessary for the body to make vitamin D—are low, such as in northeastern U.S. states with polluted skies. *—J. Raloff*

Computer paints a charged bioportrait

By employing a novel computational strategy, researchers have mapped the electrical landscape of biological molecules made up of more than 1 million atoms. Previous methods were typically limited to fewer than 50,000 atoms.

Electrostatic properties play an important role in the stability and dynamics of proteins, nucleic acids, and other biomolecules. With the new approach, scientists can model electrostatic interactions in functional parts of cells. These include microtubules, which usher nutrients and other substances back and forth within the cell, and ribosomes, which serve as protein-making centers.



Baker and McCammon

Computer visualization of electrostatic potential of a microtubule (top). Areas shown in red would be more likely to attract a positively charged molecule, and those in blue would repel such an entity. This computer model predicts that the two ends of a microtubule (bottom) are oppositely charged.

"This work signals a new era of calculations on cellular-scale structures in biology," says chemist J. Andrew McCammon of the University of California, San Diego (UCSD) in La Jolla. McCammon, Nathan A. Baker of UCSD, and their coworkers report their findings in the Aug. 28 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

To model how the charges of individual atoms interact to produce a molecule's electrostatic potential, or field, researchers solve the so-called Poisson-Boltzmann equation for points throughout the molecule. They use the equation to calculate the potential at each point on a three-dimensional grid within a box enclosing the molecule.

Last year, UCSD mathematicians Michael J. Holst and Randolph E. Bank demonstrated that it's possible to use a quick, rough solution for widely separated points to guide detailed calculations in much smaller regions. Baker and Holst adapted the strategy for electrostatic modeling of biomolecules.

Their approach parcels out the computation to a large number of processors in a novel way. Each processor, either in a single supercomputer or across a network of computers, solves the equation for the same grid of widely spaced points, then focuses on a different tiny piece of the molecule.

The processor uses the first, rough solution as a guide to arrive at the second, highly precise solution. A master processor then assembles the individual results into a detailed electrostatic portrait of the biomolecule.

The research team tested the method on a 1.25-million-atom microtubule. In less than an hour, 686 processors in the IBM Blue Horizon supercomputer at the San Diego Supercomputer Center produced an electrical map of the structure. No computer could have done the calculation in a practical amount of time using previous methods, the team notes.

One immediate goal, Baker says, is to "get the software distributed so a wider audience can start using it to perform calculations . . . on large molecules of interest." *—I. Peterson*

Pi à la Mode

Mathematicians tackle the seeming randomness of pi's digits

By IVARS PETERSON

Memorizing the digits of pi—the ratio of a circle's circumference to its diameter—presents a hefty challenge to anyone undertaking that quixotic exercise. Starting with 3.14159265, the decimal digits of pi run on forever, and there is no discernible pattern to ease the task.

The apparent randomness of pi's digits has long intrigued mathematician David H. Bailey of the Lawrence Berkeley (Calif.) National Laboratory. In the 1970s, when Bailey was a graduate student at Stanford University, he memorized the value of pi to more than 300 decimal places. It served "as a diversion during classroom lectures," Bailey confesses.

In 1986, after joining NASA's Ames Research Center in Mountain View, Calif., he tested a new supercomputer by having it compute pi to nearly 30 million digits (SN: 2/8/86, p. 91). Any errors would reflect problems in the computer. "The program actually did disclose hardware bugs," Bailey says.

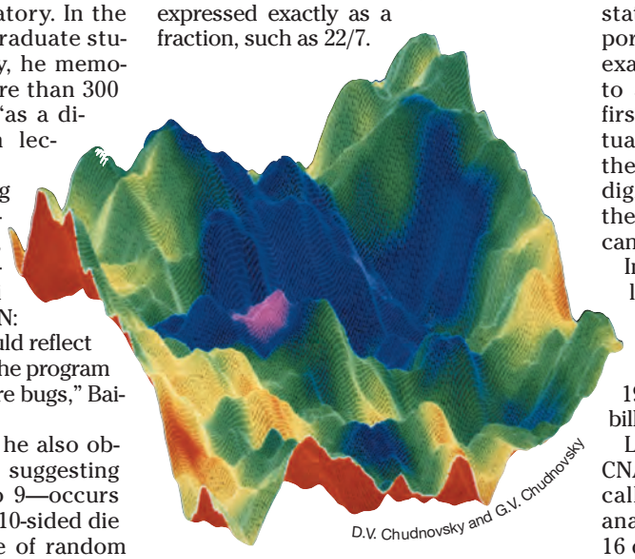
From the computer trial, he also obtained statistical evidence suggesting that every digit—from 0 to 9—occurs equally often. Tossing a fair 10-sided die would generate a sequence of random numbers having the same property.

However, like many mathematicians before him, Bailey could not prove that such a random distribution would hold beyond the first 30 million decimal digits of pi.

Now, there's a shard of hope that mathematicians may yet lay bare the apparent randomness of pi's infinite digits. Bailey and Richard E. Crandall of Reed College in Portland, Ore., have identified a potential link between two disparate mathematical fields—number theory and chaotic dynamics—that they suspect could lead to a proof that every digit occurs with the same frequency when pi is written out ad infinitum. Bailey and Crandall report their findings in the June EXPERIMENTAL MATHEMATICS. The characteristic would hold whether pi's in decimal form or in some other base.

