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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ MAY 21, 2011

Triassic Park

The surprising tale of dinosaurs' earliest days

Lava Lamp Earth

I, Rollbot

Napping Neurons

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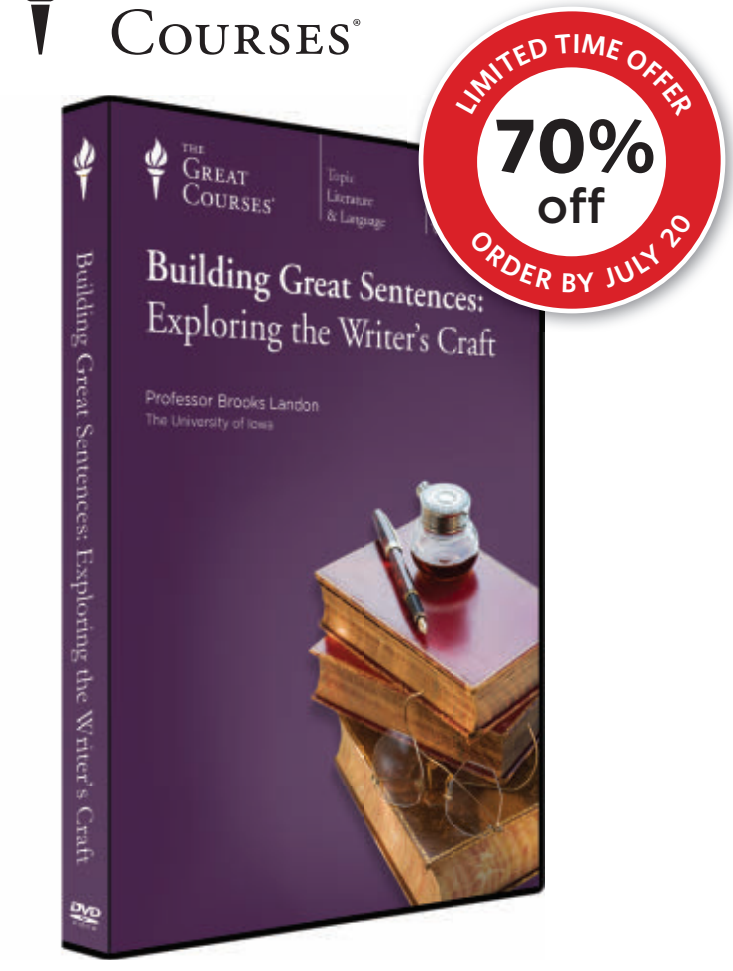

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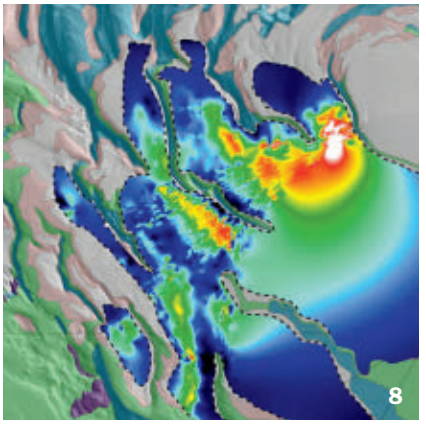

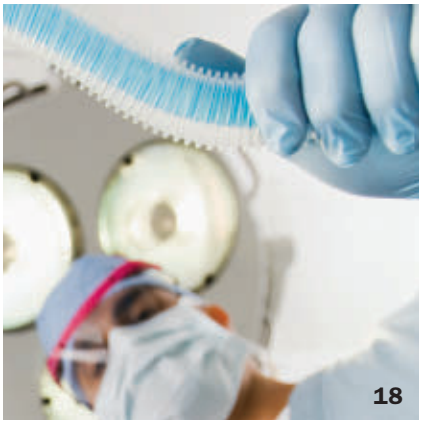

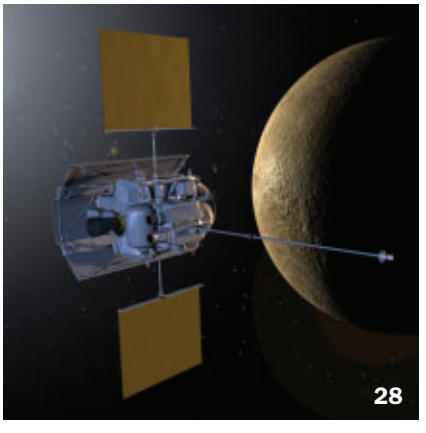

BOTTOM IMAGE: NASA, JOHNS HOPKINS UNIV. APPLIED PHYSICS LAB, CARNEGIE INSTITUTION FOR SCIENCE

ScienceNews

In The News

Features

Departments

COVER In the late Triassic, dinosaurs (early theropod shown eating a critter) lived alongside bigger and scarier creatures. *Illustration © 2010 Victor O. Leshyk, www.victorleshyk.com*

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FROM THE EDITOR

Scientific advances stem from surprises in the past

When scientists block a female dog's view of a ball, and then reveal a ball of different size, the dog reacts with surprise (signaled by extended duration of gaze). Male dogs either don't notice or don't care, as Laura Sanders reports on Page 11.

This experiment suggests that female dogs would make better scientists than the males would. For taking note of surprising phenomena is the first step toward making great discoveries.

Ponder for a moment the mystery of general anesthesia, the loss of consciousness induced by anesthetic drugs in people undergoing surgery. Despite anesthesia's widespread use and effectiveness, nobody really knows exactly how it works. But researchers are uncovering intriguing clues.

For one thing, it turns out that anesthesia is surprisingly unlike sleep, and actually much more similar to being in a coma, as Susan Gaidos reports in this issue (see Page 18). That surprise may someday lead to new methods for awakening people from comas caused by trauma. A further surprise suggests a possible strategy: A dose of an anesthetic can, paradoxically, briefly increase alertness in people just beginning to enter anesthesia or in a semiconscious state from an injury. Perhaps proper timing of appropriate doses of just the right drugs might someday help restore deep coma patients to consciousness.

Suppose that someday comas are indeed easily curable. Or that anesthesia is no longer necessary in surgery because of futuristic pain-free technologies (or better health care to begin with). Other surprising clues at the foundation of such advances might be lurking in the pages of *Science News* even now.

Many of today's stories describe primitive precursors to tomorrow's great insights and innovations — as *Science News* articles have for decades. Like the story from February 1937 about a car-sized machine capable of mathematical wonders that a pocket-sized smartphone can perform today.

That example launches a new feature in *Science News*, to appear on the back page of each issue: "From the Archive" (Page 32), celebrating something noteworthy or fun from an earlier era. In future issues we will offer you an opportunity to vote for a topic from the past that you'd like to see updated. You can bet that some of the candidates will be surprising. — *Tom Siegfried, Editor in Chief*

Pioneering audiologist invents "reading glasses" for your ears.

Neutronic Ear is the easy, virtually invisible and affordable way to turn up the sound on the world around you.

You don't have to pay through the nose to get Personal Sound Amplification Technology.

It's amazing how technology has changed the way we live. Since the end of the Second World War, more products have been invented than in all of recorded history. After WWII came the invention of the microwave oven, the pocket calculator, and the first wearable hearing aid. While the first two have gotten smaller and more affordable, hearing aids haven't changed much. Now there's an alternative… Neutronic Ear.

First of all, Neutronic Ear is not a hearing aid; it is a PSAP, or Personal Sound Amplification Product. Until PSAPs, everyone was required to see the doctor, have hearing tests, have fitting appointments (numerous visits) and then pay for the instruments without any insurance coverage. These devices can cost up to $5000 each! The high cost and inconvenience drove an innovative scientist to develop the Neutronic Ear PSAP.

Neutronic Ear has been designed with the finest micro-digital electronic components available to offer superb performance and years of use. Many years of engineering and development have created a product that's ready to use right out of the box. The patented case design and unique clear tube make it practical and easy to use. The entire unit weighs only 1/10th of an ounce, and it hides comfortably behind either ear. The tube is designed to deliver clear crisp sound while leaving the ear canal open. The electronic components are safe from moisture and wax buildup, and you won't feel like you have a circus peanut jammed in your ear. Thanks to a state-of-the-art manufacturing process and superior design, we can make Neutronic Ear affordable and pass the savings on to you.

The Evolution of Hearing Products

Invention	Date	Easy to Use?	Invisible?	Affordable?
The Ear Horn	17th Century	No	Hardly	Maybe
Wearable Hearing Aid	1935	Weighed 2.5 pounds	No	No
Digital Hearing Aid	1984	No	No	Not for most people
Neutronic Ear	2010	Yes	Yes	Yes

Just think of the places you'll enjoy Neutronic Ear

• Parties
• Restaurants
• Church • Lectures
• Book Groups • Movies
• Bird-watching and almost any daily activity

It works… but don't take our word for it. Why pay thousands to make everything sound louder when what you really need is a Personal Sound Amplification Product? We're so sure you'll be absolutely thrilled with the quality and effectiveness of this product that we are offering it to the public at a low introductory price with our exclusive trial offer. If, for any reason, you are not completely amazed by how this product improves your life, simply return it for a refund of the product purchase price within 30 days. Call now.

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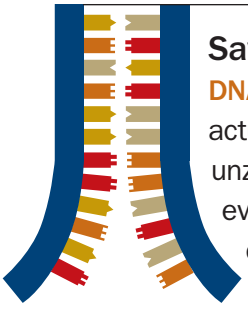


Say What?

DNA breathing \D-N-A BREE-theeng\ ***n.*** No, genetic material doesn't actually inhale and exhale. Breathing in this case refers to a natural unzipping of portions of paired DNA strands that happens normally every few nanoseconds. This unzipping exposes the DNA's chemical units, or nucleotides, to potential manipulation by enzymes. Anny Usheva-Simidjiyska of Harvard Medical School and her colleagues have discovered that prolonged exposure to terahertz radiation, a type used in some new airport scanners, can provoke DNA strands to inappropriately unzip. The change can reprogram certain cellular functions and nudge stem cells toward becoming fat cells. A paper describing terahertz effects on DNA breathing appeared in the Dec. 21, 2010 *PLoS ONE*.

Science Past | FROM THE ISSUE OF MAY 20, 1961

U.S. SPACEMAN A-OKAY — The United States broke the space barrier May 5 when Alan B. Shepard, Jr., 37-year-old astronaut, rode the Mercury capsule 302 miles down-range from Cape Canaveral, Fla. At 9:34 a.m. EST the Redstone rocket carrying the Mercury capsule lifted off the launching pad and took the astronaut for a 15-minute trip that made him exclaim, "Man, what a ride!" ... Shepard had some difficulty breathing and seeing as he went into space and back, but no more than he was prepared for. The stress on his body, including a "grayout" of his eyes, was less than he had experienced in training.... As he came back to earth, he experienced as much as 11 times the gravity of earth, or felt 11 times his normal weight.

Science Future

June 1
The 2011 hurricane season begins. For storm updates go to www.nhc.noaa.gov

June 1–5
The World Science Festival returns to New York City with its annual fun and flair. See worldsciencefestival.com

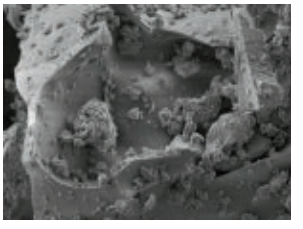
July 5–10
Watch a 360-degree underwater film and visit exhibits at the Royal Society's Summer Science Exhibition in London. Learn more at royalsociety.org

SN Online

www.sciencenews.org

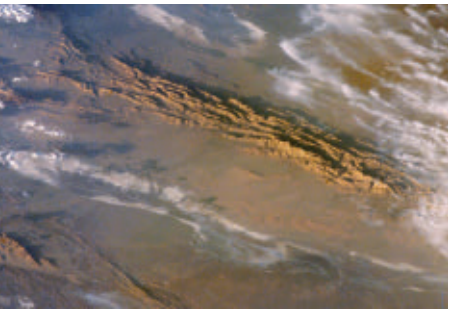
DELETED SCENES BLOG
A leaked LHC study sparks hubbub, but physicists stay skeptical of a particle find. See "Rumors of a Higgs discovery are just that."

EARTH
Eyjafjallajökull spit super-sharp ash. Read "Volcanic ash gets its close-up."



LIFE
Brain evolution preceded a diversity boom in one electricity-emitting fish. Read "Zap! More fish."

GENES & CELLS
Some quick-evolving genes may also shorten human pregnancies. See "News in Brief: Genes & Cells."



The (-est)

Researchers at the University of Montana in Missoula have pinpointed the hottest place on Earth. The Lut Desert in southeastern Iran (region shown from space) beat out contenders for five out of seven years from 2003 to 2009, with its surface temperature peaking at 70.7° Celsius (159.3° Fahrenheit) in 2005. The scientists used a sensor aboard NASA's Aqua satellite to measure the temperature people would feel if they touched the ground, a reading that is usually higher than air temps. Other hot spots included Queensland in Australia and China's "Flaming Mountain," the team reports in an upcoming *Bulletin of the American Meteorological Society*. The temperature in the Lut Desert is the most consistently hot, but it is not the hottest ever recorded: Past measurements include a 1915 soil test in Tucson that read 71.5° C (160.7° F).

Science Stats | METALLIC GLOW

While federal standards flag only low-intensity red LED lights as hazardous waste (because of their high lead content), several colors of pin-type LEDs exceed California disposal limits for silver, nickel and copper, a recent study found. Only the low-intensity yellow LED passed muster.

Metal content limits exceeded by low-intensity colored and white LED lights

	Blue	Red	White	Green	Yellow
Copper	●				
Nickel		●	●	●	
Silver			●		
Lead		●			

SOURCE: S.-R. LIM ET AL/ENVIRON. SCI. TECHNOL. 2011

CLOCKWISE FROM TOP LEFT: E. FELICIANO; S. GÍSLASON *ET AL*/*PNAS* 2011; E. FELICIANO; IMAGE SCIENCE AND ANALYSIS LAB/JSC/NASA

“One tends to think of methamphetamine as being a drug of abuse largely for fairly advanced organisms.... It was quite nifty to try and look at what’s happening in the humble fly.” —DESMOND SMITH, PAGE 14

In the News

STORY ONE

Ill-starred quest to test Einstein finally pays off

Gravity Probe B measures effect predicted by relativity

By Devin Powell

Five decades after its conception and seven years since launch, Gravity Probe B has gauged the relativistic twisting of spacetime to a precision of 19 percent.

NASA, STANFORD UNIV.

The longest-running project in NASA’s history has completed its mission. Gravity Probe B has finally confirmed that the Earth drags spacetime around as it rotates, like a spoon twisting in a jar of honey.

Other experiments had already confirmed this “frame-dragging” effect, predicted by Einstein’s theory of general relativity. The new results, marred by technical difficulties, won’t set any records for precision.

But for those who have supported the beleaguered project, which was defunded by NASA three years ago, the end of its saga is a triumph in itself.

“We’re proud that our dream wasn’t completely lost,” says Stanford University physicist Francis Everitt, who has worked on the project for 49 years. “The science is complete.”

In 1959 and 1960, the era of Sputnik, MIT physicist George Pugh and Stanford physicist Leonard Schiff independently proposed launching a gyroscope into orbit to put Einstein to the test. In Einstein’s universe, where gravity distorts spacetime, the spinning Earth should deflect the tilt of an orbiting gyroscope over time.

