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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ JULY 16, 2011

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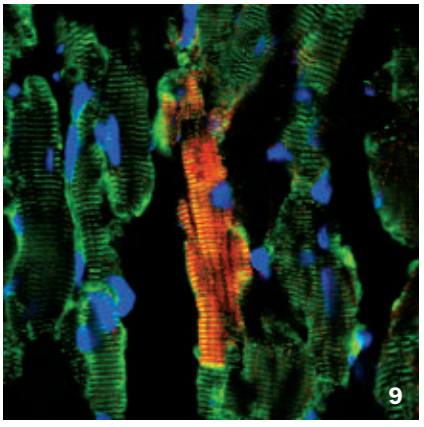

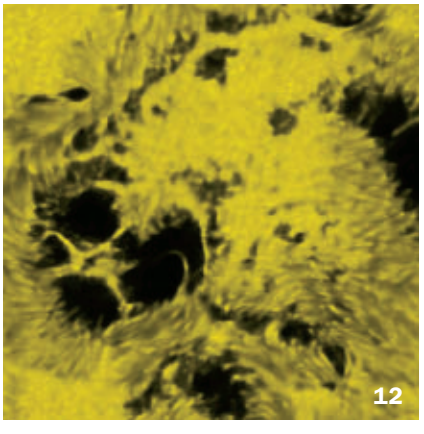

ScienceNews

In The News

Features

Departments

COVER Despite a flurry of work showing health benefits of vitamin D and an increase in the daily recommended intake, scientists still debate how much is enough.
Howard Oates/iStockphoto

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FROM THE EDITOR

Jury still out on vitamin D, without court to report to

Vitamin D is the drug the doctor ordered.

As Nathan Seppa reports in this issue (see Page 22), vitamin D has shown signs of counteracting cancer, heart disease, the flu, high blood pressure and Parkinson's disease (not to mention its well-known ability to build strong bones). Yet despite the vitamin's stellar reputation, most people don't get enough of it. Most diets don't provide vitamin D in substantial quantities. You need to expose your body to sunshine's ultraviolet rays, which trigger chemical reactions that manufacture vitamin D inside your body.

Historically, humans spent lots of time in the sun. But nowadays many people work and play in places the sun never shines, like office buildings and domed stadiums.

Consequently, many experts believe, daily doses of vitamin D ought to be vastly increased. And last fall a panel convened by the U.S. Institute of Medicine adopted higher recommendations for vitamin D intake — 600 international units for most people, substantially higher than the old advice of 200 units. But not, some observers say, substantially enough.

In fact, the panel's report has been ridiculed by some leading vitamin D researchers for ignoring much of the evidence of the multiple benefits the vitamin could confer at higher doses. Panel members argue that such evidence is circumstantial, lacks demonstration of cause and effect, and might be wrong.

Debates of this nature revive an old idea that never goes anywhere — the establishment of a science court.

Various government agencies, scientific societies and independent research bodies issue edicts from time to time on scientific questions and their policy implications. Individuals or groups who don't like the edicts dispute them and try to spin the evidence in a different direction. But there is no body to adjudicate the controversy on scientific grounds. When lawmakers eventually enact policies, the science is always diluted by politics. A science court — composed of distinguished and accomplished researchers — could render a range of verdicts, from "one side is all wet" to "evidence leans one way, but more research is needed."

Probably such a court is a bad idea, or there would already be one. But maybe it could be formulated in a way that would be useful to a society paralyzed by controversies. All things considered, having a science court should be no more controversial than the best recommendation for daily intake of vitamin D. — *Tom Siegfried, Editor in Chief*

JIM WEBB

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"New medical alarm can save you money …and save your life!"

The Designed For Seniors® MedicalAlarm provides emergency notification that is simple, reliable and affordable. It's simply the best value on the market today.

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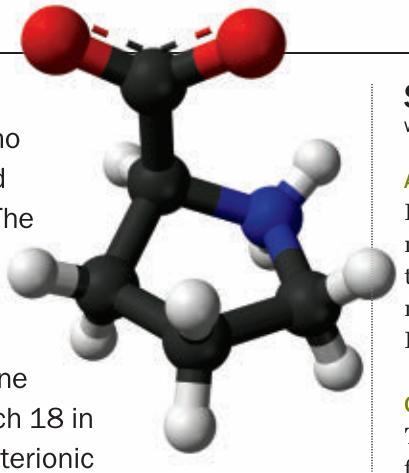

zwitterion *tsvih-tehr-EYE-ahn*\ ***n.*** A molecule with no overall electric charge but which has positive and negative charge at distinct locations within itself. The term comes from the German *Zwitter* for "hybrid" (some prefer "mongrel" or "hermaphrodite") and *ion*, a charged atom or atoms. Amino acids are often zwitterionic; the zwitterionic form of proline is shown. German researchers report online March 18 in *Environmental Science & Technology* that two zwitterionic compounds commonly used to control pH levels in experiments with ferrous iron, which is important in the breakdown of pollutants in aquatic environments, may in fact influence the chemical reactions being studied. The authors suggest that such compounds may help control the reactivity of mineral surfaces in aquatic environments.

Science Past | FROM THE ISSUE OF JULY 15, 1961

CERAMICS PROVED BEST FOR POWER GENERATORS — Ceramics have proved to be the best material for checking the white-hot stream of gases in a new kind of

electric power generators. Westinghouse Electric Corporation scientists, Pittsburgh, Pa., believe ceramics will be superior to iron and steel for magnetohydrodynamic (MHD) electric power generators. They found that ceramics, relatives of those widely used for making bricks, tile and pottery, could be used to line the walls of the MHD generators and to project into the stream of gas that provides the electric power. Magnetohydrodynamic is one of the newest methods for direct generation of electricity without using a steam turbine or rotating electric generator.

Science Future

July 23–24
Learn the secrets of bubbles at the 6th Annual Bubble Days at Baltimore's Maryland Science Center. Go to www.mdsci.org

July 27
Explore the science behind athletics from basketball and cycling to ballet's toe balancing, in Portland, Ore. Ages 21+. See www.omsi.edu/afterdark

July 30
Stargaze with Smithsonian and amateur astronomers near Paris, Va. Go to www.nasm.si.edu/events

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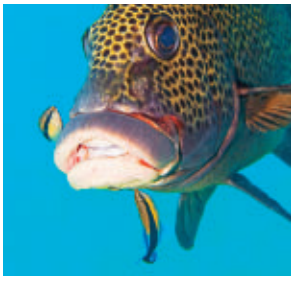
ATOM & COSMOS
Researchers finally detect muon neutrinos switching to electron neutrinos, plus more updates in "News in Brief: Atom & Cosmos."

GENES & CELLS
Triggering sleep in fruit fly brains turns the bugs' short-term memories into long-lived ones. Read "From Z's to A's."

LIFE
Male cleaner fish punish females when they scare big clients away (two cleaners and their client shown). Go to "News in Brief: Life."



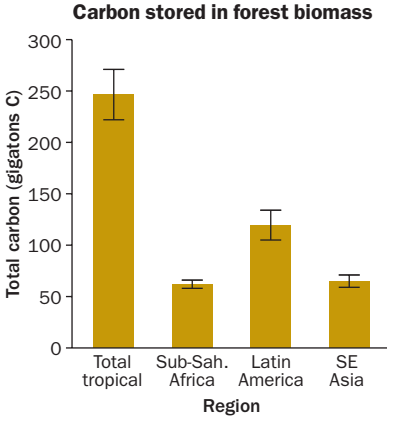
EARTH
Japan's monster wave also sent glowing air ripples over Hawaii. Read "Tsunami lit up the heavens."

CLOCKWISE FROM TOP LEFT: BEN MILLS/WIKIMEDIA COMMONS; JOÃO PAULO KRAJEWSKI; T. DUBÉ

Science Stats | CARBON CENSUS

Tropical forests in Latin America, sub-Saharan Africa and southeast Asia contain about 250 gigatons of carbon in their biomass, scientists estimate as part of ongoing efforts to curb deforestation. Latin America's share of that stock is nearly double the carbon in the other regions' biomass, they note.

SOURCE: S.S. SAATCHI *ET AL/PNAS* 2011



For Daily Use

Babies may be predisposed to ear infections if they're exposed to certain combustion and industrial by-products while in the womb. The results come from Japanese researchers reporting in the May *Environmental Research* who have linked prenatal exposure to dioxin-like compounds — chemicals coming from sources such as forest fires and waste burning — to an increased risk of ear infections, particularly among boys. Of the 364 children the scientists followed from before birth to 18 months of age, kids in the highest exposure group had five times the risk seen among the least exposed infants, the scientists report. All the babies were born in the city of Sapporo, where environmental pollution levels are deemed relatively low.

“It’s like working out the shape of a water wave by moving a light around and measuring the wave’s shadow on the bottom of the pool.” —JEFF LUNDEEN, PAGE 14

In the News

STORY ONE

Crash landing ends up mission accomplished

Wrecked probe yields data about the early solar system

By Alexandra Witze

Scientists had to pick through the debris of the September 2004 Genesis crash in Utah to extract clues about the chemistry of the early solar system.

NASA

It took seven years and a lot of picking through the Utah sand with tweezers. But scientists have finally accomplished the top goal of NASA’s Genesis mission, which flew into space in 2001 to gather particles streaming from the sun but crashed while returning them to Earth in 2004.

After painstakingly gathering and analyzing the shards, researchers say that Earth’s chemistry is not like the sun’s. Compared with the sun, the planet is enriched in two types of oxygen and one type of nitrogen, two teams report June 24 in *Science*.

“The big thing is that the planets around us are so different from the sun,” says Donald Burnett, a cosmochemist at Caltech and the Genesis project leader. “We have uncovered something very fundamental about how the Earth as a planet evolved.”

Nearly 4.6 billion years ago, the sun and then the planets formed out of a swirling disk of gas and dust. Because everything started from the same raw materials, scientists have assumed objects in the inner solar system would share the same chemistry. But in the 1970s, researchers discovered evidence that something must have altered the solar system’s chemical composition during that early era. Analyses of certain meteorites revealed that they had different proportions of oxygen isotopes compared with Earth rocks.

Isotopes are variations of chemical elements that have differing numbers of neutrons in the atomic nucleus. Oxygen-16, for instance, has eight protons and eight neutrons, whereas oxygen-17 has eight protons and nine neutrons.

“We need to know what was the average starting composition of the oxygen in the solar system,” says Kevin McKeegan, a cosmochemist at UCLA and leader of the team that analyzed the Genesis oxygen data. “If we knew where we started from, then we could better understand what happened.”

Because scientists can’t send a sample-return mission smack into the sun, the next best thing is to study the solar wind, a flood of charged particles that streams off the sun and presumably shares its chemistry. So after its 2001 launch, Genesis flew to a point upstream of Earth and gathered solar wind particles in collectors situated like a car windshield in a cloud of bugs.

After more than two years collecting samples, the mission was supposed to parachute gently home to the U.S. Army’s Dugway Proving Ground in Utah. But the chute failed to open and the capsule containing the samples plunged to Earth, crumpling on impact. The science canister inside burst open, and particles collected pristinely in outer space were exposed to all the grime on Earth.

“If you must crash a spacecraft, the best planet to crash it on is the Earth,” Burnett says. “Here you can go pick up the materials.”

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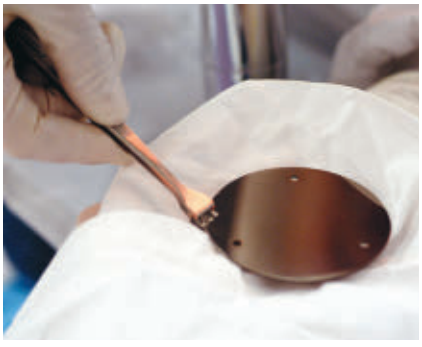
And pick them up scientists did. At first it wasn't clear whether they would be able to remove all the dirt contaminating the Genesis pieces, but lab technicians invented new ways to scrub the shards clean.

Researchers began publishing a slow but steady stream of papers on solar wind chemistry, including some showing that the sun and the Earth contain different amounts of the noble gases neon and argon. But the mission's main targets, oxygen and nitrogen, took more time because of the possibility of contamination from Earth, where oxygen and nitrogen are far more common than the noble gases.

To remove the polluted bits from one set of samples, McKeegan's team at UCLA stripped off the top layer of an unbroken collector crystal. Careful chemical analysis showed that Earth is about 7 percent richer in oxygen-17 and oxygen-18, relative to oxygen-16, compared with the sun.

At Nancy-Université in France, a team led by Bernard Marty compared nitrogen-14 and nitrogen-15 in the solar wind particles with Earth's atmosphere. Even more than oxygen, the amounts of different nitrogen isotopes vary dramatically across the solar system. Marty's team reports in *Science* that solar nitrogen looks a lot like that in Jupiter's outer atmosphere and not much like Earth's nitrogen at all. In fact, the sun is about 40 percent poorer in nitrogen-15 compared with Earth's atmosphere.



Despite a very hard landing, this metallic-glass solar wind sample collector was in pristine condition after being removed from its canister.

Scientists don't know exactly how the sun got a different chemistry from Earth (and, presumably, the rest of the inner planets). But one leading theory fingers the strong ultraviolet radiation that streamed off the newborn sun. That radiation could have caused molecules containing oxygen and molecules containing nitrogen to split apart and then form other molecules in the coalescing planetary disk, McKeegan says. Some of those newly formed molecules would have been taken up in the rocky material starting to form the Earth, and thus would carry more of a particular isotope of oxygen or nitrogen with them into the newborn planet.

Both the oxygen and nitrogen work yielded "excellent and important papers," says Andrew Davis, a cosmochemist at the University of Chicago.

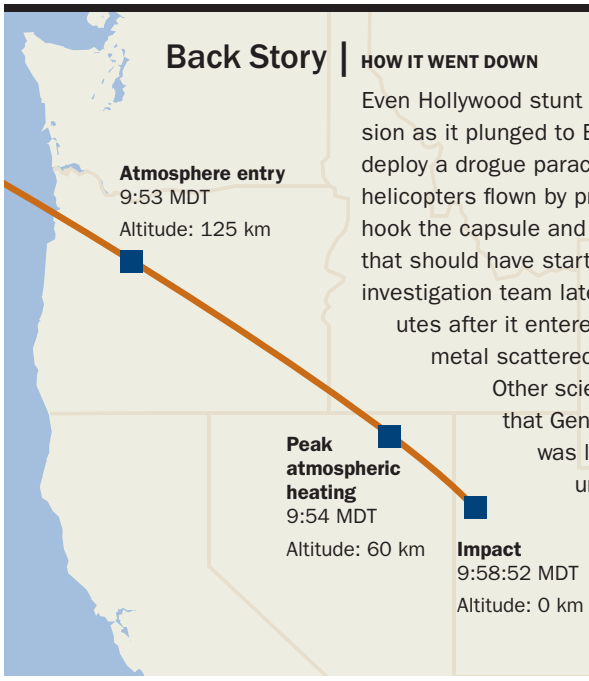
The Genesis team isn't through analyzing the shards of the spacecraft. Burnett says the team is now focusing on magnesium isotopes, which could clarify whether the solar wind changes its chemistry between when it leaves the sun and when it reaches Earth.