If the Bailey-Crandall hypothesis pans out, "this would be one of the most spectacular results about pi ever," says Stan Wagon of Macalester College in St. Paul, Minn. Establishing the crucial mathematical link necessary for a proof, however, remains a difficult, unsolved problem.

Mathematicians have long known that pi is an irrational number. In other words, it can't be expressed exactly as a fraction, such as 22/7.



D.V. Chudnovsky and G.V. Chudnovsky

This irregular landscape represents the form that emerges when a computer plots the first 1 million decimal digits of pi as a random walk.

One consequence of pi's irrationality is that its endless string of digits never repeats in a cyclic fashion. Its digits show no apparent pattern and thus seem random although they can be derived from a formula.

Pi can be calculated to as many decimal places as desired by formulas that are sums of infinitely many terms, such as $\pi = 4/1 - 4/3 + 4/5 - 4/7 + 4/9 - \ldots$. The larger the number of terms, the more decimal places are revealed.

In 1909, mathematician Émile Borel introduced the concept of normality as one way to characterize the resemblance between the digits of pi and a sequence of random numbers. If a number is normal, digit sequences of the same length occur with the same frequency. Being normal is necessary but not sufficient for a number's digits to be random.

Pi would be considered normal to base 10 if any single digit appears one-tenth of the time, any two-digit combination one-hundredth of the time, any three-digit combination one-thousandth of the time, and so on.

Bailey and other researchers amassed statistical evidence in the 1980s supporting the notion that pi is normal. For example, one would expect the digit 7 to appear 1 million times among the first 10 million decimal digits of pi. It actually occurs 1,000,207 times—close to the expected value. Each of the other digits also turns up with approximately the same frequency, showing no significant departure from predictions.

In 1999, Yasumasa Kanada and his colleagues at the University of Tokyo computed pi to a record 206 billion decimal digits (SN: 10/16/99, p. 255). Their analysis shows that 7 appears 19,999,967,594 times among the first 200 billion decimal digits.

Last year, statistician Ted Jaditz of CNA Corp. in Alexandria, Va., systematically extended this type of frequency analysis of pi's digits to clusters up to 16 digits long. His statistical tests show no significant deviation from what would be expected for a string of random numbers.

A number is said to be "absolutely normal" if its digits are normal not only to base 10 but also to every integer base greater than or equal to 2. In base 2, for example, $\pi = 11.0010010000\ldots$. If pi is normal to base 2, the digits 1 and 0 would appear equally often.

Bolstered by the statistical evidence now available, mathematicians generally consider pi and several other fundamental constants, such as the square root of 2 and the natural logarithm of 2 (log 2), to be absolutely normal. However, they haven't yet mathematically proved that even one of these fundamental constants is normal to a particular base, much less to all bases.

"Current techniques don't even begin to dent the problem," says Peter B.

Borwein of Simon Fraser University in Burnaby, B.C.

Indeed, mathematicians have very little definitive information about the digits of pi and other irrational constants. "It is not even known that all digits appear infinitely often," Wagon remarks. In the case of pi, for example, no one can yet rule out the possibility that at some point beyond the range of current computations of pi's value, its decimal digits revert to a string constrained to, say, only the digits 1 and 0. If this were so, Wagon points out, it would alter the relative frequency of the digits.

An amazing 1995 discovery in number theory provided the first hint of a new way to tackle the question of pi's normality.

Bailey, Borwein, and Simon Plouffe of the University of Quebec at Montreal unexpectedly found a simple formula that enables one to calculate isolated digits of pi—say, the trillionth digit—without computing and keeping track of all the preceding digits (SN: 10/28/95, p. 279). How such a formula possibly could arise constitutes a mystery in itself, mathematicians say.

The only catch is that the formula works for base 2 and 16 but not base 10.

So, it's possible to use the formula for determining that, say, the five-trillionth binary digit of pi is 0 (SN: 10/17/98, p. 255). But there's no way to convert the result into its decimal equivalent without knowing all the binary digits that come before the one of interest.

Similar formulas are now known for computing arbitrary, isolated digits of other mathematical constants, including log 2.

Bailey suspected early on that the existence of such formulas might have something to do with the normality of pi, log 2, and other mathematical constants. The formulas also reminded him of those used in certain computer algorithms to generate so-called pseudorandom numbers (SN: 11/9/91, p. 300). Computers follow such recipes to create strings of digits that pass for random numbers, which are often required for games, simulations, and other applications.

Crandall, who heads the Center for Advanced Computation at Reed, then identified a link between normality and so-called chaotic sequences of numbers that fall between 0 and 1. These sequences are extremely sensitive to tiny changes in the formula or starting point, and they hop from one value to another in an erratic manner. They've been used to model a variety of natural phenomena (SN: 10/31/98, p. 285).

Together, Bailey and Crandall established that if they could prove that the numbers of particular chaotic sequences (see box) are evenly distributed between 0 and 1, the normality to base 2 of pi and log 2 would follow automatically.