Everitt arrived at Stanford in 1962 to help build the world’s best gyroscope. This effort, Gravity Probe B, would ultimately cost NASA at least $750 million. By Everitt’s count, the project was nearly canceled seven times.

But on April 20, 2004, a spacecraft carried four quartz spheres into a polar orbit. The size of Ping-Pong balls and coated with the superconductor niobium, the spheres were the roundest objects ever created by human beings. A puff of gas started the gyros spinning, an onboard telescope lined them up neatly with the star IM Pegasi and the probe collected data until August of 2005.

The first analysis of this data revealed unexpected anomalies. The gyroscopes had behaved badly—wandering around and pointing in strange orientations.

Irregular patches on the surfaces of the spheres were to blame. Everitt knew about these patches and expected interactions with the gyroscope housings that would create small forces, or torques. But unanticipated patches on the housings themselves amplified these electrostatic interactions.

“The torques were 100 times larger than we were expecting,” says Everitt. “It was a horrible shock.”

Despite this setback, in 2007 the Gravity Probe B team confirmed one prediction of general relativity. According to Einstein, the Earth’s gravity warps spacetime like a bowling ball on a trampoline. This “geodetic” effect was measured with an error of about 1 percent (*SN: 4/28/07, p. 270*).

The much smaller frame-dragging effect from the Earth’s rotation, though, remained hidden in the noisy data. Theory predicted frame-dragging should

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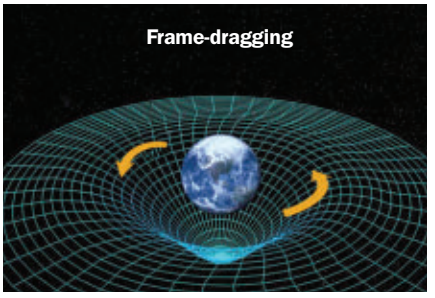


Gravity Probe B used high-precision gyroscopes (one at left) to measure the twisting of spacetime by a spinning object (right), a phenomenon predicted by Einstein's theory of general relativity.

change the orientation of the craft's spinning spheres by only 39 milliarcseconds per year, about the width of a human hair seen from 400 meters.

After NASA pulled the plug in 2008, private funding arranged by an executive at Capital One Financial and the royal family of Saudi Arabia bought some extra time to clean up the data. By comparing the overall wobble of each sphere with the tiny magnetic fluctuations on its surface, the team worked out how the patches were interacting. The researchers also discovered that the motion of the revolving spacecraft could occasionally kick the gyros into new orientations.

"What the Gravity Probe B team did to understand this problem, sort it out and get a credible answer was nothing short of heroic," says Clifford Will, a theoretical physicist at Washington University in St. Louis who serves on the mission's science advisory board.

The results of this painstaking analysis, announced at a NASA press briefing May 4 and scheduled for publication in an upcoming *Physical Review Letters*, reconfirm the geodetic effect with an error of about 0.2 percent. Gravity Probe B puts the frame-dragging effect at 37 milliarcseconds, with an error of about 19 percent, far from the original goal of 1 percent precision.

"This project has been a victim of time," says physicist Kenneth Nordtvedt of Montana State University in Bozeman, who points out that other experiments have already measured these effects.

Ignazio Ciufolini, a physicist at the University of Salento in Lecce, Italy, and Erricos Pavlis of the University of Maryland, Baltimore County confirmed frame-dragging by analyzing the orbits of the two laser-ranged LAGEOS satellites (*SN: 11/27/04, p. 348*). Publishing in *Nature* in 2004, the team reported an error of 10 percent. Two other groups of scientists in Germany and the United States have since checked the analysis, and a third satellite scheduled for launch this year could help Ciufolini and Pavlis improve their precision.

"We should be able to reach a test of frame-dragging with an uncertainty of almost 1 percent," Ciufolini says.

Proponents of Gravity Probe B say that general relativity, which is currently incompatible with quantum mechanics, should be tested in as many ways as possible. But the project's ultimate legacy may lie in its contributions to technology, not science. GPS systems developed for the spacecraft, for instance, now help farmers plant perfectly straight rows of corn.

"The technology needed to do this test didn't exist when the project started," says John Mester, a 19-year veteran of the Gravity Probe B team at Stanford.

Mester hopes to help the team publish a series of papers detailing the equipment they developed. But otherwise their mission is complete.

"We're basically done," Mester says. "None of us have a job anymore." ■

Back Story | GRAVITY PROBE A

Of the many curious effects predicted by Einstein's general theory of relativity, the slowing of time by gravity is (by comparison) relatively simple to grasp.

When gravity is stronger, time moves more slowly. This effect is often called the "gravitational redshift" because it can be detected by its influence on the color of light emitted from the surface of a massive body. (Slowing of time reduces the frequency of emitted light, shifting its color toward the red end of the spectrum.) The gravitational redshift also affects other sorts of radiation, such as radio waves.

In 1976, scientists from the Smithsonian Astrophysical Observatory and NASA's Marshall Space Flight Center tested this gravity-time effect with an experiment called Gravity Probe A. Launched to an altitude of 10,000 kilometers, the probe (payload shown, left) contained a hydrogen maser clock that emitted precisely timed microwave signals until it crashed into the Atlantic Ocean. By comparing signals from the probe with an identical maser clock on the ground, the scientists could determine whether Einstein's expectations were fulfilled. And in fact, the effect on the probe's signals matched relativity's predictions to within 7 parts in 100,000.

TOP (L AND R): NASA, STANFORD UNIV.; BOTTOM: IMAGE COURTESY OF SMITHSONIAN NATIONAL AIR AND SPACE MUSEUM

Investors…

Great Wealth Comes Down to a Handful of Good Decisions in a Lifetime—

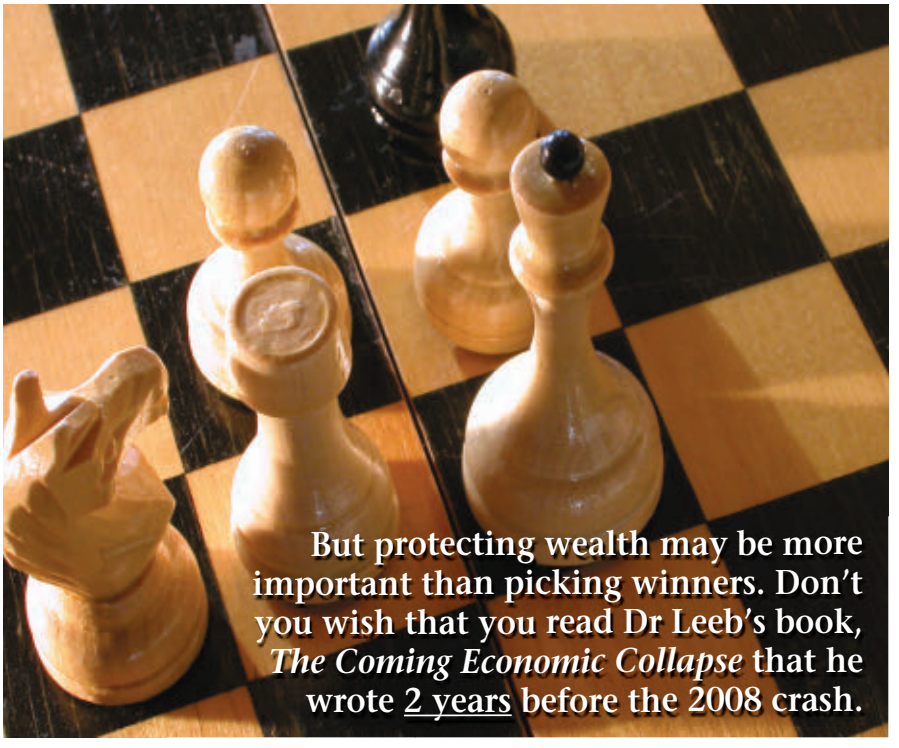
Will You Make the Right Ones?

What is the best thing about financial independence? I have a friend who knows. Yes, he has a nice house and a nice car but he has something that eludes most of us. A low- stress life. He is financially independent and money does not cause him sleepless nights. He never inherited a large sum and he married for love, not for money. He never even made a huge salary. What he did do is a little extra financial homework and bought $10,000 worth of three stocks in the early 1980s. Microsoft, Intel and Wal-Mart. Three good decisions. Three VERY good decisions. Now his portfolio is over $10,000,000. A younger friend told me of his early investments in Amazon, Google and Apple. He is not worrying about paying his light bill. Can you enjoy this kind of stress free life? I believe that the answer is yes.

The Complete Investor Calls the Bottom!
"We would buy these stocks to take full advantage of what is likely to be a very dramatic swing."
Today the market has recovered to over 11,500—***up 58% in one year***

How can you make these kinds of decisions? Are you going to get your advice from your broker? Maybe your brother in law has a hot tip? I would go a different way. I rely on a PhD. A mathematician and a professional market insider who has written 7 books on investing. He doesn't make money on commissions from your account—he makes money based on his accuracy. He understands the bigger picture, the macroeconomic state of affairs, commodities and world currencies. And he has a team of the finest financial analysts working with him.

He predicted the new dominance of China. He wrote about the huge upswing in oil prices years before it happened. He explained why gold prices shot up 400% in the last 10 years. These predictions don't happen by chance. It takes someone who can see the trends that run below the headlines; the trends that can really lead to your financial independence.



But protecting wealth may be more important than picking winners. Don't you wish that you read Dr Leeb's book, *The Coming Economic Collapse* that he wrote 2 years before the 2008 crash.

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Former planet may have a tail

Pluto appears to trail a wispy cloud of carbon monoxide

By Ron Cowen

Just like Mickey's dog, the former planet Pluto has a tail — or at least a hint of one.

Scientists have detected a wisp of carbon monoxide in Pluto's thin upper atmosphere, extending a quarter of the way to its largest moon, Charon, or about 3,400 kilometers above Pluto's surface. To the astronomers who detected it with the James Clerk Maxwell Telescope on Hawaii's Mauna Kea, the cloud appears to have properties resembling a comet's gas tail.

"Whether Pluto's atmosphere forms a tail is just a suggestion on our part," says Jane Greaves of the University of St. Andrews in Scotland.

The gas is too thin to image directly. But a tiny shift in the wavelength of microwaves emitted by the carbon monoxide hints that the gas is receding from Earth and the sun, with ions and some neutral atoms in the gas swept up by the solar wind — just as a comet's gas tail would be.

Planetary scientist Mike Brown of Caltech says that a future array of radio telescopes called ALMA will be able to detect and precisely measure the carbon monoxide emission.

Greaves and her colleagues report in the May *Monthly Notices of the Royal Astronomical Society: Letters* that the emission is brighter than a tentative detection made by another group 11 years ago, indicating that the amount of gas in Pluto's upper atmosphere has increased since then.

"Pluto's atmosphere continues to change and continues to be different from what we expect," says Brown.

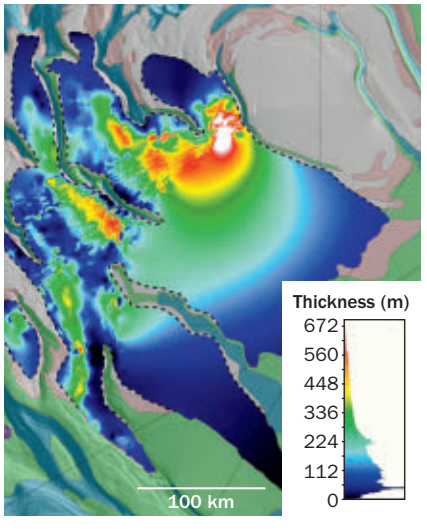
Dry ice suggests recently wet Mars

Frozen carbon dioxide could thicken Red Planet's atmosphere

By Ron Cowen

A newfound reservoir of dry ice on Mars suggests that the planet's surface has been wetter in the relatively recent past, though not necessarily warmer than today.

The new study adds to evidence that Mars once had a carbon dioxide atmosphere thick enough to keep liquid water on the surface from evaporating. It's unclear whether the planet would have been hospitable for life, however, because temperatures on Mars may actually have been slightly colder during times when the atmosphere had a greater amount of carbon dioxide.



The thickness of a newfound reservoir of frozen carbon dioxide at Mars' south polar cap varies from a few meters (blue) to more than 500 meters (red).

Roger Phillips of the Southwest Research Institute in Boulder, Colo., and his colleagues base their findings on radar studies by the Mars Reconnaissance Orbiter of the layered deposits at Mars' south polar cap. Earlier studies had indicated that a veneer of frozen carbon dioxide sits atop part of the cap with a thin layer of water ice beneath it. But a detailed analysis of radar reflected from different layers of the cap reveals that beneath the frozen water lies a volume of carbon dioxide ice 30 times greater than previously estimated, the team reports online April 21 in *Science*.

This unexpected reservoir of dry ice is intriguing, Phillips says, because about every 100,000 years Mars is known to dramatically tilt its spin axis. During these periods of high polar tilt, enough sunlight falls on the poles to vaporize the frozen carbon dioxide and release it into the atmosphere, roughly doubling the atmospheric pressure on the Red Planet. With a denser atmosphere, liquid water could persist on the surface rather than evaporating, and might account for some of the features on Mars that appear to have been carved by water, such as channels and gullies, Phillips says.

Although the newly found reservoir could nearly double the mass of carbon dioxide in Mars' atmosphere, the resulting climate alterations would be "modest" and would not generate a warmer, wetter Mars, notes Peter Thomas of Cornell University in a commentary also published online April 21 in *Science*.

Phillips concurs and notes that during times of high tilt, more carbon dioxide frost would settle on the planet's surface. The reflectivity of the frost, along with other effects, would offset any greenhouse warming from the extra gas in the atmosphere and would tend to maintain the chilly temperatures now typical.

Warmer conditions would require a much thicker carbon dioxide atmosphere supplied by an additional source of the compound, such as carbonates in Martian rocks, says Thomas. The abundance of carbonates in the rocks is still under exploration. ■

JPL-CALTECH, NASA, UNIV. OF ROME, SOUTHWEST RESEARCH INSTITUTE

Body & Brain

79 per square mile | Estimated human population density of Walker County, Texas

256 per square mile | Estimated armadillo population density of Walker County, Texas

Armadillos may transmit leprosy

Same strain shows up in patients and animals in Deep South

By Nathan Seppa

People infected with leprosy in the United States often have the same previously unknown strain of the microbe *Mycobacterium leprae* that is also carried by armadillos. Though it has been known for decades that armadillos can harbor leprosy, also called Hansen's disease, the discovery of the overlapping strain strengthens the long-held assumption that armadillos can infect people directly.

Researchers report in the April 28 *New England Journal of Medicine* that many infected people in the Deep South contracted leprosy while close to home, not in some exotic locale where the disease is more common. The only possible infectious agents would be a person or an armadillo, the only other animal known to harbor leprosy. Some of the infected people had even handled armadillos.

The findings all point to animal-to-person spread. "It's still not a smoking gun, but it's getting awfully close," says James Loughry, a zoologist and armadillo expert at Valdosta State University in Georgia who wasn't involved in this research. "It's hard to imagine that it's not being transmitted from armadillos to humans."

Richard Truman, a microbiologist at the National Hansen's Disease Program and Louisiana State University in Baton Rouge, and his colleagues compared bacterial samples from 50 patients in Louisiana and from 33 infected wild armadillos from five Southern states. A highly specific strain of the bacterium showed up in 28 of the 33 animals and in 22 of 29 patients who had never lived outside the United States and Mexico. Interviews with 15 of the leprosy patients further revealed that eight had had direct contact with armadillos.