"In my terms, we had a list of 18 measurements of things we wanted to do, and we've done about five of them," Burnett says. "My bar is pretty high, and I'm not going to rest." ■

Back Story | HOW IT WENT DOWN

Even Hollywood stunt pilots couldn't save the $264 million Genesis solar wind mission as it plunged to Earth on September 8, 2004. The original plan was for Genesis to deploy a drogue parachute and then a parafoil to slow its screaming re-entry from space; helicopters flown by professional daredevils hired by NASA would have swooped in to hook the capsule and lower it gently to the ground in western Utah. But internal sensors that should have started the drogue deployment had been installed upside down, an investigation team later found—and malfunctioning sensors meant no chute. Just minutes after it entered the atmosphere, Genesis was a haphazard collection of twisted metal scattered across a barren landscape.

Other scientists have experienced the sickening pit-in-the-stomach feeling that Genesis researchers felt that day. In 1999, NASA's Mars Climate Orbiter was lost because of an engineering mix-up between English and metric units of measurement. In 1993, the Mars Observer also disappeared in space, probably because of a rupture in the propellant system. In fact, Mars has been a veritable graveyard of planetary missions; the Soviet Union lost a number of spacecraft there in the 1970s and 1980s.



SOURCE: GENESIS MISHAP INVESTIGATION BOARD REPORT/NASA

TOP: NASA; BOTTOM: GEOATLAS/GRAPHI-OGRE, ADAPTED BY E. FELICIANO

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Loophole in traffic laws challenges current understanding of genetics

RNA wrinkle causes cell's machinery to run through stop signs

By Tina Hesman Saey

Biology's rules may be full of exceptions, but a new discovery has uncovered a violation in a rule so fundamental that geneticists call it the central dogma.

The molecular equivalent of writing one RNA letter in a different font can change the way a cell's protein-building machinery interprets the genetic code, Yitao Yu and John Karijolich of the University of Rochester in New York report in the June 16 *Nature*. They found that occasional conversions of a chemical component of RNA into a slightly different form can cause a cell's protein-building machinery to roll right through a stop sign.

That might seem like a run-of-the-mill molecular traffic violation, but it results in an entirely different protein than the one encoded by the DNA — a clear violation of the central dogma, which holds that DNA is the repository for all genetic instructions in a cell. The tenet declares that those instructions are carefully transcribed into multiple messenger RNA, or mRNA, copies, which are then read in three-letter chunks called codons by cellular machinery called ribosomes. Ribosomes then convert the mRNA instructions into proteins.

Yu and Karijolich studied pseudouridine, a slightly different version of the RNA component uridine. The enzymes that copy DNA to RNA and vice versa can't tell the difference between the two components, but the subtle chemical tweak — akin to writing a letter in a hard-to-read, byzantine font — relays an entirely different meaning to the ribosome, the researchers suggest.

> **"Misplacing a pseudouridine could make things a physiological mess."**
> JUAN ALFONZO

The result is "groundbreaking," says Nina Papavasiliou, a molecular biologist at Rockefeller University in New York City. "It says that we don't fully understand how ribosomes decode RNAs."

That discovery could also mean that genes contain more information than scientists have previously realized, Papavasiliou says.

Pseudouridine is already known to be important for the function of many types of RNA in cells. Yu and Karijolich engineered a system to discover whether mRNAs containing the modified letter might also have a slightly different function than those with plain old uridine. The researchers created a flawed copper-detoxifying gene called *CUP1* that contained a signal to stop making protein early. The team also created a system that would cause yeast cells to edit the mRNA, replacing the uridine in the codon that signals a halt in protein production with pseudouridine. If pseudouridine behaved just like uridine, then cells would prematurely stop production of the detoxifying protein and wouldn't be able to grow in the presence of copper.

Yeast cells that replaced uridine in the stop sign with pseudouridine could grow on copper, the researchers report. Looking more closely, the team found that instead of reading the stop sign as "stop," ribosomes interpreted the pseudouridine-containing codon as an instruction to insert one of the amino acids serine, threonine, phenylalanine or tyrosine into the protein.

That choice of amino acids by the ribosome has biologists reeling, because those aren't even the amino acids usually chosen when the protein factories do occasionally run stop signs.

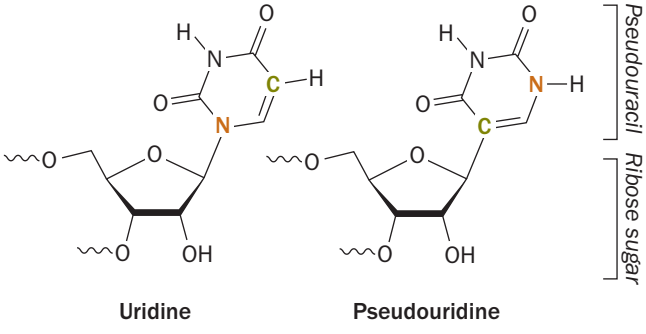
"When you know the literature, you would expect other" amino acids, says Henri Grosjean, a biochemist and geneticist at the University of Paris–South.

Apparently ribosomes haven't read those papers.

Whether pseudouridine plays a part in changing the genetic code in nature remains to be seen, but researchers are betting that it does. The implications for health and disease could be great, says Juan Alfonzo, a molecular biologist at Ohio State University in Columbus. Pseudouridines may be required to make some proteins correctly, but "misplacing a pseudouridine could make things a physiological mess," he says, causing some proteins to have flaws, even fatal ones.

And Yu and Karijolich's technique might be used to fix genetic errors, too. Introducing stop sign–busting pseudouridine into an RNA may one day help people with rare genetic diseases in which one of their genes contains an early stop codon, Alfonzo says. ■

Pseudouridine is a flipped-around, or isomerized, version of the RNA component uridine. A carbon atom, instead of a nitrogen, attaches pseudouracil to its sugar backbone. The change makes the RNA molecule stiffer.



T. DUBÉ

Cardiac tissue can regenerate

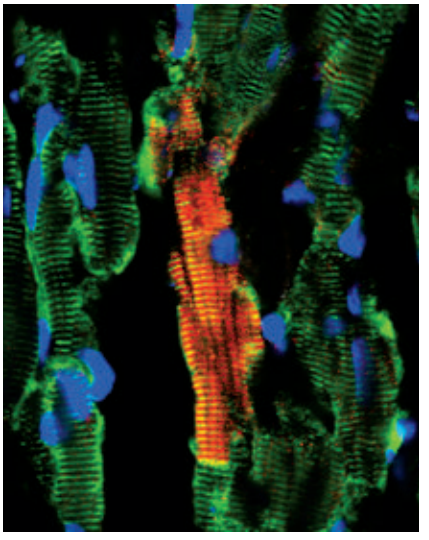
With motivation, stem cells step in after heart attack

By Tina Hesman Saey

Broken hearts may be able to mend themselves.

Given the right biochemical encouragement, stem cells in a layer lining the outside of the heart muscle can replace a small number of cells damaged by a heart attack, an international team reports online June 8 in *Nature*. A protein called thymosin beta-4 can provide just the sort of stimulus needed to turn dormant stem cells into Mr. Fix-its, say Paul Riley, a British Heart Foundation researcher at University College London, and his colleagues.

Previous evidence for the presence of stem cells within heart muscles is controversial, says Deepak Srivastava, a cardiac stem cell biologist at the University of California, San Francisco who was not involved in the study. And stem cells transplanted into hearts often don't integrate correctly, beating out of time with native cells. That's why the new discovery that the lining of the heart has stem cells with self-healing properties is so exciting. "The notion that the heart can regenerate itself is very powerful," Srivastava says.



A newly made heart cell (red) derived from a stem cell in the heart muscle's lining inserts itself into tissue (green) damaged by a heart attack.

Giving thymosin beta-4 to mice after a heart attack has already been shown to have the beneficial effect of helping more heart muscle survive. The new study shows that the protein may not only protect heart cells from further injury but may also generate a few new muscle cells from stem cells in the lining, called the epicardium.

Working with mice, the researchers found that epicardial stem cells need to be primed before they make new heart muscle. Mice treated with thymosin beta-4 for a week before a heart attack produced a small number of new heart muscle cells, but mice given the drug only after a heart attack didn't.

The finding suggests that people who are at high risk of having a heart attack could boost their ability to recover from one by taking stem cell–stimulating drugs beforehand, Riley says. But that approach may not be very practical. For one thing, thymosin beta-4 isn't available in tablet form; it has to be injected. Another drawback is that doctors aren't very good at identifying people in imminent danger of a heart attack, and it's possible that taking stem cell–stimulating drugs for long periods could have dangerous side effects.

But Srivastava bets that in the long run, the right drugs will be able to tear down barriers that keep humans from growing new hearts the way fish and frogs and other amphibians can. "We just need to unleash nature's own potential to repair itself," he says. ■

FROM TOP: P. RILEY/UNIV. COLLEGE LONDON; © *SCIENCE*/AAAS

Blue light to treat diabetes

Scientists have harnessed a light-gathering molecule usually found in the eye to produce a protein that controls blood sugar. Such a strategy could help combat diabetes and some genetic diseases. Starting with human embryonic kidney cells engineered to make a light-sensitive protein called melanopsin, researchers inserted a second gene encoding GLP-1, which governs production of insulin and other proteins that help control blood sugar. Shining blue light directly on a mouse's skin turned on GLP-1 production and brought blood sugar levels back to normal, a Swiss and French team reports in the June 24 *Science*. Martin Fussenegger, a bioengineer at the Swiss Federal Institute of Technology Zurich, wouldn't speculate on how long it might be before light-activated cells are used to treat people with diabetes or other diseases, but says "it's the first step in a new direction for treatment." —*Tina Hesman Saey*

Life

Human-like body temps for dinos

Dental analysis reveals how warm sauropod blood was

By Alexandra Witze

Scientists have done the paleontological equivalent of jamming a thermometer up a giant reptile's rear end. Reporting online June 23 in *Science*, researchers say the huge, four-legged dinosaurs known as sauropods would have registered a body temperature similar to that of any modern *Homo sapiens*.

The work provides perhaps the best glimpse yet at dinosaurs' internal temperature, a key factor in understanding their metabolism. The findings measure some 4 to 7 degrees Celsius cooler than one theory of dinosaur growth has suggested.

Once thought to be cold-blooded and sluggish, dinosaurs got a reputation makeover in the 1960s and 1970s as active, possibly warm-blooded creatures. But scientists still don't agree on exactly how dinosaurs exchanged heat with their surroundings and how warm or cold they might have been inside.

To tackle this question, a research team led by Rob Eagle of Caltech decided to look at sauropods, the biggest land animals that ever lived. Eagle's adviser, John Eiler, had invented a way to tease out body temperature by studying the number of chemical bonds formed between rare versions of carbon and oxygen in growing teeth and bone. More of those bonds form at lower temperatures, so fossilized teeth can reveal how warm it was inside the living animal.

Eagle's team analyzed teeth of several sauropod species excavated in Tanzania, Oklahoma and Wyoming. The creatures' internal temperatures clocked in between 36° and 38° Celsius. That's warmer than cold-blooded creatures like crocodiles, cooler than birds, and just about the range of modern mammals.

Tallying bonds between certain oxygen and carbon atoms in this fossilized tooth helped determine the body temperature of a dinosaur called *Camarasaurus*.

Other scientists have suggested that sauropod body temperature could have reached 40° or even higher, simply because of the sheer amount of the dinosaurs' flesh. The new work fits with other recent evidence suggesting that sauropods and modern mammals were about the same temperature, says Luis Chiappe, a paleontologist at the Natural History Museum of Los Angeles County.

Female infidelity may be inherited

Hints of 'cheating gene' passed down by philandering dads

By Susan Milius

A study of infidelity among hundreds of captive zebra finches shows that philandering tendencies can be in part inherited, says Wolfgang Forstmeier of the Max Planck Institute for Ornithology in Seewiesen, Germany. The study also reveals a partial link between male and female philandering genes that may help explain how female infidelity evolves, Forstmeier and his colleagues say online June 13 in the *Proceedings of the National Academy of Sciences*.

The benefits of infidelity for male zebra finches (left) might favor genes that can make a female (right) stray too, even if it lends her no reproductive advantage.

Just why infidelity arises in females of apparently monogamous species has ruffled feathers among biologists for years. Philandering by males is easy to explain: More quick flutters in the shrubbery mean more offspring in the next generation. But that explanation doesn't work so well for females: They often produce the same number of youngsters regardless of whether there's one father or a dozen.

An idea proposed 24 years ago suggests that there doesn't have to be any benefit to philandering females. They may simply inherit "cheating genes" that arose among male ancestors who did benefit by playing the field.

Testing the idea has been very difficult since doing a proper experiment requires knowing an awful lot about animals' private lives. Researchers filmed and monitored paternity for five generations of birds, for a total of 800 males and 754 females. The researchers switched many of the chicks from their original nests and determined that nature, not nurture, was influencing finch sexual behavior. And the scientists painstakingly documented who mated with or rebuffed whom.

The new finch study "is very, very good," says evolutionary biologist David Westneat of the University of Kentucky in Lexington. "I am still a bit skeptical that this will be of widespread importance, but we definitely need to consider this hypothesis about genetic correlations more seriously than before."

FROM TOP: THOMAS TÜTKEN/UNIV. OF BONN; W. FORSTMEIER

2.1 billion years | Age of oldest fossil evidence for multicellular life

3.85 billion years | Age of oldest geochemical evidence for life

Multicellular life arises in a test tube

Evolution experiment pushes one-celled yeast to go multiple

By Susan Milius

Since humankind missed the big moment the first time around, biologists studying the origins of complex life have coaxed single-celled microbes to evolve multicellular forms capable of reproduction.

Common lab yeast normally live as single cells that bud off single-celled offspring. But challenging generations of yeast with conditions that make solo life tough led to spiky multicelled yeast forms within about two months, said Will Ratcliff of the University of Minnesota, Twin Cities.

The experiment suggests going multicellular may happen more readily than previously thought, Ratcliff reported June 18.

