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ScienceNews

MAGAZINE OF THE AMERICAN SOCIETY FOR SCIENCE & THE PUBLIC ■ MARCH 13, 2010

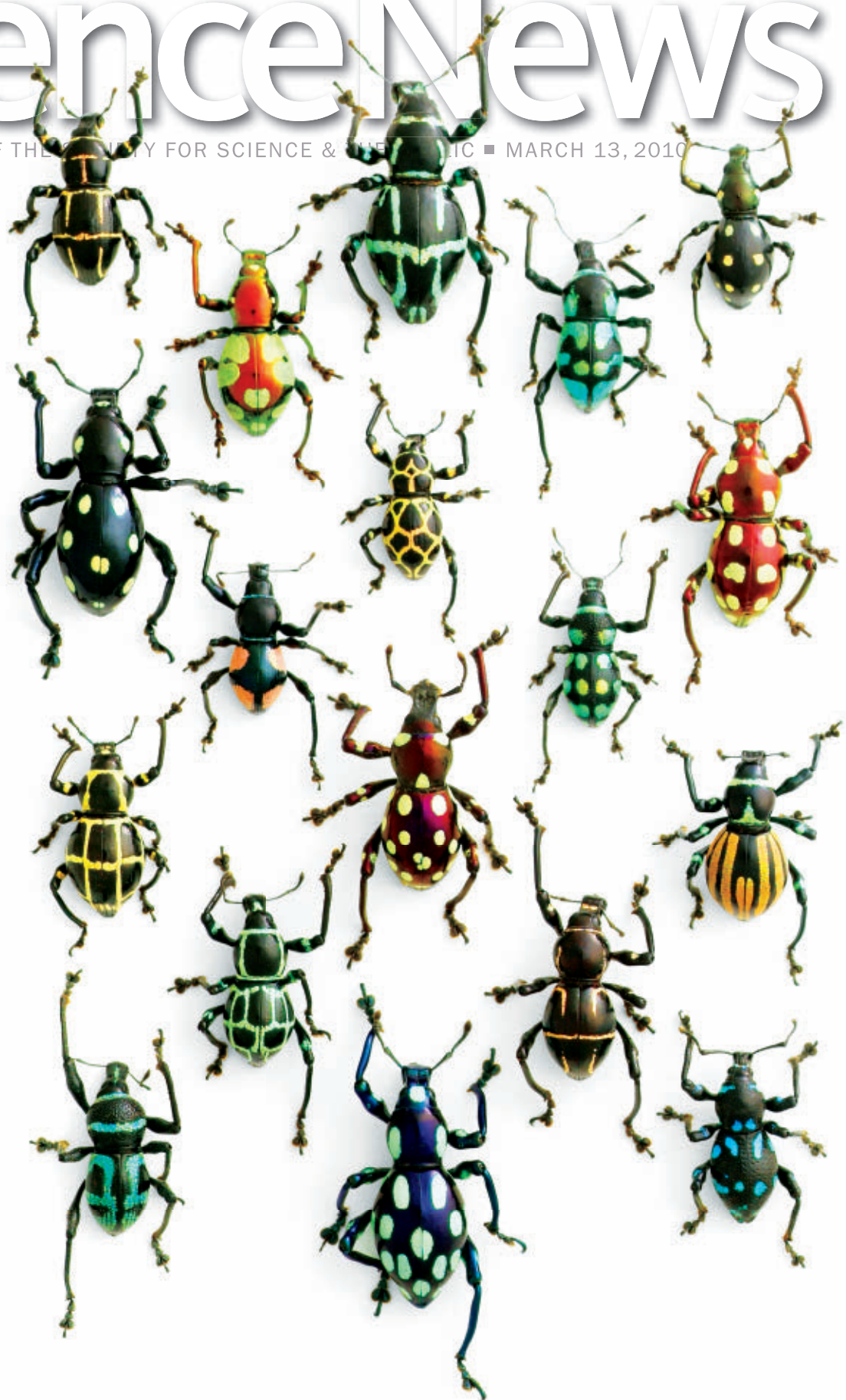
Variety Slips Away


**Biodiversity
on the decline**

DNA Reveals
Recent New World
Migration

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Targets Cancer

Quark-Gluon Soup
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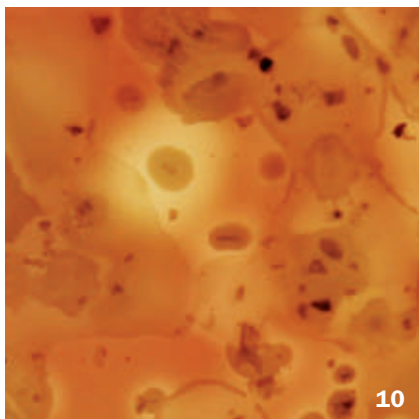
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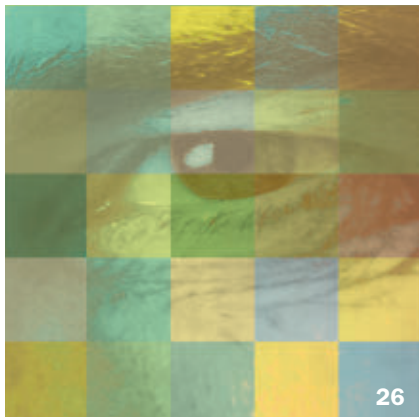
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COVER Ornately adorned weevils in the genus *Pachyrrhynchus* vary in color and pattern.
Christopher Marley
© *pheromonedesign.com*

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1719 N Street NW, Washington, DC 20036 Phone (202) 785-2255
Subscriptions: subs@sciencenews.org Editorial/Letters: editors@sciencenews.org

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FROM THE EDITOR

An idea may be wrong but still newsworthy science



Only rarely do allusions to Dr. Seuss appear in science magazines. But the pervasive noise of Whoville somehow seems appropriately analogous to a noise embedded in the very fabric of spacetime. Such noise is everywhere. If it exists.

On Page 26 of this issue, *Science News*

astronomy writer Ron Cowen describes the imaginative perspective on spacetime noise proposed by cosmologist Craig Hogan. His noise relates to one of science's most vexing problems — merging quantum physics and general relativity. His work suggests that the key to brokering that merger lies in grasping a peculiar relationship between the surface of a black hole and its contents.

As black holes gobble up matter, they grow larger in volume. But the amount of swallowed matter (measured in units that can be expressed in terms of information) is proportional not to the black hole's volume, but to its surface area. Put another way, the two-dimensional surface encodes all the information in the three-dimensional interior. It's something like the way the contents of a room are encoded on walls covered with mirrors, or how a 2-D hologram on a credit card contains a 3-D image if you know how to look at it.

Physicists have used this “holographic principle” before in their explorations of matter and gravity's mysteries, but Hogan applies it in a different way, concluding that spacetime is inherently “jittery,” blurring the notion of location. Understanding this jittery “noise” could revolutionize science's understanding of spacetime, if he's right. Of course, many physicists doubt that he is.

So why write about it? Because it's science. Antiseptic textbook accounts focusing only on the research ultimately shown to be correct cleanse science of the drama inherent in its process. Many ideas that turn out to be wrong nevertheless trigger new questions and inspire new insights.

Controversial science is not the same as crackpot non-science; Hogan is an established physicist publishing his work in a reputable journal. Its likelihood of being wrong (high, some would say) does not disqualify it as an intriguing illustration of science in action. Science includes the search for knowledge, not merely its acquisition. And who knows — if hints of Hogan's noise detected so far are verified by further experiments, then many physicists will be making a lot of noise about it. —Tom Siegfried, Editor in Chief

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It's not the advice you'd expect. Learning a new language seems formidable, as we recall from years of combat with grammar and translations in school. Yet infants begin at birth. They communicate at eighteen months and speak the language fluently before they go to school. And they never battle translations or grammar explanations along the way. Born into a veritable language jamboree, children figure out language purely from the sounds, objects and interactions around them. Their senses fire up neural circuits that send the stimuli to different language areas in the brain. Meanings fuse to words. Words string into structures. And language erupts.

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Adults possess this same powerful language-learning ability that orchestrated our language success as children.

Sadly, our clashes with vocabulary drills and grammar explanations force us to conclude it's hopeless. We simply don't have "the language-learning gene." At Rosetta Stone, we know otherwise. You can recover your native language-learning ability as an adult by prompting your brain to learn language the way it's wired to learn language: by complete immersion. Our award-winning, computer-based method does just that. Dynamic Immersion® unlocks the innate

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Scientific Observations

"Looking at the Caribbean as a region, it's an arc of island.... And what those represent is a boundary between two large tectonic plates, those of the Caribbean and the North American.... We talk frequently about a ring of fire around the Pacific, due to the plate boundaries there. Well this is a little ring of fire located just to the southeast of the United States. So every one of these countries has a certain degree of seismic hazard, and looking forward, now that this earthquake [in Haiti on

January 12] has highlighted so dramatically for us that there are these large risks, it's really incumbent upon everyone to make sure that earthquake safety policy is founded on a really good understanding that there is a seismic hazard and a good assessment about what that hazard is." —MICHAEL BLANPIED, USGS

ASSOCIATE EARTHQUAKES HAZARD PROGRAM COORDINATOR, IN A PODCAST POSTED JANUARY 21

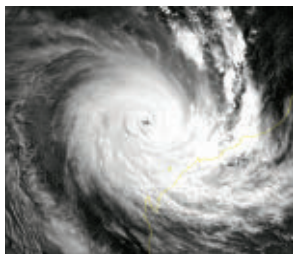
Science Past | FROM THE ISSUE OF MARCH 12, 1960

NEW WEIGHT FOR SILVER WILL NOT AFFECT DIMES — An atom of silver weighs less than previously thought, but this new finding of the National Bureau of Standards will not



affect the silver dimes in your pockets. A dime will still be worth ten cents. The new atomic weight of silver was set at 107.873 through accurate measurements with a mass spectrometer. The atomic weight currently used is 107.880. The more precise atomic weight of silver may mean

that the atomic weights of other elements may have to be adjusted.... What makes the new measurement significant is the fact that the mass spectrometer was calibrated to extraordinary accuracy through use of known mixtures of the two highly purified silver isotopes.



The (-est)

The fastest wind gust unrelated to a tornado occurred at Barrow Island, Australia, in 1996, a panel announced January 22. The World Meteorological Organization's Commission for

Climatology analyzed statistics, observations and recorded data from 1932 to the present. A wind gust at the island was clocked at 408 kilometers per hour on April 10, 1996, during tropical cyclone Olivia (satellite image shown). This blew past the previous record holder, a gust of 372 km/h observed at Mount Washington, N.H., in April 1934.

Science Future

March 19

Hubble 3D, an IMAX film about the telescope's history and highlights, premieres nationwide. See www.imax.com/hubble

March 21–25

The American Chemical Society holds its spring meeting in San Francisco. See www.acs.org

April 18–20

Influenza experts meet in Atlanta to discuss the latest findings on the H1N1 virus and their implications. See web.mac.com/tcassin/iWeb/IPIRC

SN Online

www.sciencenews.org

ATOM & COSMOS

The world's largest panoramic telescope has homed in on the constellation Orion, producing a new infrared view of its star birth area (false color shown). See "A new VISTA on stellar birthplace."



EARTH

Sea levels rose unexpectedly more than 80,000 years ago, a new study of cave formations in the Mediterranean shows. Read "Sea levels erratic during latest ice age."

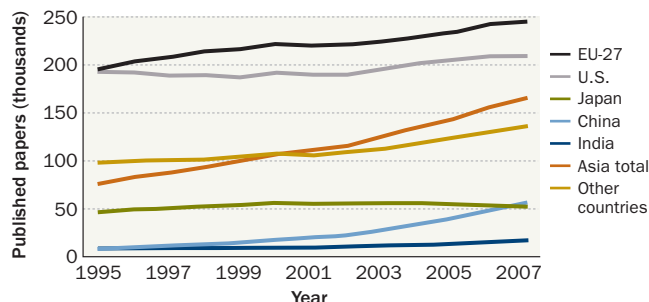
MOLECULES

A manmade molecule has taken its very first steps, blazing a trail for other artificial walkers to follow. See "Tiny molecules walk the track."

Science Stats | GLOBAL TRENDS IN RESEARCH PAPERS

The United States publishes more scientific papers than any other country. In 2007, over half of U.S. papers were in life and medical sciences.

Science and engineering articles by country/region, 1995–2007



SOURCE: SCIENCE AND ENGINEERING INDICATORS 2010/NATIONAL SCIENCE FOUNDATION

CLOCKWISE FROM TOP LEFT: PHOTO COURTESY OF USGS; EUROPEAN SOUTHERN OBSERVATORY; NOAA

“ The shine is brightest when the matter is hottest. ” — BARBARA JACAK, PAGE 8

Atom & Cosmos Cooked-up cosmic soup

Environment Cigarettes' infectious side

AAAS meeting Best sleep styles, by age

Humans Desmond Tutu decoded

Body & Brain Genetics of (some) stuttering

Life Spinosaurus gave *T. rex* the cold shoulder

In the News

STORY ONE

Greenlander has genetic ties to today's Siberians

Find suggests an additional, recent New World migration

By Bruce Bower

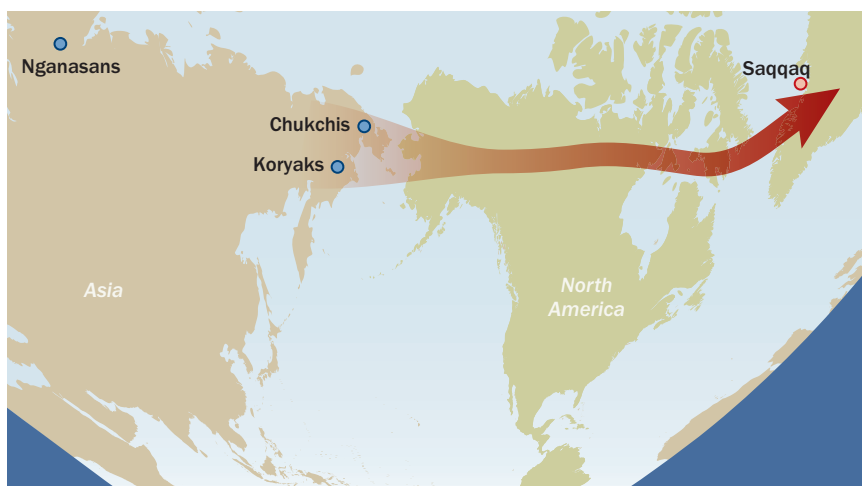
A 4,000-year-old Greenland man just entered the scientific debate over the origins of prehistoric populations in the Americas.