"What we have done is to translate a heretofore unapproachable problem to a more tractable question in the field of chaotic processes," Bailey says. "At the very least, we have shown why the [binary] digits of pi and log 2 appear to be random."

"This is interesting work," Borwein comments. "The link between [chaotic dynamics] and normality was a surprise to me."

Bailey and Crandall are now taking a closer look at the link between their hypothesis and algorithms for generating pseudorandom numbers. "This is likely the best route to making further progress on the problem" of proving that pi's digits are normal no matter how far out they go, Bailey says.

Some mathematicians are pessimistic about whether the Bailey-Crandall approach will eventually lead to a normality proof for pi and other fundamental constants. The pair's hypothesis about chaotic sequences may itself be too hard to prove, says Jeffrey C. Lagarias of AT&T Labs–Research at Florham Park, N.J.

Crandall responds by quoting German mathematician Carl Ludwig Siegel: "One cannot guess the real difficulties of a problem before having solved it."

As it stands now, pi and its mathematical cousins continue to present tantalizing mysteries that push mathematical research in new, unexpected directions. □

A flavor of pi's normality

Proof of the normality of pi may come from a link between number theory and chaotic dynamics. While this link is too complicated to explain briefly for pi, the example of log 2 (the logarithm of 2 to base e, where e is the fundamental constant 2.718281828 . . . .) illustrates the mathematicians' new approach.

Log 2 can be obtained to any desired number of decimal places from the expression given below:

$\log 2 = 1/2 + 1/8 + 1/24 + 1/64 + \ldots$, where each term has the form $1/k2^k$, starting at $k = 1$

This value works out to 0.6931471805599453 . . . .

Bailey and Crandall have proposed that the normality of log 2 to base 2 is linked to a particular iterative process, or dynamical map, that generates a sequence of numbers between 0 and 1. Here's the mathematical form for this dynamical map:

$x_n = (2x_{n-1} + 1/n) \bmod 1$

Starting with $x_0 = 0$, each iteration, n, uses the previous result, x_{n-1}, as the input for calculating the next number, x_n. The term "mod 1" is an instruction to use only the fractional remainder of each iteration's result as input for the next iteration. In other words, no input is ever larger than 1.

The process generates the following sequence: $x_0 = 0, x_1 = 0, x_2 = 1/2, x_3 = 1/3, x_4 = 11/12, x_5 = 1/30, x_6 = 7/30, x_7 = 64/105, x_8 = 289/840$ . . . . If it could be proved that the erratically fluctuating numbers x_n are evenly distributed between 0 and 1, log 2 would be deemed normal to base 2.

Establishing the same equidistribution property for a different, more complicated dynamical map would lead to a proof that pi is normal to base 16 (or, equivalently, to base 2). That would be a significant step toward the long-sought goal of proving pi's absolute normality. —*I.P.*

I. Peterson

Using the digits of pi to guide her selection of colors, artist Arlene Stamp of Calgary, Alberta, added an element of unpredictability to this tiling design in a Toronto subway station.

Biology

From Seattle, at the annual meeting of the American Ornithologists' Union

Stinking decorations protect nests

The common waxbill's habit of adorning its nests with fur plucked from carnivore scat turns out to discourage attacks from predators.

In southern Africa, these songbirds build enclosed grass nests on the ground, explains Justin G. Schuetz of Cornell University. The birds share their habitat with a goodly number of rodents and snakes that hunt for eggs.

Schuetz knew from old descriptions that the birds follow the unusual practice of pecking at scat left by servals and other carnivores. The waxbills then bring home lumps of excreted fur to tuck into the walls of their nests. "I could find some of the nests just by sniffing," says Schuetz.

Schuetz

To line their nests, common waxbills in Africa collect bits of fur from predators' scat.

A few other bird species have arranged macabre decorations when in captivity, for example, draping dead insects or dead nestlings on the top of nests. However, Schuetz couldn't find any report of experiments on how such decorations function in the wild.

The researcher set out 78 wicker imitation nests, lining half of them with fur from scat. As bait in each nest, he added two market finch eggs about the same size as a waxbill's.

During the 16 days that Schuetz monitored the imitation nests, he found a higher survival rate for eggs in the scat-adorned wicker. The potential egg eaters may have interpreted the stench as a danger sign indicating the presence of species that usually hunt them, says Schuetz.

He speculates that scat may lose some of its repulsive punch as days go by. He's seen waxbills take their latest scat haul and dunk it in a stream before carrying the wad home. Perhaps wetting the scat freshens up the odor, he says. *—S.M.*

Oops. New feathers turn out lousy

Going to the trouble of molting doesn't really get rid of a bird's lice after all. Furthermore, flying doesn't blow off tough lice—unless a bird wears nail polish. Thus go the latest bulletins from the dramatic war between bird and louse.

Brett Moyer of the University of Utah in Salt Lake City and his colleagues are upsetting the conventional wisdom about molting. When a bird sheds feathers and grows new ones, part of the reward comes from ditching parasites, researchers have assumed.

At first, the assumption seemed to hold up in Moyer's inspections. He and his colleagues saw significantly fewer lice on pigeons after a molt than before.