"It was certainly the buzz of the conference," said Lee Dugatkin of the University of Louisville in Kentucky.

Evolutionary biologists rank the shift from one to many cells — which probably happened multiple times over the course of evolution — as a major transition in the history of life.

"To be able to examine it experimentally, in real time, in the lab, is extremely exciting," Dugatkin said.

To provoke evolution in a test tube, Ratcliff and his colleagues put liquid suspensions of yeast cells through a daily ordeal. Every tube of cells got a mild centrifuge spin. Then the researchers saved a fraction of the sludgier part of each tube and — life is hard — tossed the rest.

That regimen ensured that any change in the yeast that happened to encourage settling, such as a shift toward heavier bodies made of multiple cells, promoted survival.

Under these conditions, yeast lineages that retained budding daughter cells rather than splitting them off were more likely to make it through each daily decimation. Those buds in turn retained their own buds, creating bristly multicellular organisms the researchers call yeast snowflakes (because that's what they look like).

These snowflakes reproduced by fracturing into smaller pieces that eventually grew and fractured themselves. The researchers even saw hints of a reproductive division of labor, Ratcliff said. Some snowflake cells undergo programmed cell death, or apoptosis, and the resulting weak spots appear to serve as fault lines where babies flake off.

To see if yeast snowflakes evolve the way true multicelled creatures do, the researchers created another version of the settle-fast-or-else challenge that varied in severity. Snowflake lineages receiving the harshest treatment responded dramatically, becoming twice as large as their ancestor snowflakes. Lineages under gentler treatment got smaller.

That distinction shows that the yeast snowflakes respond to evolutionary pressure as whole, multicellular organisms, Ratcliff said.

Such tests take the yeast snowflakes further than 1998 research that coaxed a microbe into a clumpy form, but didn't describe a shift in level of evolutionary response.

The yeast experiment doesn't exactly constitute starting from scratch when it comes to the evolution of multicellularity, cautions Adam Waite, who studies cooperation among yeast at the University of Washington in Seattle, because today's single-celled yeast actually evolved from long-ago multicellular ancestors.

Dugatkin doesn't find that a drawback, however. Whether the yeast take the same path to multicellularity today as the first multicelled organisms did billions of years ago, he said, makes a fascinating question in itself. ■

MEETING NOTES

Climate for divorce

Temperature and precipitation play a role in infidelity and divorce — at least among birds, says Carlos Botero of the National Evolutionary Synthesis Center in Durham, N.C. This isn't about mates getting on each other's nerves during bad weather, but about local climate affecting the success of raising chicks and of different approaches to family life. Botero and Dustin Rubenstein of Columbia University combined records of bird mating habits with data from weather stations near the mating study sites. In an elaborate analysis, researchers found that more variable climate favored both larger numbers of nestlings sired by males other than the nesting partner and more switching of nesting partners. The effect was modest for infidelity but greater for divorce. —*Susan Milius*

Scrub jay funerals

Western scrub jays mark the deaths of other species of birds in addition to their own by gathering in big, loud crowds, reports Teresa Iglesias of the University California, Davis. Biologists have documented only a few animals reacting dramatically to corpses from their own kind, and Iglesias and her colleagues are testing the jays to explore animal communication of risk. Researchers have studied alarm calls at the sight of predators, but a dead body could, in theory, convey information about risks too, if animals react to it. In tests, scrub jays clustered near dead jays and, with some differences, around deceased birds of other species, including pigeons and some species from other continents. —*Susan Milius*

Atom & Cosmos

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Next solar cycle may be a no-show

Studies suggest sun may be headed for decades of dormancy

By Ron Cowen

Already sluggish, the sun may be slipping into several decades of hibernation that could exert a cooling effect on Earth's climate, several new studies suggest.

During the last extended period of solar dormancy, from 1645 to 1715, Europe plunged into some of the coldest winters on record. But Earth's atmosphere, which now contains an abundance of greenhouse gases, differs in composition compared with three centuries ago, and solar physicists say they're unsure how a long solar hiatus would affect the planet's 21st century climate.

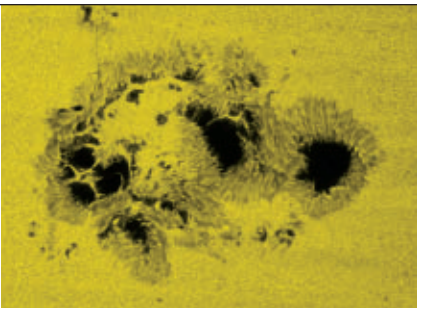
It's also possible that the beginning of the next 11-year solar cycle — which is marked by the emergence of dark blemishes called sunspots at high solar latitudes — may simply be delayed by a few years, rather than shut down for decades.

Three teams presented their results June 14 at a meeting in Las Cruces, N.M., of the American Astronomical Society's Solar Physics Division. The scientists base their findings on multiple observations of the sun's outer atmosphere and visible surface as well as the movement of magnetic fields inside it. The sun's 11-year cycle is governed by flows of hot gas, or plasma, that transport parcels of the solar magnetic field.

The evidence "all indicates that the next solar cycle will be delayed by two to five years," but that a longer break is possible, says Dean Pesnell of NASA's Goddard Space Flight Center in Greenbelt, Md., who didn't participate in the studies.

Frank Hill of the National Solar Observatory in Tucson and colleagues used ground-based detectors to monitor changes in the solar surface due to the reverberation of sound waves inside the sun. These solar sonograms previously revealed an east-west flow of material deep inside the sun that presaged, years in advance, the onset of the last two solar cycles. But the flow preceding the next solar cycle, which the team expected to see in 2008 or 2009, still isn't there.

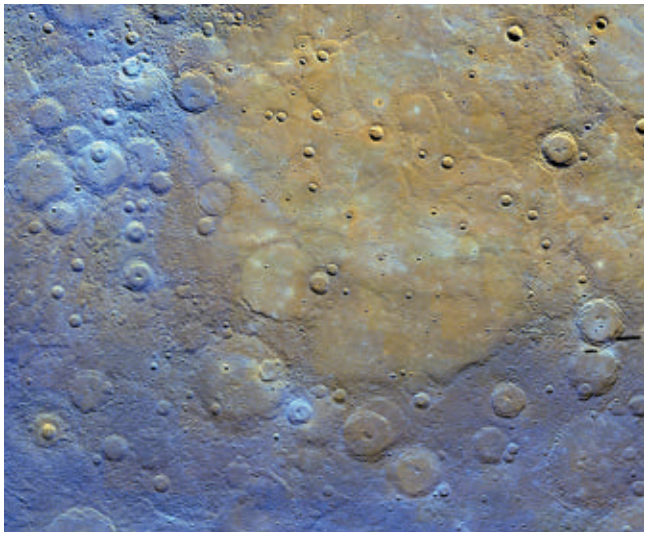
In a second study, Richard Altrock of the National Solar Observatory in Sunspot, N.M., and colleagues mapped the distribution of highly ionized iron atoms in the sun's outer atmosphere. The distribution of these ions acts as a tracer for the movement of magnetic fields in the sun.



Sunspots like these could disappear for decades if the sun goes into long-term hibernation, as some now predict.

Near the peak of a solar cycle, the magnetic field at the sun's poles reverses direction, with the old field erased by the new, oppositely directed field. But the current delayed cycle may not be strong enough to fully erase the old field. The findings suggest that this cycle's solar maximum, predicted to occur in 2013, may be weak or not occur at all.

A third study finds that the strength of the magnetic fields that produce sunspots has declined over the past 13 years. If that continues, the blemishes could disappear around 2022, says coauthor Matt Penn of the National Solar Observatory.



Mercury's messages

Mercury's composition makes it unique among the solar system's rocky planets, data from NASA's MESSENGER spacecraft reveal. Released June 16, the craft's images of the northern plains (shown) suggest that massive volcanic eruptions sculpted the region some 3.7 billion years ago, burying craters under kilometers of lava. Some craters on the sunbaked planet are chilly enough to hold frozen water. From new measurements of polar craters, scientists have confirmed that some of the craters' floors never receive sunlight and could contain water ice, as hinted at by reflective zones observed by Earth-based radar. MESSENGER also detected surprising amounts of sulfur and potassium — elements thought to have largely evaporated during Mercury's hot formation or soon after. "This is changing our view of the origin of Mercury," says Larry Nittler of the Carnegie Institution for Science. — *Ron Cowen*

FROM TOP: NSO; NASA, JHU APL, CARNEGIE INSTITUTION FOR SCIENCE

Earth

0 mm/year | Sea level rise in North Carolina, 100 B.C.–950

0.6 mm/year | Sea level rise in North Carolina, 950–1400

2.1 mm/year | Sea level rise in North Carolina, 1880–1920

Sea level has risen an average of 2.1 millimeters a year along the North Carolina coast since the late 19th century.

A. KEMP/YALE UNIV.

Marsh sediment analysis reveals fastest sea level rise in 2,000 years

Core samples show rapid increase starting in 19th century

By Janet Raloff

Sea levels began rising precipitously in the late 19th century and have since tripled the rate of climb seen at any time in at least two millennia, a detailed analysis of North Carolina marsh sediments reveals.

"This clearly shows the recent trend is not part of a natural cycle," says Ken Miller of Rutgers University in Piscataway, N.J., who was not associated with the analysis.

Andrew Kemp of the University of Pennsylvania and his colleagues spent five years plumbing salt marsh sediments that had remained largely undisturbed for thousands of years. Kemp, now at Yale, and his team drilled cores at two sites, unearthing the microscopic remains of single-celled shelled organisms known as foraminifera.

Foraminifera vary in their salt tolerance. So as the sea level changed over millennia, so did the mix of species living at any given site, explains coauthor Benjamin Horton of the University of Pennsylvania. Knowing the modern-day distribution of foraminifera at various water depths along the modern-day coast, the researchers could infer past sea levels at the two core sites from the abundance of different species in successive sediment layers. Radioisotope dating showed that the sediments recorded 2,100 years of sea level history, the researchers report online June 20 in the *Proceedings of the National Academy of Sciences*.

"We know what sea level has done, in a broad sense, going back 20,000 years," Miller says. But detailed records of what's happened over the past 2,000 years have been spotty, he says.

The cores show that sea level at the North Carolina sites was largely unchanged from 100 B.C. until A.D. 950. Then sea level underwent a four-century rise averaging 0.6 millimeters per year. After another 500 years of stability, sea level began its most recent advance after 1865. Since then, it has been climbing an average of 2.1 millimeters annually. And at least for the last 80 years, Horton says, "the fit with North Carolina tide gauge data is one-to-one: It's perfect."

The results validate the use of general equations relating past temperatures with sea level changes to predict sea level rise as the climate continues to warm, says Aslak Grinsted of the University of Copenhagen's Centre for Ice and Climate.

"What's great about this new record is that it's really high resolution and continuous," Grinsted says, "and quite consistent with records all around the world." ■

NEWS BRIEFS

Ice melt boosts Earth's waistline

Melting ice has changed the shape of the Earth, making it more bulgy at the equator. Satellite measurements between 1975 and 2009 show an unexplained change starting in the mid-1990s. Researchers at the University of Colorado at Boulder have now combined those measurements with data from the gravity-sensing GRACE satellites and report that ice melting off Greenland and Antarctica is to blame. Solid ice near the poles has transformed into liquid water distributed around the planet, the team reports in an upcoming *Geophysical Research Letters*. —*Alexandra Witze*

Mangroves absorbed quakes

Buried remnants of mangrove swamps help soak up the shock of earthquakes, protecting island coasts from damage. A new analysis of a site in the French Antilles suggests that these soft deposits protect the stiffer overlying soil from deforming. The effect is similar to that provided by rubber dampening systems for buildings in earthquake-prone areas, French researchers report in the June *Bulletin of the Seismological Society of America*. —*Devin Powell*

Earth's early core

Long ago, something happened deep inside the Earth. New studies of ancient rocks reveal how strong the Earth's magnetic field was as its liquid core began to cool and solidify. About 2 billion years ago, the difference between the north and south magnetic poles became surprisingly weaker, scientists led by Aleksey Smirnov of Michigan Technological University in Houghton report in an upcoming *Physics of the Earth and Planetary Interiors*. —*Alexandra Witze*

Matter & Energy

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Friction science gets an update

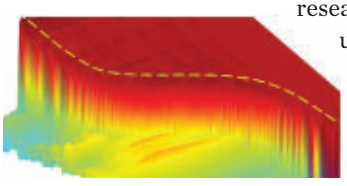
Studies analyze nuances in earthquake stresses, slips

By Devin Powell

By playing with plastic blocks that stick and slip much like rock, physicists are challenging centuries-old ideas about the nature of friction. Seemingly unimportant differences at small scales can have big consequences, an Israeli team reports in an upcoming *Physical Review Letters*.

"If you want to know how hard you have to push a specific object [to overcome friction], and you want to know to high precision, right now we don't know what the answer is," says Jay Fineberg, a physicist at the Hebrew University of Jerusalem.

The force needed to start an object sliding traditionally depends on two things: its weight (and any other downward forces) and a number called the coefficient of static friction. This number is thought to be dictated by the roughness of an object and the surface beneath, as well as the material each is made of; rubber's coefficient is larger than Teflon's on the same surface.



Plastic blocks sliding past each other (red shows most contact, blue the least) illustrate friction at work in earthquake ruptures.

Fineberg and colleagues squeezed pairs of plexiglass blocks together with forces meant to simulate the crush of colliding pieces of Earth's crust. One block was pushed sideways until it slipped, while gauges alongside the blocks measured the stresses building up where the blocks touched. These stresses, the researchers found, tend to be unevenly distributed.

Different ways of pushing and pressing on the blocks can change the coefficient of static friction by as much as a factor of about two, they found.

A dose of reality for quantum math

Canadian team devises direct way to measure wave function

By Devin Powell

The fuzzy quantum shape that describes the physical state of a single particle, its wave function, has been directly measured in the laboratory, giving this mathematical concept a small dose of reality.

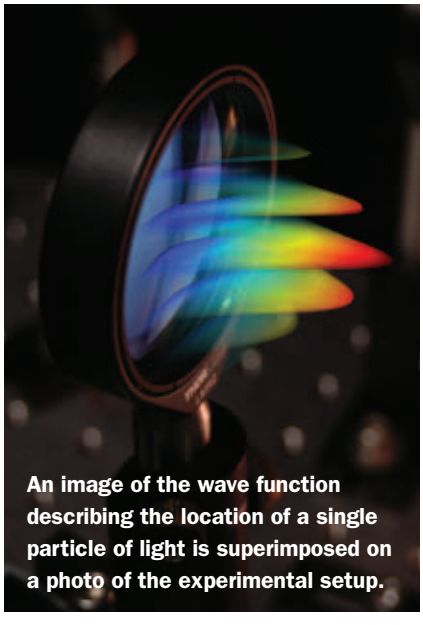
Like a bubble on the breeze, the wave function usually disappears when poked or prodded for information. But scientists in Canada have worked out a gentler way to touch it, they report June 9 in *Nature*.