A nearly complete sequence of nuclear DNA extracted from strands of the long-dead man's hair — the first such sequence obtained from an ancient person — highlights a previously unknown and relatively recent migration of northeastern Asians into the New World about 5,500 years ago, scientists say.

An analysis of differences, or mutations, at single base pairs in the ancient Greenlander's nuclear genome indicates that his father's ancestors came from northeastern Siberia, report geneticist Morten Rasmussen of the University of Copenhagen and his colleagues in the Feb. 11 *Nature*.

Three modern hunter-gatherer groups in that region — the Nganasans, Koryaks and Chukchis — display a closer genetic link to the Greenland individual than do Native American groups living in cold northern areas of North America, Rasmussen says.

A largely complete mitochondrial DNA sequence from the ancient man's hair, extracted by the same researchers



DNA from a 4,000-year-old man found near a Saqqaq site closely links him with the Nganasans, Koryaks and Chukchis, suggesting a Siberia-to-Greenland migration.

in 2008, places his maternal ancestry in northeastern Asia as well.

Danish-led excavations more than 20 years ago unearthed four fragmentary bones and several hair tufts belonging to this ancient man, dubbed Inuk. His frozen remains were found at a site from the Saqqaq culture, the earliest known people to have inhabited Greenland. Saqqaq people lived in Greenland from around 4,750 to 2,500 years ago. One popular hypothesis traces Saqqaq ancestry to Native American groups that had settled Arctic parts of Alaska and Canada by 11,000 years ago.

Inuk's strong genetic ties to Siberian populations suggest a different scenario. "We've shown that this ancient individual was not related to Native Americans but derived from an expansion of northeastern Asians into the New World and across to Greenland," says geneticist and study coauthor Eske Willerslev of the University of Copenhagen.

The team's new comparative anal-

ysis of Inuk's previously sequenced mitochondrial DNA indicates that the Saqqaqs diverged from their closest present-day relatives, Siberian Chukchis, an estimated 5,500 years ago. That calculation implies that ancestral Saqqaqs left their Asian relatives shortly before departing for the New World and rapidly traversing that continent to reach Greenland. No land bridge connected Asia to North America at that time, so migrants probably crossed the Bering Strait from what's now Russia to Alaska by boat, Willerslev speculates.

Reasons for why these New World newcomers headed due east to Greenland remain unclear. As experienced Arctic hunters and cold-weather specialists, they may have preferred inhabiting harsh environments of the far north, Willerslev suggests. Archaeological evidence indicates that the Saqqaq people ate seals, birds and fish.

Willerslev's group also identified base pair patterns in Inuk's nuclear DNA that



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SN Today at www.sciencenews.org

are associated in modern populations with type A-positive blood and brown eyes, as well as with thick, dark hair and large, flat front teeth typical of Asians and Native Americans. Inuk also possessed DNA signatures for an increased susceptibility to baldness, dry earwax characteristic of Asian populations, a relatively slow metabolism and the broad, short body type commonly found in residents of cold climates.

DNA analyses of ancient humans and their ancestors usually face enormous technical challenges. Fossil bones get contaminated with the DNA of those who unearth these finds as well as with fungal and bacterial DNA. Measures to enrich paltry ancient DNA samples include generating multiple samples of the same genetic sequences and isolating genetic fragments that show no signs of contamination.

Because DNA from hair typically contains little contamination from fungi or bacteria, Rasmussen's team focused on Inuk's locks. Frozen conditions following death also helped to preserve Inuk's DNA and reduce contamination. The team generated 20 copies of his genome to



Genetic material extracted from hair of a long-dead Greenland man suggests that he had brown eyes and dark hair, as depicted in this artist's illustration.

confirm that significant contamination had not occurred.

About 84 percent of the DNA extracted from Inuk's hair was his. Rasmussen's team then sequenced 79 percent of Inuk's nuclear DNA and identified more than 353,000 base pair variations.

"It is amazing how well-preserved this ancient genetic sample is, presumably due to its rather young age and the permafrost in which it was found," remarks geneticist Svante Pääbo of the Max Planck Institute for Evolutionary

Anthropology in Leipzig, Germany.

In contrast, 40,000- to 70,000-year-old Neandertal bones studied by Pääbo's team have yielded genetic sequences that, because of substantial contamination, generally include no more than 4 percent Neandertal DNA. Pääbo and his colleagues recently extracted and sequenced 63 percent of the total Neandertal genome from a bone (*SN*: 3/14/09, p. 5). "I am envious," Pääbo says, referring to the completeness and quality of Inuk's recovered DNA.

Rasmussen and Pääbo agree that a major challenge will be to sequence ancient human genomes from places where remains have not been permanently frozen and most preserved genetic material consists of microbial, rather than human, DNA.

Another challenge is to gain a firmer grasp of genetic variation in modern Arctic populations, so that scientists can more precisely trace Inuk's geographic roots. "It will become easier to make sense of the genetic data from Greenland as more and more present-day humans become sequenced over the next few years," Pääbo says. ■

Back Story | NEW WORLD MIGRATIONS

DNA analyses have hinted at a number of possible dates and patterns for the peopling of the Americas.



1 Early mitochondrial DNA analyses suggested three waves of migration that correspond to three Native American language groups—Amerind (brown arrow), Na-Dene (blue arrow) and Eskaleut (orange arrow).



2 Another study suggests that a founding group of up to 5,400 people settled in Beringia (blue arrow) and later moved south and east, once the snow blocking their entry into the heart of the Americas melted (*SN*: 2/16/08, p. 102).



3 Analyses of two rare sequences of mitochondrial DNA suggest that two separate groups trekked across the land bridge and went their separate ways. Other groups may have also made separate entries (*SN*: 1/31/09, p. 5).

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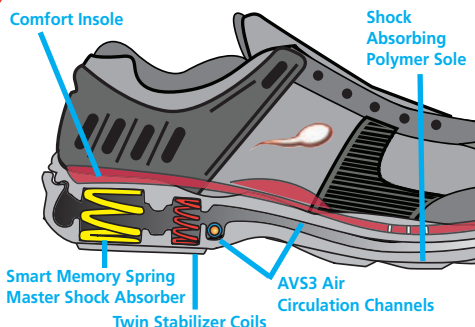
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Physicists cook cosmic soup to 4 trillion degrees

Quark-gluon plasma shows sign of peculiar asymmetry

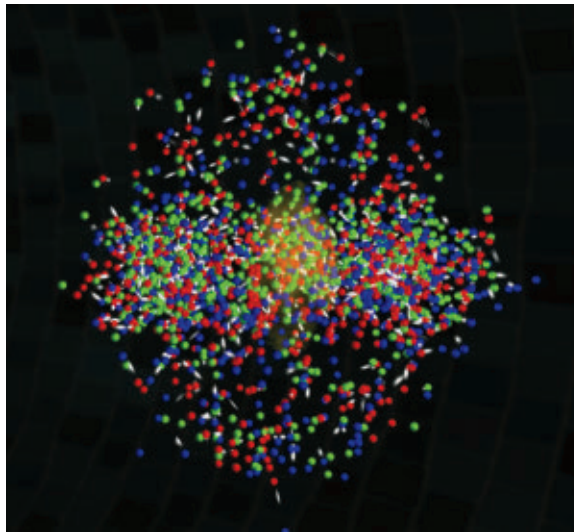
By Laura Sanders

Talk about hot and heavy. Scientists have taken the temperature of a minuscule glob of dense, hot matter formed in the grisly aftermath of collisions between gold atoms traveling near the speed of light. The material reaches an estimated 4 trillion degrees Celsius, about 250,000 times hotter than the sun's interior, and higher than any temperature ever reached in a laboratory, researchers reported at a news briefing on February 15.

The measurements, to be published in *Physical Review Letters*, provide a more detailed description of the superhot, superdense soup of matter called quark-gluon plasma, which may mimic the conditions of the infant universe. Other studies of the soup hint that discrete pockets of the matter break a special kind of symmetry.

In the new study, gold ions were smashed inside an underground track, 3.9 kilometers around, at Brookhaven National Laboratory's Relativistic Heavy Ion Collider on Long Island, N.Y. The collisions caused protons and neutrons to melt, freeing their constituent particles, quarks and gluons. The resulting material, called quark-gluon plasma, was tentatively reported at RHIC several years ago. By taking its temperature, RHIC researchers confirmed that the material consists of quarks and gluons. The new temperature reading also "tells us which point in the universe's history we are probing," said Steven Vigdor, a member of the research team at Brookhaven.

"We hope experiments of this kind give windows into new phases of matter," comments physicist Chris Quigg of the Fermi



A strange state of matter called quark-gluon plasma, produced by collisions of gold ions (simulation shown), reaches 4 trillion degrees Celsius, researchers report.

National Accelerator Laboratory in Batavia, Ill., who was not involved in the work. "There is something new to study."

The gold-gold collisions created a blob about a trillionth of a centimeter across that existed for only a little more than a trillionth of a trillionth of a second. So scientists couldn't stick a thermometer in it, said Barbara Jacak of Stony Brook University in New York, who worked on the temperature measurement. Instead, Jacak and colleagues detected photons — packets of light — as they moved away from the newly formed material, to see how hot the material was. Just as a hot iron rod turns from red to yellow to white as it heats up, light from the material changes properties depending on how hot it is. "The shine is brightest when the matter is hottest," Jacak said.

The average temperature, based on roughly a billion collisions, was measured at about 3 trillion degrees Celsius, Jacak said. By running theoretical models backward, the scientists deduced that the soup reached 4 trillion degrees soon after it was created.


The newly measured temperatures provide strong evidence that the substance is indeed a quark-gluon plasma,

as earlier experiments had indicated. This quark-gluon soup may share properties with the unbelievably hot, dense matter that pervaded the universe soon after the Big Bang, giving physicists a new way to explore properties of the early universe.

Although the substance is called a plasma, in some ways it behaves more like a liquid than a plasma or a gas (*SN: 4/25/09, p. 26*). "We are extremely anxious to find out how this works," Jacak says. "Why is it a liquid?"

The work establishes that the protons and neutrons have melted, but detailing the soup's precise ingredients poses "a fascinating question," Quigg says. "There are many phases. We don't know yet the degree to which these are separate."

In other experiments, the scientists found hints of asymmetry in the force that binds quarks in protons and neutrons. At extreme temperatures where matter changes forms, just the conditions present when RHIC's gold ions collide, asymmetrical "bubbles" might form, physicists theorize, breaking the symmetry in the strong nuclear force. The RHIC results hint that asymmetrical bubbles form for all but head-on collisions of gold ions, suggesting left-right symmetry breaking.

A similar asymmetry may explain why the universe is populated mostly with matter rather than equal amounts of matter and antimatter. If matter and antimatter were created in equal parts, as symmetry would dictate, then the two would annihilate each other, leaving nothing. Understanding how left-right symmetry is broken might give scientists new clues to how a matter-antimatter asymmetry was created in the early universe. 

1.18
trillion eV

Highest proton
beam energy
at LHC in 2009

3.5
trillion eV

Proton beam
energy target
for LHC in 2010

7
trillion eV

Max LHC proton
beam energy —
a goal for 2013

Large Hadron Collider finally set to begin regular proton beam collisions

Accelerator will be limited to half power for 18 to 24 months

By Ron Cowen

After more than a year of delays, the most powerful atom smasher on Earth is finally ready for regular collisions of its two proton beams, expected to begin around March 1. But to help safeguard CERN's Large Hadron Collider from further electrical problems, the accelerator will run at only half its maximum energy for the next 18 months to two years, said Steve Myers, CERN's director for accelerators and technology, during a talk on February 13.

That decision all but guarantees a new and major delay in discovering new elementary particles including the long-sought Higgs boson, whose existence would account for why subatomic particles have mass.

Starting in mid-March, each of the twin beams of protons accelerated by the Large Hadron Collider are expected to carry an unprecedented energy of 3.5 trillion electron volts. But that's just half the 7 TeV per beam that the particle accelerator is designed to have, Myers noted. The collider, situated outside Geneva, won't run at full power until 2013, he said.

The lower-than-designed operating energy aims to ensure that the collider doesn't suffer any additional electrical problems. In September 2008, an electrical short in the system powering some of the collider's superconducting magnets forced a shutdown of the accelerator for more than a year. The short caused a thermal runaway in a section of the superconducting magnetic system, not only damaging magnets but also flooding part of the 27-kilometer accelerator with helium gas.

After a yearlong set of repairs during which about 106 magnets were either refurbished or replaced and 6,500 new detectors were added to the system's magnetic protection system along with 250 kilometers of new cable, that particular problem "can never happen again," said Myers.

But during tests in April 2009, scientists discovered another set of problems. Electrical flaws were found in copper bus bars housing superconducting cables.

The copper problem is not a complete showstopper but means that the LHC can operate safely only at 3.5 TeV per beam. At higher energies, the faulty connection could vaporize the copper and cause further damage to the collider. After 2011,

the collider will shut down for a year of upgrades and then is expected to finally achieve its maximum energy in 2013, Myers said.


Late last year, the LHC achieved what was then the highest energy of any accelerator — 1.18 TeV per beam, beating out the Fermilab's Tevatron in Illinois. Because of all the delays with the LHC, the Tevatron's operating life has already been extended two years, to 2011, and Fermilab scientists are closely watching the LHC's progress to determine whether they might keep the Tevatron working until 2012, said Joseph Incandela of the University of California, Santa Barbara.

In the meantime, even operating the LHC at 3.5 TeV per beam will take physicists "into new territory," Incandela said, where the discovery of new physics, including signs of a new theory of elementary particles known as supersymmetry, is still possible. ■


The collider is expected to finally achieve its maximum energy of 7 TeV per beam in 2013.