When the researchers counted lice by washing them off the pigeons, however, the difference in lousiness disappeared.

So, where had all the lice been hiding on the newly molted pigeons? During a molt, Moyer found, pigeons' lice squeeze down into the sheaths of developing feathers. Also, after the molt, the lush new plumage makes lice hard to find.

Lice that frequent the wing feathers of pigeons and other doves keep their grip when the birds take flight by hunkering down in a feather. The lice hide between the barbs sprouting from the central shaft, reports Moyer's Utah colleague Sarah Al-Tamimi.

To investigate why lice don't fall off, she checked the wings of tethered pigeons before and after they flew the length of a football field. When she altered the feathers so the lice that were a bit too plump to fit between the barbs, she found that the lice kept their grip. The snug match between louse and feather may help explain why lice remain so specific to hosts, says Al-Tamimi. So, she wondered how they'd held on.

In the troughs between wing-feather barbs, tiny hooked filaments interlock. To see whether the lice were gripping these structures, Al-Tamimi partially filled some troughs with nail polish. When she flew these pigeons, significantly more lice slipped off than usual. *—S.M.*

When rare species eat endangered ones

This year completes the relocation of the largest nesting colony of Caspian terns in North America from one island to another, reports Daniel Roby of U.S. Geological Survey in Corvallis, Ore.

Dredges dumping spoils created Rice Island in the Columbia River, and in the mid 1980s, observers noted Caspian terns breeding there. By 2000, 8,000 pairs of the terns were nesting in the estuary, 10 percent of the species. "Worldwide populations are generally not faring well," Roby says.

Life looked good for the terns until studies in the late 1990s revealed that salmon smolts made up 74 percent of the birds' diet. The birds caught 10.2 million of these young salmon, representing 11 percent of those swimming down the Columbia. The exact impact wasn't clear, but the numbers sparked alarm. "The situation of salmons is really quite desperate," says Roby.

In an attempt to lower the toll, biologists tried to persuade the colony to move to East Sand Island, a dredge-spoil mound closer to the mouth of the Columbia. The new location offered more species of fish as alternative food.

To suggest that terns were already congregating on East Sand Island, biologists dotted it with models of the birds and patio speakers broadcasting recorded calls. Attracted to what seemed to be the vanguard of the breeding colony, real birds settled among them. Nesting success on the new island surpassed that of the old colony.

In 1999, about 15 percent of Rice Island birds shifted. Now the whole colony has moved, and the birds consume 6.4 percent of the salmon smolts swimming down the Columbia. That's an improvement, Roby says, but hardly an end to the debate over what do about one vulnerable species eating another one. *—S.M.*

Big woodpeckers trash others' homes

Woodpecker biologist Daniel Saenz now has the data to show that frustrated scientists aren't imagining things. Pileated woodpeckers really are attracted to the homes of red-cockaded woodpeckers.

Saenz of the Wildlife Habitat Laboratory in Nacogdoches, Texas, frets over the cavities that the small, endangered red-cockaded woodpeckers peck out of healthy pine trees. The 8-inch-long birds routinely spend 6 years excavating before a cavity reaches the right size. A finished cavity houses a single bird.

The pileated woodpeckers, like most of the clan, usually whack their cavities out of dead trees in which a fungus has already softened the wood. However, Saenz and other biologists have seen pileated woodpeckers start slamming away at the painstakingly excavated red-cockaded cavities, making the openings too large for the original owners to tolerate when the invader abandons the task. The 16-inch-high birds "can ruin years of work in one afternoon," laments Richard Conner, also from the Texas lab.

Saenz's study confirms that the smaller birds' nesting trees attract pileated woodpeckers. In Texas' Angelina National Forest, his team compared 827 trees with red-cockaded cavities to 110 uninhabited pines. The researchers found 5 percent of excavated trees attacked but none of the others.

Pines growing amid sprouting hardwoods seemed more appealing habitat to pileated woodpeckers than did pines with little brush below. Saenz counts the observation as yet another reason to insist that forest managers stick to the program of burning out brush to protect red-cockaded habitat. *—S.M.*

The Seeing Tongue

In-the-mouth electrodes give blind people a feel for vision

By PETER WEISS

Blind since birth, Marie-Laure Martin had always thought that candle flames were big balls of fire. The 39-year-old woman couldn't see the flames themselves, but she could sense the candle's aura of heat.

Last October, she saw a candle flame for the first time. She was stunned by how small it actually was and how it danced. There's a second marvel here: She saw it all with her tongue.

The tongue, an organ of taste and touch, may seem like an unlikely substitute for the eyes. After all, it's usually hidden inside the mouth, insensitive to light, and not connected to optic nerves. However, a growing body of research indicates that the tongue may in fact be the second-best place on the body for receiving visual information from the world and transmitting it to the brain.

Researchers at the University of Wisconsin–Madison are developing this tongue-stimulating system, which translates images detected by a camera into a pattern of electric pulses that trigger touch receptors. The scientists say that volunteers testing the prototype soon lose awareness of on-the-tongue sensations. They then perceive the stimulation as shapes and features in space. Their tongue becomes a surrogate eye.