"Measuring the wave function itself is not ... thought to be a possible thing," says Stanford physicist Onur Hosten. "It's not really thought to be something physical."

This interpretation dates to the 1920s, when physicist Max Born argued that the wave function, represented by the Greek letter psi, is a useful mathematical tool for calculating probabilities for a particle's location or speed. The equation for the wave function is the starting point, for instance, for drawing the colorful shapes in chemistry textbooks that show the probability of an electron being in a certain spatial region.

To calculate a wave function, scientists usually collect lots of indirect measurements using quantum state tomography.

"It's like working out the shape of a water wave by moving a light around and measuring the wave's shadow on the bottom of the pool," says Jeff Lundeen, a physicist at Canada's National Research Council in Ottawa. His team devised a direct interrogation by combining weak measurements, which provide uncertain information but do little damage, with strong measurements, which provide certainty but destroy the wave function. "This doesn't provide any more information than other methods," says Lundeen. "It just gives it to you in a different way."



An image of the wave function describing the location of a single particle of light is superimposed on a photo of the experimental setup.

To demonstrate how this works in the lab, the team measured the wave function for the position of a single particle of light, or photon. The team polarized photons so that the angle of each particle gave a rough idea of its location, leaving enough uncertainty to not disturb the wave function. Eliminating all photons that were moving in one specific direction — a strong measurement of momentum — allowed mapping the wave function using the particles that remained.

Lundeen and colleagues aren't challenging Heisenberg's uncertainty principle, which says that the location and momentum of a particle can't be simultaneously measured. The team had to weakly measure many photons to work out the position information. And all these particles had to be identical, which could limit the usefulness of the technique.

FROM TOP: © *SCIENCE*/AAAS; J. LUNDEEN, CHARLES BAMBER

100 percent | PGA Tour pro's chance of sinking a one-foot putt

50 percent | PGA Tour pro's chance of sinking a 7.8-foot putt

5 percent | PGA Tour pro's chance of sinking a 38-foot putt

Engineered cells alive and lasing

Coherent light generated with green fluorescent protein

By Devin Powell

The first living laser is nothing to be afraid of. It's just a single cell pulsing with light that may lead to new ways of probing microscopic realms.

The secret to the cell's splendor is called green fluorescent protein, or GFP, researchers report online June 12 in *Nature Photonics*.

First discovered in jellyfish, this glowing protein has long helped biologists illuminate cells and their inner workings. When struck by blue light, its electrons essentially jump up and down and fluoresce with green light.

The green light emitted by one GFP molecule can also trigger another GFP molecule to spit out identical green light. Two physicists have now used this phenomenon, called "stimulated emission," to set off the chain reactions required to make laser light from GFP.

"They've shown that you can do lasing action in a live cell without destroying the cell," says physicist Stefan Hell of the Max Planck Institute for Biophysical Chemistry in Göttingen, Germany.

In their first experiment, Seok-Hyun Yun and Malte Gather of Massachusetts General Hospital and Harvard Medical School placed two mirrors close together and filled the space in between with liquid containing GFP. Brief pulses of blue light excited the proteins, which set each other off with help from the mirrors and created pulses of green laser light more intense than the original blue light.

The principle is similar to that of dye lasers, which also amplify light using dissolved organic molecules — not proteins, but compounds such as coumarin dyes, derived from substances in grasses that smell like freshly mowed hay.

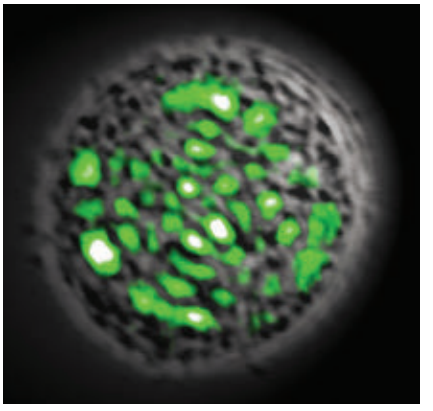
Then the physicists pimped their GFP laser by replacing the free-floating molecules with a single mammalian cell containing a bit of DNA that churns out a mutant form of the fluorescent protein. When stimulated, the cell could pulse with light a few hundred times before the GFP gave out (technically, photobleached).

"The interesting thing here is that the cell keeps making the GFP protein as it grows," says Steve Meech, a physical chemist at the University of East Anglia in Norwich, England. Unlike a dye laser, a living laser could heal itself over time by replacing photobleached molecules.

Other colors should also be possible.

"There are other types of fluorescent proteins found in coral reefs in the sea that might be useful for lasers," says Yun.

Lasing proteins could provide a more sensitive biological tag for identifying molecules inside cells. Changes in the distribution of the proteins within a cell should change the characteristics of the emerging laser light.



A genetically engineered cell creates laser light (green) using green fluorescent protein, discovered in a jellyfish.

Yun and colleagues are also replacing the mirrors with reflective nanostructures inside cells. Such cells might be able to lase from within biological tissue.

M. GATHER

Better putting with geometry

Physicist golfer offers advice on getting ball into the hole

By Devin Powell

A Yale physicist with a lifelong passion for golf has figured out a better way to putt on a slope. Thanks to the geometry of the game, he says, there's a magic spot just uphill of a hole. The trick is to line up the putt not only from where the ball lies, but also from equidistant points nearby. Do that and the sweet spot will reveal itself.

"Many golfers use a mental image of pouring a bucket out on the green and visualize where the water would flow," says Mark Broadie, a researcher at the Graduate School of Business at Columbia University who has developed a new statistic for measuring putting performance.

Robert Grober, an experimental physicist at Yale University, imagines the ball sitting on a circle centered at the hole. At the 12 o'clock position, the ball travels directly downhill along a straight line to find the hole. But a ball hit from, say, 4 o'clock must roll uphill along a curve to reach the hole. Grober calculated these curves from different points on a circle, treating the green as a tilted flat surface and taking into account the pull of gravity and the resistance of the grass.

These curves can't be calculated on the fly by golfers on the links — players have to rely on instincts, not computers. But every curve can be achieved by aiming along a straight line at a particular area just uphill of the hole. The trick is to find that spot. Grober drew these straight lines from different points along the circle and found that they come together at almost exactly the same place.

"No one is used to thinking about all of these putts having the same target line," says Grober, who reported his results online at arXiv.org on June 9.

Molecules

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Soft tissue may have been dino's

Study supports claims of 80 million-year-old collagen

By Rachel Ehrenberg

Reports in recent years of soft dinosaur tissue from fossil bones of a *T. rex* and a duck-billed hadrosaur elicited skepticism from the scientific community. But a new analysis of the bits of protein in question supports their ancient origins.

The same collagen molecular building blocks extracted from the dinosaur fossils are found in sheltered portions of collagen fibers that, in rats and humans, are tucked away and so are perhaps less susceptible to degradation, researchers report online June 8 in *PLoS ONE*.

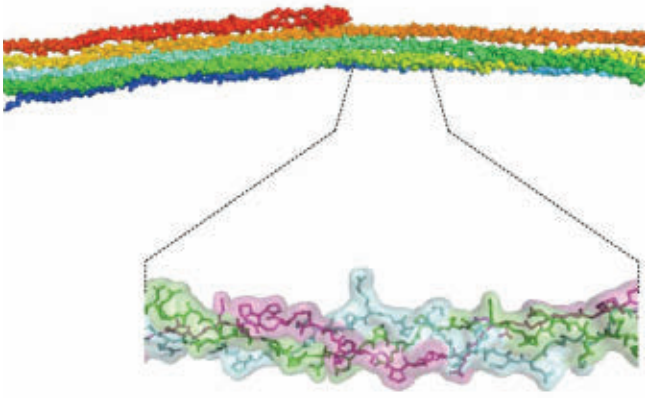
Collagen is known for its role in connective tissue such as tendons, ligaments and skin, but it's also the primary protein in bone. At large scales, collagen fibers look pretty much the same: a triple helix of twisted cords that are further twisted into fives and packed into larger ropes. But in any one section of the molecule, the building blocks differ. The amino acids linked to make the protein aren't the same in all parts of the fiber, and those differences dictate various interactions between the molecule and its neighborhood, says study coauthor Joseph Orgel of the Illinois Institute of Technology in Chicago.

"Most people regard collagen as a structural molecule, but it seems to function as an information molecule as well," Orgel says. "There's a whole constellation of chemical sites that tell cells how to interact with it."

Those chemical characteristics, such as water-loving sections or regions with extra hydrogen bonding, also might make some parts of a collagen molecule more susceptible to degradation than others, Orgel and colleagues reasoned. So they investigated which particular amino acids were strung together in the collagen bits that had been extracted from 68 million-year-old *Tyrannosaurus rex* bones and an 80 million-year-old duck-billed dinosaur fossil. Then the researchers looked at where those particular bits show up in the collagen fibers of rats and humans. All of the snippets mapped to protected internal regions, where they might degrade more slowly than in other sections.

"None are in the exposed area of the fiber," Orgel says. If any collagen could survive millions of years, it would not be a random assortment but the sheltered kinds of molecules that were observed, he says. "We were rather pleasantly surprised and taken aback."

An early critic of the *T. rex* soft-tissue report, Matthew Collins of the University of York in England, says the results are exciting and the approach thoughtful, but he's not convinced yet. The new study used data from the initial disputed reports. "We would like to see lots of samples from lots of labs," he says.



Collagen contains millions of five-stranded ropes (above), each strand a triple helix (below). Possible dino-bone collagen maps to the structure's most protected parts.

J.D. SAN ANTONIO *ET AL*/*PLOS ONE* 2011

A new spin on lengthy nanowires

Kilometer-long fibers are millionths of a millimeter across

By Rachel Ehrenberg

In a feat that puts Rumpelstiltskin to shame, scientists have spun a multitude of high-tech materials into bundles of superfine nanowires more than 1,000 meters long. The technique, reported online June 12 in *Nature Materials*, easily produces uniform, orderly arrays of gossamer-thin materials that could have broad use in sensors, energy-harvesting devices and medical diagnostics.

It's not often that the prefixes *nano-* and *kilo-*, which span 12 orders of magnitude, come together, says study leader Mehmet Bayindir of Bilkent University in Turkey. But a modern take on the spinning wheel allowed Bayindir and his team to draw nanothreads that are mere billionths of a meter across out to kilometer lengths.

This spring, MIT researchers successfully created semiconducting wires embedded in a fiber by tweaking a top-down setup that's employed in industry to make spools of optical fibers.

In a similar approach, Bayindir and colleagues started with a solid rod of material wrapped in a sturdy polymer. This bulk rod, about 10 millimeters across, is then softened with heat and drawn out in a long thread, yielding wire micrometers across. These threads are then cut down to 10-centimeter lengths and consolidated into a bundle, which is then heated and spun into an even finer thread of threads: A cross section reveals a tidy arrangement of wires within the wire. After a few rounds the team has millions of uniform nanowires that, end to end, would circle the globe.

Body & Brain

2.6 percent Stroke incidence in people who don't use olive oil

1.5 percent Stroke incidence in people who use olive oil frequently

Ketamine depression effect found

In mice, the anesthetic quickly boosts levels of a key protein

By Laura Sanders

The anesthetic ketamine works against depression by quickly boosting levels of a brain compound that has been linked to the condition, a new study in mice shows. The research may lead to highly effective and fast-acting antidepressants that provide relief within minutes, scientists report online June 15 in *Nature*.

Even when they are effective, traditional antidepressants can often take weeks or months to improve symptoms. "You can control malignant hypertension within minutes; a bad increase in blood sugar, bad migraines, asthma attacks, within minutes," says psychiatrist Carlos Zarate of the National Institute of Mental Health in Bethesda, Md. "Yet why in psychiatry should we be satisfied with, 'Just hang on for a few weeks or a few months, and you're going to get better?' That's not acceptable in my mind."

> **"Why in psychiatry should we be satisfied with, 'Just hang on for a few weeks or a few months, and you're going to get better?' "**
>
> CARLOS ZARATE

The new study may point to faster alternatives, Zarate says: "Here is increasing evidence that you can go more directly at the target, and that's maybe why you get more of a rapid antidepressant effect."

Mice receiving a single injection of ketamine showed fewer signs of depression just half an hour after the shot, and they continued to show multiple signs of reduced depression for a week, researchers at the University of Texas Southwestern Medical Center at Dallas found. For example, after one dose of ketamine, mice struggled longer to stay afloat in a beaker of water instead of giving up and sinking.

At high doses, ketamine renders a person unconscious. At lower doses, the drug can induce euphoria, hallucinations and out-of-body experiences, properties that make "Special K" a popular drug of abuse. In the study, Ege Kavalali and his colleagues used doses too low to induce psychotic effects.

The researchers found that ketamine kicks off a series of biochemical changes in the brain that culminate in the production of a protein called BDNF. Low BDNF levels have been linked to depression. The scientists also found that mice genetically engineered to be unable to produce BDNF didn't respond to ketamine.

So far, ketamine has been used in several small trials to treat people with severe depression. The drug seems to work quickly and effectively, but scientists haven't clearly understood how.

"Originally, it was a rather serendipitous finding that this thing works," says Kavalali. Understanding how ketamine triggers antidepressant effects could open up a whole new way to think about treating depression, he says, perhaps by developing drugs that have the same net effect as ketamine.

"This article gets to the idea that there are probably agents that have similar potential — and might not have the drawbacks of ketamine — to give people relief a lot faster," says clinical psychologist Rebecca Price of the University of Pittsburgh.