Loughry says 6 to 10 percent of armadillos he has tested in Mississippi and Alabama have leprosy. Other studies put the rate as high as 20 percent in the wild.

Armadillos with leprosy harbor a rare bacterial strain that also infects people.

The nine-banded armadillo is the only armadillo found in the United States. There are many kinds of armadillos in Latin America, but it is not known if the other types contract leprosy.

Since John James Audubon and John Bachman recorded in the 1840s that armadillos lived in southern Texas, mainly near the lower Rio Grande, nine-banded armadillos have expanded their range to much of the Deep South and northward to the southern tip of Illinois.

Leprosy remains very rare in the United States, with about 150 new cases each year, says James Krahenbuhl, director of the National Hansen's Disease Program. "Public education can actually decrease disease risk by limiting contacts [with armadillos] and increasing awareness among physicians in these locations," he says. The disease is curable but can require more than a year of antibiotics.

Half-asleep rats look wide awake

Parts of brain can doze off even in an active animal

By Tina Hesman Saey

Some parts of a rat's brain can fall asleep even while the animal seems fully awake.

Researchers at the University of Wisconsin–Madison and colleagues in Italy kept rats up four hours later than usual. Even though the rats stayed awake, electrodes implanted in their brains showed that some brain cells went to sleep while neighboring ones remained active, the team reports in the April 28 *Nature*.

The rats were also prone to making mistakes during slightly difficult tasks, a finding that may have implications for sleep-deprived people.

As far as neuroscientist Giulio Tononi and his team could tell, the rats were fully awake and playing with objects that the team had supplied to keep the animals up past their bedtimes. Only electrodes implanted in two parts of the brain recorded the neuron naps.

But just because the rats weren't nodding off doesn't mean their brains were working well. The team tested the sleep-deprived rats' ability to reach through a plexiglass wall and grasp a sugar cube. The task involves some coordinated moves, such as rotating the wrist, that aren't part of a rat's normal repertoire, so if the animals' brains aren't firing on all cylinders, the grab could fail.

When brain cells fell asleep in the motor cortex — a part of the brain that controls movement — rats failed in attempts to grab the sugar cubes for several hundred milliseconds afterward. But sleeping neurons in the parietal cortex, which is not involved in the task, did not lead to mistakes.

If the finding applies to people, it could mean that lost sleep is even more dangerous than previously believed, leading to slips of the tongue, driving mistakes, errors of judgment or other problems.

"So many humans are walking around with a sleep debt," says Christopher Colwell, a neuroscientist at UCLA. "This is probably part of the everyday situation for a lot of people."

EYEWIRE

Life

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Eyespot deficits stymie peacocks

Females appear to require a minimum number of flecks

By Susan Milius

The tale of how the peacock got his eyespots has taken a new turn.

His shimmering train of feathers tipped with eye-shaped spots ranks among the most cited examples of what Darwin called sexual selection. In this singles bar approach to evolution, flashy plumage and other ornaments arise not because they enhance survival of the fittest but because they favor reproduction of the sexiest.

Basic principles aren't in doubt for the peacock exemplar. Yet "everybody uses it without knowing much about how it works," says Roslyn Dakin of Queen's University in Kingston, Canada.

She found that a train with especially high numbers of eyespots did not seem to improve a male's chances of dazzling a female into mating — but having too few spots was definitely a hindrance.

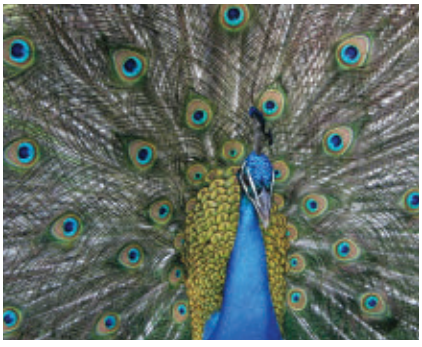
That flies in the face of classic experiments on peacock courtship, Dakin and Robert Montgomerie, also of Queen's, acknowledge in an upcoming *Animal Behaviour*. But they also report additional work suggesting a new explanation for why peahens sometimes don't appear to care about eyespot number.

Eyespots seemed a good predictor of a male's chances of success in past studies of peafowl in England. A female cruising among males routinely picked the one who showed her the most eyespots, says pioneer of peacock science Marion Petrie of Newcastle University in England. Snipping 20 feather tips out of males' trains lowered courtship success.

But feathers ruffled in 2008, when Japanese researchers studying feral peacocks reported finding no courtship advantage for eyespot number in seven years of data.

Dakin and Montgomerie have now studied the issue in two peafowl populations in Canada and one in the United States. Dakin repeated part of Petrie's eyespot-snipping experiment. As predicted, males deprived of 20 of their eyespots — leaving fewer than 138 in the displays — managed to mate fewer times overall than fully eyespotted males.

When Dakin and Montgomerie pooled their eyespot data with other published reports, eyespot effects didn't show up among 102 peacocks for the top 75 percent of trains ranked by spot number. Yet the most eyespot-challenged birds, flashing spot numbers only in the 120s and 130s, rarely had any mating success at all. "It certainly looks like a threshold," Dakin says.



Having a lot of eyespots isn't necessarily important to a peacock's mating success, but having too few virtually guarantees bachelorhood.

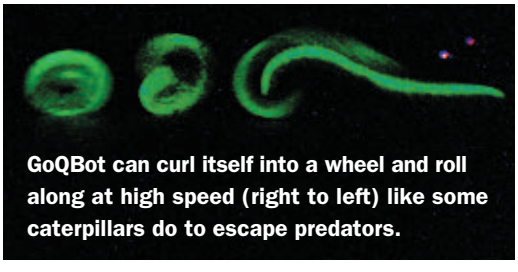
The threshold idea makes sense at first glance, says Adeline Loyau, a peacock researcher at the CNRS research station in Moulis, France. The struggle to understand the long-familiar peacock, she adds, "suggests that we are still far from unraveling the mechanisms of mate choice." ■

Robot cartwheels like a caterpillar

GoQBot curls itself up into a ball, then takes off spinning

By Rachel Ehrenberg

Inspired by a caterpillar that makes like a wheel and rolls away from predators, researchers have created a robot that curls itself into a loop and peels out at speeds faster than a half meter per second.



GoQBot can curl itself into a wheel and roll along at high speed (right to left) like some caterpillars do to escape predators.

Called GoQBot, the 10-centimeter-long robot has a hammer-shaped head and a silicone body embedded with metal coils. The coils contract, musclelike, when pulsed with current, and within 200 milliseconds the crawling bot becomes a wheel and rolls off at impressive speeds.

"Once you get into a ball and rolling, you get dramatic increases in speed," says Satyandra Gupta, director of the Maryland Robotics Center at the University of Maryland in College Park. "This is an exciting development."

Robots like GoQBot may someday aid in search and rescue operations that require both crawling through tight, dangerous spaces and moving across flat ground, says Huai-Ti Lin, who created GoQBot as a graduate student at Tufts University in Medford, Mass.

Described in the June *Bioinspiration and Biomimetics,* GoQBot was designed to help researchers better understand the "ballistic rolling" that certain caterpillars display when frightened.

"You poke the animal and you don't know where it's gone," says Lin, now at Harvard University. "It's wicked fast."

FROM TOP: R. DAKIN; H.-T. LIN

"Man, ants are cool." —ERIC KLAVINS

Great Dane minds don't think alike

Female and male dogs react differently to unexpected sights

By Laura Sanders

Female dogs might have a leg up on males when it comes to detecting the unexpected. In an experiment designed to mess with their furry heads, Fidos appeared oblivious to a surprising outcome while Fidettes took note.

The results, published online April 27 in *Biology Letters*, highlight that, like humans, animals display sex differences in how the brain works.

In the study, researchers led by Corsin Müller of the University of Vienna tested 50 pet dogs, including poodles, Australian shepherds, golden retrievers and mutts. The team designed an experiment to test whether the dogs would notice a ball that inexplicably grew or shrank. In some trials, for instance, a tennis ball would roll behind a screen, and after a short wait, a larger ball would appear on the other side. (Human babies begin to detect this violation of how the world works during the first year of life.)

When the ball was a different size after emerging from the screen, female dogs stared at it longer than they did when a ball of the expected size appeared, an indication to Müller and colleagues that the females had noticed something amiss. In contrast, male dogs looked at the surprising ball and the ball of the expected size for similar amounts of time.

Though the researchers weren't expecting to find a sex difference, the results aren't too surprising, says Müller. "For humans, there is plenty of evidence for all kinds of differences between men and women in cognitive processes," he says.

So far, the researchers can't tell if male dogs really don't perceive the difference, or do detect it but don't care, Müller says.

Whether a dog had been neutered didn't seem to make a difference in the experiment, suggesting that the brain differences behind the effect were established early in the dogs' development and were not a result of sex hormones circulating in adult dogs at the time of the test.

Researchers don't know why this sex difference exists. Müller and his colleagues don't think strong evolutionary pressure on a dog ancestor has a role.

But neuroscientist Timothy Koscik of the University of Iowa points out that females need to effectively nurture offspring, and that might have provided strong pressure to set up this behavioral difference. "If you're going to draw any line between males and females," he says, "that's probably the most obvious and most meaningful one to draw."

Teamwork keeps fire ants floating

Research shows how whole colonies build rafts to safety

By Daniel Strain

Fire ants know how to survive a flood: They turn their bodies into life rafts.

A new study explores the physics that keeps waterborne colonies of fire ants, sometimes containing tens of thousands of bugs, afloat. Linked together, the ants form a watertight seal that keeps them from drowning, engineers from the Georgia Institute of Technology in Atlanta report online April 25 in the *Proceedings of the National Academy of Sciences*.

Fire ants (*Solenopsis invicta*), an invasive species around much of the globe, are ready for disaster. When their Brazilian homes flood, entire colonies take to the waves. "They have to stay together as a colony to survive," says study coauthor Nathan Mlot of Georgia Tech. Their double-decked rafts — about half the ants float on the bottom holding the rest up — can bob along for weeks.

Groups of fire ants keep afloat with cooperation and some basic physics.

The ants' seafaring success comes down to both small and big properties. On the small scale, single ants can float, at least to a degree, similar to a pin or a water-striding insect. When wet, fire ants can also capture tiny air bubbles, probably thanks to the thin layers of hair covering their bodies, giving these intrepid mariners additional buoyancy. On the large scale, ants weave together so tightly by biting onto their neighbors' legs that water can't sneak through the cracks.

And the rafts are flexible enough to withstand some jostling. Mlot and his colleagues filmed the emergency raft construction by dropping up to 7,000 ants into water. No matter how many bugs clung to the rafts, these structures adopted the same 8-millimeter-thick "pancake" shape. When the team plucked ants off the top, others from the bottom crawled up.

"Each ant is operating on a few simple rules of engagement," Mlot says.

With these simple rules, ants have been able to build extraordinary structures, says Eric Klavins, a computer scientist at the University of Washington in Seattle. By studying how ants interact, engineers may be able to design robots that run on smaller processors and can work in concert to build things like emergency bridges.

"Man," Klavins says, "ants are cool."

N. MLOT AND TIM NOWACK

Earth

"It looks kind of like a lava lamp." —ALAN LEVANDER

The Colorado Plateau may have risen through a geological process that peels away material from below.

FROM TOP: DOUG DOLDE/WIKIMEDIA COMMONS; LEVANDER LAB/RICE UNIV.

Grand Canyon's high surroundings may be product of continental lift

'Drip' deep within Earth possibly buoyed Colorado Plateau

By Alexandra Witze

For all its glorious views, the Colorado Plateau remains an ugly mystery to geologists. They can't figure out why and how it rose thousands of feet over the millions of years it took to carve spectacular natural wonders like the Grand Canyon and Monument Valley.

The answer may lie deep beneath the plateau's chiseled landscape, a study in the April 28 *Nature* suggests. Hot rock welling up from below invades the plateau, causing blobs to drip off the bottom.

"It looks kind of like a lava lamp," says the study's leader, Alan Levander of Rice University in Houston.

Geologists have wondered about the high plateau's origin ever since early explorers stood on the edge of the Grand Canyon and peered down at the Colorado River through 1,500 meters of layer-cake rock.

The geologic province roughly covers the Four Corners area where Utah, Colorado, New Mexico and Arizona come together. About 2 kilometers above sea level, the plateau behaves as a single, mostly undisturbed chunk of crust even as tectonic forces crumple the landscapes on either side.

To the east, the Rocky Mountains thrust toward the sky; to the west, the Basin and Range province wrinkles in long ridges of mountains and valleys. But something, mysteriously, has kept the Colorado Plateau high and intact.

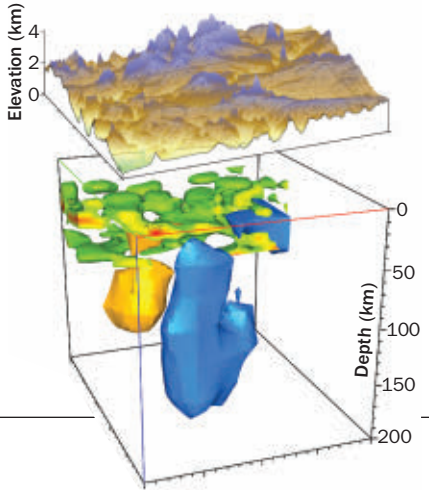
Most theories focus on the uppermost layers of the Earth's innards: the crust; the "lithospheric mantle" below that, which moves with the crust as a relatively hard outer shell about 150 kilometers thick; and even deeper, the "asthenosphere," which flows like a fluid.

Levander's team probed these hidden realms by studying how seismic waves travel through the Earth. The data come from the USArray project, in which geologists blanket the continent with a dense north-to-south band of seismometers periodically moved from west to east.

By studying the waves' progress, the scientists spotted a weird feature sloughing about 200 kilometers down, just north of the Grand Canyon. This blob, they say, is part of the crust and lithospheric mantle that peeled off to founder in the planet's depths.

Blame the asthenosphere. When it rises from below, this less-dense layer infiltrates the stiffer crust above and then freezes, weakening the lithosphere and eventually chiseling chunks of rock away. Over time, more blobs fall off, lightening the plateau and allowing it to rise upward like a floating cork.

Lava lamp Partially molten material from Earth's interior (gold) may trigger slabs of crust to peel off and "drip" back down (blue), perhaps explaining the rise of the Colorado Plateau (top).



Geologists have previously spotted other places where blobs might once have dripped, Levander says, such as along the Idaho-Oregon border. But in the Colorado Plateau, he says, "it looks as if we've caught one of these as it happened."

Though the plateau drips have probably been happening for the last 25 million years or so, he says, they really took off about 6 million years ago — allowing the plateau to rise in earnest and ancient rivers to begin to carve the Grand Canyon.

Other researchers have proposed versions of the drip idea before, but without the detailed seismic observations of the Earth's guts.

Some scientists, though, aren't yet convinced. "The tendency is to say we have what looks like a drip and therefore it is a drip," says geophysicist Mousumi Roy of the University of New Mexico in Albuquerque. "We need to be really careful about that interpretation." Two years ago, Roy and her colleagues described an alternate theory to explain plateau uplift, in which the lithosphere warmed but did not drip.