MEETING NOTES

Improving dental dosimetry

A tiny chip of tooth enamel can tell the tale of radiation exposure, Barry Pass of Howard University in Washington, D.C., reported February 16. Radioactivity creates long-lived unpaired electrons when it hits tooth enamel; the higher the dose, the more unpaired electrons. Researchers can detect this signal with electronic paramagnetic resonance, which relies on electromagnetic waves hitting the tooth and interacting with the unpaired electrons. This technique once required so much enamel that an entire tooth might need to be extracted. Using a higher frequency of electromagnetic waves, Pass and colleagues were able to determine radiation doses from samples as small as 2 milligrams. These "enamel biopsies" must be removed from the tooth, but are so small that they don't interfere with the tooth's function. —*Laura Sanders* 

Shaving extra dimensions

Any extra dimensions of space curled inside the three that humans inhabit are less than 50 micrometers in diameter, physicists reported February 15. Ted Cook of the University of Washington in Seattle and colleagues used a torsion pendulum to probe how gravity works at small scales. If the force's strength differs from expected when objects are very close, it could indicate that gravity leaks into extra dimensions. Earlier work showed that gravity's pull is normal when objects are 56 micrometers apart, meaning any extra dimensions must be smaller than that. But Cook's setup is twice as sensitive, allowing him to winnow the limit even further. He eventually hopes to push the limit below 30 micrometers. —*Lisa Grossman* 

Environment

21
percentProportion of adults
who smoked in the
United States in 200845
percentProportion of smokers
who reported trying to
quit in previous year

Germ in tobacco potential source for infections blamed on smoking

Tests find hundreds of bacterial species in major brands

By Janet Raloff

Cigarettes host a bacterial bonanza of hundreds of different germs, including those responsible for many human illnesses, a new genetics study reports.

The data support findings described last September by scientists at the Roswell Park Cancer Institute in Buffalo, N.Y. They extracted tobacco particles sitting atop filters or inside cigarette packaging and placed the particles in a sterile culture medium that simulated human lungs. In most cases, the team was able to grow bacteria that had been present on the near-microscopic flakes.

Scientists have long known that smokers and people exposed to secondhand smoke experience high rates of respiratory infections, notes Amy Sapkota of the University of Maryland in College Park. The presumption has been that smoking impairs lung function or immunity — which it may, she acknowledges.

“But nobody talks about cigarettes as a source of those infections,” she says. So she and her colleagues screened leafy bits of cigarettes for bacterial DNA.

The scientists probed for ribosomal

material, protein-building elements that read and execute instructions encoded within a cell’s DNA. Sapkota’s team homed in on long, species-specific regions of this material known as 16S markers and compared them with those of known bacteria.

Checking 16S markers for close to 800 known bacteria revealed matches to many hundreds of markers in the four brands of cigarettes screened: Marlboro Red, Camel, Kool Filter Kings and Lucky Strike Original Red. All were purchased in Lyon, France, where Sapkota was completing postdoctoral studies.

In a paper published online in *Environmental Health Perspectives*, Sapkota’s team lists many of the most prevalent bacteria present, including *Campylobacter*, which can cause food poisoning; *Clostridium*, *Corynebacterium*, *Klebsiella*, *Pseudomonas aeruginosa* and *Stenotrophomonas maltophilia* — all of which are associated with pneumonia and other infections; *E. coli*; and a number of *Staphylococcus* species that underlie serious hospital-associated infections.

Such genomic analyses can’t prove whether the DNA in unlit cigarettes came from live germs. But Alejandro Rooney of the Agricultural Research Service in Peoria, Ill., says that, based on data he published five years ago, at least some could have.

In seeking the source of severe respiratory disease in some U.S. troops in Iraq, most of whom were new smokers, “We looked at the microbes that you could culture from cigarettes and that were alive,” Rooney says. Most bacteria belonged to families that form spores. “And that makes sense,” he says, because tobacco in

cigarettes is dry. And spore-forming bacteria like *Bacillus subtilis* can survive in a state akin to suspended animation until they reach a suitable environment.

Roswell Park immunologist John Pauly agrees. In a paper last September in *Immunological Research*, he and his colleagues reviewed studies showing that live germs inhabit all types of tobacco products, although in most cases few


to none of the microbes had been identified by species.

Pauly’s group also summarized tests at Roswell Park showing that about 60 percent of cigarette filters they examined — representing 11 brands — contained tobacco particles. The tobacco also hosted bacterial toxins. And as a rule, the team reported,

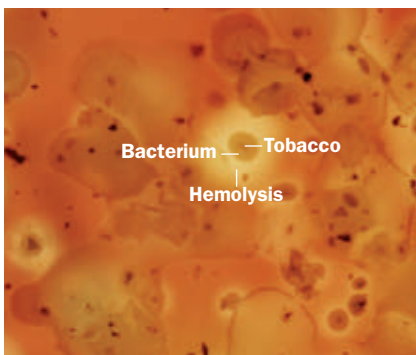
“bacteria grew from greater than 90 percent of the randomly selected flakes.”

When cultured with blood, Pauly’s team demonstrated, “those tobacco-derived bacteria frequently destroyed the red blood cells.”

Bacterial contamination of tobacco tends to occur after harvesting. “When you place it in a curing situation, for example — a barn with high temperatures, high humidity, poor ventilation and blocked-out sunlight — you get a near-perfect environment for growing bacteria and fungi,” Pauly says.

Cigarette companies have been awarded a host of U.S. patents for killing microbes. These include one issued six years ago to three Virginia scientists on behalf of cigarette maker Philip Morris. It covers the use of an antibacterial wash on fresh or partially cured tobacco as a cost-effective method “of reducing both the numbers and activity of bacterial and fungal populations.” The patent points out that these microbes are responsible for producing endotoxins and tobacco-specific nitrosamines. Those nitrosamines are “the number one carcinogens found in both smoking and smokeless tobacco products,” Pauly says. 

Markers for known bacteria matched hundreds of bacteria from four brands of cigarettes.



Bacteria from tobacco, grown in the lab with blood, are surrounded by remnants of red blood cells destroyed by bacterial toxins in a process called hemolysis.

J. PAULY, L. SMITH, M. RICKERT, A. HUTSON AND G. PASZKIEWICZ/ROSWELL PARK CANCER INST.

AAAS Meeting

Brain cells at the breaking point

Fracture study could lead to insights into traumatic injury

By Laura Sanders

Rigid pathways in brain cell connections buckle and break when stretched, scientists report, a finding that could aid in the understanding of exactly what happens when traumatic brain injuries occur.

Up to 20 percent of combat soldiers in Iraq and an estimated 1.4 million U.S. civilians sustain traumatic brain injuries each year. But the mechanics behind these injuries have remained a mystery.

New research presented February 19 shows that forces similar to those that cause traumatic brain injury can damage tiny conduits called microtubules.

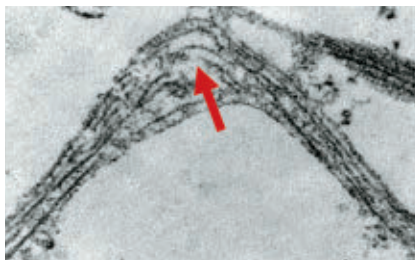
Microtubules extend down the length of axons—which transmit electrical signals in brain cells—serving as “superhighways of protein transfer,” said Douglas Smith of the University of Pennsylvania in Philadelphia, who conducted the research with colleagues. Brain cells rely on microtubules to move important cel-

lular material out to the ends of axons.

Car crashes, bomb blasts and falls can damage these intricate links, and destroying even a small number of them can cause devastating damage.

“You can have very small lesions in very discrete pathways which can have phenomenal impact,” said Geoffrey Manley, a neurosurgeon at the University of California, San Francisco, who did not participate in the research.

When Smith and colleagues quickly




Sudden forces cause structures inside axons to break (arrow), leading to damage, a new study shows.

stretched brain cells growing on a silicone membrane, the microtubules inside the axons immediately buckled and broke, spilling their contents.

“This disconnection at various discrete points spells disaster, and things are just dumped out at that site,” Smith said. “Microtubules are the stiffest component in axons, and they can’t tolerate that rapid, dynamic stretch.”

Like Silly Putty pulled slowly apart, axons can adjust to gradual stretching, Smith said. But sudden forces, like those that happen in blasts and collisions, can cause the Silly Putty to snap.

In their lab dish experiments with brain cells on silicone, the researchers were able to minimize microtubule damage with a drug called Taxol, commonly used to treat cancer. But it’s too early to say whether the drug would work in people with traumatic brain injuries.

Currently, traumatic brain injury research is in “the abyss between bench and bedside,” Manley said. So figuring out exactly what happens in traumatic brain injuries could lead to new approaches to treatment. 

Stem cells fuel prostate tumors

Mouse study also shows role for gene in malignancy

By Laura Sanders

Some self-renewing stem cells may play a role in prostate cancer, and a certain gene in these cells contributes to the malignancy, research presented February 20 suggests. Prostate cancer is the most common malignancy in men in Western nations, affecting one in six men.

Like many other tissues in the body, prostate tissue is made up of several different kinds of cells, including a class called basal stem cells. Normally these cells divide to replenish prostate tissue,

but sometimes they become cancerous. Instead of producing normal cells, these stem cells lead to tumors.

“Think about cancer as a disease of stem cells,” said study coauthor Owen Witte, a Howard Hughes Medical Institute investigator at the University of California, Los Angeles. Mutations can cause “normal stem cells to lose their regularized behavior and instead turn into an incipient cancer.”

Witte and his colleagues wanted to determine which class of cells generates prostate cancer in mice. They separated mouse prostate cells into different groups based on type, then introduced mutations often found in prostate cancers. Then the researchers implanted the cells back into mice one type at a time.

Basal stem cells outpaced the other groups by far in their cancer-forming

ability, the researchers reported February 9 in the *Proceedings of the National Academy of Sciences*. Earlier studies suggested that the same thing might also be happening in human prostate cancers.

“When we apply stem cell thinking to cancer, we find that in the run-up to cancer—the premalignant period—many, many genetic and heritable changes occur in the line of stem cells,” commented Irving Weissman of Stanford University.

A gene called *BMII* is important for basal stem cells’ self-renewal and may also play a role in malignancy. When *BMII* activity was knocked down in basal stem cells, the cells were no longer able to self-renew, nor did they form tumors, Witte reported at the meeting. “We get a dramatic change in the rate of growth and the tumor outcome by blocking this one single pathway,” Witte said. ■

AAAS Meeting



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Tumor tracking gets personal

Bringing genomics to cancer detection and surveillance

By Eva Emerson

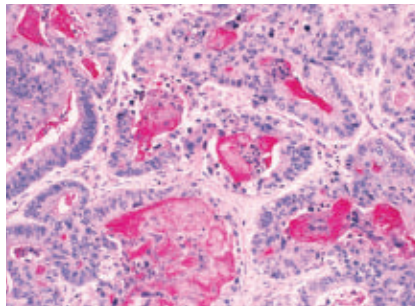
A new way to identify cancer's genetic scrambling may allow doctors to better monitor how patients respond to treatment and detect a tumor recurrence.

Wholesale juggling of chunks of DNA is common in cancer cells, but cataloging those changes hasn't been easy. Now, a small study of colorectal and breast tumor cells shows that these genetic rearrangements can be reliably identified and that these genetic changes are unique to each individual's tumor. While that individuality may stymie efforts to design therapies to target these rearrangements, their presence alone can be useful as a marker of cancer's waxing and waning, scientists reported at a news briefing February 18 and in the Feb. 24 *Science Translational Medicine*.

The ability to rapidly identify such rearrangements from individual tumors offers doctors a potentially powerful way to track tumor activity in patients.

In a commentary in the same issue, Ludmila Prokunina-Olsson and Stephen Chanock of the National Cancer Institute in Bethesda, Md., say the new study "lays an important foundation," but caution that some issues still need to be worked out before the next-generation method used in the study becomes a "this-generation" medical tool.

Though the cost per patient—the team spent about \$5,000 characterizing the specific genetic changes in each of the six people studied—is still high, most believe it will drop fairly quickly, said study author Victor Velculescu of the Kimmel Cancer Center at Johns Hopkins University in Baltimore. He is optimistic the work will lead to a commercially available blood test in a few years.



Tracking chunky rearrangements in tumor DNA (colon cancer cells above) provides hints about patient health.

In the study, scientists from Johns Hopkins and Life Technologies Corp. of Foster City, Calif., compared the genomic sequence from a tumor biopsy with that of normal tissue taken from the same person. Looking at four patients with colorectal cancer and two with breast cancer, scientists identified four to 17

unique genetic rearrangements in each tumor. The rearrangements were dramatic in nature, Velculescu said, more like "switching the order of chapters in a book than a typo in a word in the text." The team found the rearrangements only by using massively parallel sequencing methods capable of reading hundreds of millions of DNA letters and advanced computers to analyze results.

Using custom-made DNA probes for two patients, the team was able to detect as little as one tumor DNA fragment in 400,000 normal DNA fragments. Scientists then tracked blood levels of the tumor marker in one patient before and after tumor surgery. Levels dropped after surgery, only to rise again. After more treatment, marker levels dropped substantially, but a small amount was still detectable, consistent with a small part of the tumor having spread. ■

Marine reserve placement is key

Targeting heaviest-fished areas can boost conservation

By Alexandra Witze

Saving both fish and the fishermen who depend on them appears to come down to one thing: location, location, location.

Marine protected areas need to be located in the right spots to have the maximum effect, researchers report. The work was presented on February 21 and appears in papers published online February 22 in the *Proceedings of the National Academy of Sciences*.

In the Black Sea, for instance, setting aside just 20 to 30 percent of the most affected areas within marine reserves could accomplish nearly all the goals of protecting the entire reserve, reported a team led by Benjamin Halpern of the National Center for Ecological Analysis and Synthesis in Santa Barbara, Calif. Precisely placing reserves, he said, "can have a dramatic effect on their ability to improve overall ocean health."

Halpern's work could also help illuminate which areas are worth protecting. The biggest potential gain, he said, comes in areas that are heavily fished, where setting aside large chunks led to ocean health improvements of up to 50 percent.

Managing marine protected areas can meet conservation goals while benefiting fishermen who work nearby, said Andrew Rassweiler of the University of California, Santa Barbara. He is a coauthor of another new study, which modeled how fish larvae disperse through the ocean from a marine protected area in southern California. A nearby fishery can improve its economic return by as much as 10 percent if it tracks how and where the larvae grow into big fish it can catch, he reported at the meeting.

"People fishing can make more money with smaller impacts on the species being fished," he said.

28
percent

Fraction of U.S.
adults deemed
scientifically literate

35
percent

Fraction of Swedish
adults deemed
scientifically literate

14
percent

Fraction of U.K.
adults deemed
scientifically literate

Don't know much about ...

A measure of U.S. science literacy has increased — to 28%

By Janet Raloff

Over the past two decades, science literacy — an estimate of the share of adults who can follow complex science issues and maybe even render an informed opinion on them — has nearly tripled in the United States. To a meager 28 percent.

U.S. adults had to answer such questions as What is a stem cell? What is an experiment? True or false: Nuclear power plants contribute to the destruction of Earth's ozone layer. To be deemed literate, people had to get at least 70 percent of the answers right, explained Jon Miller of Michigan State University in East Lansing.