Researchers caution that more studies are needed to fully understand how ketamine works in people. Severely depressed people, who have made up the bulk of study groups so far, may respond to the drug differently than people with less severe depression. ■

NEWS BRIEFS

Link between virus and chronic fatigue syndrome nixed

A 2009 finding of a mouse virus called XMRV in chronic fatigue patients (*SN: 11/7/09, p. 13*) might have stemmed from tainted laboratory compounds. In two studies published online May 31 in *Science*, separate teams of U.S. scientists report that the earlier finding appears to have arisen because the lab reagents and cell lines used in the analysis were contaminated with the virus. One of the teams also finds no evidence of XMRV in the blood of chronic fatigue patients, including dozens who had been found to have the virus in the 2009 study, which was done by a different group. The cause of chronic fatigue syndrome remains unknown, the authors of the new studies argue. — *Nathan Seppa*

Olive oil versus stroke

People who consume olive oil copiously appear to be less vulnerable to stroke than those who avoid using it, medical records from 7,600 people in France show. Scientists used questionnaire responses to classify people as those who never use olive oil; those who use it either to cook or as a dressing, such as for bread or salad; or those who use it for both of those purposes. The French team then tallied up the number of strokes among the study participants over a five-year period. After adjusting for other differences among the groups, the most frequent users of olive oil were 41 percent less likely to have had a stroke than the abstainers, the researchers report online June 15 in *Neurology*. — *Nathan Seppa*

Collapsing Coastlines

How Arctic shores are pulled a-sea

By Daniel Strain

Gray waves surged over miles and miles of open water, breaking against the bluffs underlying Kaktovik. The tiny village sits precariously on the Beaufort Sea, a frigid body of water bordering Alaska's northeastern Arctic coast. As the choppy waters inundated vulnerable stretches of shoreline, the surf carved deep chasms into the tall bluffs.

Torre Jorgenson, a geomorphologist working near Kaktovik, watched the storm boil up, shaking homes and boats for nearly two days in July 2008. Dramatic erosion followed soon after. Blocks of graphite-colored earth, as much as 10 meters wide and several meters deep, toppled into the sea one by one like skyscrapers in a Japanese monster film.

"The locals had never seen that type of erosion," says Jorgenson, also president of the U.S. Permafrost Association. "It was something new, a regime change."

The erosion Jorgenson witnessed was a potent warning to Kaktovik's residents of the instability of their coastal home. Seaside bluffs and beaches across the Arctic are inhabited by indigenous northerners — such as Inupiat living in Kaktovik — as well as clutches of plants and animals that thrive in the cold air. But these shores are mercurial, crumbling away bit by bit with each season.

As human-driven climate change progresses, many fear that the Arctic's coastlines will begin to break apart faster than ever. That's bad news for the region's human and other inhabitants. In 2009, the U.S. Army Corps of Engineers identified 178 communities struggling with erosion in Alaska, three of which have perhaps a decade before collapsing completely.

Though they provide shelter and sustenance, the Arctic's coastlines haven't received as much scientific attention as the nearby icy hills and seas, says geochemist Thomas Douglas. How these shores respond to, and possibly fuel, the changes accompanying global warming will be crucial for understanding the North's future, he says.

"You can't just take what sea ice people say or what tundra vegetation people say and just say, 'OK, well, it's the same on the coast,'" says Douglas, of the U.S. Army Cold Regions Research and Engineering Laboratory in Fairbanks, Alaska. "It is this zone of mixing basically amongst everything: Between ice and land. Between cold air and warmer air. Between where rivers meet the ocean."

So international researchers are now working to develop a global view of the threats to northern coastlines. Recent collaborations have mapped current Arctic erosion rates, illustrating the wide variation in the land's retreat. New data from Alaska show the complicated relationship between sea ice cover and erosion and suggest that, in some regions, land loss may already be gaining momen-

Storms can ravage coastal permafrost, as shown near the village of Kaktovik, Alaska.

tum. Teams of scientists are also working to estimate the nutrients carried in this eroding turf in an attempt to predict how sped-up erosion may alter coastal food chains. While the work moves forward, human communities scramble to defend themselves, or flee from receding shores.

Circling the pole

On some of Kaktovik's calmer days, Jorgenson, who spends much of his time studying nearby shores, doubles as a science teacher, giving local schoolkids lessons on a familiar topic: erosion.

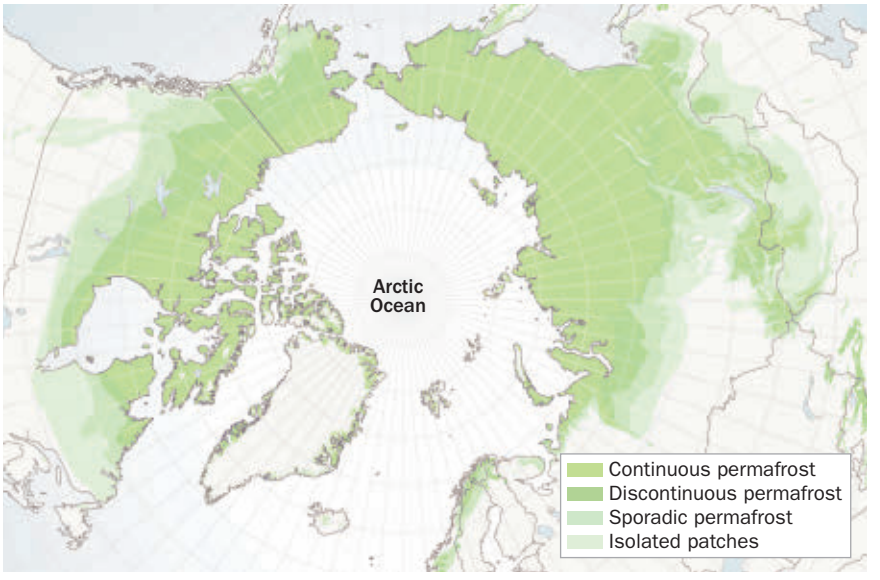
"I start out the class telling them we're going to predict when your house is going to fall into the ocean, and their eyes all get really big," Jorgenson says. "They're really disappointed when we calculate it's going to be 350 years."

Each year, warm summer waters lap against Kaktovik's bluffs, slowly pulling away dirt and rocks. This inchmeal progression is nothing new; the students' parents and grandparents probably saw the coast trickle away bit by bit during their childhoods, too.

Scientists going back to the 1950s have monitored North America's crumbling Arctic closely, says Hugues Lantuit, a geomorphologist at the Alfred Wegener Institute for Polar and Marine Research in Potsdam, Germany. Lantuit and his colleagues recently bridged decades of field studies with satellite data to draw what the team calls the most complete map of erosion across the Arctic, from Alaska to Greenland and Siberia.

The map reveals that Arctic land today falls back on average by about half a meter per year along more than 60,000 kilometers of twisting and winding coastline. These rates vary wildly depending on the beach or bluff in question, Lantuit's team reported online in February in *Estuaries and Coasts*.

Drew Point, an exposed site on the Beaufort Sea, loses more than eight meters of land each year, for instance. Other studies have shown that nearby locales can collapse away by as much as 25 meters per year. Taken as a whole, these erosion rates may not differ drastically from those to the south, but temperate beaches don't ice over in the winter, Lantuit notes.



Dirty slurry Much of the Arctic's land is frozen as permafrost. When ocean waves hit permafrost, they cause any ice trapped within to melt, unlocking and pulling away dirt as well.

"What is amazing is that you have those comparable rates even though you have only four months of open water in the Arctic," he says.

The difference rests with the ice. Not in the water, but on land. Across much of the Arctic, the ground stays frozen year-round. Mix soil and water, shake up the slurry, then freeze it, and you get something akin to much of the Arctic's frozen dirt, or permafrost. Some patches of Arctic ground along the Beaufort Sea are as much as 70 percent ice by volume. This ice-soil mix doesn't just crumble when ocean waters lap. The water also licks the land like a Popsicle, causing the icy parts to melt. And where there's more ice in the soil, there's more melting and more bits of land being drawn seaward.

The team's erosion map paints a vivid picture of how the Arctic quickly breaks apart under today's processes. But many scientists fear that climate change may already be speeding up the region's coastal dynamics, including erosion.

A swiftly moving Arctic

Soil scientist Jerry Brown was part of the first wave of scientists to explore the dynamics of Alaska's frozen coasts in earnest. In 1963, he attended the inaugural International Permafrost Conference at Purdue University in West Lafayette, Ind. The event drew a number of scientists from North America and also a handful of Soviet scientists. The teams ate up each other's coastal data, which had been until that point locked on either side of the Iron Curtain. But global climate change hadn't yet caught the attention of the scientific world, so its influences on erosion didn't come up in conversation.

"We were just thinking of it as normal processes," says Brown, who in 1983 helped to found a research collective called the International Permafrost Association.

At permafrost conferences today, the talk is different. Scientists agree that the Arctic will be among the first regions to show the toll of global warming. Alaskan and Canadian beaches aren't yet balmy vacation destinations, but the average Arctic air temperature for the last decade is the warmest since 1900. Human-driven warming as well as natural climate shifts are probably combining to push the Arctic further away from its historic state.

Many researchers are now investigating whether Arctic shores will erode faster as beaches warm, and one

especially vulnerable coastline may already be feeling the shrink.

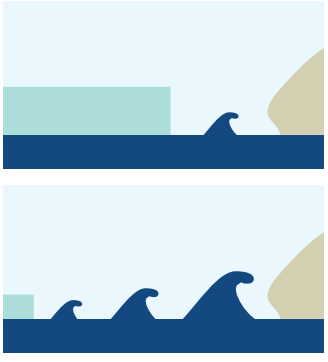
That coast, a stretch of the Alaskan Beaufort Sea west of Kaktovik, has never been calm. Features such as islands and points that dotted these shores when early explorers first mapped the coast have since disappeared. But shoreline fissures and crags may be growing increasingly more vulnerable. Recently, a team of U.S. researchers, including Jorgenson, collected a series of historic aerial photographs from a 60-kilometer span of the coast dating back to the 1950s and compared the photos with modern images.

When scientists started taking pictures here, land loss was proceeding at a fast clip, about seven meters per year. By 2002 to 2007, those rates had doubled to nearly 14 meters per year along these beaches, Jorgenson, Benjamin Jones of the U.S. Geological Survey's Alaska Science Center in Anchorage and colleagues reported in *Geophysical Research Letters* in 2009.

"If we see like 15 meters a year ... that's a very dramatic number," says Irina Overeem, a geomorphologist at the University of Colorado at Boulder who wasn't involved in the 2009 study. "I don't think there's many sites around the world that match that."

Overeem, who also monitors erosion in northern Alaska, has lost a lot of recording equipment to the encroaching sea. She is attempting to track the culprits behind the erosion that steals her gear, and the reasons for that erosion's acceleration. Again, Overeem and other scientists have turned to ice for an explanation. In this case, though, the responsible ice doesn't cover the land. During much of the year, it's only accessible by boat.

Like a beating heart, sea ice expands around Alaska and then thaws away with the seasons. Despite these cycles, swaths of ice still commonly cling to the beaches during some summers. Or they did until recently. "In the last 15 years, that has not happened," Overeem says. Instead, summer sea ice has stayed away from the shoreline for longer and longer. At certain sites along the Beaufort Sea, ice and land meet for about 50 days less each year than they did in the 1970s.



Fetching storms Melting ice exposes more water surface. This extra "fetch" gives waves extra room to build up—meaning more storm damage and erosion.

Ice loss fuels rising sea levels worldwide, but it's particularly bad for local coasts. In cooler months, sea ice serves as the Arctic's blanket, keeping an insulating layer between seashores and lapping waves. When coasts lose this blanket, those same waves lap and siphon away soil with abandon. In the Arctic, open water means quicker erosion, Overeem says. Along one stretch of the Beaufort Sea, the rates of erosion sped in tandem with lengthening open water seasons, she and colleagues reported in San Francisco last year at a meeting of the American Geophysical Union.

Less ice also means worse damage from storms, like the one that inundated Kaktovik in 2008, says storm scientist David Atkinson of the University of Victoria in Canada. Sea ice protects the coast from such catastrophes, which can tear down entire blocks of earth. On the simplest level, landbound ice keeps waves from tearing at the shore. That blanket can also, however, keep waves from building up in the first place.

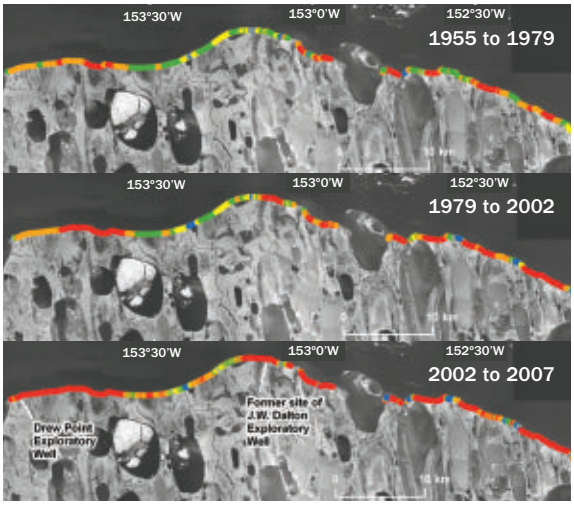
To make a big wave, Atkinson explains, winds need a lot of room to blow. Extensive sea ice leaves little open water — or fetch — to be had, and as a result, the surf has little room to gain momentum. "You might have a 100-mile wind, but if you only have a mile of open water fetch, you might only get 3-foot waves," says Atkinson. But if the ice drops away tens of miles, "now the same storm can produce a much more damaging marine response."

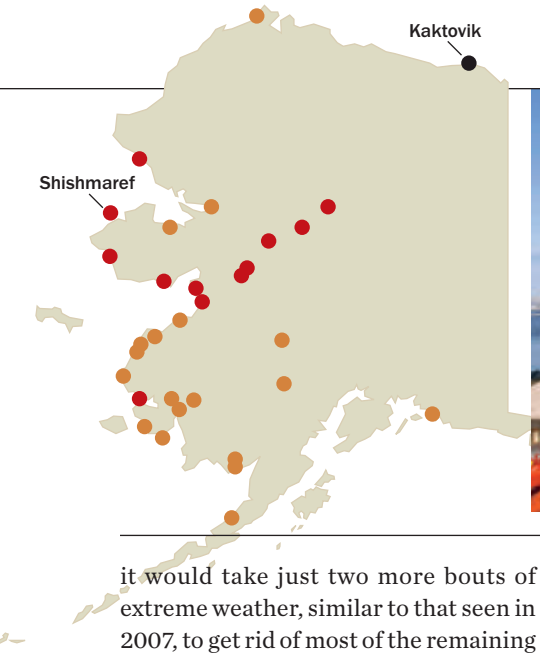
Because of these ice-erosion connections, how much land the Arctic stands to lose probably depends on future ice melting there. And the future looks grim, says James Overland, an oceanographer with the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory in Seattle.

2007 was not a good year for ice forecasters such as Overland. A freak weather pattern sent warm winds blowing north, melting swaths of sea ice already weakened from years of steady temperature increases. As a result, summer ice extent shrank to a record low level, nearly 40 percent below the historic average. Regions that were once dependably capped with ice all year turned slushy. "Essentially, we were really unlucky in 2007," Overland says.