In particular, she says, the new work assumes that rock infiltrating from below would make the lithosphere more dense by rearranging atoms such as iron into minerals with less space between the atoms. But this "refertilization" process is messier in real life than in theory, Roy argues. The chemical changes aren't well understood, she says, and probably don't lead to chunks of lithosphere getting more dense and breaking off.

The drip theory can't explain all of the plateau's uplift, Levander notes. He and his colleagues are now looking for drips elsewhere across the country. ■

1.15 meters — Mean annual coastal erosion on Alaska's Beaufort Sea

0.87 meters — Mean annual coastal erosion on East Siberian Sea

Warming Arctic comes unglued

Rising rates of erosion strike region's ice-rich coastlines

By Janet Raloff

Arctic coastlines — a third of the globe's shores — are retreating an average of half a meter annually, a 10-nation regional assessment concludes. A warming climate is the apparent cause, according to a related Alaskan study that also calculates the amount of carbon and other nutrients in soil being washed into Arctic waters.

Annual erosion in some spots exceeds 8 meters, the new State of the Arctic Coast Report estimates. That rate is higher than anywhere else on Earth — and escalating. Scientists had suspected as much, but until now had not amassed sufficient data for confirmation, says Volker Rachold of the International Arctic Science Committee in Potsdam, Germany, which copublished the new report with the Land-Ocean Interactions in the Coastal Zone Project, the Arctic Council's Arctic Monitoring and Assessment Programme, and the International Permafrost Association.

Arctic coasts are especially vulnerable, says Rachold, because here "ice is what holds everything together." So coastal sediments are coming unglued in the region, where global warming is exaggerated.

A related analysis, focusing on Alaska's Beaufort Sea coast, finds that land losses now are twice the rate typical of the 1950s through 1980. Chien-Lu Ping of the Palmer Research Center at the University of Alaska Fairbanks and colleagues quantified the rates and then, for the first time, correlated erosion risk with soil type.

On average, Ping says, 70 percent of Arctic coastline is ice — sometimes tiny crystals, other times blocks meters on a side. Ping's team reports online April 20 in the *Journal of Geophysical Research* that height above sea level and ice content are key predictors of erosion risk.

The most ice-rich soils face "double jeopardy" from warming, Ping explains. Icier soils initially expand to create high bluffs, vulnerable to undercutting by warming waters and waves as seas are increasingly freed of year-round ice cover. As warming air thaws icy patches in the region's permafrost, affected soils can sink to sea level or below.

By narrowing its focus to a meters-long scale in breadth and depth, Ping's group found a strong and convincing link between ice content and Arctic coastal erosion, says geoscientist Paul Overduin of the Alfred Wegener Institute for Polar and Marine Research in Potsdam.

Genes & Cells

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Three flavors of intestinal bugs

Every gut has a favorite; how it chooses remains unclear

By Tina Hesman Saey

There are three types of people, and by their bacteria ye shall know them.

A consortium of researchers from Europe and Asia examined the DNA profiles of bacteria in fecal samples taken from 39 people belonging to six different nationalities. Each person had a diverse group of microbes, but closer analysis revealed that the bacteria fall into three major types of communities, the researchers report online April 20 in *Nature*.

Each of the newly identified microbial mixes — called enterotypes — is named for the dominant type of bacteria in the group. People with the *Bacteroides* enterotype have an abundance of *Bacteroides* bacteria and several associated types, while people with *Prevotella* and *Ruminococcus* enterotypes have more of those bacteria. *Ruminococcus* was the most common of the three types.

The researchers didn't find any correlation between a person's enterotype and age, body weight, nationality, geographic location or diet. "We still don't know what is driving these three types," says Peer Bork, a bioinformatician at the European Molecular Biology Laboratory in Heidelberg, Germany. He and his colleagues speculate that the different communities may form around key bacteria that dispose of excess hydrogen in the form of methane or hydrogen sulfide. Another possibility is that the first organisms to colonize a person's intestines may determine the community makeup. Or a person's immune system may determine which microbes are allowed to settle in.

> "I can roughly tell you how old you are if you give me a stool sample."
>
> PEER BORK

Although the species mix wasn't linked to any particular human trait, certain groups of genes or biochemical functions carried out by the bacteria did match up with traits. "I can roughly tell you how old you are if you give me a stool sample," Bork says. Body mass index also correlated with the presence of certain microbial genes and biological processes.

How bacteria use their genes is probably more important than which species are present, says Jeremy Nicholson of Imperial College London. "There's this obsession with microbial speciation, which bugs do what," he says, "but what is actually important is the capabilities of the microbial community as a whole."

The researchers don't yet know if a person's enterotype changes over time or stays the same throughout life, or if certain enterotypes predispose people to diseases.

Flies on meth burn through sugar

Effect may explain why addicts often have a sweet tooth

By Daniel Strain

A famous antidrug ad compares the brain on drugs to a frying egg. Now, a study gives a broad look at how methamphetamine might scramble the entire body.

The new research illustrates the many genetic and cellular impacts of meth exposure in fruit flies. In addition to likely wreaking havoc on muscles and sperm, the drug seems to kick a fly's sugar metabolism into overdrive, researchers report online April 20 in *PLoS ONE*.

Though flies and people are very different beasts, meth appears to tweak some of the same basic biochemical networks in both, says Barry Pittendrigh, a coauthor of the new report.

Meth batters cells throughout the fly's body. "It's a really horrible compound," says Pittendrigh, a molecular entomologist at the University of Illinois at Urbana-Champaign. The drug seems to kick off muscle degradation, disrupt sperm production and even speed up the aging process in a host of cells.

Studies in mice and humans have documented the drug's devastating impacts on the heart, fertility and on cell aging. The new study also reveals how meth can act like a back-alley strangler.

When cells can't get enough oxygen, such as during exercise, they break down sugar molecules like a chop shop does stolen cars — quickly and messily. Cells exposed to meth seem to go into this same chop shop mode, says study coauthor Manfredo Seufferheld, also at Urbana-Champaign. Why isn't clear — the drug could somehow be cutting cells or parts of cells off from the body's oxygen supply. But meth may also switch on a few key genes that persuade cells to metabolize sugar as though the cells were suffocating even when oxygen is plentiful. Either way, such inefficient sugar crunching could leave cells with an insatiable appetite for carbohydrates.

This change in sugar metabolism may help explain why speed addicts develop a pronounced sweet tooth. "They consume absolutely every gram of sugar that they have available," Seufferheld says. Feeding that sweet tooth may slow meth's ravages, he suggests. Drug-addicted flies with extra sugar in their diets survived longer than their sugar-deprived compatriots, the team discovered.

"One tends to think of methamphetamine as being a drug of abuse largely for fairly advanced organisms," says Desmond Smith, a geneticist at UCLA. "It was quite nifty to try and look at what's happening in the humble fly."

Environment

For longer versions of these and other Environment stories, visit **www.sciencenews.org**

Chemicals linked to kids' lower IQs

Studies identify effects from pesticides still used on farms

By Janet Raloff

Children exposed in utero to substantial levels of neurotoxic pesticides have somewhat lower IQs by the time they enter school than do kids with virtually no exposure, three studies find.

The researchers screened women for exposure to organophosphate compounds such as chlorpyrifos, diazinon and malathion. These bug killers, which can cross the human placenta, work by inhibiting brain-signaling compounds. Although the pesticides' residential use was phased out in 2000, spraying on farm fields remains legal.

All three studies began in the late 1990s and followed children through age 7. In more than 300 low-income Mexican-American families, exposures came mostly from farmwork, researchers from the University of California, Berkeley and their colleagues report. In two comparably sized New York City populations, exposures probably traced to bug spraying of homes or eating treated produce.

Among the California families, the average IQ for the 20 percent of children with the highest prenatal organophosphate exposure was seven points lower compared with the least-exposed group.

A Columbia University study followed low-income black and Hispanic mothers. Each additional 4.6 picograms of chlorpyrifos per gram of blood in a woman during pregnancy correlated with a drop of 1.4 percent in her youngster's IQ and 2.8 percent in a measure of the child's working memory.

A more diverse group of New York City families recruited by the Mount Sinai School of Medicine points to genetics as a major determinant of risk. Children who showed the biggest cognitive impacts tended to have mothers carrying a gene variant for a slow-acting version of the enzyme that breaks down organophosphates. This variant is present in roughly one-third of all Americans, says study leader Stephanie Engel, now at the University of North Carolina at Chapel Hill.

All three studies appear online April 21 in *Environmental Health Perspectives*.

"There was an amazing degree of consistency in the findings across all three studies," notes Bruce Lanphear of Simon Fraser University in Vancouver. That's concerning, he says, because a drop of seven IQ points "is a big deal. In fact, half of seven IQ points would be a big deal, especially when you see this across a population."

Each IQ-point drop will add up to extra costs in lost earnings over an individual's lifetime, he says — and even, potentially, to higher education and other costs to deal with behavioral and learning problems that may occur during childhood.

Ozone loss makes subtropics rainier

Antarctic hole changes weather patterns almost to equator

By Alexandra Witze

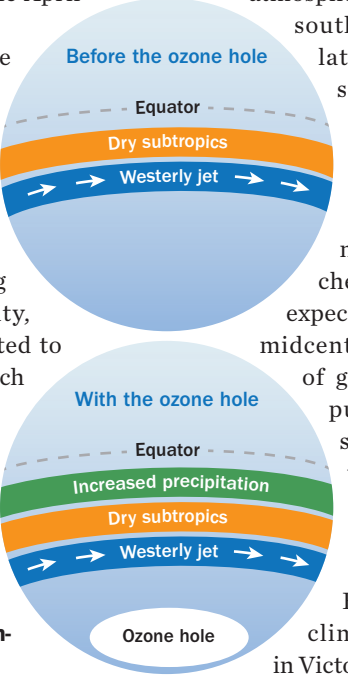
From high above the South Pole, Earth's ozone hole can affect rainfall as far away as the tropics, scientists have found.

Thinning ozone pulls weather patterns southward in the Southern Hemisphere, bringing more rain to a band that includes eastern Australia and the southwestern Indian Ocean, researchers report online April 21 in *Science*.

Previous studies have shown how annual ozone thinning affects polar weather by cooling the upper atmosphere. Sarah Kang, a postdoctoral fellow at Columbia University's engineering school in New York City, and her colleagues wanted to see if these changes stretch toward the equator.

The scientists used computer simulations to model how climate would behave with and without the ozone hole, then compared those findings with observations of rainfall from 1979 to 2000. The models with the ozone hole best matched the rainfall record for that period, which saw lots of precipitation between about 15° and 35° S latitude.

The shift happens, Kang says, because ozone loss causes a westerly atmospheric jet to move further south, which pulls a mid-latitude band of dry air south. The region near the equator, in turn, gets wetter.



By pulling atmospheric circulation patterns poleward, the Antarctic ozone hole has brought more rainfall south of the equator.

The 1989 Montreal Protocol banned many ozone-destroying chemicals, and scientists expect the hole to recover by midcentury. But rising levels of greenhouse gases also push atmospheric jets southward, so global warming may counteract any changes from the healing ozone hole, says Nathan Gillett of Environment Canada's climate modeling center in Victoria.

SCIENCE/AAAS

Humans

"We all have limits on our attention capacity." —DANIEL SIMONS

Bad multitaskers blind to surprises

Study explains why some just can't see the gorilla in the room

By Bruce Bower

People who don't notice unexpected happenings while concentrating on a task often have difficulty with what amounts to mental multitasking, a team led by psychology graduate student Janelle Seegmiller of the University of Utah reports in the May *Journal of Experimental Psychology: Learning, Memory and Cognition*.

Previous studies of this effect have instructed participants to count the number of times people in a video pass a basketball to one another. Nearly half of the viewers don't notice a person in a gorilla suit walking among the players, pausing for a few chest thumps and then departing.

Why people counting passes sometimes overlook a wandering ape is poorly understood. Explaining this effect is no laughing matter, though, since it corresponds to real-life attention mishaps, such as drivers gabbing on cell phones who fail to see pedestrians in crosswalks or red lights at intersections.

A flair for allocating attention to different objects simultaneously may help flush out intrusive gorillas, but everyone overlooks unexpected events on occasion, says psychologist Daniel Simons of the University of Illinois at Urbana-Champaign. "We all have limits on our attention capacity," says Simons, who codirected the 1999 study that documented the invisible gorilla phenomenon.

Seegmiller's group first tested the ability of 197 college students, ages 18 to 35, to solve simple math problems and remember individual letters that followed each problem. After completing sets of problems, the students tried to recall, in order, the letters they had seen.

Participants correctly answered most math problems, which showed that they did not focus just on remembering letters.

Students then watched a gorilla video, in which two teams with three players each passed basketballs. One team wore black outfits and the other white. Participants simultaneously counted the black team's bounce and aerial passes.

Overall, 58 percent of the students noticed the gorilla while counting passes. Importantly, 67 percent of those who remembered letters especially well after solving math problems spotted the gorilla, versus 36 percent of those with the poorest letter memory.

Neandertals had right-hand bias

Fossil tooth evidence could be a sign of language ability

By Bruce Bower

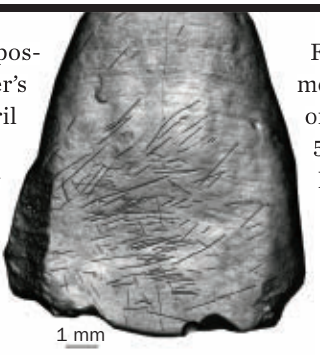
Right-handedness reaches back a half million years in the human evolutionary family, at least if scratched-up fossil teeth have anything to say about it.

Stone-tool scratches on the teeth of most Neandertals and their presumed European ancestors occur at angles denoting right-handedness, say anthropologist David Frayer of the University of Kansas in Lawrence and his colleagues. Scientists have linked prevalent right-handedness in human populations to a left brain hemisphere that controls right-sided body movements and functions crucial to language. So given the new tooth evidence, populations of largely right-handed Neandertals and their predecessors must have possessed a gift for gab, Frayer's team proposes online April 14 in *Laterality*.

Humanlike inner ear fossils also show that Neandertals' ancestors could hear all the sounds employed in modern tongues, Frayer asserts.

Other researchers contend that, based on vocal-tract reconstructions informed by skull and upper-body fossils, Neandertals were physically incapable of articulating some modern speech sounds. In these scientists' view, language as spoken today originated in *Homo sapiens* sometime after 200,000 years ago.

Frayer's findings coincide with previous reports of right-handed sharpening patterns on 120,000-year-old Neandertal stone tools (*SN: 11/21/09, p. 24*), says archaeologist Natalie Uomini of the University of Liverpool in England.



Stone-tool marks consistent with right-handedness appear on a 30,000-year-old Neandertal tooth.

D. FRAYER

Frayer's team used a method developed by paleontologists who excavated 500,000-year-old fossils of Neandertal ancestors in Spain. The Spanish team found that when using a stone tool to cut a piece of meat by biting down on one end and holding the other end taut, right-handers make accidental scratches that angle in a consistent direction. Left-handers make scratches going the other way.

Front teeth from 17 European Neandertals that lived between 130,000 and 30,000 years ago revealed scratches consistent with right-handedness in 15 cases and left-handedness in two cases. Comparable scratch data from 12 Neandertal ancestors, previously obtained by Marina Lozano of Universitat Rovira i Virgili in Spain and her colleagues, denoted right-handedness in each individual.