The new U.S. rate, which he reported

February 21, is based on questionnaires administered in 2008. Sweden, the only European nation to exceed U.S. science literacy, ranked seven percentage points higher on a 2005 survey. The U.S. figure exceeds slightly the 2005 science literacy in Denmark, Finland, Norway and the Netherlands and is double the rate in the United Kingdom.


U.S. improvements do not reflect better pre-college science education, Miller contends, since scores on tests of kids' science achievement have remained stable — and low. A better explanation, he says, is the undergraduate curriculum.

"The United States is the only country in the world, right now, that requires all of its university students take a year of general education," Miller said, "which

means they all have a year of science." Successful learning also has to do with expectations, he maintains. And unlike in U.S. high schools, college professors insist students learn — or fail them.

Science literacy may also climb as adults encounter relevant issues, said sociologist Jeong-Ro Yoon of the Korea Advanced Institute of Science and Technology in Daejeon. Farmers may take notice, for example, if a genetically modified crop was suddenly slated to be planted upwind of their fields.

Miller concedes that some of the rapid increase in U.S. science literacy may reflect such self-education by adults, aided by the Internet.

For instance, as soon as a loved one develops cancer, he noted, parents or spouses often immerse themselves in anything and everything available on likely causes of the disease and treatment options. 



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EX-095-210



Longer sleep can boost older brains

Study finds uninterrupted rest matters more for the young

By Laura Sanders

Quantity, not quality, of sleep may determine how well older people's brains function the next day, researchers reported February 21. For youngsters, though, quality may be more important. Sleep affects young and old brains differently, the study shows, and the findings may ultimately lead to new ways to offset age-related cognitive decline.

The link between sleep and learning has been well-established, comments Matthew Walker of the University of California, Berkeley. "It's critical to sleep before learning. Sleep almost prepares the brain like a dry sponge to soak up new information."

Contrary to common belief, older adults don't sleep substantially less than younger adults. From age 35 to 85, people actually lose only about an hour of nightly sleep on average, psychologist and study coauthor Sean Drummond of the University of California, San Diego said. Rather, what changes is sleep

efficiency—a measure of the portion of time spent tossing, turning or lying awake in bed. "The biggest, most common, most robust change is that we spend more time awake in the middle of the night," Drummond said.

In the new study, 33 adults with a mean age of 67 and 29 adults with a mean age of 27 slept in a lab while Drummond and colleagues measured the duration and quality of their sleep. The next day, the researchers tested participants' brain activity and performance on a learning and memory task.

Older adults who had slept for more total time the previous night were able to more accurately remember a list of random nouns than older adults who had slept fewer hours. What's more, functional MRI experiments showed that regions of the brain important for learning and memory had higher activation in older adults who had slept more hours.

Sleep quality seemed to have no effect on performance, Drummond said. "For older adults, the absolute minutes of sleep they got last night has a significant influence on performance today."

In younger folks, on the other hand, the quality of sleep was critical, Drummond found. Young adults who slept with limited interruption performed better and

had higher brain activity in certain regions than those who woke up frequently during the night.

"Sleep last night does impact performance and brain function today, and it does so differently depending on whether you're in your mid-20s versus your mid-60s," he said. "Older adults need to get a certain amount

of sleep. Young adults need to get that sleep in a consolidated chunk."

The good news, Drummond said, is that disrupted sleep among the elderly is not harmful in itself. Rather, it's the actual total minutes of sleep that need to be watched. Tuning sleep quantity may help prevent cognitive decline with age, he said. ■

"Sleep almost prepares the brain like a dry sponge to soak up new information."

MATTHEW WALKER



Dolphins' diabetic turn-on

New research bolsters evidence that bottlenose dolphins go into a harmless diabetic state that pumps up blood glucose levels during overnight fasting. The research, presented February 18, suggests that dolphins may be a good model for studying diabetes in people. Most animals—but not dolphins—get their glucose fix from eating carbohydrates. "Brains need sugar to function, but a diet of fish has no sugar," said Stephanie Venn-Watson of the National Marine Mammal Foundation in San Diego. Blood chemistry work shows that dolphins may have a "diabetic switch" that helps keep the brain well-fed even when they haven't eaten for some time. In the new study, Venn-Watson and colleagues report that the condition may become pathological. Three dolphins with abnormal insulin levels also had iron overload, a condition associated with diabetes in people. A similar diabetic switch may lurk in humans, she said. While humans and dolphins aren't closely related, both have big brains and blood cells that can move large amounts of glucose. "Maybe we can find the switch in humans," she said. —Rachel Ehrenberg

ACTIONSPORTSNC/ISTOCKPHOTO

“By and large, the kids [conceived with in vitro fertilization] are fine. But if there are [differences] you can measure, then you should.” —**CARMEN SAPIENZA**

MEETING NOTES

Early disruption of schizophrenia gene causes problems later


Disrupting a gene implicated in schizophrenia early in development leads to brain anomalies and behavioral defects later in life, a new study in mice finds. The results, presented February 22, may help researchers understand how early developmental problems contribute to schizophrenia—a disease that typically shows up after adolescence.

In humans, mutations in a gene called *DISC1* are known to cause flaws in networks of brain cells long before symptoms of schizophrenia appear. Researchers led by Akira Sawa of Johns Hopkins University School of Medicine in Baltimore developed a new technique to diminish *DISC1* activity in mice that are still developing in the womb.

The animals' brain chemistry and behavior seemed normal at 28 days. But at 56 days, mice that had reduced *DISC1* activity in the womb had lower levels of the neurochemical dopamine in the brain's prefrontal cortex, the team found. These mice also performed worse on behavioral tests of information processing.

In further experiments, researchers treated the mice with the schizophrenia drug clozapine, which elevates dopamine levels. After treatment, the mice showed reduced behavioral defects. The results give researchers hope that interventions at the adult stage can overcome deficits incurred early in development, Sawa said.

Psychologist Tyrone Cannon of the University of California, Los Angeles calls Sawa's research “critical and elegant work.” Although scientists have known for over 50 years that disorders like schizophrenia are highly heritable, he says, “it's taken us quite a bit of

time to realize just how complex the genetic architecture of these disorders is, and to develop strategies that can begin to unravel the mystery of their inheritance.” —*Laura Sanders* 

IVF kids show shift in levels of gene activity

Researchers have found substantial effects on the activity of dozens of genes related to growth, metabolism and related functions among children conceived through in vitro fertilization, epigenetics researcher Carmen Sapienza of Temple University School of Medicine in Philadelphia reported February 21. “By and large, the kids are fine,” Sapienza said. “But if there are [differences] you can measure, then you should.”

With IVF in general, “we're kind of doing an experiment here,” he said.

Epidemiological studies have revealed a greater incidence of low birth weight in children conceived with IVF. Among other health issues, low birth weight is a risk factor for obesity, hypertension and type 2 diabetes later in life.

In the Oct. 15 *Human Molecular Genetics*, Sapienza and his colleagues described differences in DNA methylation on some 700 genes chosen because of their known role in growth and metabolism. The team found different methylation levels in 5 to 10 percent of those genes, investigated in a group of children conceived via IVF compared with children conceived naturally.

Methylation does not affect the genetic information itself, but how genes are expressed throughout life. Sapienza's team determined that the differences in DNA methylation patterns did translate to differences in activity for some of the genes, several of which are known to play a role in fat cell development or insulin signaling.

Despite the differences, about 90 percent of the children in the IVF group were still within the normal range of gene activity levels, Sapienza said. —*Eva Emerson* ■

Brain tells signs from pantomime

The brain can apparently tell the difference between a word and a gesture—even when the word is a gesture.

Karen Emmorey, a cognitive neuroscientist at San Diego State University, has been looking at the brain activity of deaf people as they interpret American Sign Language. She showed 10 subjects pictures of objects that have actions associated with them—a cup for *drink*, say, or a broom for *sweep*. She asked participants to either sign the ASL word that goes with the picture or to pantomime using the object. In some cases, such as *drink*, the word and the gesture are the same: Subjects pretended to hold a cup in one hand and brought it to their mouths. For other words, such as *sweep*, the sign and the pantomime look different.

By taking positron emission tomography images of the volunteers' brains during the activities, Emmorey found different regions of the brain lighting up when the deaf subjects signed than when they pantomimed, even when the word and gesture were identical.

“For sign production we find language regions engaged,” Emmorey reported February 19. But when subjects pantomimed, the brain regions that lit up were those associated with grasping, manipulation and motor planning.

“The fact that many signs are iconic doesn't change the fundamental organization of language, nor does it change the neural systems that underlie language,” she said. —*Lisa Grossman* ■

Humans



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Bushmen have more diversity

Study of southern Africans finds genetic treasure trove

By Tina Hesman Saey

An archbishop and four Bushmen walk into a lab. What emerges is no joke, but a more complete picture of human genetic diversity than ever seen before.

A new study of five Africans has identified more than 1 million new human genetic variants and could contribute to a better understanding of the genetics underlying many human diseases. The data might also lead to more effective medications for Africans, who often derive less benefit from drugs than the people of European ancestry who are the most common test subjects in drug development trials.

Archbishop Desmond Tutu and four Bushmen leaders from Namibia contributed their DNA for the new study, published in the Feb. 18 *Nature*. Researchers decoded the complete genetic blueprint of Tutu, who belongs to the Bantu ethnic group, and !Gubi, one of the Bushmen. The international team also deciphered the protein-coding portions of the three



!Gubi is one of four Bushmen who participated in a study of genetic diversity in southern Africans.

other Bushmen's genomes.

The data confirm that the Bushmen are among the most genetically diverse people in the world and reveal about 1.3 million previously unknown variations in all five men's genomes. These variations, called SNPs, change a single nucleotide, or chemical building block, of DNA.

Because African populations are not well represented in genomic studies, this research "is going to set the stage for future studies in Africa," says Sarah Tishkoff, a human geneticist at the University of Pennsylvania in Philadelphia

who was not involved in the project.

The new research also reveals evidence of mixing between hunter-gatherer Bushmen and agricultural Bantu people. Tutu has a female heritage marker usually found only in Bushmen, indicating that the archbishop has a female Bushmen ancestor. And one of the Bushmen has a type of Y chromosome often found in Bantu men, indicating a Bantu male ancestor.

The new study could help scientists assess newly discovered links between genetic variation and disease, says Stephan Schuster, a geneticist at Pennsylvania State University in University Park and one of the project's leaders. For instance, a variant in the *LIPA* gene has been linked to a fatal lipid metabolism disorder called Wolman syndrome. But three of the Bushmen carry the variant and are still in good health at approximately 80 years old, possibly indicating that the change is not actually disease-causing or that other genetic variants might counteract it.

Driving hazardous to cell phone use

Operating a car impairs drivers' ability to recall information

By Bruce Bower

Phones don't just interfere with driving—it turns out the reverse is also true.

Driving dents the capacity to describe and remember information in cell phone messages, at least for some of the youngest and oldest drivers, a new study finds. These subjects had a harder time relaying stories they had heard in cell phone messages while driving, say psychologist Gary Dell of the University of Illinois at

Urbana-Champaign and his colleagues.

Both older and younger drivers seated next to a passenger while operating a vehicle in a simulator had more difficulty correctly retelling brief stories, versus repeating them while sitting in an unmoving "car," the researchers report in the February *Psychonomic Bulletin & Review*. Participants, especially those over age 60, also remembered less about stories after simulated driving than after sitting in the unmoving car.

Driving skills also took a hit while subjects retold the stories, the investigators say. Earlier studies have found that driving worsens while talking on cell phones or sending text messages.

This new research challenges the notion that conducting important business conversations while driving boosts productivity.

"Safety concerns aside, if the quality of a conversation matters to your business, then it is best to reserve your conversation for times when you are not operating a motor vehicle," remarks psychologist David Strayer of the University of Utah in Salt Lake City.

Body & Brain

1
percent

Fraction of the human population that stutters

Genes may explain some stuttering

Defects on chromosome 12 found in small portion of cases

By Nathan Seppa

After testing hundreds of people who stutter, researchers have nailed down defects in three genes that may account for a fraction of cases, researchers report in the Feb. 25 *New England Journal of Medicine*.

Scientists don't fully understand why most children who stutter overcome it, why stuttering persists in others and above all, what causes the condition.

In the new study, scientists examined genes on a specific strand of chromosome 12, previously linked to stuttering, using DNA obtained from 123 stutterers in Pakistan and 270 in the United States and England. The researchers

also tested 96 people in Pakistan and 276 in North America who didn't stutter, as a control group.


In 21 of the stutterers, the researchers found that one of three genes on chromosome 12 was mutated, a rate of about 5 percent. Only one of these mutations showed up in a nonstutterer, in one of the Pakistani controls. None occurred in the Western controls.

All three genes carrying the mutations encode enzymes that play a role in the proper function of lysosomes, compartments that serve as cellular recycling centers. Extraneous materials are pulled into lysosomes, where the materials are chopped up and digested.

If the recycling process in lysosomes

goes awry on a large scale, the result can be a fatal cascade of cell death, tissue damage and organ failure, says study coauthor Dennis Drayna, a geneticist at the National Institute on Deafness and Other Communication Disorders in Rockville, Md.

But people who stutter, including participants in the new study who tested positive for one of the three mutations, typically have no such dire disease.

Syuichi Ooki, a physician at Ishikawa Prefectural Nursing University in Kahoku, Japan, wasn't surprised that these mutations appeared in genes involved in a rudimentary area of cell metabolism. Mutated genes can lead to a chain of events and induce unforeseen biological changes, Ooki says. "Therefore, mutation of genes involved in a basic metabolic process can unexpectedly affect human behavior." 



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Life



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To escape rivals, simply sail away

Sail-backed dinos avoided *T. rex* by taking to the water

By Sid Perkins

Paleontologists may have solved the mystery of how spinosaurs and tyrannosaurs — two dinosaur groups that included many large, fierce predators — could have lived in the same regions at the same time. A new study suggests that, like many pairs of surly neighbors, they simply avoided each other.

Spinosaurus, the sail-backed dinosaurs made famous by a star turn in the movie *Jurassic Park III*, belonged to a group of meat-eating dinosaurs called theropods. But unlike tyrannosaurs and most other theropods, spinosaurs had conical, unserrated teeth similar to those found in crocodiles, says Romain Amiot, a paleontologist at University of Lyon 1

in Villeurbanne, France, and coauthor of the new study. And although spinosaurs had long, crocodile-like snouts and fossilized stomach contents suggest their prey included fish, the creatures didn't have any skeletal features that hint at a semiaquatic lifestyle, such as feet specialized for swimming.