The coast's protective blanket may never recover, Overland says. He suspects

Tracking loss A recent study along one 60-kilometer stretch of Alaska's Beaufort Sea coast found that mean annual erosion rates increased from 6.8 meters per year from 1955 to 1979 to 13.6 meters per year from 2002 to 2007 (detailed erosion rates are shown at right).





Counting costs The U.S. government has identified more than two dozen Alaskan villages threatened by imminent flooding and erosion (orange and red dots), some of which are planning relocation efforts (in red). Beyond the cost of moving, many fear that traditional culture will suffer. Already Inupiat Herbert Nayokpuk (shown), a resident of Shishmaref, has to use a boat instead of sled dogs or a snowmobile for spring seal hunts.

it would take just two more bouts of extreme weather, similar to that seen in 2007, to get rid of most of the remaining summer ice across the entire Arctic. In a paper published in 2009 in *Geophysical Research Letters*, Overland and a colleague forecast that Arctic summers would be largely free of sea ice by 2037.

"The Arctic really is the canary in the coal mine for global change," Overland says.

Bracing for change

Along the Arctic coast, that change has been a muddy affair for scientists. Sloughing permafrost can form what Donald Forbes of the Geological Survey of Canada in Dartmouth, Nova Scotia, calls a "big amphitheater" with tall, ice-rich walls. These amphitheaters collect wide pools of mud at their bases — researchers stepping in the wrong spot often find themselves up to their waists in the muck.

Such mud pools are erosion at its dirtiest, and some scientists are now wondering if the dirt will disrupt marine life as much as it disrupts research. Falling cliffs dump a lot of soil into the water, providing potential nutrients like carbon and nitrogen to nearby organisms. Jorgenson and his colleagues estimated that along 2,000 kilometers of the Beaufort coast, 150 million kilograms of organic carbon dumps into the sea annually. That's about as many nutrients as flush out of all the rivers along that same stretch of coast combined, the team reported in April in the *Journal of Geophysical Research*.

Early studies have shown that all that dirt does wind up in the bellies of many shallow-water critters. But exactly which organisms eat the turf food first, and how much of it gets eaten, isn't clear, says Kenneth Dunton, an ecologist at the University of Texas at Austin's Marine Science Institute in Port Aransas. Without knowing the path that carbon takes through the Arctic food web, scientists can't be sure how bigger soil buffets will affect coastal ecosystems, he says.

The future for human communities across the Arctic is similarly murky. Kelly Eningowuk grew up in the village of Shishmaref, built on a sandy and inherently unstable island on the Bering Strait. A wide beach once sat between Shishmaref and the cold waters beyond. During Eningowuk's childhood in the 1980s and 1990s, however, erosion removed all but a narrow strip of that shoal. Today, several buildings, including tanneries and a classroom, risk collapsing into the ocean entirely.

Shishmaref is one of the three Alaskan communities that the U.S. Army Corps of Engineers has said faces particularly dire erosion rates. The village elected to migrate to a new site a few miles inland, what Eningowuk calls "the ultimate adaptation." Ultimate and pricey. From start to finish, the relocation could cost up to $200 million, the Army Corps has estimated.

The cultural costs of a changing climate may be equally high. For Inupiat, hunting by ice cements the bonds between fathers and sons learning how to safely stalk seals and the bonds among women who help butcher the quarries. "It's so much more than food," says Eningowuk, now executive director of the Alaskan branch of the advocacy group the Inuit Circumpolar Council. "It's really our identity. I can't imagine not having it."

Inupiat are adaptable, Eningowuk says, but changes will come fast. That reality became clear to her a few years ago after a near tragedy. Her grandfather, Delbert, had hunted seals and walrus just off Shishmaref since he was a young man and he knew as well as anyone how to read ice, distinguishing safe from weak footing. But, at nearly 80, he fell through a patch of spring ice into the freezing water, surviving by a stroke of luck. "If he can't read what's going on," Eningowuk says, "obviously it's changing so fast."

Rising temperatures in the Arctic, of course, will affect more than small villages like Kaktovik or Shishmaref. Despite its remoteness, the Arctic is still tightly connected to the rest of the world, says Volker Rachold of the International Arctic Science Committee in Potsdam. With this global view, erosion, intrinsically tied to sea ice, isn't just a problem for Northern peoples, he says. As ice melts around them, sea levels will rise along warm and cold ports alike; the Arctic is, in many ways, the planet's thermostat.

"It's not only that things are happening much faster there," Rachold says. "It's also that things happening in the Arctic have a direct impact on the rest of the globe." ■

Explore more

- For the State of the Arctic Coast 2010 report, visit arcticcoasts.org

MAP: GEOATLAS/GRAPHI-OGRE, ADAPTED BY T. DUBÉ, DATA: U.S. GOVERNMENT ACCOUNTABILITY OFFICE 2009; PHOTO: GILLES MINGASSON/GETTY IMAGES

the power of D

Sunshine vitamin's potential health benefits stir up, split scientists

By Nathan Seppa

A nutritional supplement that is free of charge, offers a wide range of health benefits and poses little risk sounds like fodder for a late-night TV commercial. But proponents of vitamin D are increasingly convinced that the sunshine vitamin delivers the goods, no strings attached.

It offers a safe route to better health, these advocates say, by promoting proper function of the bones, heart, brain, immune system, you name it. Yet, the proponents claim, most people don't get enough. Whereas humans' prehistoric ancestors lived outdoors and made oodles of vitamin D in their sun-exposed skin, people today have become shut-ins by comparison — and scant sun exposure means low vitamin D.

Of course, not everyone sees such a grand reach for the vitamin. While scientists concur that it is essential for bone maintenance, some stop right there. The skeptics note that vitamin D's other promising qualities have shown up largely in studies that fall short of the gold standard of medicine — the randomized controlled trial, in which groups of people get either a placebo or the real thing. While a handful of randomized trials have shown additional benefits, others have not, leaving a gap in the vitamin's otherwise sterling reputation.

This debate came to a head last November, when an Institute of Medicine panel of scientists announced new vitamin D recommendations. The old intake levels were barely high enough to prevent rickets, a bone condition associated with the Industrial Revolution. The IOM panel boosted the recommended daily intake of the vitamin from 200 to 600 international units per day for most of the population. The new dose is about 15 micrograms, in the range of vitamin D found in most multivitamins.

But these amounts still fall short of prehistoric people's intakes by a Stone Age mile. Living outdoors with little clothing, these people manufactured thousands of international units, or IU, every day, perhaps getting three to five times as much as most people get now.

Vitamin D proponents cite a boatload of studies, some randomized and some

YELLOWJ/SHUTTERSTOCK

not, suggesting that a population getting more vitamin D would be healthier overall. A recent Nebraska study links increased vitamin D intake to less cancer risk, for example, while Japanese scientists find that the vitamin helps fight influenza. Other recent work has connected higher levels of vitamin D with lower risks of hypertension, Parkinson's disease and heart disease.

With these studies in hand, the Endocrine Society put out its own recommendations in the July *Journal of Clinical Endocrinology & Metabolism*. The society, the world's oldest and largest group devoted to hormone research, called for vitamin D intake levels two to three times higher than the IOM's recommendations.

More randomized trials are needed to settle the question, says Patsy Brannon, a molecular nutritionist at Cornell University and a member of the IOM panel. Until then, she says, it would be difficult to justify raising the levels further. It might even be imprudent because soaring levels could be toxic, she says.

That's almost too much for nutritional biochemist Bruce Hollis to bear. A longtime vitamin D researcher at the Medical University of South Carolina in Charleston, Hollis recently oversaw a randomized controlled trial showing that low blood levels of vitamin D in pregnant women may lead to more preterm births. He has called for much higher doses. "These new IOM levels won't accomplish anything," Hollis says. "It's just insane."

Cancer connection

Endocrinologist Robert Heaney of Creighton University in Omaha, Neb., has spent a good part of his career compiling evidence that vitamin D has value in bone health and beyond, particularly in the fight against cancer. In a recent study, his team randomly assigned 1,180 healthy postmenopausal women to receive calcium, a placebo or 1,100 IU of vitamin D plus calcium daily.

Over four years, the trial data showed that those on the placebo had higher cancer rates than the other groups, but the findings revealed little difference between those getting calcium alone or calcium with vitamin D. Since cancer starts microscopically and can grow undetected for months or years, the researchers also ran an analysis that skipped the first year — an effort to discount preexisting cancers. During the last three years of the study, 6.8 percent of the placebo group and 3.6 percent of those getting only calcium developed cancer, compared with 2.0 percent of those getting vitamin D plus calcium, Heaney's team reported in 2007 in the *American Journal of Clinical Nutrition*.

The Nebraska study is one of many looking for a possible link between elevated cancer risk and low vitamin D in the blood. Researchers have found a similar association between vitamin D and colon cancer and the formation of precancerous growths in the colon called polyps. And Michael Holick, a biochemist and endocrinologist at Boston University, can reel off studies demonstrating less prostate and ovarian cancer in populations with high sun exposure (meaning higher vitamin D levels).

Holick, who chaired the committee that put out the Endocrine Society guidelines, acknowledges a risk of skin cancer from sun exposure in his 2010 book *The Vitamin D Solution*. But he and others have estimated, based on rates of cancer in the northern and southern United States, that lives saved from greater sun exposure would far exceed those lost to skin cancer.

Evidence for some cancers, he says, is better than others. "If I were to pick one cancer where vitamin D is sure to matter, it would be colon," he says. "The second would be breast cancer."

It's one thing to crunch numbers and notice such associations among populations; it's quite another to make a biological link. But some of vitamin D's essential functions are directly anticancer in nature. For example, vitamin D regulates tumor-suppressing proteins called p21 and p27 and triggers other processes that inhibit cell proliferation. Vitamin D has also been shown to limit angiogenesis, the process whereby a tumor builds a web of blood vessels to nourish itself.

Tenacious D

Using an entirely different bag of tricks, vitamin D can stifle infections, a capability that was presaged nearly a century ago when doctors successfully treated

Degrees of D People's vitamin D blood levels differ because of various factors, including skin color and sun exposure. Though scientists disagree on the level needed for good health, most peg the value between 20 and 40 nanograms per milliliter. Data below come from specific populations.

FROM TOP: FETHI BELAID/AFP/GETTY IMAGES; PER-ANDERS PETTERSSON/GETTY IMAGES

Vitamin D blood levels around the world

African-Americans with MS	12 ng/ml
Men in Finland	13 ng/ml
Veiled Tunisian women, age 20–60 (top)	14 ng/ml
Elderly African-American men in the United States	19 ng/ml
Danish girls taking 600 international units daily	24 ng/ml
Elderly Afro-Caribbean men living in Tobago	35 ng/ml
Healthy black children in South Africa (bottom)	37 ng/ml
Elderly people in Florida taking 2,000 IU daily	43 ng/ml
Lifeguards in Missouri	65 ng/ml

tuberculosis with sun exposure. The strategy is now understood to stem from increased vitamin D, which has been shown to trigger cells to produce a handy protein fragment called LL-37 that kills the TB bacterium.

The vitamin appears to defend against viral infections, too. The annual winter flu season comes at a time when people garner little vitamin D from sunshine and blood levels fall. The timing may not be a coincidence, says Reinhold Vieth, a biochemist at the University of Toronto. Low vitamin D levels might offer the virus the edge it needs to gain a foothold in the population and spread from person to person.

Japanese researchers recently bolstered this theory with a study in which they randomly assigned 167 schoolchildren to get 1,200 IU of vitamin D daily and 167 other kids to get a placebo from December 2008 through the following March. Over that time, 31 children not getting the vitamin and 18 receiving it came down with the flu, Mitsuyoshi Urashima of Jikei University School of Medicine in Tokyo and colleagues reported in May 2010 in the *American Journal of Clinical Nutrition*.

Another study in the United States showed that substantially more people with low vitamin D develop upper respiratory infections than do people with more of the vitamin, and taking up to 2,000 IU a day reduced such infections by two-thirds in one trial. A Dutch research team also reported online in May in *Pediatrics* that babies with low levels of vitamin D at birth were several times as prone to develop a severe respiratory viral infection in the first year of life as were newborns with ample amounts.

Fighting infection is all well and good, but too much immunity can be a terrible thing. Ask anyone with an autoimmune disease, in which crossed-up immune defenses attack a person's own tissues. Even milder immune missteps such as asthma and allergy can be difficult to endure.

But taking extra vitamin D doesn't exacerbate these immune overreactions. If anything it provides an immune gyroscope that moderates them. "Vitamin D makes the immune system smarter, not stronger," says John Cannell, a forensic psychiatrist at Atascadero State Hospital in California who also studies vitamin D.

Allergy, an immune reaction to innocuous substances, offers an example. When researchers led by Michal Melamed of the Albert Einstein College of Medicine in New York City analyzed vitamin D levels of more than 3,000 children, allergies to peanut, oak and ragweed showed up more often in children with less than 15 nanograms of vitamin D per milliliter of blood than in kids with at least 30 ng/ml, a level many scientists consider the minimum for good health.

"Vitamin D is seen as essential in immune function," says Melamed, an epidemiologist and nephrologist. In theory, she says, lacking it early in life disrupts the immune system "and you start having immune reactions to things you should tolerate."

Asthma, another immune malfunction that can wreak havoc in the lungs, also shows links to low vitamin D levels. In a study conducted at National Jewish Health respiratory hospital in Denver, researchers found that people with asthma who also had low levels of vitamin D had poorer lung function than asthmatics who had higher levels of the vitamin. The results, reported in 2010 in the *American Journal of Respiratory and Critical Care Medicine*, show that harboring less than 30 ng/ml of vitamin D was associated with higher concentrations of TNF-alpha, an immune protein known to exacerbate inflammation.

A more destructive immune revolt called autoimmunity has a link to vitamin D as plain as a map of the world. Patients with the autoimmune condition type 1 diabetes, or juvenile-onset diabetes, have to receive insulin injections for life because insulin-making cells in the pancreas are killed off by a self-directed onslaught. Cedric Garland, a public health researcher at the University of California, San Diego, has mapped type 1 diabetes around the globe, noting low rates in Barbados, Brazil, Sudan, Algeria and Cuba but a high rate of the disease in Finland, Scotland, Norway, Sweden and New Zealand. In

Beyond the sun A fair-skinned person basking in the sun in a bathing suit could get 20,000 international units of vitamin D in half an hour. Natural and fortified foods offer much less (estimates below). Though an Institute of Medicine panel recently recommended that adults up to age 70 get 600 international units daily, guidelines from the Endocrine Society suggest 1,500 to 2,000 IU.