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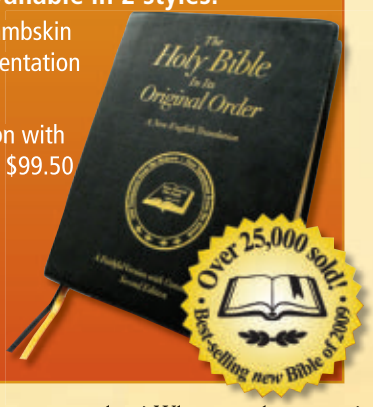

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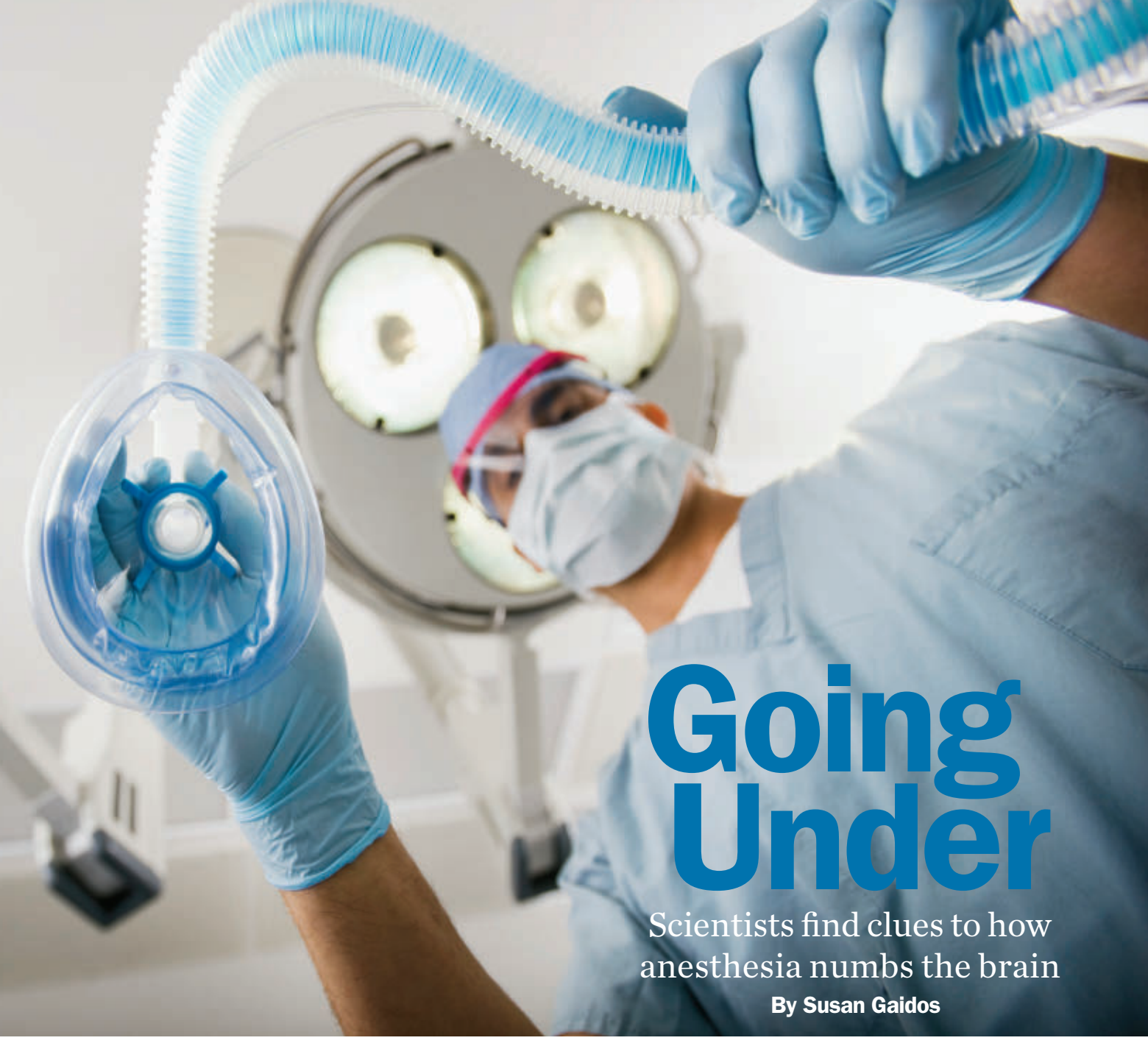


Going Under

Scientists find clues to how anesthesia numbs the brain

By Susan Gaidos

Emery Brown knows how to take the sting out of surgery. As an anesthesiologist, he has steered hundreds of patients to pain-free oblivion, allowing doctors to go about their business resetting bones, repairing heart valves or removing tumors. During surgery he continually monitors his patients, keeping tabs on their heart rate, blood pressure and breathing. Recently, he has also been eyeing what happens in their brains.

Rather than going under the knife, some of the people in Brown's care are going into scanners to reveal how the brain responds when people are knocked out. These deep glimpses could answer vexing questions about how people enter the state of unconsciousness known as general anesthesia and what happens in the brain while they are there.

Although it is widely used and remarkably effective, anesthesia's neural mechanisms have long remained mostly mysterious. While every anesthetic drug has its own effect, scientists know little about how the various versions work on the brain to transport patients from normal waking awareness to dreamless nothingness.

Understanding how such compounds meddle with the nervous system might lead to anesthetics capable of tweaking neural circuits more precisely, delivering only what is needed where it's needed, says Brown, of Massachusetts General Hospital in Boston. Fine-tuning the drugs' effects could also help doctors bring patients into and out of consciousness more quickly and safely, avoiding the side effects that can occur when medications act at brain sites other than

FUSE/GETTY IMAGES

those intended or act at targeted sites for too long a time.

That may be reassuring to the more than 20 million patients who are put under general anesthesia each year in the United States. Though new drugs and procedures have made anesthesia safer and more comfortable, patients still may experience nausea, abnormal heart rhythms or fogginess after surgery. In extremely rare cases more serious effects such as brain injury or death can result.

"We've made a lot of progress in anesthesiology as far as taking care of patients," Brown says. "But it'll be much more reassuring when we can say to them, 'We have a good idea what's happening inside your brain.' "

Beyond all that, mapping the pathways of neural activity taking the brain to this particular type of unconsciousness may help scientists understand how it compares with sleep and coma, which may ultimately lead to new sleep medicines or new ways to help patients recover after a severe brain injury.

Painless experiments

Before general anesthesia's discovery in the 1840s, patients simply had to endure the trauma of surgery, although alcohol or opiates sometimes numbed the pain. After observing in 1844 that nitrous oxide — or laughing gas — could stifle pain, dentist Horace Wells had a tooth pulled while on the gas. Taking several deep inhalations, he nodded off, giving his colleague ample time to yank the tooth. Feeling no pain during the procedure, Wells took his discovery to the medical community: At Massachusetts General Hospital, he gave a patient a whiff of nitrous oxide before extracting a tooth.

The demonstration didn't go as planned, as the patient moaned during the procedure. But another dentist, William Morton, began experimenting with ether. In 1846 Morton used ether to knock out a patient while a surgeon removed a neck tumor. By 1847 either ether or chloroform was routinely administered during surgery to put patients into a dreamless, pain-free state. In the early 20th century, as surgical procedures advanced, these gases were replaced by mixtures of nitrous oxide and oxygen or intravenous narcotics, ultimately giving doctors more control over zonked-out patients.

Today, anesthesiologists administer about a dozen drugs to produce the desired effects. Sedatives help with relaxation, opiates take away the pain and a muscle relaxant paralyzes the body. Other drugs added to the mix render patients unconscious and make sure they don't remember the experience.

During surgery, anesthesiologists know when to intervene. They use a mechanical ventilator to control breathing, ensuring that a patient is inhaling and exhaling slowly, deeply and rhythmically, and they continually check for signs of perspiration. Beeping monitors signal trouble if it should arise.

Though not standard practice, brain activity is recorded during some surgeries. Electroencephalograph, or EEG, signals track brain cell firings by measuring surface electrical activity through sensors usually placed on a patient's forehead. Some EEG monitors do additional number crunching — translating readings into ballpark assessments of a patient's level of consciousness and spitting out a number ranging from 0 to 100. A value of 100 means that the patient is fully awake, while a score of 0 — a flatline — indicates no brain activity at all. Anesthesiologists generally want to keep a patient's score within a range of 40 to 60.

While such measurements give anesthesiologists a rough way to gauge how much anesthetic is needed — preventing too much or too little — the devices can't always tell whether or not a patient retains any sensory awareness. Anesthesiologist George Mashour of the University of Michigan in Ann Arbor says that doctors still don't have a monitor that can reliably detect consciousness in a paralyzed and otherwise unresponsive patient.

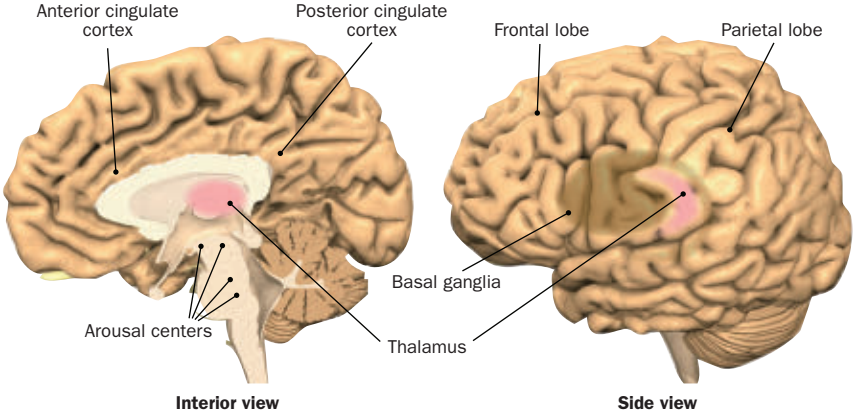
"The reality is, there is no standard device or monitor for the brain during surgery," Mashour says. "Which is pretty interesting if you consider the fact that the brain is one of the main target organs of general anesthesia."

Lights out

One of the difficulties in learning how the brain suspends consciousness is the way in which general anesthesia is induced, Brown says. Drug mixtures are administered first intravenously and then by inhalation, sending multiple drugs throughout every part of the brain and nervous system within seconds. Because the drugs go everywhere, it has been difficult to discern which circuits need to be hit for a person to reach a surgery-ready state.

But a picture is beginning to emerge. Using PET (positron emission tomography) and functional MRI scanners, scientists can actually image brain activity when people go under. Though such techniques can't be used during surgery,

Turning off By imaging people's brains as they ease into a state of general anesthesia, researchers are getting a better sense of which brain regions shut down (some key players labeled) and in what order. Such information may help doctors better target anesthetic drugs.



BOTH: PRIMAL PICTURES/PHOTO RESEARCHERS, ADAPTED BY JANEL KILEY

they help reveal which brain areas are affected by anesthetic agents and when.

Images studied so far suggest that anesthetic drugs wield their effects by altering connections between nerve cells, making it difficult for different brain areas to talk. Areas highly affected by the communication breakdown include the cerebral cortex, the wrinkled layer of "gray matter" at the surface of the brain; the thalamus, a ball of tissue at the center of the brain; and the brain's arousal centers, located at the top of the brain stem, the intersection between the brain and the spinal cord.

Studies looking at how various knockout drugs break up the organized patterns of activity among these brain regions reveal disruptions in several circuits. A key circuit involves the cortex and thalamus. The cortex plays a role in attention, language and information processing, and the thalamus acts as a relay station for sensory information flowing into the brain. By passing signals to each other via nerve cells, the two areas help people make sense of what they see, hear and feel.

Studies in animals and humans on anesthetics show that blood flow to the thalamus is reduced, disrupting this crucial connection. But last summer, scientists directed by Irene Tracey of Oxford University in England reported that another brain structure, the putamen, is actually the first to unhook from the rest of the brain under anesthesia. Located within the basal ganglia, a bundle of nuclei deep in the brain, the putamen plays a role in controlling movement. Though this disconnection had been noted in animal studies, Tracey's team was the first to document it in humans.

Eight healthy volunteers were placed in an fMRI machine after receiving a dose of the widely used anesthetic propofol. As the volunteers became unconscious, they were intermittently asked to reply to verbal cues or were zapped with a pain-causing device.

Those who are "minimally conscious" can respond to low doses of sedative drugs by waking up.

Tracey's team noticed that as people became unresponsive, connectivity between the putamen and other brain regions decreased steadily while the connection between the thalamus and cortex remained intact. The findings, reported in the *Journal of Neuroscience*, fit with observations from the operating room, where patients often exhibit brief, jerky movements as they slide into a surgery-ready state, Tracey says. Such movements may represent the uncoupling of normal controls from the main motor system in the brain. Tracey's group is now combining fMRI with measurements of electrical activity in the brain to further explore how this uncoupling occurs.

"The EEG is brilliant at telling you something happened over on the right-hand side and in a millisecond moved on to the left, but you don't know where on the right or quite where on the left," Tracey says. By pairing that info with fMRI, the scientists hope to pick up on subtle connectivity changes as they occur.

Similar studies are under way at Massachusetts General, where Brown and researcher Patrick Purdon are combining fMRI and EEG to document how different knockout drugs act in various brain regions. These studies and others may help answer another key question about the ability of anesthetics to induce unconsciousness: Is the brain taken down in a single step, like turning off a light in a room, or is there a hierarchy of switches to be flipped?

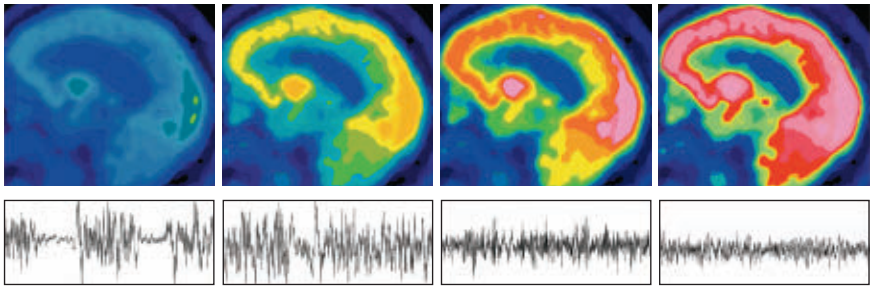
Tracey says that, from a biological or evolutionary perspective, one might think of anesthesia "as a house with lots of rooms, where you take the lights out in a different order." Such a step-by-step disconnection might allow the brain to better preserve some functions until unconsciousness is reached.

Wake-up call

Scientists see a similar series of disconnections in brain areas when people catch their daily dose of z's. Sights, sounds and other distractions often melt away as the chatter between the thalamus and cortex quiets and sleep ensues. But even at the deepest stage of sleep, a barking dog or a good shake can rouse a person. Most certainly, the slice of a knife will do the job.

In contrast, people under general anesthesia can't be stirred. As the drugs take effect, patients are rendered senseless, numb to the world around them and within. Though the anesthetized brain uses some of the same neural machinery as sleep, studies of brain activity show that the two states are in fact entirely different. The steady, slow-rolling EEG patterns induced under general anesthesia more closely resemble those seen in coma. Brown, Nicholas Schiff of Weill Cornell Medical College in New York City and Ralph Lydic of the University of Michigan reviewed the similarities

Cerebral kick-start The stages that the brain passes through as a person slides into anesthesia may parallel the stages seen among brain-injured patients recovering from coma (cerebral metabolism and EEG readings represented below). Minimally conscious patients receiving a sedative sometimes exhibit a temporary burst of excitability called "paradoxical excitation." Researchers have seen similar excitations as people move toward an anesthetized state.