But the ratios of oxygen isotopes in the creatures' teeth tell a different story, Amiot and his colleagues report in the February *Geology*. Creatures that spend a lot of time in and around the water — like hippos and crocodiles — typically have lower oxygen-18 to oxygen-16 ratios in their bones and teeth than their land-lubber counterparts.

In spinosaur teeth from 12 sites, including southeast Asia, north Africa, England and Brazil, the researchers found that average oxygen isotope ratios were substantially lower than those of tyrannosaurs or other theropods living in those regions at the same time. The isotope ratios were, however, similar to those of contemporaneous crocs and



Isotopic analysis suggests spinosaurs (illustrated above) spent much of their time in or near lakes and rivers.

turtles, a sign that the spinosaurs probably spent much of their time in and around lakes and rivers.

The new findings “solve the big ecological problem of how spinosaurs could live in the same areas as tyrannosaurs,” Amiot says. “They were avoiding competition for food and territory by dividing up the ecosystem,” he says. ■

Human noise may distract animals

Tests using boat sounds find hermit crabs less attentive

By Susan Milius

Noisy humans may be distracting hermit crabs to death by diverting their attention from approaching predators, a new study by UCLA researchers concludes.

When boat noise roared over a beach, the crabs weren't as quick as usual to hide inside their shells to avoid a predator, behavioral ecologist Daniel T. Blumstein and his students found. In an upcoming *Biology Letters*, they propose the boat roar may not be masking the sound of an approaching predator so much as distracting the crabs from looking out for danger.

Distraction makes



sense, the researchers contend, because boat noise had an effect even during tests with a mock predator that made no noise. Blumstein and his colleagues studied wild hermit crabs on St. John in the U.S. Virgin Islands by playing recordings of boat noise provided by a Hollywood sound engineer. For a silent menace, the researchers used poles to swing a black T-shirt covering an inflatable doughnut toward the crabs.

On a quiet beach, the crabs typically snapped back into their shells

Blasts of noise appear to distract Caribbean hermit crabs from an approaching danger.

before the T-shirt had swung within 80 centimeters. During the playbacks of noise, though, the T-shirt could approach to almost 60 centimeters on average.

“Ingenious,” comments ecologist Richard Fuller of the University of Queensland in Brisbane, Australia. He and his colleagues have found that urban noise pollution has a stronger effect than light pollution on whether European robins switch from daytime singing to nocturnal serenades.

People have added all kinds of new roars and rumbles to nature's sounds, and a growing body of research shows that the increasingly loud world affects animals. The new study “opens the way for much more work on the effects of human noise on complex behavioral systems, not just the simple drowning out of acoustic signals,” Fuller says.

Blumstein would now like to know whether crabs get used to the blasts. 🐚



AMERICAN HISTORY

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Losing life's variety

2010 is the deadline set for reversing declines in biodiversity, but little has been accomplished **By Susan Milius**

No silly hats or shouted countdowns. But entomologist Scott Miller is hosting a small event to mark the beginning of 2010, which the United Nations has declared the International Year of Biodiversity. Miller's occasion is low-key, on a weekday, before noon even, and there's no bubbly in sight. But there are other reasons for not quite calling this a celebration.

This is a poignant year for anyone who cares about the rich diversity of life on

planet Earth. 2010 was supposed to be a milestone. The 193 nations participating in a treaty called the Convention on Biological Diversity had agreed to "achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth."

Fat chance. The official document assessing the 2010 global outlook for biodiversity won't be released until May,

but conservationists and trend watchers predict at best a few bright points among worsening losses. Even a preview statement from the treaty secretariat says that, as of late January, "all the indications are that the 2010 target has not been met."

Policy has achieved little for biodiversity, but scientists have fared better in coming to understand just what biodiversity means for the fundamental workings of an ecosystem. From grasslands to oceans, ecologists are finding

CHIP CLARK/THE SMITHSONIAN

Sky-blue hairstreaks display the subtle diversity within one butterfly species.

that greater diversity tends to boost an ecosystem's productivity and reinforce its stability.

Biologists around the world are thus bootstrapping themselves out of despair and seizing the occasion to explain biodiversity and why it matters.

Earth's vast diversity

Miller's mini-New Year's event may be low on champagne, but it's a world-class demonstration of what biodiversity is. He's using insects to convey the variety of life by giving a little tour of his workplace, which happens to be the Smithsonian National Museum of Natural History in Washington, D.C. As the Smithsonian's deputy under secretary for science, he has a lab that looks out on part of the research collection of insect specimens — there are 35 million of them.

Leading the way through the public exhibit halls toward the stored collections, Miller strides past dramatic fossil displays: half-billion-year-old remains of weird, spiky creatures from Canada's Burgess Shale, an Irish elk with antlers that loom like roof-mounted satellite dishes and other vanished marvels.

Though things have been disappearing for a long time, humanity has revved up extinction rates in the past few centuries to as much as a thousand times the rates during much of Earth's history, according to the 2005 Millennium Ecosystem Assessment. That status report, the work of some 1,360 scientists, names habitat change, climate change, introduction of invasive species, overexploitation and pollution as the big causes of this anthropogenic extinction. And the report calls for urgent action.

Not far from the elk, Miller opens an inconspicuous security door into the museum's private world. The "nation's attic" has wide, well-lit corridors, and

when Miller reaches the giant room storing much of the pinned insect collection, he pauses to let the sight sink in.

It's not attic-y at all, but has the super-clean, bright feel of movie sets for secret, high-tech installations. Ranks of some 1,800 cabinets, almost ceiling-high, near-white and identical, march into the distance.

Miller starts with a few shallow wooden drawers topped with glass. The collection's 135,000 drawers hold specimens from just about every kind of place an insect has ever been: tiny leaf min-

ers that excavate within a single mangrove leaf and harvester ants that scurry over desert sands, for example.

All these insect habitats — the whole range of ecosystems on the planet — rank as a form of biodiversity, Miller says.

He lifts trays holding insects grown from larvae picked out of fruits in Papua New Guinea. The assembled rows appear to contain duplicates of a tiny brown-winged thingy, but his trained eye recognizes dozens of species.

Another tray holds dozens of postage-stamp-sized brown moths pinned in evenly spaced rows. The moths also look the same at first glance, and Miller says this drawer holds nothing but a single species of spruce budworm, an infamous pest of eastern forests in North America. Staring closely, though, reveals shades of brown, from mahogany and chocolate to almost beige. And the wings are mottled with yet tinier variations on the theme.

These individual differences count as biodiversity too. Differences at the ecosystem, species and genetic levels all matter, Miller says.

Recent wipeout

Losses at all these levels had roused enough concern by 1992 for an Earth Summit in Brazil to produce the Convention on Biological Diversity treaty. Enough nations had ratified the treaty by 1993 for it to become a binding legal document. By now, all nations have agreed to participate

except for Andorra, the Holy See and the United States. Political opposition in 1993 prevented the full U.S. Senate from voting on whether to ratify the treaty, and the issue has lain dormant since.

At a meeting in 2002, the participants adopted the strategic plan that set the date, 2010, for achieving the reduction in losses. Now, like serial New Year's resolvers pledging to lose 10 pounds, signatory nations have to get on the scale.

The treaty secretariat's January preview of the reckoning provided only broad trends with arrows and pie charts to indicate whether various goals had been met. (On a global scale, they had not.)

"It's not looking good," says Jean-Christophe Vié, deputy coordinator of the species program at the International Union for Conservation of Nature in Gland, Switzerland. The nonprofit maintains the Red List, a registry that ranks the status of various species, from thriving ("least concern") to extinct.

Though comparing IUCN data over time is difficult because the scope and criteria have changed, the Red List provides a snapshot of where biodiversity is now.

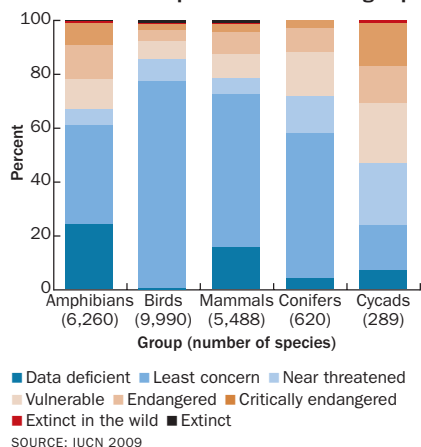
At the end of 2009, an IUCN report found plenty of creatures, mostly animals and plants, still in peril. Of the 44,838 species that the IUCN had evaluated by 2008, 16,928 met at least the criteria for

"It's not because one beetle or one frog is going extinct that we are worried.... It's that the losses are massive."

JEAN-CHRISTOPHE VIÉ

Categorizing concern The International Union for Conservation of Nature assigns each assessed species a category of concern. Of the groups below, amphibians and cycads have the largest portions of endangered species, thanks in part to habitat destruction and overcollection.

Red List status of species within various groups



“facing a high risk of extinction in the wild.” Evaluators said some of them met more dire criteria, facing “very high” or “extremely high” extinction risks. That troubled group included one in eight of the bird species, one in five mammals, one in four corals and one in three amphibians. (Scientists have formally described some 1.7 million species, and estimates of total richness run from 3 million to 10 million.)

Another indicator, the Living Planet Index, averages changes in the sizes of populations of 1,686 vertebrate species. The index, put out by the World Wildlife Fund, the Zoological Society of London and their partners, slid almost 30 percent from 1970 to 2005.

In this deadline year, “biodiversity is still declining—there’s no doubt about it,” Vié says.

Though species losses are only one measure of diversity, if a species is crashing, so is any genetic variety within it. And taking more and more species from an ecosystem raises concerns that the swamp, woods or pond will lose its distinctive traits, becoming something else, in a form of system-level extinction. So, as crude as they are, tallies of species’ statuses let conservationists take the pulse of life on the planet.

The meaning of loss

As for the impact of these declines, Vié says, “I don’t think people get it.” Too often biodiversity loss has come to mean extinction of some creature a continent away. “It’s not because one beetle or one

frog is going extinct that we are worried,” he says. “It’s that the losses are massive.”

So just what’s going to happen when so much biodiversity disappears has become a pressing question. Plenty of experiments, albeit accidental ones, have already demonstrated that subtracting even one species can change an ecosystem. The Millennium Assessment report lists 21 such “experiments,” carried out by fishing fleets, overenthusiastic gardeners or even wildlife managers.

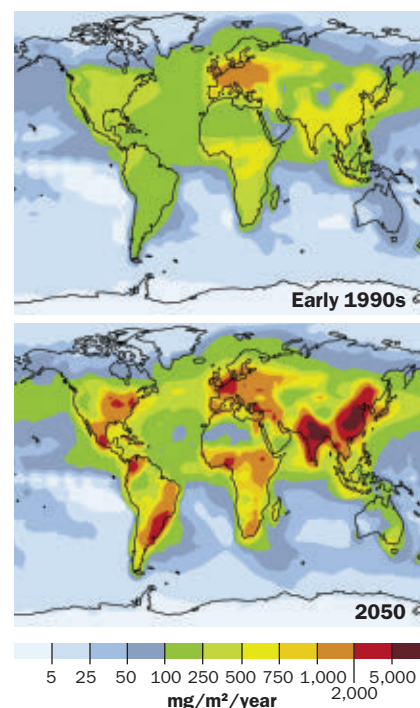
Removing sheep and cattle in an attempt to restore Santa Cruz Island, Calif., for example, let nonnative plants spread over the landscape unchecked. And harvesting of triggerfish in Kenya’s reefs allowed sea urchin populations to boom, leading to increased coral erosion.

Ecologists have also started intentional experiments that explore how biodiversity affects the basic workings of an ecosystem, such as how much life it supports or whether it will repair itself after a disaster such as a drought.

Drought inspired the longest-running of the post-treaty wave of biodiversity experiments, says David Tilman of the University of Minnesota in St. Paul. For reasons that had little to do with biodiversity, he and his colleagues were monitoring grassland plots at the university’s Cedar Creek Ecosystem Science Reserve. Then a drought hit.

In looking at the pathetic, shriveled plants, Tilman and his team found that plots with 20 or so species had about half the living matter, or biomass, recorded in the same plots in a normal year. But plots

Trends in reactive nitrogen deposition



SOURCE: MILLENNIUM ECOSYSTEM ASSESSMENT

Drivers of change The Millennium Ecosystem Assessment lists the deposition of reactive nitrogen, due in part to increased fertilizer use, as an important cause of ecosystem change. Other drivers include habitat fragmentation, overexploitation and climate change.

with one or two produced only one-tenth of the biomass of a normal year.

“We actually didn’t believe the results when we first saw them,” Tilman says.

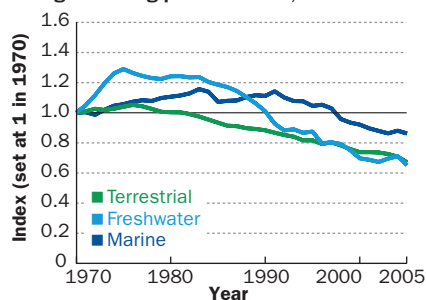
Tweaking the analysis this way and that still produced the same findings. So Tilman set up an experiment as a deliberate test of the effects of species number on biomass. With 168 plots of one to 16 species, the experiment has been running for 16 years. In the early years it led to a paper presenting evidence that yes, under the same conditions, plots with more species of plants eventually tend to yield more biomass than plots with fewer species.

A 2006 paper in *Nature* by Bradley Cardinale of the University of California, Santa Barbara and his colleagues supports these findings. The team concludes that, overall, tests have shown that greater diversity in systems from grassland plants to rock-hugging marine invertebrates increases the basic productivity of an ecosystem.

Monitoring losses The Living Planet Index, actually an average of three indexes, tracks populations of 1,686 species to provide measures of vertebrate status. Tropical species have been hardest hit. Rabb’s fringe-limbed treefrog (shown) is categorized by the IUCN as “critically endangered.”



Changes in living planet indexes, 1970–2005



SOURCE: WWF, WWW.PANDA.ORG

WHAT TO DO: Count the costs

Nature is underpriced, says economist Partha Dasgupta. No one pays the mountainside for the trees it grows or the sea for the fish it provides.

Figuring out the economic values of nature's services and incorporating them into such indicators may be one way to curb destruction of biodiversity. For without a fair accounting, nature looks like a free lunch, and, Dasgupta says, "If you don't pay for something, you overuse it."