Earlier research had used the skin as a route for images to reach the nervous system. That people can decode nerve pulses as visual information when they come from sources other than the eyes shows how adaptable, or plastic, the brain is, says Wisconsin neuroscientist and physician Paul Bach-y-Rita, one of the device's inventors.

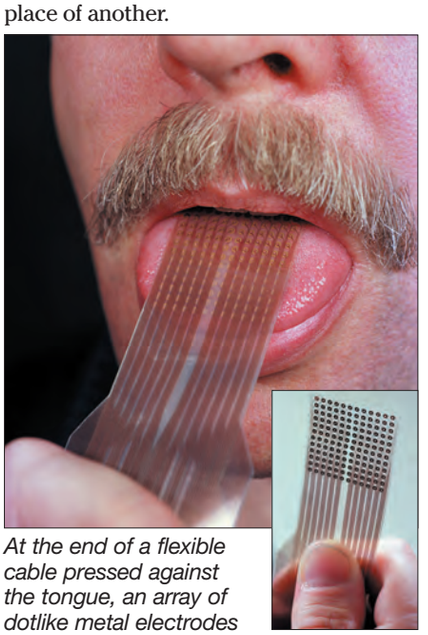
"You don't see with the eyes. You see with the brain," he contends. An image, once it reaches an eye's retina, "becomes nerve pulses no different from those from the big toe," he says. To see, people rely on the brain's ability to interpret those signals correctly.

With that in mind, he and his colleagues propose that restoring sight is only one of the many trajectories for their research. Restoring stability to those with balance disorders is another. So is bestowing people with brand new senses, such as the capability to use heat to see in the dark.

First things first, however, and for the Wisconsin scientists that means restoring lost vision. Swapping the sense of touch for sight is not a new idea. In the 1960s, Bach-y-Rita, his colleagues, and other scientists began developing and testing devices that enable the skin of blind people to pick up visual information.

For Bach-y-Rita, the experiments also provided insight into the brain's plasticity. His more general goal has been to find out how well one sense can take the place of another.

J. Miller



At the end of a flexible cable pressed against the tongue, an array of dotlike metal electrodes (inset) stimulates touch-sensitive nerves with electric pulses. Patterns of pulses represent images from a video camera (not shown).

Until the 1980s, "one of the axioms of neuroscience was that there was no plasticity in the adult central nervous system," says Edward Taub of the University of Alabama in Birmingham. Today, the field has turned around in response to many studies, including Bach-y-Rita's. Now, scientists view the brain as almost as malleable in old age as in youth, he adds.

The idea of tongue as eye evolved from the earlier skin-as-eye studies. Bach-y-Rita and his coworkers had been placing touch-stimulating arrays on areas of people's skin, such as the back and the abdomen. The scientists used either electrodes or little buzzers to excite nerve endings of the skin in a pattern that corresponded to visual images.

They found that after receiving training, blind people using these systems could recognize shapes and track motion. Some subjects could perceive the motion of a ball rolling down an inclined plane and bat it as it rolled off the plane's edge. Others could carry out an assembly-line task at an electronics plant. It required them to recognize glass tubes lacking solder and then to deposit some solder into those tubes.

These results impressed Bach-y-Rita and his colleagues enough to begin trying to apply their basic research toward designing aids for the blind, he says.

The researchers' early systems had the look and feel of what they were—experiments. The buzzers were noisy, heavy, and power hungry. Although electrodes could stimulate nerves quietly and efficiently, high voltages and currents were necessary to drive signals through the skin. That sometimes led to uncomfortable shocks.

Because of these drawbacks, Bach-y-Rita began thinking about the tongue. "We brushed him off," recalls coworker Kurt A. Kaczmarek, an electrical engineer and perception researcher, also at the University of Wisconsin. "He tends to be a bit ahead of his day."

In time, however, Kaczmarek was convinced. "One day, I said 'Okay, Paul. Let's go up to the lab and try it.' It turns out, it worked quite well," he says.

Tongue stimulation, however, isn't the only way to circumvent blindness. One competing approach, for example, is to implant microchips in the eyes or brain (SN: 4/12/97, p. 221). Another scheme, devised by a Dutch scientist, converts images to what he calls soundscapes, which are piped to a blind person's ears.

To Bach-y-Rita, his team's switch from skin to tongue stimulation was crucial. "We now, for the first time, have the possibility of a really practical [touch-based] human-machine interface," he declares. He and his coworkers founded

the Madison-based company Wicab, to exploit the potential. Kaczmarek points out the fledgling company may be in for some competition, since a German inventor already has been granted a U.S. patent for a tongue-vision system.

"Using the tongue for seeing is a whole new approach. . . . I think it has great promise," says Michael D. Oberdorfer, program director for visual neuroscience at the National Eye Institute in Bethesda, Md. His office has been funding some of the Wisconsin group's work.

The tongue is a better sensor than skin for several reasons, says Bach-y-Rita. For one, it's coated in saliva—an electrically conductive fluid. So, stimulation can be applied with much lower voltage and current than is required for the skin.