E.N. BROWN *ET AL./NEJM* 2010

between general anesthesia and coma in the Dec. 30 *New England Journal of Medicine*.

Schiff, a neurologist who helps brain-injured patients recover consciousness, is poring over the EEG patterns seen in anesthesia cases looking for common links to those found in patients recovering from coma. Such commonalities may point to a "signature" for awareness that could be detected with EEG.

While he has yet to find such a marker, Schiff has identified brain behaviors that are similar in the two groups. As drugs administered to patients undergoing general anesthesia begin to take effect, activity between neurons may actually increase for a short period. (The same effect can explain the excitable feeling you get after a single glass of wine.) As more medication is given, patients give in to sedation.

Schiff sees similar patterns of temporary excitability in some brain-injured patients. Those who are "minimally conscious" — meaning they show only occasional awareness of themselves and their surroundings — can respond to low doses of sedative drugs by waking up. Here, the anesthetic drugs "kick-start" the brain, helping it to turn itself back on.

"Patients might start to speak, or suddenly gain the ability to stand or walk or chew or swallow," Schiff says.

Over time, with repeated doses, the mere act of being alert can help the underactive brain make gains toward recovery, Schiff says. In the January 2010 *Trends in Neurosciences*, he suggests that a switching mechanism explaining this excitatory effect may rely on links between the thalamus, the cortex and two brain regions — the globus pallidus and the striatum — that help regulate activity between the cortex and thalamus.

Back in the operating room

While Schiff looks for a signature of awareness for patients in coma, other labs are looking for markers that might help anesthesiologists track surgery patients' awareness.

By correlating the squiggly EEG signals of anesthetized brains to images showing changes in blood flow in specific brain regions, Purdon and Brown hope to identify patterns that could be used in the operating room.

"Once you know that connection, you can then identify specific EEG patterns and make inferences about what different brain systems are doing when you see that pattern," Purdon says.

Mashour and University of Michigan physicist UnCheol Lee are taking advantage of graph theory, a mathematical approach used to study networks, to link the EEG patterns seen in anesthetized patients to knowledge about the underlying brain networks. Ideally, such a system could be set up to track the moment-to-moment changes seen in patients during surgery.

The team has already found that clinicians may get more information on patient awareness by gluing the EEG monitors farther back on the head, rather than on the forehead. In the April *Anesthesiology*, Mashour's team showed that networks in the parietal region display greater levels of disruption during anesthesia than those in the front of the brain. "The parietal lobe may be an important hub or point of convergence for information processing in the brain," he says.

Such studies may allow anesthesiologists to fine-tune their procedures during surgery, knowing exactly where to steer the brain to balance drugs' main effects against a host of potential side effects.

"Certain brain areas, if activated, can cause nausea and vomiting. Others can adversely affect your respiratory system," Brown says. "If I can have a drug avoid going there, I'd love to do that."

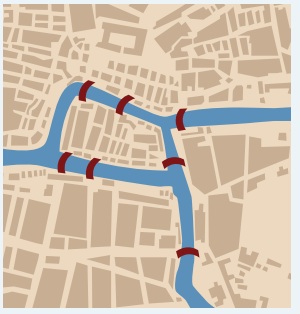
Michael Alkire, who studies the neural biology of anesthesia at the University of California, Irvine, says that by knowing how anesthetics affect different brain areas, researchers may be able to develop new therapies or find ways to customize treatments. He foresees a day when a patient's genes are analyzed before surgery to determine sensitivity to drugs or potential to suffer certain side effects. "If you know that a patient is very anxious, and maybe that anxiety is related to the amygdala function in the brain, you might want to use a different agent or anesthetic for that case," he says.

Understanding how anesthetics work in the brain could also lead to entirely new ways of creating anesthetic states. Future anesthesia may rely on *Star Trek*–like devices with energy fields capable of disrupting key circuits, for example.

In such a scenario, patients wouldn't need to take any type of medication at all, meaning side effects would be minimal, Alkire says. "But first," he says, "we have to figure out the anesthetics." ■

Explore more

- E.N. Brown *et al*. "General anesthesia, sleep, and coma." *New England Journal of Medicine*. December 30, 2010.



Bridges in the brain

Mathematician Leonhard Euler proved in the 18th century that there was no journey through Königsberg, Prussia, that would take a walker across each of the city's bridges once and only once. By simplifying the city's layout — four land areas connected via seven bridges (as shown) — into a series of nodes connected via paths, Euler established the foundations for modern network theory. Today researchers study the brain by similarly reducing it to an architecture of nodes and paths. Neurons or groups of neurons are Königsberg's landmasses, and connections between those neurons are the city's bridges. Recent work suggests anesthesia can disrupt the brain by interfering with the system in two ways — changing the layout of the nodes and altering the efficiency of the pathways.

JANEL KILEY

Dawn of the

Paleontologists probe the majestic reptiles' origin and rise

By Alexandra Witze ▪ Illustration by Victor O. Leshyk

Any 10-year-old knows how the dinosaurs met their end: A huge meteorite slammed into Mexico's Yucatán Peninsula 65 million years ago, blasting the planet beyond anything imagined by Bruce Willis in *Armageddon*.

But neither kids nor Hollywood have spent much time thinking about how dinosaurs appeared in the first place. "We know a heck of a lot more about the extinction of dinosaurs than their origins," says Randall Irmis, a paleontologist at the Utah Museum of Natural History and the University of Utah in Salt Lake City.

Lately, though, new discoveries have begun to flesh out the script of dinosaurs' earliest days. From ghostly footprints in a Polish quarry to the bones of a pint-sized predator in Argentina, these findings tell a more complete and nuanced tale of dinosaur genesis. Dinosaurs, it turns out, were not predestined to rule the planet for more than 130 million years.

Instead, dinosaurs appeared on the scene tentatively, perhaps as early as 250 million years ago. Paleontologists are now unearthing fossils so primitive that they may be close to the common ancestor at the root of the dinosaur family tree — the "ur-dinosaur," as Paul

Sereno of the University of Chicago puts it. Ingloriously, that creature probably looked something like a chicken: two-legged, scurrying around in the corners, snapping up plants, insects, small animals and whatever else passed its way.

Other new findings come not from dinosaurs themselves, but from some of their closest relatives. Just as a long talk with an estranged cousin can help fill in family history, these discoveries are illuminating how dinosaurs evolved alongside other animals.

"We're really in a renaissance in our understanding of early dinosaur history," says Stephen Brusatte, a paleontologist at the American Museum of Natural History in New York City.

In the beginning

A famous extinction event may have wiped most dinosaurs out, but another extinction, just as spectacular, made way for their inauspicious rise. It occurred 252 million years ago, at the boundary between the Permian and Triassic periods of geologic time.

Scientists aren't sure what caused the Permo-Triassic extinction; there's no impact crater to serve as a "smoking gun" like there is for the close of the dinosaur era. But Earth was roiled by huge environmental changes, from massive volcanic eruptions in Siberia to radical shifts in ocean chemistry. For whatever reason, 90 percent of marine species and 70 percent of land species went extinct.

Triassic neighborhood Though some dinosaurs, such as a theropod called *Coelophysis* (**D**), did live in the late Triassic, they did not rule the landscape. Existing non-dinos included large armored herbivores called aetosaurs (**C** and **E**), mammal-like reptiles known as dicynodonts (**A**), land-dwelling ancestors of today's crocodiles (**B**), salamander-like amphibians (**G**) and other aquatic predators (**F** and **H**).

Dinosaurs

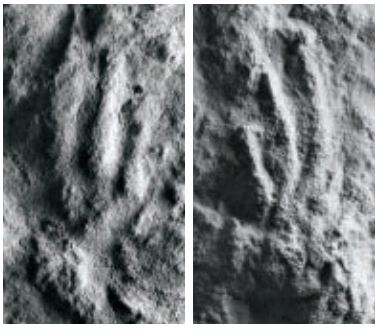
That left the slate clean for dinosaurs to arise in the early part of the Triassic. "You had your status quo basically wiped out, and new groups had the opportunity to originate and flourish in this post-apocalyptic world," Brusatte says.

Beyond dinosaurs, those new groups included the ancestors of creatures that would look familiar today, such as lizards, frogs and salamanders. These animals — in particular, the crocodile-like creatures known as crurotarsans — were far more abundant than the first dino pip-squeaks. "If you were standing in the Triassic, you would say these crocodile-like animals, not dinosaurs, would expand and be dominant" in the eons to come, says Brusatte.

Triassic Park was not exactly Jurassic Park. But dinosaurs were around, and new research hints at when they first appeared and what they looked like.

Fossil footprints from Poland's Holy Cross Mountains provide the oldest clue. Last fall Brusatte and his colleagues, including University of Warsaw paleontologist Grzegorz Niedźwiedzki, reported finding three sets of tracks, the oldest dating back 250 million years. That's right after the Permo-Triassic extinction.

Only several centimeters long, these tracks were made by a four-legged creature no bigger than a house cat. But certain characteristics of the footprints are distinctly dinosaur-like, Brusatte says.



Trackways uncovered in a Polish quarry may be the earliest sign of dinosaurs, predating known bone fossils by about 20 million years.

Among other traits, the outer digits — the first and fifth toe — are smaller than the others, and the long bones of the foot bunch together more closely than in non-dinosaurs. The trackways are also narrow, as if they were made by an upright-walking creature instead of a sprawled-out crurotarsan, the team reported last year in the *Proceedings of the Royal Society B*. If confirmed, the tracks would be the oldest dinosaur evidence anywhere, and would suggest that dinosaurs evolved even earlier than scientists had thought, hard up against the end of the Permo-Triassic extinction.

Yet not everyone is convinced that the footprints are definitive evidence of dinosaurs. At the time the Polish trackways were formed, there were plenty of other dinosaur-like creatures roaming the landscape, points out Max Langer, a paleontologist at the University of São Paulo in Brazil.

Written in bone

Researchers usually say that the earliest dinosaurs lived 230 million years ago, because that's the approximate age of the oldest known actual bones. These fossils come from the high desert of northwestern Argentina, near the border with Chile. There, a rock formation known as the Ischigualasto serves as a veritable treasure trove of the earliest dinosaurs, where for decades paleontologists have dug up and identified a boatload of new species.

Several of these earliest animals remain a puzzle. Scientists aren't quite sure how to classify some of the most ancient species.

The dinosaur family tree includes three main branches: theropods, typically two-legged, meat-eating animals; sauropodomorphs, typically the four-legged, long-necked plant eaters; and ornithischians, the "bird-hipped" dinosaurs that included famous groups like the stegosaurs and the horned dinosaurs. Sauropodomorphs and ornithischians went extinct 65 million years ago; a few theropods survived the meteorite impact and gave rise to modern birds.

Problems arise when researchers try to assign very primitive dinosaurs to one of these three branches. For instance, one of the Argentinean dinos, *Herrerasaurus*, was a two-legged meat eater about the size of a crocodile. Some researchers call it an early theropod, but others say it falls even deeper back in the family tree, somewhere just outside being either a theropod or a sauropodomorph.

Not that such classifications were significant at the time; if you were prey in the early Triassic, says Langer, "it probably wouldn't matter if you were being chased by a basal theropod or a basal sauropodomorph."

Another Argentinean creature, the smaller *Eoraptor*, has a similar identity crisis. Upon its discovery in the 1990s, it was labeled an early theropod. But in January in *Science*, it was reclassified as a sauropodomorph, in part because researchers hadn't seen certain diagnostic features in its skeleton, such as a twisted thumb, until they re-examined it recently. *Eoraptor* may thus belie its fierce-sounding name and be something of a mellower, occasional plant muncher.

Paleontologists changed their minds about *Eoraptor* after they unearthed yet another close relative: *Eodromaeus*, a small, fleet theropod whose name means "dawn runner" (*SN: 2/12/11, p. 10*). *Eoraptor* and *Eodromaeus* may belong to different dinosaur branches, but they still look a lot like each other, says their discoverer, Ricardo Martinez of the Universidad Nacional de San Juan in Argentina. In turn, *Eoraptor* resembles yet another plant eater from Ischigualasto, reported on by Martinez and a colleague in 2009 in *PLoS ONE*.

Clues from cousins

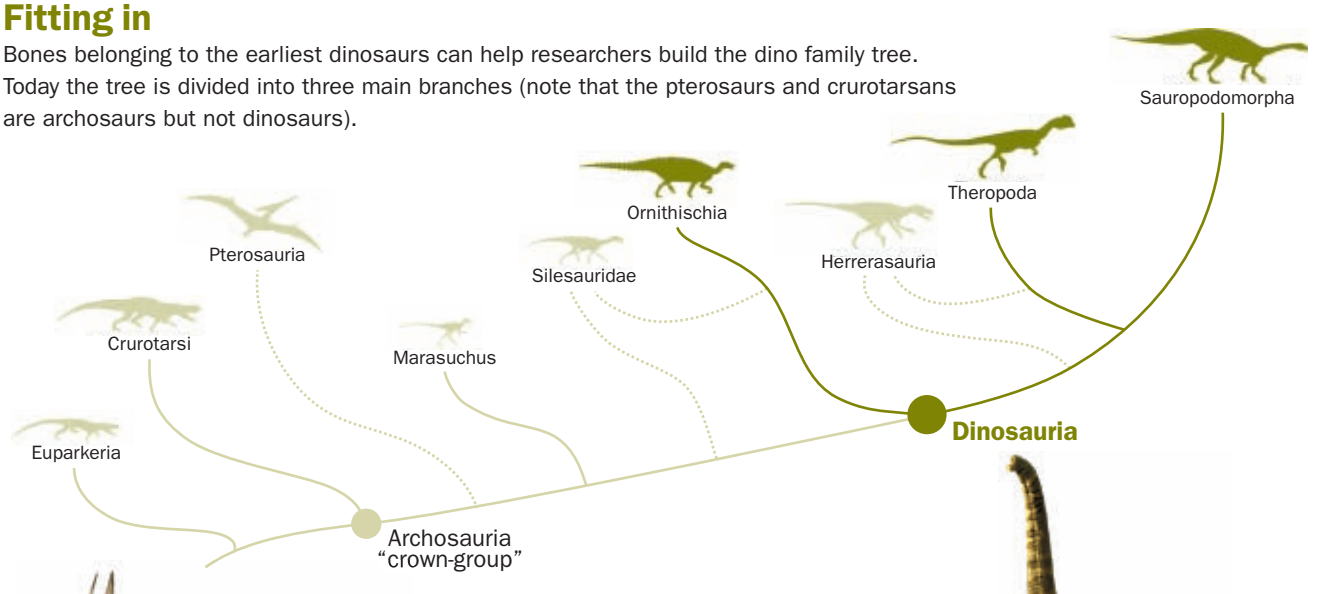
Just as faded, black-and-white pictures of ancestors start to look the same, fossils of these early dinosaurs sometimes resemble one another to the point of indistinction. All of them begin to look like an unprepossessing chicken. Still, scientists say that knowing which creatures appeared when can fill in vast yawning blanks on the dinosaur ancestry chart.