To highlight the economic value of nature on a big scale, Dasgupta, of the University of Cambridge in England, is pushing for a nature-inclusive alternative to the Gross Domestic Product as an economic indicator.

The GDP reports the total value of human-made goods and services without deductions to reflect losses of capital, especially natural capital. Gross, as opposed to net, is "the rogue word" in Gross Domestic Product, he says.

Dasgupta is now urging nations and the World Bank to monitor another measure that he and others have been refining in recent years. "Comprehensive wealth per capita" adds human and natural assets to tallies of capital, and should provide a much-needed way to see whether growth is sustainable, he argues in the January 12 *Philosophical Transactions of the Royal Society B*.

Dasgupta compared GDP to his new measure of wealth per capita for five countries and for sub-Saharan Africa from 1970 to 2000 (see table). All the nations averaged annual increases in GDP, and sub-Saharan Africa was slipping only 0.1 percent a year. But when Dasgupta used his wealth indicator, the figures looked different. He incorporated natural resources and human resources. With this measure, sub-Saharan Africa looked even worse than it had based on

Average percent growth in two economic indicators, 1970–2000

Country/region	Wealth per capita	GDP per head
Sub-Saharan Africa	-2.8	-0.1
Bangladesh	-0.8	1.9
India	-0.4	3.0
Nepal	-0.4	1.9
Pakistan	-1.4	2.2
China	4.5	7.8

SOURCE: ADAPTED FROM DASGUPTA, 2010

GDP, and the nations, except China, slipped from the positive into the negative column.

What's still missing from the new indicator, Dasgupta says, is a calculation for the complete range of services that ecosystems perform. Many more ecosystems need assessment before there's enough data to include these factors in a wealth analysis.

Edward Barbier of the University of Wyoming in Laramie, who has studied Thailand's coastal mangroves, is building up some of the information on ecosystem damage and services. Since 1975 an estimated 50 percent or more of

the country's mangroves have been destroyed to make way for shrimp farms along the coast. The tsunami that bashed the coast in December 2004 raised interest in one of the mangroves' previously underappreciated services—their ability to soften the wallop of incoming waves.

Barbier factored storm protection into a 2007 economic analysis that speaks to land use and restoration choices. He estimated the net returns

for shrimp farms at \$1,078 to \$1,220 per hectare (in 1996 dollars, based on investing for five years and then abandoning the farm). If farmers were required to restore the farms with their acidified, compacted soil so that the mangrove ecosystem could thrive again, shrimp farming wouldn't be worthwhile. Restoration costs at least \$8,812 per hectare, the researchers calculate.

But, Barbier found, a fully functioning mangrove ecosystem would be worth the restoration cost. The value of the mangroves—including the protection they give to larvae in fisheries, products harvested directly from the mangroves and storm protection—added up to at least \$10,158 per hectare. —Susan Milius

What causes that burst of productivity has led to lively debate. Having more species may increase the chances of getting one super-producing plant that plumps up biomass. That scenario, called a sampling effect, could play out in some systems, but Tilman says he thinks his plots are getting an extra boost from the powers of competition. When species crowd into an area, they compete for resources and become efficient at using them.

Experiments so far suggest that sampling effects explain about one-third of this productivity increase, Cardinale and

his team reported in 2007 in *Proceedings of the National Academy of Sciences*. The other portion, the team says, comes from ways that species in a mix complement each other—by promoting growth and through division of labor.

Plants sprout at the foundation of an ecosystem's food web, capturing energy from the sun. Diversity, though, also has an effect on the creatures that eat the plants, says marine ecologist Emmett Duffy of the College of William & Mary's Virginia Institute of Marine Science in Gloucester Point.

Duffy has worked with flowering plants called seagrasses that grow entirely under water. Much of their success depends on the little arthropods called amphipods and isopods that graze on the seagrass blades and remove algal scum that can dim the light. With more species of grazers at work, over time, algae were cleared off more efficiently and grazers increased in number, Duffy says.

Another underwater experiment supports the notion that biodiversity provides stability. A study published in the December 2009 *Ecological Applications*

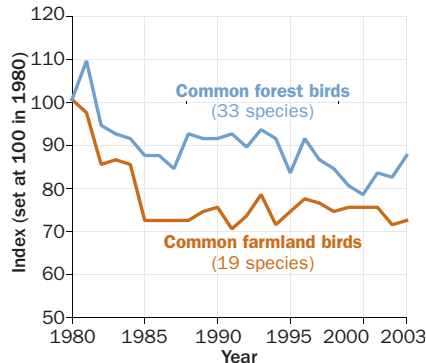
shows that keeping more fish in the sea may give an ecosystem some protection against unwanted algae.

Biologists have warned that burgeoning algae, encouraged by excess nutrients in the water, ranks as one of the most serious threats to the Baltic Sea. To see if the region's declines in perch and other predatory fish also encourage algal outbreaks, Britas Klemens Eriksson of the University of Groningen in Haren, the Netherlands, and his colleagues set up field experiments. Keeping top predators away from study plots began a cascade of changes that eventually led to fewer small creatures grazing on algae.

"Not all species are created exactly equal," says Boris Worm of Dalhousie University in Halifax, Canada. If a top predator disappears, change can shoot through an ecosystem. "It's like hitting a node in a power grid—and the lights go out everywhere," he says.

Worm's own work suggests that fisheries in the more species-rich of the world's marine ecosystems appear less likely to collapse and faster to recover than fisher-

Population declines in European birds



SOURCE: CONVENTION ON BIOLOGICAL DIVERSITY

Close-up on birds Scientists have been tracking declines in bird populations around the globe for decades. *Eriocnemis isabellae*, native to Colombia, has recently been labeled critically endangered by the IUCN.



ies in species-poor regions. The analysis, based on more than 50 years of data from the Food and Agriculture Organization of the United Nations, was published in *Science* in 2006.

Even genetic variation within the same species has been shown to affect how well ecosystems pull up their socks and repair

themselves. Jay Stachowicz of the University of California, Davis remembers a New Year's Eve call from his then-student Randall Hughes. Brant geese had found Hughes' study plots of eelgrass clones, which she had genetically analyzed with great care. And the geese had eaten just about all of the eelgrass.

WHAT TO DO: Prioritize wild spaces

Reversing the downward spiral of biodiversity will take more than protecting wild places, but that's where scientists are starting. Declaring protected zones across a range of terrestrial ecosystems is the one area where clear progress toward saving biodiversity has been made, says an upcoming United Nations report. Now researchers are making strategic picks for sheltered zones to fill in the gaps on land and in the sea.

Just documenting diversity doesn't guarantee that a place becomes a park. Selecting good bits requires understanding how critters use space and weighing competing claims for it.

One recent approach looks to double the punch of the



case for setting aside land by identifying biodiverse places that also provide documented ecosystem services, says Taylor Ricketts, who heads the World Wildlife Fund's Conservation Science Program, based in Washington, D.C. Though the two don't match tidily, Ricketts has found a few natural sweet spots important for their variety of living things and for such boons as storing abundant carbon or collecting water.

The Natural Capital Project, based at Stanford University, is refining software to allow fine-scale analyses, and Tanzania, the state of Hawaii and others are already using the software.

To pick worthy spots, scientists must also understand how protectees use space, a big puzzle in the seas. Selecting a reef (Papahānaumokuākea marine reserve shown), requires knowledge of where the juvenile fish and corals that populate those waters traveled from.

A modeling technique that includes ocean currents can give a broad picture of dispersing sea creatures, says Eric Trembl of the University of Queensland in St. Lucia, Australia. The technique predicts that coral larvae in the Pacific travel some 50 to 150 kilometers before settling in. Of particular interest to conservationists, Trembl says, might be reefs that serve as stepping-stones for surfing corals and reef clusters that are especially isolated. —Susan Milius

"I tell my students, you've got to make lemonade out of the lemons," Stachowicz says. Hughes kept monitoring the disaster zone. Eelgrass plots with more genetic diversity tended to regrow to their former density faster, she and Stachowicz reported in *Proceedings of the National Academy of Sciences* in 2004.

But biodiversity doesn't always show a short-term effect. For eelgrass growing in the wild, only one of the two characteristics that Hughes and Stachowicz measured, shoot density, correlated with genetic diversity, and only in the winter. That's the time for goose attacks and other miseries, so maybe that's when bounce-back power really matters, Stachowicz and Hughes, now of Florida State University Coastal & Marine Laboratory in St. Teresa, speculated in May 2009 in *Ecology*. Likewise, biodiversity effects showed up in the long run but not the short-term in work on algal-species mixes, Stachowicz and colleagues reported in *Ecology* in 2008.

Regardless of the technical ecology research, Miller says, preserving biodiversity is just common sense. He makes what's been called the "intelligent tinkerer" argument: When fiddling with something complicated and not entirely understood, it's not smart to throw away parts — especially when those systems keep humanity alive on the planet. Miller hands over a printout of a list he's made of some services: clean water, wild fish, pollinators for crops, protection from erosion, clean air.... Pulling pieces out of ecosystems puts these services at risk.

Also, he points out, biodiversity has aesthetic and spiritual values. Stewardship of the natural world stands as an obligation of certain religious traditions. And some deep urge in humankind, what entomologist Edward O. Wilson of Harvard University has called "biophilia," may draw people to other living things.

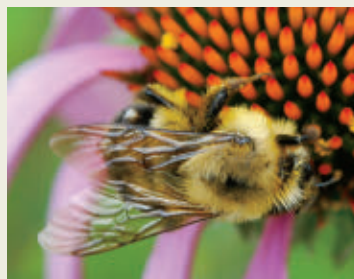
Back among the insects, Miller pulls out a drawer with row after row of ranks of iridescent blue *Morpho* butterflies to illustrate his point. Most people have at one time or another admired portraits of these beauties, but such images don't do justice even to museum specimens,

WHAT TO DO: Tend the not-so-wild

Maintaining biodiversity by protecting wild or lightly inhabited land alone would overlook the realities of this crowded century, says Mark Goddard of the University of Leeds in England. Humankind's footprints already cover a lot of space.

In 2008, for the first time, more than half the planet's people lived in cities. So bits of greenery in yards or urban parks need attention, Goddard and his colleagues argue in the February *Trends in Ecology and Evolution*. Surveys show that remnants of nature in built-up environments can boast impressive populations of some species. Bumblebees of several kinds proved more abundant in San Francisco's urban parks than in two parks outside the city. In Britain, the density of one bumblebee species's nests in suburban yards matched the density in hedgerows in the countryside. And the frog *Rana temporaria* declined in the English countryside but thrived in towns. If biodiversity can be promoted in a city's crazy quilt of greenery, the areas could add up, Goddard says.

Conservationists are already experimenting with incentives, pledges and certification programs to coax private landowners to make the most of their yards. In



the United Kingdom, the Royal Society for the Protection of Birds has inspired more than 25,000 people to improve their habitats through the Homes for Wildlife plan. And in the United States, the National Wildlife Federation's Certified Wildlife Habitat program has reached more than 100,000 properties. Yards and urban parks do present harsh challenges, such as bird-unfriendly cats. But early research

has started sorting out what factors might soften urbanization's impacts.

Even the most artificial of landscapes might be rendered at least a little friendlier to biodiversity, say two forest ecologists at the University of Quebec City in Montreal. Tree plantations, usually created as rows of a single species destined for harvest for timber or pulp, "have a bad reputation," Alain Paquette says. In the February *Frontiers in Ecology and the Environment*, he and Christian Messier argue that plantations need not become biodiversity deserts. Foresters might leave patches of previous stands for animal habitat as the next stand grows, or tighten up soil preparation to reduce erosion. One hefty change would be to trade monocultures for polyculture plantations growing several tree species.

Foresters have resisted the mix, in part because harvesting gets complicated. But Paquette and Messier report that planting fast-growing hybrid poplar as nursemaid species to shelter slower-growing trees shows promising early results. Last year the researchers set out young trees in test plots of up to a dozen species to find out what kinds grow well together. Paquette says he hopes that experiments that have predicted higher biomass in the presence of greater species diversity will apply to practical forestry, too. — Susan Milius

which shimmer and glow as the angle of view tilts. Next, Miller displays something less familiar: a drawer of adult Heliodinidae moths, which are bigger than rice grains but not by much. Bending close, he points out blazes of russets and rich browns mixed with white on tiny but lovely wings. There's inspiration in

known diversity and in the variety that has yet to be admired. And that is indeed something to celebrate. ■

Explore more:

- IUCN: www.iucnredlist.org
- Millennium Ecosystem Assessment: www.millenniumassessment.org

*Oh, the noise!
Oh, the noise! Noise! Noise! Noise!
That's the one thing he hated!
The NOISE! NOISE! NOISE! NOISE!*

—DR. SEUSS, *HOW THE GRINCH STOLE CHRISTMAS*

By Ron Cowen

The Grinch detested the noise created by the tiny residents of Whoville. Cosmologist Craig Hogan, in contrast, has become enamored of a noise he claims is generated by something even tinier — a minuscule graininess in the otherwise smooth structure of spacetime.

Call it Hogan's noise. Many physicists are skeptical, but if his hunch about the existence of this subatomic clatter proves correct, it could have a mind-boggling implication: that the entire universe is nothing more than a giant hologram.

What's more, it would mean that the structure of spacetime on subatomic scales might soon be revealed. "What's new is that we can make a prediction and design an experiment to measure something on the tiniest of scales in the universe, and that's what hasn't been done before," says Hogan, director of the Fermilab Center for Particle Astrophysics in Batavia, Ill., and a researcher at the University of Chicago.

In fact, it's just possible that a detector in Hannover, Germany, built for an entirely different study, may have already recorded the noise generated by the smallest units of spacetime in the universe.

But Hogan's model would go even deeper than that. It could lead to a major revision in how scientists think about spacetime, says theorist Bernard Schutz, director of the Max Planck Institute for Gravitational Physics in Potsdam, Germany. Hogan's hypothesis suggests that information encoded on a tiny piece of spacetime could somehow influence the amount of information available to an observer from a region far, far away — violating a principle of physics known as locality. Rejecting locality would have major implications for attempts to knit

together the quantum world — the subatomic realm — with Einstein's general theory of relativity, which deals with gravity and the structure of spacetime on the very largest cosmic scales.

In most models that try to apply quantum theory to spacetime, the universe is indeed grainy, Schutz notes.

But that graininess is usually the same everywhere in the cosmos. In contrast, Hogan's model suggests the graininess isn't uniform. It gets amplified the farther an observer resides from grains in a remote region of spacetime. That concept "would be a major revolution" in quantum gravity research, Schutz says.