Also, the tongue is more densely populated with touch-sensitive nerves than most other parts of the body. That opens up the possibility that the tongue can convey higher-resolution data than the skin can.

What's more, the tongue is ordinarily out of sight and out of the way. "With visual aids to the blind, there are cosmetic issues," says Oberdorfer. "And you'd want something easy to wear that doesn't interfere with everyday activities."

Currently, the Wisconsin researchers' tongue-display system begins with a camera about the size of a deck of cards. Cables connect it with a toaster-size control box. Extending from the box is another cable made of flat, flexible plastic laced with copper wires. It narrows at the end to form the flat, 12-by-12, gold-plated electrode array the size of a dessert fork. The person lays it like a lollipop on his or her tongue. Stimulation from electrodes produces sensations that subjects describe as tingling or bubbling.

The Wisconsin researchers say that the whole apparatus could shrink dramatically, becoming both hidden and easily portable. The camera would vanish into an eyeglass frame. From there, it would wirelessly transmit visual data to a dental retainer in the mouth that would house the signal-translating electronics. The retainer would also hold the electrode against the tongue.

The tongue display still has a long way to go in terms of performance, the researchers admit. In the July 13 BRAIN RESEARCH, Bach-y-Rita and his colleagues Eliana Sampaio and Stéphane Maris, both of the Université Louis Pasteur in Strasbourg, France, report results from the first clinical study of the tongue display.

After an initial, brief training period, 12 first-time users—6 sighted but blindfolded and 6 congenitally blind, including Marie-Laure Martin—tried to determine the orientation of the E's of a standard Snellen eye chart. On average, they scored 20/860 in visual acuity. The cutoff for legal blindness is 20/200 with corrected vision.

"It's not normal sight," comments Taub. "It's like very dim shadows. But it's remarkable. It's a beginning."

One obstacle to better vision with the device is the low resolution of its 144-electrode display. Engineers on the team say they expect to quadruple the array density in the next few years.

A more serious problem is the range of contrast that can be replicated on the tongue, Kaczmarek notes. In a typical image, the eye may simultaneously see lighted regions that are 1,000 times brighter than the dimmest ones. But the ratio of strongest to weakest tongue stimulation can only be about 3 to 1. "That's one of the things we're struggling with," Kaczmarek says.

K. Kamm/U. Wis.-Milwaukee

Blindfolded but tongue-tuned to a video camera (white box beside laptop), Alyssa Koehler mimics hand gestures by Sara Lindaas. These sighted, occupational-therapy students are part of a team devising a curriculum to train blind children to use the image-translating system.

Exactly how the tongue supplies the brain with images remains a focus of the Wisconsin team's research. In his 1993 book, *The Man Who Tasted Shapes* (Putnam), Washington, D.C.–based neurologist Richard E. Cytowic made much of how flavors stimulating the tongue of a friend and, later, an experimental subject, would elicit visual sensations. However, that type of involuntary and poorly understood sensory blending, which is known as synesthesia, probably goes beyond what's needed to explain the operation of the tongue display, Bach-y-Rita says.

Instead, there's plenty of evidence, he says, that even those brain regions devoted almost exclusively to a certain sense actually receive a variety of sensory signals. "We showed many years ago that even in the specialized eye region, auditory and tactile signals also arrive," he notes.

Also, many studies over the past 40 years indicate that the brain is capable of massively reorganizing itself in response to loss or injury. When it comes to seeing via the sense of touch, reorganization may involve switching portions of the visual cortex to the processing of touch sensations, Bach-y-Rita says.

In that vein, the first clinical study of the tongue device showed that users got better with practice. Of the dozen subjects in the initial evaluation, two went on to receive an additional 9 hours each of training. When retested, they had doubled their visual acuity, scoring an average of 20/430.

The brain's apparent ability to shunt data for one sense through the customary pathways of another may enable the Wisconsin researchers to apply their device beyond vision replacement. "It's not just about vision," says Mitchell E. Tyler, a biomedical engineer with the group. "That's the obvious one, but it's by no means the only game in town."

The team began tests this summer of a modified system that's intended to assist people who have lost their sense of balance because of injury, disease, or reactions to antibiotics. The unit gathers signals from accelerometers mounted on a person that indicate when he or she is tilting and in what direction. By stimulating the tongue with patterns representing the degree and direction of tilt, such a device may act as an artificial vestibular system. Then, the person might be able to correct bodily position and avoid falling, Tyler explains.

Although the main emphasis of the Wisconsin research has been rehabilitation, the group also foresees using its technology to aid people who don't have sensory deficits.

Interest in enhancement of the senses has come primarily from the military. While Bach-y-Rita and his colleagues were using external skin as a receiver of light-derived images, the Defense Advanced Research Projects Agency in Arlington, Va., funded them to develop a sonar-based system to help Navy commandos orient themselves in pitch darkness. The prototype worked, Bach-y-Rita says.

Tyler proposes that ground soldiers could also receive data by means of infrared cameras or other sensors that would alert them, through the tongue, to the presence and positions of enemy troops or tanks. Civilian workers, such as firefighters, might also benefit from such interfaces.