Sometimes, information about a more

PHOTOS BY G. NIEDŹWIEDZKI, S.L. BRUSATTE *ET AL/PROCEEDINGS OF THE ROYAL SOCIETY B* 2010

Fitting in

Bones belonging to the earliest dinosaurs can help researchers build the dino family tree. Today the tree is divided into three main branches (note that the pterosaurs and crurotarsans are archosaurs but not dinosaurs).



Ornithischians

After ornithischian tooth remains were reidentified as coming from crocodile-like creatures and not dinosaurs, the evidence for this group in the late Triassic was whittled down to just three body fossils from a small area of southern Gondwana. These creatures, known as the "bird-hipped" dinosaurs because of their hip structure, were probably small, just over a meter long—at least at first. Size increased during the early Jurassic, and over time horned dinos like *Triceratops* and *Einiosaurus* (shown) arose.

Theropods

Theropods—the two-legged, meat-eating dinosaurs made famous by *Tyrannosaurus rex*—probably date to around 230 million years ago. Though the name means "beast foot," most theropods alive during the Triassic were small and slender, around 2 meters in body length. Mightier creatures are known from the Jurassic, during which theropods became more common and varied (*Cryolophosaurus* shown). Other dinos went extinct around 65 million years ago, but some small, nonflying theropods gave rise to modern birds.

Sauropodomorphs

Sauropodomorphs came in two forms—the big bipedal omnivores and the bigger, four-legged, barrel-chested, long-necked herbivores (*Brachiosaurus* shown). Evidence for these creatures dates to about 230 million years ago in South America, and by about 200 million years ago they could be found across South America, Europe, Africa and Asia. Sauropodomorphs have the best fossil record among the dinosaur branches in terms of diversity and abundance, but relationships within this branch remain controversial.

FROM TOP: M.C. LANGER *ET AL/BIOLOGICAL REVIEWS* 2010, ADAPTED BY T. DUBÉ; DINOSAUR ILLUSTRATIONS: JULIUS T. CSOTONYI

distant relative can help flesh out the family tree. That's why paleontologists are also looking at fossils of animals that weren't true dinosaurs but were very closely related to them.

Technically, a dinosaur is defined as any member of the group whose lineage includes both the horned dinosaur *Triceratops* and the modern house sparrow (because of those theropods whose descendants fly around today as birds). Today's crocodiles and lizards are not descended from the common ancestor of *Triceratops* and the sparrow, and hence are not dinosaurs.

Many other creatures in the Triassic were also reptiles but not dinosaurs. Among these are a group known as silesaurids: mostly four-legged, mostly plant-eating creatures. For paleontologists, silesaurids are turning out to be nearly as exciting as dinosaurs, because silesaurid bones help illuminate crucial differences between dinosaurs and their relatives deep in the reptilian past.

Last year, scientists reported finding the oldest known silesaurid, a creature that lived 244 million years ago in what is now Tanzania. Less than 10 million years after the Permo-Triassic extinction, this animal had already evolved characteristics of later silesaurids, such as a beak-shaped lower jaw and teeth shaped like leaves. That evolution shows that the silesaurid and dinosaurs have not been closely related for a long, long time, says team leader Sterling Nesbitt, now at the University of Washington in Seattle.

The Tanzanian creature is also the oldest dinosaur relative ever found. During the Triassic, the Earth's continents were united as Pangaea, with one southern landmass known as Gondwana and one northern one known as Laurasia. Africa was part of Gondwana, which is

also where most of the Triassic dinosaur fossils have been found. So dinosaurs and their close relatives may have originated in Gondwana before spreading to other parts of the world, says Irmis.

That concept was bolstered in 2009, when Nesbitt, Irmis and colleagues described a theropod that lived 213 million years ago in what is now New Mexico (*SN Online: 12/11/09*). Despite coming more than 15 million years after the "dawn" dinosaurs of Argentina, this creature — called *Tawa* after the Hopi name for the Pueblo sun god — still has a lot to tell paleontologists.

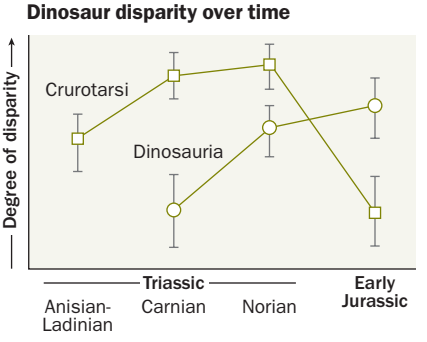
That's because the rocks that contain *Tawa* look quite a bit like those from Argentina 230 million years ago. The New Mexican fossil might represent a creature that evolved in an environment and landscape similar to the home of the earliest dinosaurs known, or it might be the descendant of a long-distance migration. "Although *Tawa* was found in the Northern Hemisphere, it probably was a lineage that originated in the Southern Hemisphere," Irmis says.

Tawa's skeleton also shares many features with *Herrerasaurus* and other primitive dinosaurs, and so it helps paleontologists classify those earlier creatures as true theropods. *Tawa* mixes earlier dinosaur characteristics with later ones, allowing researchers to see when certain features, such as air sacs within the spinal column, evolved.

Another dinosaur unearthed recently in New Mexico is similarly helping paleontologists understand the relationships among early theropods. At 205 million years old, this animal, called *Daemonosaurus*, is younger than *Tawa* yet still retains certain characteristics from its ancestors.

Discovered in 230-million-year-old rocks in Argentina, *Eodromaeus* (skull shown) ate meat while a similar-sized dino from the same time and region ate plants.

Dino rise During the late Triassic, dinosaurs showed less range in morphology and body types, called disparity, than the crocodile-like crurotarsans. This changed in the Jurassic.



SOURCE: S.L. BRUSATTE *ET AL/EARTH-SCIENCE REVIEWS* 2010

Known from a single buck-toothed skull, *Daemonosaurus* has relatively large bones at the tips of its jaws, as *Herrerasaurus* did, mixed with the vertebral air sacs that generally characterize later dinosaurs. Once again, paleontologists can use such findings to untangle which features appeared when in theropod history. A team led by Hans-Dieter Sues of the Smithsonian National Museum of Natural History in Washington, D.C., described *Daemonosaurus* online in April in the *Proceedings of the Royal Society B*.

Dino dominance

For all the recent insight into the dawn of the dinosaurs, one question still looms: How did such specimens come to dominate the planet? Somehow these runty chickenlike creatures managed to give rise to the formidable *T. rex*, *Triceratops*, *Stegosaurus* and more.

One clue may lie in yet another mass extinction. Around 200 million years ago, at the end of the Triassic period, something traumatic happened on Earth. As Pangaea began splitting apart, great quantities of magma poured out along the planetary seam that would become the middle of the Atlantic Ocean. Atmospheric carbon dioxide levels spiked, and the chemistry of the oceans shifted dramatically.

Life suffered. Crurotarsans and other non-dino reptiles were some of the worst-hit creatures, losing large fractions of the species living at the time. Their disappearance opened up ecological niches — and may have been the lucky break dinosaurs needed to move into new roles, many scientists think. (Similarly, mammals got the chance to rise to prominence after most of the dinosaurs were wiped out.)

New findings may yet revise this part of the story. Martinez and his colleagues are working on a detailed analysis of plants and animals throughout the Ischigualasto rocks and are finding that dinosaur fossils might not be quite as rare there as once thought. And dinosaurs didn't automatically and rapidly move into open ecological niches, Martinez says; sometimes, after the competing groups disappeared, dinosaurs took several million years to expand and diversify into those roles.

Other times, dinosaurs simply did better in some parts of the world than others. In North America, for instance, sauropodomorphs and ornithischians didn't even show up until after the Triassic was over, Irmis reports in an upcoming issue of *Earth and Environmental Science Transactions of the Royal Society of Edinburgh*.

Researchers are now pushing to see how many more early dinosaurs they can find, and where. In Argentina, Martinez is working on another new find, details of which he won't reveal. And Niedźwiedzki and others continue working in Poland, looking for more footprints and perhaps actual fossil bones of Triassic dinos.

No matter what, expect new findings in the years to come. "If the fossils can wait for us for 230 million years," says Martinez, "we can wait several years more." ■

Explore more

■ S.L. Brusatte *et al*. "The origin and early radiation of dinosaurs." *Earth-Science Reviews*. July 2010.

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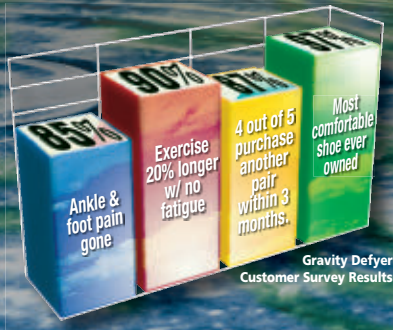

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Into orbit

Long journey MESSENGER swung by Earth and Venus before passing Mercury three times and settling into orbit around the first rock from the sun (right).

August 2004
Launch from Cape Canaveral, Fla.

August 2005
Earth flyby

October 2006
First Venus flyby

MESSENGER pays a yearlong visit to Mercury

By Ron Cowen

Hidden by the sun's glare and dismissed as a heavily cratered rock no different than Earth's moon, Mercury has for decades been relegated to the back burner of planetary research. But studies of the planet closest to the sun have now ignited.

On March 17, NASA's MESSENGER spacecraft became the first probe to enter orbit around the metal-rich body (*SN Online: 3/17/11*). MESSENGER — short for Mercury Surface, Space Environment, Geochemistry and Ranging — completes a lap every 12 hours, traveling an oval path that swoops close to the planet's north polar region and keeps a greater distance from the southern pole.

A yearlong effort to understand the planet's volcanism, core, magnetic field and other features got under way April 4, when the craft's suite of seven instruments began regularly beaming data to Earth. With MESSENGER gleaning new information, researchers will attempt to solve a number of unanswered questions about Mercury, many brought to light when the craft flew by the planet in 2008 and 2009.

These earlier encounters with Mercury revealed that volcanic upheaval played a major and perhaps dominant role in sculpting the planet's surface. That finding was a surprise to scientists who had thought that the solar system's tiniest planet wouldn't have retained enough heat to drive widespread volcanic activity.

The first hints of volcanism came in the 1970s when Mariner 10, the only other spacecraft to fly past Mercury, captured images of smooth plains between heavily cratered regions. But it took MESSENGER's flybys to uncover convincing evidence of lava flows. These flows had all but erased small craters within a Texas-sized impact basin called Caloris. More curious, the craft spotted more than 36 deposits on crater floors and the rim of Caloris indicating that some volcanic eruptions were highly explosive, powered by the rapid expansion of gases bubbling out of magma like carbon dioxide rushing out of seltzer water.

MESSENGER is getting a detailed look at cratered regions near Mercury's two poles.

Explosive volcanism on Mercury is a puzzle because the planet's hot birth should have immediately driven away compounds that easily vaporize, says MESSENGER lead scientist Sean Solomon of the Carnegie Institution for Science in Washington, D.C. Any remaining volatile compounds ought to have exited the planet early in its history, when scientists believe a massive body collided with Mercury.

During MESSENGER's yearlong mission, gamma-ray and X-ray detectors will examine the composition of surface rocks to look for signs that volatile gases could in fact have driven the volcanism.

"We should get relatively unambiguous measurements of the atomic composition of surface rocks and their variation from place to place," says Bill McKinnon of Washington University in St. Louis. "You can't claim to know a planet's history if you don't know what the planet's rocks are made of."

Depending on what the craft finds, theorists may have to invoke nontraditional volatile compounds as possible explosive power sources or consider models in which comets or asteroids delivered volatiles after Mercury had begun cooling.

Hidden within

Studying surface rocks may also offer clues about Mercury's unusually high density, another of the planet's strange properties. This density, first deduced in the early 1950s from the planet's gravitational influence on other planets, suggests that Mercury has an iron core that accounts for some 60 percent of its mass, says Solomon. In contrast, the metallic cores of Earth, Mars and most likely Venus make up only about 30 percent of the mass of those planets.

Explanations vary, from a collision that stripped away lightweight silicates in the planet's outer shell to an abundance of iron in the region of the planet-forming disk from which

NASA, JOHNS HOPKINS UNIV. APPLIED PHYSICS LAB, CARNEGIE INSTITUTION FOR SCIENCE

CRAFT AND MERCURY: NASA, JOHNS HOPKINS UNIV. APPLIED PHYSICS LAB, CARNEGIE INSTITUTION FOR SCIENCE

Mercury emerged. But each theory predicts a different composition for surface rocks, so analyzing those rocks could point to the early solar system processes most important for the planet's formation and evolution.

Identifying those mechanisms may offer insight about the formation of planets beyond the solar system, particularly those born close to their parent stars. "Almost everything we learn will be relevant for the interaction of close-in extrasolar planets with their host stars," Solomon says.

Magnetic measurements made during orbit will further illuminate Mercury's interior, including how heat transfers between layers of material at the planet's core. The craft's flybys already have confirmed a small but persistent magnetic field, suggesting that Mercury's core is divided into two parts — a hot outer portion, made of molten iron, circulating around a cooler inner core of solid iron. The churning of the planet's liquid outer core could act as a "dynamo," driving the magnetic field.

Like the magnetic field of Earth, the only planet known for sure to have a liquid-iron dynamo, Mercury's field broadly resembles that of a dipole, a bar magnet with a north and south pole. But the strength of the dipole field near Mercury's core is only about one-thousandth the intrinsic strength of Earth's field, and Solomon and his colleagues would like to find out why.

MESSENGER's magnetometer will look for deviations from the field that a perfect bar magnet would generate. By comparing the observed deviations with those predicted by different dynamo theories, scientists hope to zero in on the model that best explains how the planet's weak field comes about.

"The hardest question to answer is probably the origin of the magnetic field," says Francis Nimmo of the University of California, Santa Cruz.

Inside to out

Researchers do know that Mercury's persistent magnetic field is part of a larger story involving a delicate balance between heating and cooling inside the planet.

On the one hand, an active dynamo requires a source of internal heat to keep the planet's outer core molten. On the other hand, both the MESSENGER and Mariner 10 flybys suggested that the planet has cooled substantially over time. Huge cliffs, or scarps, mark the tops of faults that mar Mercury's surface, meaning cooling has caused the planet to contract like a shriveling raisin.

MESSENGER flybys revealed that the planet has shrunk about one-third more than previously estimated, pointing to a higher rate of cooling. Accounting for both the internal heating required for the dynamo and the cooling revealed by the scarps "has been a conundrum that's interested me since Mariner 10," says Solomon. MESSENGER's examination of the scarps from orbit "will provide us with a story not only on the amount of the shrinkage of the planet but when it happened relative to other geological processes — the whole history of cooling."

The rate and timing of the cooling should also hold clues to how Mercury's outer core retains enough heat to remain molten and thus keep the dynamo and magnetic field alive.

Though Mercury's active magnetic field sets the pockmarked planet apart from Earth's moon, the two bodies share some secrets: Both may possess pockets of frozen surface water and therefore hold clues to the abundance of water in the solar system.

Like some areas of the moon, some of Mercury's craters lie in permanent shadow and may be cold enough to trap ice deposits delivered by asteroids and meteorites over millions to billions of years. Radar studies from Earth have already suggested the presence of frozen water, and MESSENGER will seek confirmation by looking for a signature of hydrogen in the polar regions.