Hogan's noise

A cosmologist suggests a novel way to uncover the nature of spacetime on the smallest scales

PHOTO OF HOGAN: FERMILAB;
ILLUSTRATION: T. DUBÉ

Cosmologist Craig Hogan is proposing that the universe is a hologram made of tiny grains, or pixels, of spacetime.

Holographic pixels

Physicists often describe spacetime as “pixelated,” or carved up into tiny, indivisible units with a length of only about 10^{-35} meters — one ten-trillionth of a trillionth the diameter of a hydrogen atom. That’s much too small to be detected directly in any experiment. Or so most people have assumed.

Hogan combines the idea of pixelated spacetime with the notion, borrowed from string theory and quantum mechanics, that the universe is equivalent to a hologram. That notion holds that a surface enclosing a volume of space encodes all the information contained in that volume. Just as the hologram imprinted on a credit card reveals a third dimension, so too does an imaginary surface in spacetime appear to create an extra dimension.

The position of every particle in space is represented in quantum theory by a wave function, a mathematical formula for describing the probability that the particle has a particular location. In Hogan’s model, each grain of spacetime can be

thought of as having a wave function associated with it, making spacetime fuzzy. (The fuzziness means that the position of a particle can only be known as precisely as the length of each grain.)

Each grain is much too small to measure. But as a wave travels through space, it interferes with waves from adjacent grains (adjacent patches of spacetime), producing an interference pattern — a band of light and dark fringes — that on a distant screen is large enough to be measured.

In Hogan’s model, the larger the hologram, the larger the interference pattern. If the hologram is big enough, the traveling waves produce a kind of macroscopic jitter, or noise, which could be recorded with a relatively inexpensive experiment, Hogan asserts.

He and his colleague Mark Jackson, now at Leiden University in the Netherlands, described their ideas last year in *Physical Review D*. Hogan has also posted his latest work online on arXiv.org.

If Hogan is right, he has made a breakthrough in understanding the quantum world. Despite decades of effort, physicists have not yet successfully melded quantum theory with gravity, an essential step in forming a complete theory of the universe. Since the 1950s, scientists have managed to develop complete quantum versions of the other three known forces in nature — the electromagnetic force; the strong force, which binds protons and neutrons together; and the weak interaction, which is responsible for certain kinds of radioactive decay. Gravity is the last holdout.

Most attempts to quantize gravity assume the existence of quantum fields that obey the concept of locality, which holds that an event in one region can affect only what happens in an adjacent region. A change in an electric field in one region of space, for instance, affects only

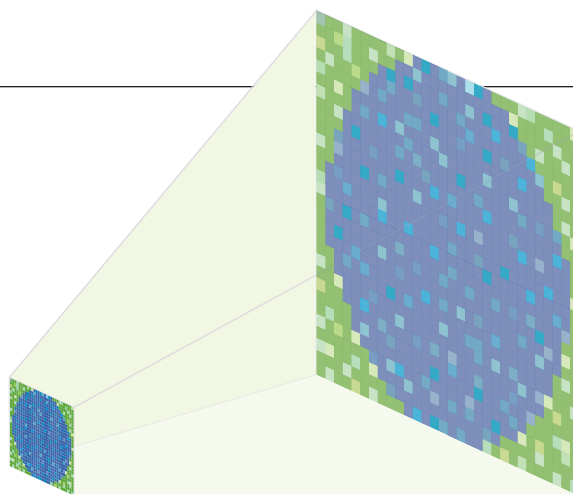
fields in an adjacent region. But Hogan’s model suggests that theorists should seriously consider a quantum theory of gravity in which two very different regions of spacetime, despite their vast separation, can still profoundly influence each other, Schutz notes.

But like many physicists, Schutz says he is skeptical about the details of Hogan’s model, which appears to be mainly conceptual. Hogan, for his part, readily admits his model is not fundamental — it doesn’t explain why there is a fundamental unit of length, for instance — but it predicts a specific type of noise that could be verified by experiments.

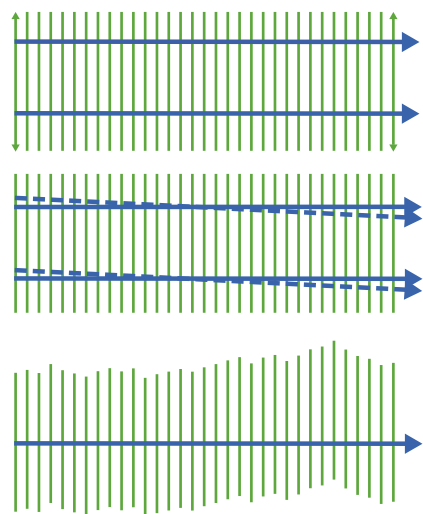
“One thing that Hogan emphasizes in his papers is that he is providing phenomenology rather than underlying theory” about holography, spacetime and information, says theorist Christopher Herzog of Princeton University.

Black illusions

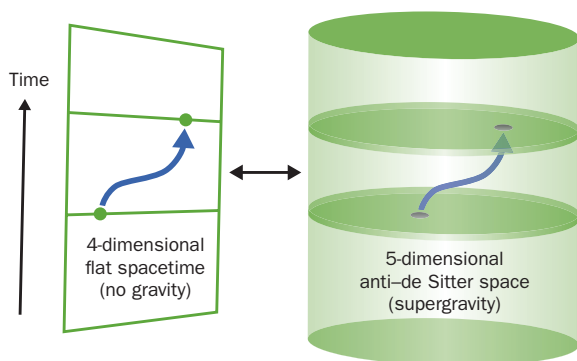
Gravity was first theoretically linked to information in the 1970s, when Stephen Hawking of the University of Cambridge in England and Jacob Bekenstein, now at the Hebrew University of Jerusalem, realized that there was a deep relationship between thermodynamics, which is the study of heat transport, and black holes. According to the second law of thermodynamics, the entropy of a system — a measure related to the amount of information it holds — cannot decrease



Projecting spacetime According to the holographic principle as envisioned by Craig Hogan, each grain of information encoded on a surface (left) becomes larger when seen by an observer a great distance away, just as the graininess inherent in a movie is magnified when projected onto a big screen. The noise then becomes detectable in a relatively inexpensive experiment.



Feel the noise Spacetime in Hogan’s model is represented as waves (vertical lines show wave fronts) traveling in one direction (blue arrows). The waves spread (middle panel) because of uncertainty in their momentum predicted by quantum theory. This uncertainty may be measurable as noise, or jitter (bottom panel).



Holographic twist According to physicist Juan Maldacena's holographic principle, a theory of gravity in a particular 5-D model of spacetime (right) called anti-de Sitter space is equivalent to a theory without gravity in a 4-D flat spacetime.

over time. Hawking showed that for that to be true, a black hole must increase its entropy by an amount greater than the entropy carried by a body that falls into the hole.

Bekenstein calculated that the entropy of a black hole is entirely determined by its effective surface area, or event horizon, not its volume. The event horizon is the imaginary surface that surrounds a black hole and marks the point of no return: Any entity—be it a planet or a string quartet—that gets closer to the hole than the event horizon is doomed to fall in.

In the 1990s, two scientists dramatically extended this idea into a “holographic principle” that states that a volume of space can be entirely described by what happens on its boundary. Nobel laureate Gerard 't Hooft of the University of Utrecht in the Netherlands first proposed the idea. Stanford physicist Leonard Susskind then gave the idea a more precise description according to the precepts of string theory, which holds that each elementary particle can be represented by tiny, vibrating snippets of string in nine or 10 dimensions of space, rather than the usual three.

Applying the holographic principle to the real world has proven challenging. It can be difficult to relate a theory about a volume of space with, say, five dimensions, to a simpler theory that envisions a universe that is restricted to the boundary, or surface, of that volume—a universe with one less dimension. But in 1997, Juan Maldacena,

now at the Institute for Advanced Study in Princeton, N.J., used string theory to show that in one model, there truly is a one-to-one correspondence between the description of a volume of space in a higher dimensional theory that includes gravity and a lower dimensional theory—the boundary of that space—in which gravity plays no role.

Consider, once again, Hogan's proposed holographic surface. It's made of tiles that each have a length, about 10^{-35} meters, equal to a fundamental unit known as the Planck length, named for Max Planck, the father of quantum theory. The information encoded on the surface corresponds to the number of Planck tiles covering that surface.

According to the holographic principle, the information on the surface must be exactly the same as that contained within the volume. But that can be true only if the volume is much grainier, or blurrier, than the Planck-length tiles on the surface. In other words, the tiles that fill the volume are much bigger than those on the surface. Effectively, the blurriness of the information encoded on the surface becomes magnified within the volume enclosed by the hologram.

Hogan calls this magnification “the holographic uncertainty principle.” He sees it as an extension of the uncertainty principle proposed by German physicist Werner Heisenberg in 1927. Heisenberg famously noted that the position and momentum of a subatomic particle cannot both be precisely measured at the same time.

“I think Hogan must see himself as a sort of latter-day Heisenberg,” says Herzog. “Just as Heisenberg provided us with an uncertainty principle without a full-fledged theory of quantum mechanics,

Hogan is hoping that his holographic uncertainty principle will be a similarly important result in a full theory of quantum gravity.”

This larger size of the tiles within the volume becomes noticeable only at very large distances from the holographic surface, Hogan notes. A sensitive device that could measure changes in length in two perpendicular directions at large distances from the surface might therefore be sensitive to this fundamental limit of encoding information, he says.

That ought to put a smile on the face of scientists trying to uncover and comprehend the smallest units of spacetime. But not everyone is convinced.

Theorist Maldacena notes that “theories of quantum mechanical spacetime, such as string theory, are constructed so that they respect the symmetries of spacetime, such as the symmetries of special relativity.” In contrast, he says, Hogan's proposal violates one of the

foundations of special relativity, namely that lengths (and time) are not absolute quantities but contract or expand in such a way that the speed of light always has the same numerical value, regardless of the speed of an observer.

Hogan agrees that his theory of holographic noise does indeed violate special relativity. But he adds that relativity theory does not take into account the quantum nature of spacetime. Some as-yet-unknown symmetry of quantum gravity is likely to supersede some of the concepts of special relativity, which might break down on the tiniest of subatomic scales, he asserts.

Because of this violation, Hogan's model is not consistent with the holographic ideas in string theory, Maldacena insists. “So it would be more accurate to call his noise ‘Hogan's noise,’” he says.

Regardless of what it's called, this new kind of noise brings together elements of several previous ideas, as Hogan acknowledges. In 1999, Giovanni Amelino-Camelia, now at the University of Rome La Sapienza, published a study suggesting

“The whole of spacetime ... is jittering around.”

CRAIG HOGAN

that quantum-gravity noise might show up in large-scale experiments.

Noisy experiments

Indeed, Hogan is hoping that two experiments — one ongoing, the other in the planning stages — may find evidence for the quantum clatter.

Since 2002, a British-German apparatus called GEO600 has been searching for the notes of a cosmic symphony — ripples in spacetime known as gravitational waves — that general relativity says ought to exist. Such waves should be generated any time a dense body, such as a neutron star or black hole, is accelerated.

The experiment, based in Hannover, Germany, hasn't found any of these waves. But part of the signal that GEO600 has detected might be accounted for by holographic noise, Hogan says.

GEO600, like some other gravitational wave detectors, uses laser light to measure tiny changes in the relative lengths of two perpendicular arms of an interferometer. A gravitational wave would alternately expand one arm ever so slightly while compressing the other. GEO600 uses a single laser beam, split into two beams by a half-silvered mirror, to measure and compare the two lengths.

Because of the experiment's design, GEO600 is much more sensitive to the sideways motion of the beam splitter than are other large gravitational wave detectors. And an unexplained sideways

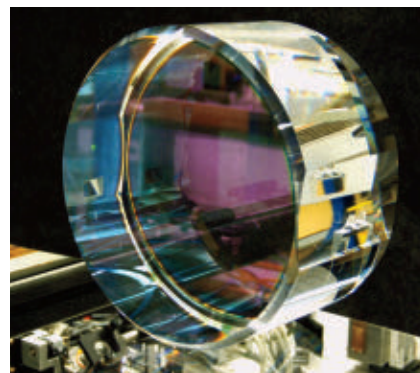
motion of the beam splitter is just "the effect claimed by Hogan as a consequence of his holographic noise," says GEO600 principal investigator Karsten Danzmann of the Leibniz Universität Hannover.

In fact, about a year ago, Danzmann and his colleagues thought an unexplained noise that GEO600 had recorded could be Hogan's noise. However, most of the instrumental noise recorded at relatively low frequencies — from a few hundred hertz to over 1,000 hertz — has now been accounted for by known sources within the detector, says Danzmann. "But the uncertainty in our noise is still large enough to accommodate a signal as predicted by Craig Hogan," he adds.

Hogan's noise is predicted to have the same strength at all frequencies, and Danzmann's team is now analyzing motion of the beam splitter recorded at higher frequencies. Within a year, the team should know whether its findings support Hogan's prediction.

"Hogan gets to the point of 'predicting' ... the actual magnitude of the 'noise anomaly' seen at GEO600," says Amelino-Camelia. "The reason why I essentially stopped working on my quantum-gravity noise proposal was that indeed I couldn't find any way to really get a robust intuition for the magnitude one should or could expect for this noise."

But even if GEO600 finds a jitter that resembles the noise that Hogan predicts,



Scientists have detected small, unaccounted-for motion in GEO600's beam splitter (shown), some of which may have come from Hogan's proposed noise.

it will take a much more sensitive experiment to prove the fuzzy, holographic nature of spacetime, says Schutz.

Such an experiment is now in the planning stages at Fermilab, Hogan says. The proposed \$2-million apparatus would feature a pair of interferometers, each with perpendicular arms 40 meters in length. Initially, the two experiments would be placed next to each other, testing a key prediction of Hogan's theory: The noise recorded by two adjacent devices ought to be correlated.

"They move together because the whole of spacetime they are sitting in is jittering around," says Hogan. If one device records a type of motion that might be attributed to quantum jitter but the other device does not, Hogan's theory would be ruled out.

But if the noise is detected, the next test would be to move the two interferometers farther apart. At large separation, the correlation between the amount of noise in the two detectors should shrink to zero according to Hogan's model, says Stephan Meyer of the University of Chicago.

If it all works, the experiment could give a first glimpse of the tiniest scraps of spacetime. But whether Hogan's noise will be revealed, only time — make that spacetime — will tell. ■

Explore more

■ Links to Craig Hogan's publications: astro.fnal.gov/people/Hogan



The GEO600 experiment in Germany may be able to detect a jitter in spacetime by picking up sideways motion in a beam splitter that divides one laser beam into two. The beams then travel down perpendicular arms (shown) 600 meters long.