That's pure speculation right now. Martin's bouts of vision; however, are much more than that. In a new film that aired on Canadian television in June, a smile spreads across Martin's face as she gets her first glimpse of a candle flame.

The film, *Touch: The Forgotten Sense*, highlights some of the Wisconsin work. Its message is this: Touch works in a thousand ways, often without people even being aware of its roles.

By taking this sense into new arenas, such as the tongue display, Bach-y-Rita and his coworkers intend to extend touch's repertoire even more. □

Biomedicine

Stem cell research marches on

While the ethical and political debates rage over stem cells from human embryos, scientists continue to discover how those cells work and what they can do.

About 2 weeks before President Bush made his decision to fund certain kinds of stem cell research (SN: 8/18/01, p. 105), investigators from Johns Hopkins University in Baltimore reported at a meeting that injections of human embryonic stem cells restored some mobility to paralyzed rodents. The damage to the spinal cord, which the researchers cause by injecting a virus into the animals, mimics amyotrophic lateral sclerosis, also known as Lou Gehrig's disease. Although the research has not been published in a scientific journal, several lawmakers on Capitol Hill viewed videotape of once-paralyzed rodents walking after the treatment. Congress is now considering how to regulate stem cell research.

Meanwhile, an Israeli research team has further demonstrated the flexibility of human embryonic stem cells by converting them into two potentially valuable types of cells. Under the proper conditions, the lab-grown stem cells transform into insulin-secreting cells that could help treat people with diabetes, Joseph Itskovitz-Eldor of the Technion-Israel Institute of Technology in Haifa and his colleagues report in the August DIABETES. Some of the same scientists report in the August JOURNAL OF CLINICAL INVESTIGATION that they have converted human embryonic stem cells into cardiomyocytes, the muscle cells that drive the beating of the heart. —*J.T.*

Healing the heart from within

While some scientists work toward repairing injured hearts with stem cells, others wonder if they can coax human hearts into fixing themselves. After all, some nonmammalian animals regenerate heart tissue (SN: 11/1/97, p. 280).

Challenging the dogma that human-heart cells don't divide, a research group reported in the June 7 NEW ENGLAND JOURNAL OF MEDICINE that such cells proliferate in people who have suffered a heart attack, albeit not enough to heal the organ (SN: 7/7/01, p. 13). Now, through studies of a mouse strain with unusual powers to regenerate tissue, scientists have found that some mammals can indeed heal their own hearts.

Several years ago, Ellen Heber-Katz of the Wistar Institute in Philadelphia accidentally discovered that a certain strain of mouse heals holes punched into its ears, and leaves no scars (SN: 2/21/98, p. 118). In the Aug. 14 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, they report that these mice also extensively regenerate heart tissue damaged by surgical means, whereas other mice don't.

Heber-Katz and her colleagues continue to look for genetic differences in the mice that might be behind the tissue regeneration. They're also finding hints that the rodents can regenerate nerve cells and bone. —*J.T.*

Insulin lowers more than blood sugar

Millions of people with diabetes control their blood sugar with insulin. Might the hormone also protect their hearts?

Insulin injections into nondiabetic obese people reduced their production of several inflammatory molecules and increased synthesis of certain anti-inflammatory agents, according to tests of blood samples by researchers at the State University of New York at Buffalo. This response to insulin injections suggests that chronic use of the hormone could have long-term benefits, including limiting inflammation in blood vessels and thereby protecting the heart from atherosclerosis, the investigators speculate.

"This is a brand new property of insulin," says Paresh Dandona. He and his colleagues report their results in the July JOURNAL OF CLINICAL ENDOCRINOLOGY AND METABOLISM. —*J.T.*

Paleontology

That's no footprint, it's got no toes

A favorite spot among paleontologists and paleotourists, the rock formations near Isona, Spain, are famous for fossils of large bones and eggs. However, the sign that tells tourists about dinosaur footprints in one area may need updating.

At the site in question, thousands of oval depressions currently identified as prints dot the sandstone landscape, says Jordi Martinell, a paleontologist at the University of Barcelona. Ripples in the rocks and fossil crustacean burrows suggest that the site was a lagoon more than 65 million years ago.

On average, the oval indentations are 43 centimeters long and 34 cm wide, and there's about one of them every square meter over a broad area. Scientists interpreted the pits as fossil footprints because of the area's abundance of dinosaur remains.

Upon close inspection, none of the supposed tracks includes the hallmarks of a large animal's footprint, Martinell notes. There are no traces of toes. The pits have a U-shaped cross section, not the flat bottom expected from a big dinosaur foot. Also, sediments below the depression haven't been deformed, which would be expected if a heavy dinosaur had stepped in soft mud. Furthermore, the pits don't form clear trackways. Nor do many overlap—a situation unlikely if numerous dinosaurs had walked in the same area, says Martinell.

If dinosaurs didn't make the oval depressions, then what did? In the August PALAIOS, he and his colleagues suggest that the fossils actually record the feeding behavior of stingrays.

Evidence for the new interpretation comes from living stingrays. In portions of the Gulf of California, for example, stingrays leave circular or oval pits 10 to 30 cm across in the mud as they forage in the burrow-riddled tidal flats.