Natural food sources:

Cod liver oil, 1 tsp	400–1,000 IU
Fresh wild-caught salmon, 3.5 oz	600–1,000 IU
Canned tuna, 3.5 oz	236 IU
Sun-dried shiitake mushrooms, 3.5 oz	1,600 IU
Egg yolk	20 IU

Fortified foods:

Milk, 8 oz	100 IU
Orange juice, 8 oz	100 IU
Yogurt, 8 oz	100 IU
Cereal, one serving	100 IU
Margarine, 3.5 oz	429 IU

Pharmaceutical and supplemental:

Multivitamin	400–1,000 IU
Vitamin D catch-up pills	400–50,000 IU

SOURCE: M.F. HOLICK *ET AL/J. CLIN. ENDOCRINOL. METAB.* 2011

FROM TOP: URGUPLU/ISTOCKPHOTO; JMSILVA/ISTOCKPHOTO; FSTOP123/ISTOCKPHOTO

2008 in *Diabetologia*, he and colleagues note that the latitude effect follows sun exposure closely.

There are exceptions. Sunny Sardinia has the highest type 1 diabetes rate in the world, apparently because of the population's genetic profile, and Latvia ranks low. But the overall trend is unmistakable. Many researchers have also noted a latitude trend in multiple sclerosis, a suspected autoimmune disease that is practically unknown in the tropics and most common in Scandinavia.

Because these observations constitute indirect evidence and not causality, some scientists dismiss the latitude theory. But under a microscope, the evidence becomes more direct.

Multiple sclerosis researcher Jorge Correale of the Raúl Carrea Institute for Neurological Research in Buenos Aires has found that patients in the throes of an MS relapse have vitamin D levels lower than do healthy people or patients in remission. MS is marked by inflammation that damages nerve coatings. Vitamin D enhances the development of an inflammation-fighting protein called interleukin-10 and reduces production of two pro-inflammatory proteins in blood from patients, Correale's team reported in 2009 in *Brain*.

Brainwork, babies, blood pressure

Cancer, rogue immunity and infection are just three of the many ailments vitamin D may help ameliorate:

- Bruce Hollis and colleague Carol Wagner, also of the Medical University of South Carolina, randomly assigned 350 pregnant women to get 400, 2,000 or 4,000 IU of vitamin D daily starting in the second trimester. Women getting the highest dose were less prone to have preterm labor or preterm birth than the lowest-dose group, the researchers reported at a scientific meeting in 2010.
- By sifting through medical records, scientists from Kaiser Permanente found hypertension rates of 52 percent among adults with low vitamin D but rates of only 20 percent among those with plenty of vitamin D. The report appeared in the March *Journal of Clinical Hypertension*.
- In a study reported in 2010 in the *Archives of Neurology*, Finnish scientists investigating Parkinson's disease found that nearly three decades after study volunteers submitted blood samples, those with the lowest initial vitamin D levels were most likely to develop the disease.
- Among elderly people in England, those with low vitamin D were at least 40 percent more likely to fail standard cognitive tests than those with high levels of the vitamin, a 2009 report in the *Journal of Geriatric Psychiatry and Neurology* showed.
- Patients with blood levels of less than 30 ng/ml of vitamin D were slightly more likely to have heart disease and faced a doubled risk of diabetes compared with patients who had higher vitamin D levels, researchers from the University of Kansas Medical Center in Kansas City reported at a meeting in 2010.

Jack of all trades

Vitamin D differs from other vitamins in one major way: It is nearly impossible to get enough of it in the diet naturally. Instead, the sun provides it.

After the ultraviolet rays of the sun trigger the synthesis of vitamin D in the skin, the body modifies the vitamin into a steroid hormone. Such hormones are heavy hitters in molecular biology, which probably explains the vitamin's seemingly broad benefits — ranging from maintaining bone strength to sharpening mental acuity.

Vitamin D triggers a huge range of cell activities by binding to the aptly named vitamin D receptor, a protein docking port found on cells throughout the body. This connection — like a password opening up a new computer screen — instructs the cell to activate or silence certain genes. Gene activity in turn influences which proteins are made or not made by the cell. Since the vitamin D receptor is found on a wide array of cell types, such gene tweaking can influence immune reactions, cell growth, muscle maintenance, calcium absorption, metabolism and other processes.

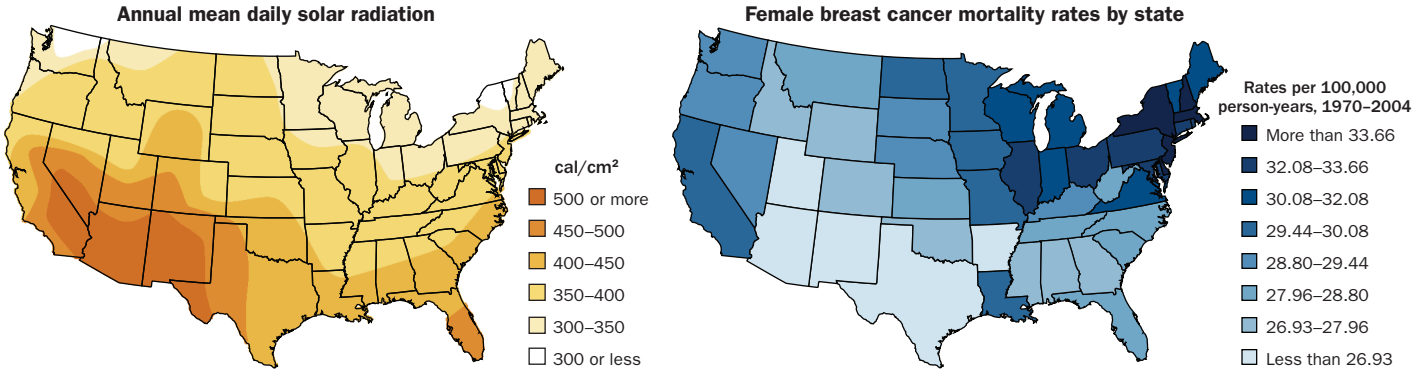
Sreeram Ramagopalan, a geneticist at Oxford University in England, and his colleagues reported in 2010 in *Genome Research* that more than 200 genes are awakened or silenced by vitamin D binding to its receptor. Other evidence suggests the number of genes indirectly affected by vitamin D could exceed 2,000.

Many details of the vitamin's activity are still hazy, says Wesley Pike, a biochemist at the University of Wisconsin–Madison. But some are known. "For instance, vitamin D is largely pro-differentiative," Pike says. Cell differentiation is like specialization, in which an existing cell takes on a new duty. "And cells promote differentiation at the expense of growth," he says. Genes modulated by vitamin D hamper cell proliferation, meaning the vitamin has anticancer potential.

And while other activities of vitamin D are still being sorted out, one of its best-understood tasks is protection from disease. Cells called macrophages that kill bacteria, for example, don't always have the chemicals required to do their job on hand, says Robert Heaney of Creighton University in Omaha, Neb. So, in a pinch, the cells consult their gene library — with the help of vitamin D — and use the DNA blueprints stored there to synthesize the needed chemicals.

Vitamin D may not cure anything by itself, Heaney says. "But it's waiting in the wings, outside of cells," he says. "It's an enabling compound."

—Nathan Seppa



On the map Scientists who study vitamin D can't help but notice that a host of diseases seem to vary with latitude. Type 1 diabetes, multiple sclerosis and even some cancers appear to be more common in areas that get less sun — meaning less opportunity for the body to produce vitamin D. The maps above illustrate the apparent link between solar radiation and breast cancer mortality rates.

SOURCE, FROM LEFT: D.M. HARRIS AND V.L.W. GO/*J. OF NUTRITION* 2004; NATIONAL CANCER INSTITUTE

D is for discord

The IOM panel members acknowledged all of these findings — and didn't use any of them in setting vitamin D recommendations. They were very forthcoming about why.

"We looked extensively at those areas," Brannon says. In non-bone research, she says, "we found very limited randomized controlled trials, and evidence for cause and effect was not present."

Some studies did get special note. Hollis' trial in pregnant women is interesting but had yet to appear in a peer-reviewed journal, Brannon says, so it wasn't used in setting the recommendations. The Nebraska cancer study was discounted because the most convincing finding used only three of the four trial years, says panel member JoAnn Manson, an endocrinologist and epidemiologist at Harvard Medical School. She says the full scope of a trial is the only fair measure and that secondary analyses lack credence.

Two large randomized controlled trials are now getting under way and will provide new evidence.

Physician Carlos Camargo of Harvard Medical School and colleagues at the University of Auckland are randomly assigning 5,100 older adults in New Zealand to get a monthly pill containing either a placebo or 100,000 IU of vitamin D — equal to about 3,300 IU a day. The trial will assess heart disease, infections and fractures. "It's a high enough dose to get most participants up to 35 to 40 nanograms per milliliter, which is where we think we'll find optimum benefits," Camargo says.

Manson is leading a U.S. trial in which 20,000 people age 60 and older are being randomly assigned to get 2,000 IU a day or a placebo. Some will also get omega-3 fatty acids. Since they don't know what they are getting, participants are allowed to take vitamin D supplements up to 800 IU daily on their own. Researchers will measure heart disease, cancer and stroke among the participants.

Manson says she hopes the trial "will provide important information about the balance of benefits and risks" of vitamin D.

Whatever the results, though, these two trials may not settle the question. A randomized trial is only as good as its design, Cannell says. Giving people huge doses of vitamin D once a month creates unnatural swings in the body. "Our ancestors didn't get one day of sun then 29 days without it," he says.

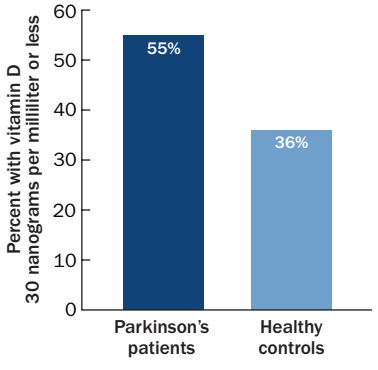
And Hollis says that the range between the amounts of vitamin D taken by the two groups in Manson's trial may not be wide enough to establish an effect. Even if it were, differences between the groups could be blurred by natural sun exposure.

Regardless of the results, which won't be available for at least four years, Garland says scientists have enough data to justify higher vitamin D recommendations. Waiting for more evidence simply leaves many people at risk of deficiency, he says.

Besides, randomized controlled trials have never been the sole arbiter of medical thinking or policy, Garland says: "If they were, we would all still be smoking cigarettes and no one would be wearing seat belts." Nobody was randomly assigned to such hazards. Rather, a flood of other evidence established their risk and benefit. ■

Aging brain Studies have shown a link between vitamin D blood levels and some age-related disorders. The chart below shows that Parkinson's patients more often have lower levels than healthy controls.

Vitamin D insufficiency in Parkinson's patients versus healthy controls



SOURCE: M.L. EVATT *EL AL/ARCH. NEUROL.* 2008

Explore more

- M.F. Holick *et al*. "Evaluation, treatment and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline." *Journal of Clinical Endocrinology & Metabolism*. July 2011.

E. FELICIANO

Bonus: Barber Silver Half Dollar

Can you pass an easy coin test?

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2. _____ Kennedy Half Dollar (1964)
3. _____ Walking Liberty Half Dollar (1916-1947)
4. _____ Roosevelt Dime (1946-1964)
5. _____ Washington Quarter (1932-1964)
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7. _____ Barber Dime (1892-1916)

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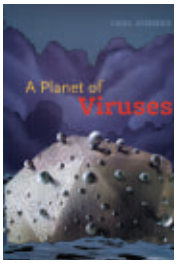
A Planet of Viruses

Carl Zimmer

Reading a book about microbes leaves no doubt about who is in charge: They are. Some of Zimmer's previous books have placed parasites and bacteria at the top of biology's pecking order. In his latest book, *they* are viruses. The tiny microorganisms that challenge our notions about what is alive are found in every nook and cranny on Earth, making this truly a planet of viruses.

Zimmer's collection of essays takes readers on a guided tour of some of the wonders of this viral world, from ocean-going to bacteria-eating viruses, plus stops for the world's biggest virus and viruses that put horns on rabbits. There's also plenty about humans in sections on HIV, the common cold, influenza and other viruses that infect and inhabit the human body.

As with any great journey, this virtual tour opens your eyes and expands your horizons. You'll learn amazing facts. But this is no textbook. Zimmer does not do boring or stuffy; reading his work is like hanging out with the smartest, most interesting guy you have ever met as he regales you with tales of his travels and fascinating finds along the way. He does



get a touch preachy when he admonishes doctors and patients alike for using antibiotics to treat the common cold. (Antibiotics kill bacteria. They are useless against viruses, such as those that cause colds.) But it's worth sitting through that one small lecture to hear the rest of the stories.

This is a short book with bite-sized chapters. But like viruses, these essays pack a lot of information into a small structure and will infect you, in this case with a desire to know more.

— Tina Hesman Saey

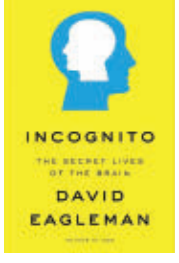
Univ. of Chicago Press, 2011, 109 p., $20

Incognito: The Secret Lives of the Brain

David Eagleman

People only think they know what they're doing. In reality, great ideas, decisions and opinions are all generated well before the conscious brain is in on the task, argues Eagleman, a neuroscientist.

In fresh, clear prose unencumbered by neuro-jargon, Eagleman weaves descriptions of simple, relatable experiments and compelling case studies throughout the book, convincing the



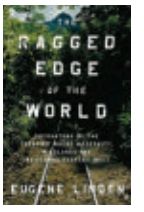
reader that deep, mysterious machinations of the brain are calling the shots.

The insight that much of what drives behavior happens behind the scenes of conscious thought has huge implications for the justice system, a topic that Eagleman tackles with relish in later chapters. He invokes the infamous case of Charles Whitman, the University of Texas at Austin's clock-tower sniper. An autopsy revealed a nickel-sized tumor that was impinging on parts of the brain linked to aggression and fear in Whitman, a former Eagle Scout and U.S. Marine.

The current legal system is based on the idea that, with a few key exceptions, most people are equally able to make decisions, control impulses and understand consequences, Eagleman writes. "While admirable, the notion is simply not true," he concludes. Brain inequalities make assigning blame problematic, Eagleman proposes, so courts should assess "modifiability," which considers what can be done to rehab an individual offender's brain.