BOTH: MAX PLANCK INSTITUTE FOR GRAVITATIONAL PHYSICS (AEI)/LEIBNIZ UNIVERSITÄT HANNOVER

To their credit

In Tom Siegfried's article, "The Top 10 science news stories since time began" (*SN*: 1/2/10, p. 2), No. 5 is "Watson and Crick elucidate DNA's double helix structure, 1953." I am annoyed that, as usual in articles about the early understanding of DNA, Rosalind Franklin's name has been left off. Even Watson and Crick admitted that without her work they could not have been successful.

Ted Coskey, Seattle, Wash.

Tom Siegfried's list of the Top 10 "science news favorites from the dawn of civilization" includes the comment that "analyses of new science should be undertaken with some caution, and a sense of history." Certainly, as Siegfried notes, one can argue with the items he chose for his list or the order in which he placed them, but if this list is to be presented with a proper sense of history, it should not repeat the mistakes of the past in providing proper credit.

With regard to No. 10, nuclear fission: History tells us that Lise Meitner (with her nephew Otto Frisch) elucidated nuclear fission (by explaining what Hahn and Strassmann had observed, but signally failed to explain). We know this now (with the benefit of some history) despite the Nobel committee's overlooking both Meitner (unconscionable) and Frisch (probably unfair).

Science News Letter's publication of Hahn and Strassmann's "discovery" at the time of the confirmation of Meitner's theory by Frisch is simply the error of the contemporaries in not recognizing Meitner's pivotal role in establishing the theoretical underpinnings of fission. Moreover, it was Meitner who recognized the potential for a fission chain reaction. Meitner's name belongs there with Hahn and Strassmann (and Frisch's arguably does too).

As to No. 5, DNA's structure: Though Watson and Crick never gave her any credit (and, indeed, showed a lack of class and intellectual honesty by disparaging her abilities and work), it is abundantly clear that Rosalind Franklin's X-ray diffraction images were critical in

guiding them to their proposed structure for the DNA helix. Her insightful criticism of Watson and Crick's first proposed structure for DNA (which had the base pairs on the outside rather than the inside of the helix) is also a historical fact. The Nobel committee gets off on this one on the technicality that Franklin was dead by the time the award was made — and the Nobel Prize is not awarded posthumously — but there's no evidence that the committee would have included her if she had been living. But, without question, Franklin should be listed along with Watson and Crick by anyone who claims to be listing the discoverers of DNA's structure with a proper "sense of history."

John M. Craig, Orem, Utah

I always enjoy your perspectives, including your list of science news favorites in the Jan. 2 *Science News*. However, I was disappointed that for item 10, the discovery of nuclear fission, you give the credit to Hahn and Strassmann, and do not even mention Lise Meitner.

While it is true that the 1944 Nobel Prize for this discovery went to Hahn, hindsight reveals that Meitner was unjustly excluded as the true discoverer of fission. Meitner had been working with Hahn from the early 1920s. While, as a woman and a Jew, she could not openly hold any important position in the lab, it was she who first appreciated that an experiment Hahn conducted at her urging after events in 1938 forced her out of Germany was in fact nuclear fission, a result Hahn had not yet come to terms with. To add insult to injury, Hahn was most ungracious to Meitner, giving her no credit whatsoever, but jealously claiming the discovery to himself. I feel history should be kinder to the true deserver of credit when the opportunity presents itself. Keep up the great work you do.

David Clough, Weed, Calif.

My list did not attempt to credit all who contributed to those major discoveries. It is certainly true that Lise Meitner

played a major role in the discovery of fission and in figuring out what Hahn and Strassmann had done. Rosalind Franklin's work was important in Watson and Crick's elucidation of the DNA double helix, but it is not correct that they never credited her. At the end of the paper reporting their discovery (in Nature on April 25, 1953), they wrote: "We have also been stimulated by a knowledge of the general nature of the unpublished experimental results and ideas of Dr. M.H.F. Wilkins, Dr. R.E. Franklin and their co-workers at King's College, London." — Tom Siegfried

Creationists evolving

I've been following the arguments of creationists, now intelligent designers, for years. Eugenie Scott makes an important point about scientists becoming engaged citizens in her commentary "Accept it: Talk about evolution needs to evolve" (*SN*: 8/1/09, p. 32). She reflects on how creationists have had to evolve in their arguments in order to survive. Is it ironic that they have become perfect examples of evolution?

Patrick Dunn, Mishawaka, Ind.

In Ardi's defense

Regarding "Partial skeleton gives ancient hominids a new look" (*SN*: 10/24/09, p. 9), how did *Ardipithecus* defend itself against predators when on the ground? Ground-dwelling baboons mount a formidable defense by fighting in a cooperative manner like a pack of dogs, using sharp canine teeth in long snouts. In contrast, Ardi could have carried tree limbs and rocks in her strong arms. Standing firmly on her legs, Ardi could have wielded these weapons in a deadly manner. Since teeth were not used for fighting, the canine teeth of hominins became smaller and the snout shorter.

A. Bjornson, Peabody, Mass.

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The Encyclopedia of Weather and Climate Change: A Complete Visual Guide

J.L. Fry, H.-F. Graf, R. Grotjahn, M.N.

Raphael, C. Saunders and R. Whitaker

There's an old saying among meteorologists: Climate is what you should expect, weather is what you'll actually get. With explanations a little more complicated than that, *The Encyclopedia of Weather and Climate Change* provides enough detail for weather buffs of all ages.

Besides being lavishly illustrated with more than 2,000 color photos, maps, diagrams and other images, this hefty volume — organized into six topical sections, each written or vetted by a different expert — thoroughly explores Earth's weather and climate. The authors tackle questions such as how meteorologists monitor, map and predict the weather; where



on Earth tornadoes are most likely to strike; and how the planet-warming greenhouse effect works, among others.

From descriptions of flow patterns in the oceans and atmosphere to details about localized turbulence that can jostle or even bring down an aircraft, the entries are comprehensive yet easy to understand, with detailed captions and explanatory text alongside illustrations.

The book delves into how regional climate has sculpted ecosystems and enumerates the intricate connections linking climate and weather to phenomena that affect people, such as droughts, famine and disease. On the flip side, the authors graphically show how human activities — especially agriculture, industry and deforestation — have boosted atmospheric concentrations of carbon dioxide and influenced climate dramatically, possibly for centuries to come. — *Sid Perkins*
Univ. of California Press, 2010, 512 p., \$39.95.



Gold Medal Physics: The Science of Sports

John Eric Goff

How athletes, Olympian and otherwise, perform some of their most amazing physical feats. *Johns Hopkins Univ. Press, 2010, 214 p., \$25.*



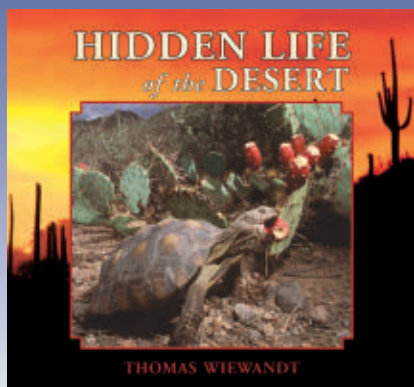
Being with Animals: Why We Are Obsessed with the Furry, Scaly, Feathered Creatures Who Populate Our World

Barbara J. King

A fascination with animals is an intrinsic part of human nature, an anthropologist argues. *Doubleday, 2010, 258 p., \$24.99.*

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Jane Lubchenco


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New NOAA climate office would meet growing needs

As the U.S. Global Change Research Program's 2009 report indicates, climate-related impacts are already evident and expected to increase. Signs of change abound. Sea level rise. Longer growing seasons. Increases in heavy downpours. Droughts. Extended ice-free seasons and more.

Individuals, decision makers and government officials are asking how they can best prepare their families, businesses and communities for the impacts of climate change. They worry about managing flood risks, planting the right crops, allocating water and making smart business decisions. In just about every sector the need for data and other climate information to support vital decisions is on a fast track, from requests to inform local planning policies, to regional and national questions about energy and food security, to worldwide concerns about diminishing water resources. The National Oceanic and Atmospheric Administration is the nation's primary source of data and research on the oceans and atmosphere, and demands on the agency to provide trusted, timely and accessible information are growing quickly.

Yet NOAA's and the nation's climate-related information resources are not organized to meet the growing demand. To remain relevant and responsive, NOAA must adapt.

Recognizing the urgency of climate-related information needs, Commerce Secretary Gary Locke and I have announced the intent to establish the NOAA Climate Service. This new entity would bring together long-standing NOAA capabilities into a single office. NOAA already responds to millions of annual requests for climate information through Nobel Peace Prize-winning researchers and assessments, observations, predictions, training and critical on-the-ground service delivery. With one highly visible, responsive point of entry to climate science and services, NOAA will be better prepared to continue its internationally recognized role in the development and delivery of climate science, tools, products and information.

Thomas R. Karl, director of NOAA's National Climatic Data Center, will serve as transitional director of the NOAA Climate Service. Six new Regional Climate Services directors will provide leadership in developing an integrated climate services program.

No single agency can tackle climate change alone. Underpinned by scientific integrity and working closely with NOAA's many federal, regional, state, local, academic and

private sector partners, the new climate office will work effectively within the federal family, leverage other partnerships and address gaps wherever possible. I continue to be grateful for the enthusiastic support of Commerce Secretary Locke and the many excellent recommendations we have received, including those from the NOAA Science Advisory Board, National Academies and National Academy of Public Administration.

In our proposed reorganization, NOAA's Office of Oceanic and Atmospheric Research will continue to incubate research that leads to new knowledge as well as many valuable products and services. OAR made significant contributions that helped open the world's eyes to the risks of greenhouse gas emissions, climate change and ocean acidification. Growing new research within OAR and strengthening science across NOAA remain top priorities.

When Commerce Secretary Locke and I announced the proposed NOAA Climate Service, we also introduced the new NOAA Climate Portal at www.climate.gov. As a single portal to climate information, data, products and services, this dynamic new site is a first step toward making the rich scope of NOAA's and others' information available in one easy-to-use resource.

NOAA's new climate portal offers timely access to a variety of resources: an interactive "climate dashboard" enabling users to see a range of constantly updating climate datasets over adjustable timescales; details about NOAA data products, with links to the sources of comprehensive datasets; *ClimateWatch*, an online magazine highlighting new climate research explained by the scientists themselves; educational resources; and easily understood facts and presentations about climate science and climate impacts.

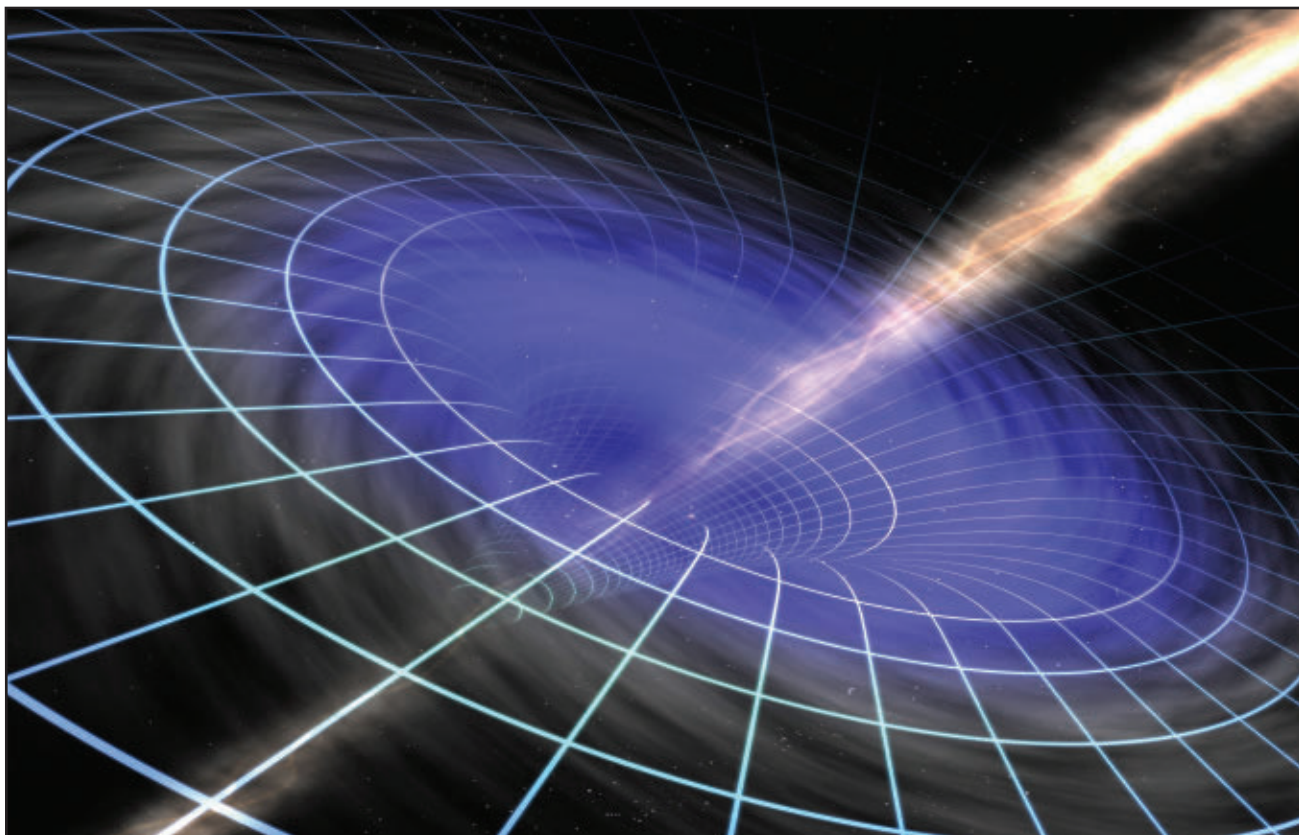
The Obama Administration recognizes that climate change is one of the greatest challenges facing our nation. How we face this challenge, how effectively we tackle the public health, economic and environmental threats it poses, and how effectively we embrace the opportunities it presents, will shape our lives and our legacy to our children and all future generations. NOAA's proposed climate office is a major step in a critically needed new direction. ■



NOAA will be better prepared to continue its internationally recognized role in the development and delivery of climate science.

Scientist Jane Lubchenco is Under Secretary of Commerce for Oceans and Atmosphere and administrator of the National Oceanic and Atmospheric Administration.

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