Finding ice on the planet closest to the sun would further feed the blaze of renewed interest that MESSENGER has ignited in Mercury. After presenting scientists with a storehouse of new knowledge, the spacecraft will end its mission on March 18, 2012 — unless NASA decides to extend the craft's tour for an additional year.

Encores aside, MESSENGER will run out of fuel in a few years and crash into Mercury's surface, melding with the planet it will have so thoroughly explored. ■

Explore more

- Visit the MESSENGER mission website at messenger.jhuapl.edu

Let Them Eat Shrimp: The Tragic Disappearance of the Rainforests of the Sea

Kennedy Warne

For anyone wondering just what the heck "rainforests of the sea" might be, they're the world's largely unsung, highly imperiled, biologically fabulous coastal forests of mangroves. And it's a telling point that the word *mangroves* does not appear on the cover of a book devoted to their marvels and troubles.

Rainforests of the land evoke a lot more international concern, and Warne includes in the last chapter of his vivid and pithy book a vignette of a scientist glooming about the undeservedly low public profile of mangroves. Warne's book sets out to remedy this, but it's far from mere lecturing. Warne, founding editor of *New Zealand Geographic*, visits mangroves around the world and lets what he sees and the people he meets make their own case. The book is a travelog with attitude.

Warne explores mangroves and their creatures from tigers to (possibly) fishing monkeys. His travels take him to places where the rising demand for coastal areas for aquaculture, particularly shrimp farming, has wiped out mangroves. One farmer tells Warne how aquaculture income let him educate his children, but the cost of such ventures hangs heavy in drinking-water wells now ruined with saltwater and land too salt-tainted to grow food. Warne finds hope too, in restoration projects and a complex but encouraging example of Tanzanian villagers struggling to balance competing local opinions in managing mangroves.

Even armchair travelers play a role in mangroves' fate, Warne says. Ninety percent of shrimp for sale in the United States is imported, and two-thirds of it comes from farms. A good start, he says, would be asking where your next shrimp comes from. —*Susan Milius*

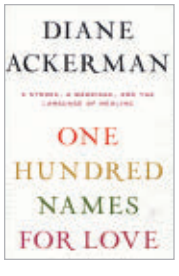
Island Press, 2011, 166 p., $25.95.

One Hundred Names for Love: A Stroke, a Marriage, and the Language of Healing

Diane Ackerman

In this personal account of a stroke's devastation on the brain, a nature writer chronicles her husband's battle to recover his lost words.

One day, a clot lodged in the brain of Paul West, a professor, poet and novelist. The stroke left West, a man with a biting wit and a deep intellect, able to mutter only one syllable over and over: "Mem, mem, mem."



Ackerman carries readers along as her husband confronts his aphasia. She describes the science—part neuroscience, part cognitive science and part intuition—of figuring out what was damaged in West's brain and how to fix it. In one memorable scene, renowned neurologist Oliver Sacks, a friend of the family, comes to visit and coaxes West—who can barely speak—to sing "Happy Birthday" and "Jerusalem."

On his road to recovery, West becomes a "king of malaprops and a geyser of neologisms," Ackerman writes. His neural hiccups—saying "skellington" instead of skeleton, and calling a computer a "light dancing mailbox"—reveal the idiosyncrasies of the brain. Ackerman leaves the impression that the brain, and particularly one holding such vast verbal stores, has an astounding capacity to heal.

At times, the scientific descriptions lapse into generalizations and oversimplifications, losing the nuances and precision of brain research that scientists are still struggling to understand. But Ackerman's powerful narrative, compelling subjects and imaginative, lively writing more than make up for those occasions. —*Laura Sanders*

W.W. Norton, 2011, 322 p., $26.95.

The Information

James Gleick

The story of information itself takes readers on a ride through history, from the first alphabet to the bits and bytes of the modern Information Age. *Pantheon, 2011, 526 p., $29.95.*

The Cloud Collector's Handbook

Gavin Pretor-Pinney

For weather buffs or anyone who has hunted cloud animals, this clearly written guide to the skies makes a game of spotting the many kinds of clouds. *Chronicle Books, 2011, 143 p., $14.95.*

Quantify!

Göran Grimvall

A fun survey of the use of numbers to make sound judgments, from gravity's effects on sports records to statistical analysis of the weather. *Johns Hopkins Univ. Press, 2011, 218 p., $25.*

Driven to Extinction

Richard Pearson

A scientist examines how species have reacted to past climate shifts and how organisms may respond in the future. *Sterling, 2011, 263 p., $22.95.*

The Great Sperm Whale

Richard Ellis

A rich exploration of the evolution and biology of this giant sea creature. *Univ. Press of Kansas, 2011, 368 p., $34.95.*

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Ain't got the beat

Obviously, Bruce Bower hasn't tried to teach tourists how to dance. "A man oblivious to music's tempo" (*SN: 3/26/11, p. 9*), though not common, is not rare. In the last 35-plus years I've shown more than 10,000 visitors to New Orleans how to do the Cajun two-step or waltz, and perhaps 1 to 2 percent exhibit "beat deafness." In spite of the music's strong beat, I have run into one or two a month who are not blessed with even the slightest sense of rhythm. I do refrain, however, from asking them to be included in a neurological study.
Ben Rauch, Chatawa, Miss.

Regarding "A man oblivious to music's tempo": I have never been able to dance or skate to the music. My partners would say, "Move with the beat," and "You're not keeping time." I would ask them to explain what they meant by "the beat" and never got a decent answer. The condition has never been a problem (to me). In fact, I never thought I had a problem!
Don Wilfong, San Ramon, Calif.

When my wife shared your article with her fellow music teachers, it drew peals of laughter. One by one they responded with, "They don't know Jonathan," "They've never met Heather," et cetera. While thankful that true "beat deafness" is not common, each has dealt with this with one or more students.
Jim Hogan, El Sobrante, Calif.

The next pollinators

I read "Backup bees" (*SN: 4/9/11, p. 18*) with great enjoyment. The article mentioned planting alternative forage for blue orchard bees near almond orchards. This is good. However, most industrial farms practice extensive monoculture (miles of the same crop), where there is no alternate forage for any pollinator, native or nonnative. Without a variety of food blooming at different times, any insect pollinator in the area will have a short, troubled life.

Alternative pollinators can, and should, be found to honeybees. More important, new methods of agriculture that provide a variety of food sources for pollinators must be developed, or we are all in a lot of trouble.
Karen E. Bean, Maple Falls, Wash.
Bean is a beekeeper at Brookfield Farm Bees & Honey Inc.

Excellent point. The smaller farms benefiting from wild pollinators that I mentioned had good bee habitat nearby. And without thoughtful farming, domesticating new pollinators could mean nothing more than exposing more species to the disease risks, pesticide exposures and habitat problems that honeybees often face now. —Susan Milius

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Marketplace

From the Archive

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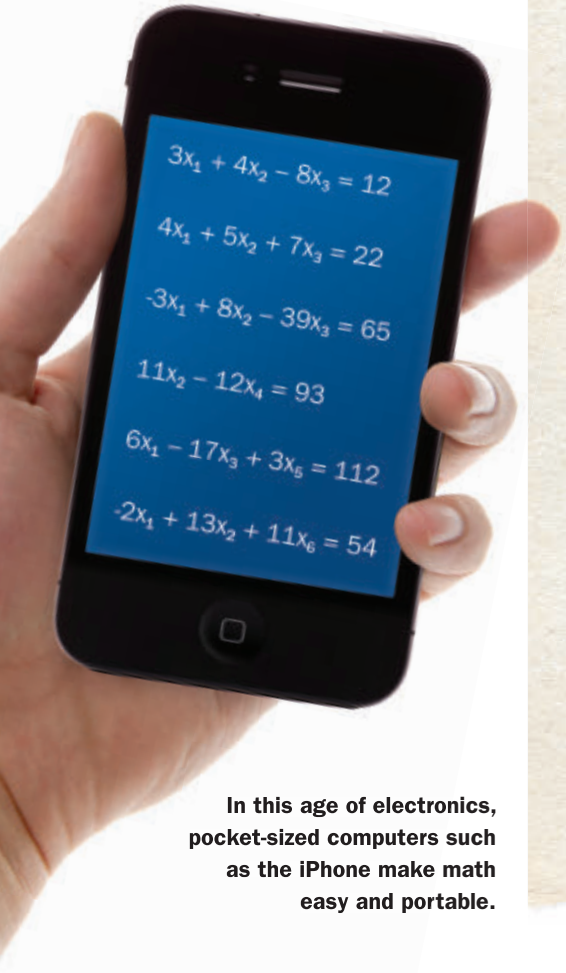

In this age of electronics, pocket-sized computers such as the iPhone make math easy and portable.

Robot Mathematician Solves Nine Simultaneous Equations

A ONE-TON machine that in a single action can solve nine simultaneous equations with nine unknowns so complicated in form they might well require days of laborious computation by trained mathematicians has been developed at the Massachusetts Institute of Technology. Known as the simultaneous calculator, the machine is the product of three years' research by Dr. John B. Wilbur of the department of civil engineering. Cooperating with him has been Dr. Vannevar Bush, vice-president of technology and dean of engineering, who under the Institute's program to eliminate delay and complications in engineering and research, has previously made important contributions to the mechanical solution of mathematical problems, including the famous differential analyzer. The simultaneous linear algebraic equations solved by the new machine occur constantly over a wide range of engineering and scientific analyses. Thus although the calculator was originally designed for the solution of problems in civil engineering, such as those involved in the construction of skyscrapers, it is expected to prove equally useful in such diverse fields as nuclear physics, geodetic surveying, genetics and psychology. The mathematician will be able to use it for the evaluation of determinants especially and in several other fields, since the machine under some circumstances can solve for even more than nine unknowns. The machine weighs approximately 2,000 pounds and has more than 13,000 separate parts, including 600 feet of flexible steel tape and almost 1000 ballbearing pulleys.

UPDATE

'Robot Einstein' outdone by today's cell phones

One generation's most impressive inventions can over time become another's oddities — rendered obsolete and even cumbersome by more advanced technologies. Such was the case with a mechanical calculator developed by John Wilbur of MIT in the 1930s.

By tilting a series of plates and then making a single movement of the mechanism, Wilbur could solve a system of nine linear equations with nine variables in just a few seconds. Solving such sets of algebraic equations had — and still has — cross-disciplinary appeal, because the technique allows scientists to study complex systems in which many variables depend on each other. At the time, solving for nine variables in this way could take days with a paper-and-pencil approach.

Now, though, a 2,000-pound machine with 1,000 ballbearing pulleys like the one that Wilbur developed is far from necessary. Computers rely on electronics rather than mechanics, and those electronics improve every year. An app available for the iPhone today can solve a system of 200 linear equations with 200 variables in 0.15 seconds. And it fits in your pocket.

As for Wilbur's car-sized machine, it seems to have vanished along with its usefulness. For many years the machine, dubbed "Robot Einstein," sat in a hallway of Building 1 at MIT, home to the department of civil engineering. But the machine was last seen in the late 1950s, and (though a replica has turned up in Tokyo) no one has been able to track down the original's whereabouts. — *Elizabeth Quill*

Vote for future topics
The *Science News* archive includes nearly nine decades' worth of blasts from the scientific past. In future issues, *Science News* will offer readers the opportunity to vote on topics to be updated.

At first and even second blush, you will think this is the famous brand "X" watch that sells for over $1,000. But this is the Rodell-7 Argonaut™ Watch, the last watch you will ever need to buy. And, incredibly, it can be yours for only ~~$129~~ $69 (or even less) – read on!*

Fairy Tales

You may have seen ads telling you of watches of which only a few were laboriously handmade by "little old watchmakers" somewhere in Germany or Switzerland or watches that will lose only one second in a million years (you should live that long!), that wars were fought over them and that recently one of them was sold for over $1 million by one of the great auction houses.

A Unique and Wonderful Watch

We won't insult your intelligence with such fantastic stories. But we will tell you one very important and sobering fact: Virtually all those fancy watches have mechanical movements. And mechanical movements have scores of tiny parts. Their wear and tear are mitigated by jeweled bearings. But that will help only for so long. Ultimately – and that sometimes may be as little as a year – these movements will wear out and that is the end of them. Because it is not possible or practical to repair them you have to throw those watches away or keep them as a reminder of your folly.

The Argonaut™ Watch is powered by the finest Japanese quartz movement. The only moving parts are the hands and the date disk. Nothing will wear out. We guarantee its proper functioning for three years. Once every two years or so, you'll need a new battery. It shouldn't cost you more than $5.

The Watch is of quality solid stainless steel construction. It is as watertight as an oyster. It is tested to 10atm, and that means that it will be water-tight to about 330 ft. It comes with a most elegant stainless steel band that is virtually indestructible.

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So don't let yourself be bamboozled by fanciful tales of watches by "little old watchmakers" and by other nonsense. Buy a watch (or watches) that will last you a lifetime and that you will in all likelihood be able to bequeath to your son or grandson in as good condition as when you bought it, a watch with an accuracy of 2 or 3 seconds per month, a watch that will never need repair, that will let you play with the mermaids and that has a no-questions-asked 3-year warranty. Forget about those $200+ mechanical watches. They are nothing but trouble. Order your quartz **Argonaut™ Watch(es)** today.

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100-Year-Old San Francisco Mint Gold Saved From Destruction

Above: The San Francisco Mint (center) was one of the few buildings left standing after the great earthquake of 1906.

Actual size is 21.6 mm

Over a century ago in 1906, San Francisco was devastated by a massive earthquake. On that date the San Francisco Mint forever ceased production of the historic Lady Liberty $5 Half Eagle gold piece. It was the end of an era for the coin that had been made of 90% fine gold with the famous "S" mintmark since the California Gold Rush. Yet for even those coins that survived the calamity of the terrible 1906 earthquake, an even worse fate lay ahead.

Reserved from Massive Meltdown in 1934

In 1934, U.S. gold coins were officially recalled by the Federal Government and melted down into 100-ounce and 400-ounce gold ingots. An estimated 90% of all the San Francisco Liberty $5 gold coins were lost forever.

Surviving "S" Mint Liberty gold coins, few and far between, are increasingly valued by today's collectors. Now, GovMint.com has authorized the limited release of 100-year-old, "S" Mint $5 gold Half Eagles saved from the San Francisco earthquake and subsequent official U.S. Treasury meltdown. These coins are struck in 90% gold and date between1866 and 1906 (date is our choice). They are collector quality, with a numismatic grade of Extremely Fine. During this limited release, you can get these authentic 100 year old gold coins for as little as $650 each (compare with current advertisements from retail coin dealers of up to $799 each).

The History of The West In Your Hands

The history of the American West lives on in these glittering gold coins. The San Francisco Mint was built during the California Gold Rush and minted gold delivered from the miners. San Francisco and the western states grew out of the gold and silver strikes and the immigrants who came from all across the land to build a new future. The images of Miss Liberty and the American Eagle on each U.S. $5 gold coin symbolize our nation's freedom, strength and faith. These precious and enduring coins are becoming more precious and sought-after with each generation and are a valuable legacy for you and your loved ones.

Order Risk Free Before They're Gone

The supply of 100-year-old San Francisco "S" Mint $5 Half Eagle XF gold coins is limited. Due to huge changes in the value of gold (a 38% increase in the last year alone) no one can predict the future value of this coin. Listed prices cannot be guaranteed and are subject to change without notice. Your immediate action is advised—call toll-free 24 hours a day, 7 days a week.

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