The book's pithy observations, breezy language and wow-inducing anecdotes provide temporary pleasure, but the book's real strength is in its staying power. A reader will be left to mull over Eagleman's provocative ideas about "biologically informed jurisprudence." *— Laura Sanders*

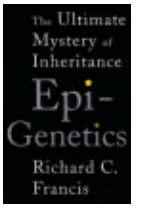
Pantheon Books, 2011, 304 p., $26.95



The Ragged Edge of the World

Eugene Linden

A journalist follows cargo cults in New Guinea, Pygmies in Africa and other groups to trace industrialization's effects. *Viking, 2011, 256 p., $26.95*



Epigenetics

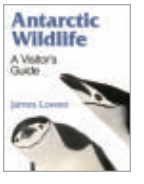
Richard C. Francis

A rollicking narrative goes beyond the gene to show how external influences shape genetic legacy. *W. W. Norton & Co., 2011, 224 p., $25.95*

Sex, Drugs and Sea Slime

Ellen Prager

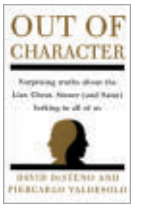
A tastefully scandalous tour of defensive secretions and extreme sexual flexibility backs up a plea for ocean conservation. *Univ. of Chicago Press, 2011, 200 p., $26*



Antarctic Wildlife: A Visitor's Guide

James Lowen

This photographic field guide could come in handy on a cruise of the Antarctic Peninsula, or just be a fun way to learn about life way down under. *Princeton Univ. Press, 2011, 240 p., $22.95*



Out of Character

David DeSteno and Piercarlo Valdesolo

Subtle changes in environment and context can lead anyone to act as either a saint or a sinner, two psychologists argue, highlighting the flexibility of character. *Crown Archetype, 2011, 259 p., $25*

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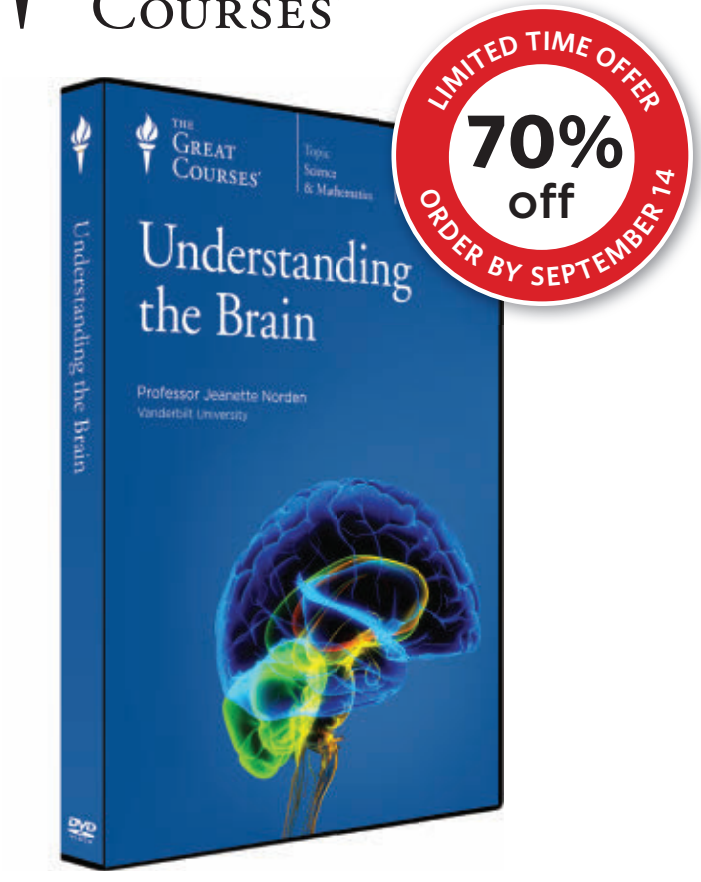

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8. Central Nervous System—Cellular Organization
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10. Neurotransmitters
11. Stroke
12. The Visual System—The Eye
13. The Visual System—The Cortex
14. The Auditory System
15. The Somatosensory System
16. Agnosias
17. The Motor System—Voluntary Movement
18. The Motor System—Coordinated Movement
19. Parkinson's Disease
20. Language
21. The Limbic System—Anatomy
22. The Limbic System—Biochemistry
23. Depression
24. The Reward System—Anatomy
25. The Reward System—Drugs
26. Brain Plasticity
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28. Processing of Negative Emotions—Fear
29. Music and the Brain
30. Sexual Dimorphism of the Brain
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Yawn and open your ears

I read with interest your article on yawning ("Yawn," *SN: 5/7/11, p. 28*). Over the years I have formulated a private theory on at least one of the reasons why we yawn and would like to share my speculations with your readership. My insight essentially began when I noticed that immediately after yawning my hearing acuity noticeably improved (sometimes dramatically so) for at least a short period of time. I have observed this phenomenon in myself on multiple occasions over my life span from adolescence to my current age of 67 years.

I believe the process of yawning opens the eustachian tubes which equalizes the pressure in the middle ear which, in turn, allows for improved sound conduction through the ossicles into the inner ear. This pressure adjustment should also affect the back pressure on the membrane of the round window to improve the fine tuning of the cochlear hair cells' response.

Whatever the details of the mechanism, a case can easily be made that improved hearing is an advantage for both predator and prey that would be differentially favored by natural selection. As to why yawning should be contagious and why it should tend to occur when one is drowsy or bored: If group members are signaling to each other unconsciously through their yawns to awaken and prick up their ears, this could confer a survival advantage not only to the group as a whole, but to each individual and thus to their "selfish genes."

Robert Gorkin, via e-mail

Other causes of yawning: Reading about it. I had at least 22 while reading that article.

Louise Lacey, Kensington, Calif.

Pondering poison origins

I wonder if it was not the caterpillars that gave the cyanide-producing genes to the bird's-foot trefoil plant ("Prey, predator make same poison," *SN: 5/7/11, p. 11*). Look how clever this would be: First, the caterpillar does not expend energy to make cyanide, and second, no other organism can eat the trefoil! No more competition with other creatures consuming its food.

E.G. Howard, Hockessin, Del.

Rutherford tribute

I have enjoyed my subscription to *Science News* for years and give a subscription to my son for his birthday present each year. (He returns the gesture by giving me one to *Rolling Stone* magazine.) In your May 7 issue, Tom Siegfried did an article about Ernest Rutherford ("Atomic anatomy," *SN: 5/7/11, p. 30*). I enjoyed reading about Mr. Rutherford and his contributions to the nuclear age.

I would like to see more articles like this, on other scientists, in each issue to inform readers about history and the people who have contributed to our understanding of the sciences.

Don Hansen, via e-mail

I enjoyed the Rutherford piece. Maybe someday Tom Siegfried can write about (if he has not already) the incomparable Michael Faraday. The older we get, the more we like to know about the people who got us where we are.

John E. Rhoads, Wichita Falls, Texas

Traveling salesman solved, slowly

Well, send me the million dollars. The article "Cells can chart efficient course from A to Z" (*SN: 5/7/11, p. 14*) states, "Scientists still don't have one clean algorithm that can crunch the numbers, no matter how many cities, and find the shortest route." Replacing the expression "clean" with "efficient" would, alas, prevent me from cashing that check. Any casual programmer can write a "clean" algorithm to address the traveling salesman problem — it simply won't finish running before the sun goes dark.

Incidentally, my clean (but inefficient) algorithm requires factorial time, not exponential time. I'm pretty sure that bringing it down to merely exponential time would win me that million dollars in prize money.

Joseph C. Nemeth, Fort Collins, Colo.

Exceptional dinos

Alexandra Witze's feature "Dawn of the dinosaurs" (*SN: 5/21/11, p. 22*) was a fun read, about something that I hadn't seen addressed before. I have one question regarding the proposed extinction at the end of the Triassic period. Why were dinos hit less hard than non-dinos?

William Check, via e-mail

No one knows. —Alexandra Witze

Starry-eyed

I've been a subscriber for over 40 years, and I found the "Stellar oddballs" article (*SN: 6/4/11, p. 18*) to be the most interesting and exciting *Science News* article I've ever read! Well done!

Duane Morse, Phoenix, Ariz.

Corrections

The caption in the graphic accompanying the news story "Natural catastrophe begets nuclear crisis" (*SN: 4/9/11, p. 6*) should have said that the nuclear reactor design uses water to moderate (not absorb) neutrons.

An article in the June 4 issue ("Stellar oddballs," *SN: 6/4/11, p. 18*) incorrectly reported that the Kepler spacecraft would operate for four or five years longer. It should have said that the craft might operate four or five years beyond its normal mission timeline, which ends in 2013.

The table on Page 23 of the article "Healthy aging in a pill" (*SN: 6/4/11, p. 22*) misstated the effect of caloric restriction on mouse life span. It should have said that mice on a calorie-restricted diet live 30 to 50 percent longer than normal.

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From the Archive

To read the full 1928 article, visit
www.sciencenews.org/archive_dinodemise

Dinosaurs died of rickets

Thirty-five-ton dinosaurs, that languidly lived and loved in the slimy lagoons of the Mesozoic Age, some 135,000,000 years ago, probably disappeared off the earth because their supply of ultra-violet light was cut off by vast clouds of volcanic dust obscuring the face of the sun. And so the biggest brutes that ever walked became extinct from the action of rickets, universally known today as a malady of babies.

This is one of the newest theories of science to account for the disappearance of the dinosaurs, proposed by Dr. Harry T. Marshall, pathologist of the University of Virginia. Migrations, new enemies and the cold climatic changes brought about by the glaciers of an age of ice, along with the great reptiles' own stupidity, great size, and sluggish habits, all helped the extinction along, but ultra-violet deficiency is felt by Dr. Marshall to be the main cause.

Lack of ultra-violet light and the anti-rachitic vitamin D bring about a disturbance of the mineral chemistry of the body that results in malformed bones. Deprived of sunlight, one of their necessary sources of vitality, and probably forced to eat strange foods as the changed climatic conditions fostered new types of plants, the great beasts gradually grew weaker and weaker.

"If the ancient types of animal were dependent upon the sun's short rays," explained Dr. Marshall, "ultra-violet deficiency should have been followed by rather rapid extinction."
—Marjorie MacDill

Without vitamin D, bony dinos such as *Triceratops* would have been toast.

DINO ILLUSTRATION: SYLDAVIA/ISTOCKPHOTO; PAPER: PAPHIA/ISTOCKPHOTO

UPDATE

Throw theory a (malformed) bone

It should go without saying that not all ideas are created equal. But even equally logical, intriguing and all-around plausible ideas don't receive equal access to serious scientific investigation. What separates those that move forward from those that fall flat often comes down to one feature: falsifiability.

In 1928, Harry Marshall suggested that a lack of vitamin D, the result of increased volcanic activity and thus ash-laden skies, could lead to all sorts of troubles for the dinosaurs. Within a few generations, he said, malformed bones, vulnerable young, shifting food sources and digestive disturbances could wipe out the creatures entirely. While Marshall's idea has some logic to it — particularly now that researchers think a meteorite hit Earth 65 million years ago, shrouding the planet in dust — it has been largely ignored.

The problem, says Kevin Padian of the University of California, Berkeley, is that like hundreds of other theories behind the dinosaurs' demise, Marshall's proposal isn't testable. Even Marshall admitted: "Extinction produced in this manner should leave only slight traces in the fossil bed." The best evidence that could ever be expected, he said, would be a bone with signs of rickets or a defective tooth.

That would be cool, Padian says. But even then, establishing a causal connection would be required. And researchers would need some proposals for which dinos would have been affected first, why and how — and then evidence for those hypotheses, too.

But just because an idea doesn't deserve equal consideration right now doesn't mean it should be scrapped entirely. Stalled theories are handy to have around. If the right bone ever arrives, scientists should be ready to shift gears and dig in. *—Elizabeth Quill*

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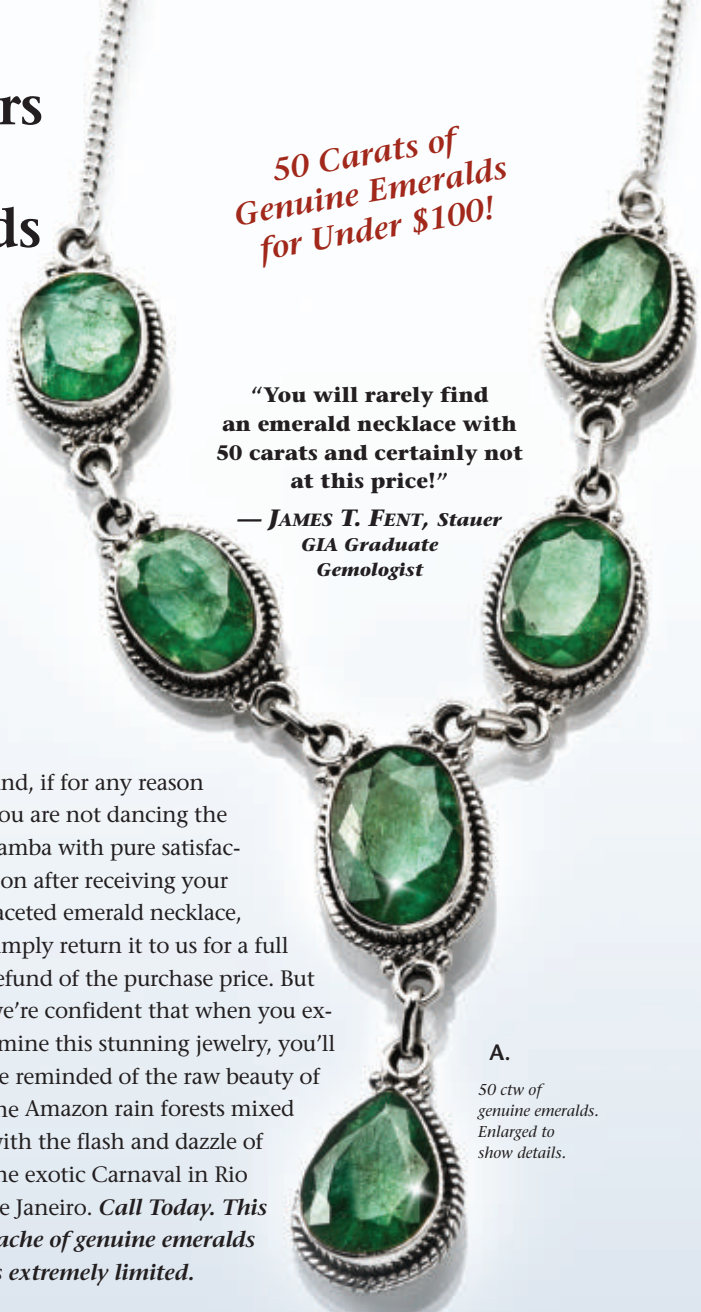

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