Each square meter in these locations can hold up to three depressions, which closely resemble the indentations at Isona. Despite their abundance, the pits dug by living stingrays almost never overlap because the creatures usually don't look for food where the mud is already disturbed. —*S.P.*

Completing a titan by getting a head

When paleontologists unearthed the skeleton of a 70-million-year-old titanosaur in Madagascar in the late 1990s, they also recovered something that had been missing from previous such finds: a skull that matches the body.

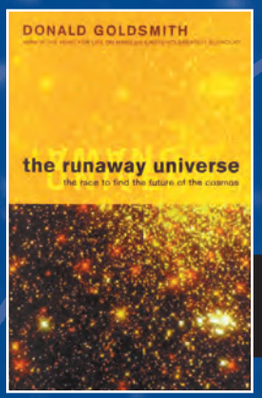
Titanosaurs form one group of sauropod dinosaurs, the massive, four-legged plant eaters that had long necks and tails. Most types died out more than 100 million years ago, but titanosaurs were more successful. They stuck around until the extinction of all dinosaurs about 65 million years ago, and their fossils have been found on every continent except Antarctica.

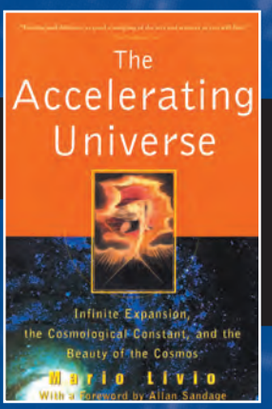
Scientists have described almost three dozen types of titanosaurs, says Kristina Curry Rogers, a vertebrate paleontologist at the Science Museum of Minnesota in St. Paul. Until recently, researchers knew most of these species only from skeletal fragments and isolated bits of skull.

In contrast, the emerging portrait of the new Madagascan titanosaur is based on the skeleton of a juvenile that's about 75 percent complete, as well as skull portions of two juveniles found with it. These bone fragments are consistent with the nearly complete skull of an adult that Curry Rogers and her team excavated from nearby rocks of the same age. Adults of the new species—which the team dubbed *Rapetosaurus krausei* in the Aug. 2 NATURE—would have been about 12 meters long.

The image of what a complete titanosaur looked like may help scientists solve broader paleontological puzzles, Curry Rogers notes. Researchers know two Mongolian titanosaurs only from their skulls, and most South American species left fossils with no heads. A better theory about the relationship among all the dinosaurs in this group could illuminate how they evolved and dispersed around the globe. —*S.P.*

Universe-al Reading





For decades, astronomers have sought to discover the ultimate fate of the universe. Will the cosmos continue forever in its expansion, which began billions of years ago with the Big Bang? Or will gravity someday reverse the process, producing a "Big Crunch?" Two groups of astronomers have recently announced a discovery that seems to resolve the issue but that also shakes the science of cosmology to its very foundation: The expansion of the universe appears to be accelerating. *The Runaway Universe* is the story of these astronomers who have stood the world of cosmology on its ear—and of their race to discover the future of the universe.

—from Perseus *Perseus Publishing, 2001, 232 pages, 6" x 9 ¼", paperback, $16.00*

In this entertaining and lively exploration of the universe, Hubble Space Telescope scientist Mario Livio introduces us to the "old cosmology," which culminated in the view of a perfectly balanced universe. He then presents all of the fascinating ideas being explored by cosmologists in the "new cosmology," which has been inspired by the discovery of acceleration of the universe. Providing extraordinarily clear explanations of all the key concepts and theoretical ideas, *The Accelerating Universe* is a marvelous guide through this most exciting frontier in science today.

—from John Wiley & Sons, Inc *John Wiley & Sons, Inc., 2000, 274 pages, 6 ⅛" x 9 ¼", paperback, $15.95*

The historic search for atoms and their stellar origins is truly one of the greatest detective stories of science. In effect, it offers two epics intertwined: the birth of atoms in the Big Bang and the evolution of stars and how they work. In *The Magic Furnace,* Marcus Chown leads readers through the major theories and experiments that propelled the search for atomic understanding from Democritus in ancient Greece to Binning and Rohrer in 20th century New York. He clarifies the science, explaining with enthusiasm the sequence of discoveries that proved the existence of atoms as the "alphabet of nature" and the finding of subatomic particles and atomic energy potential. From there, he engagingly chronicles the leaps of insight that eventually revealed the elements, our world, and the universe to be a product of two ultimate furnaces: the explosion of the Big Bang and the interior of stars such as supernovae and red giants. Chown successfully makes these massive concepts accessible for all science enthusiasts.

—from Oxford University Press *Oxford University Press, 2001, 232 pages, 6 ¼" x 9 ½", hardcover, $25.00*

How old is the universe? *The Birth of Time* recounts how scientists have achieved the definitive answer to this mystery. Research astronomer John Gribbin offers an insider's view of the thrilling scientific discovery of the 1990s, when Hubble Space Telescope data revealed that the universe is older by at least one billion years than the oldest stars.

—from Yale University Press *Yale University Press, 1999, 237 pages, 5" x 7 ¾", paperback, $11.95*

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