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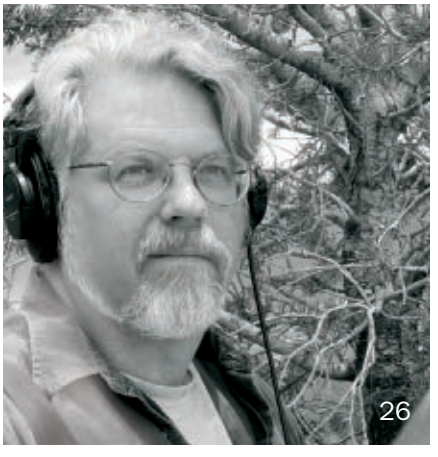

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ScienceNews

In the News

Features

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On the cover: Mount St. Helens' 1980 eruption was rated at category 5 on the Volcanic Explosivity Index. **Photo:** Getty/InterNetwork Media

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Dreaming of a day with no need for sleep

A lot of the enchantment of science is the prospect it offers for making dreams come true.

Imagine, for instance, a Nirvana-world where science writers and editors work 24/7, pausing to eat now and then but never needing to sleep. There would be more news to read on the *Science News* website, all important research advances would be covered and the world would be a better place.

That's a dream, of course, because writers and editors (like everybody else) need to sleep. Science has never quite conclusively established *why* everybody needs to sleep, but one obvious reason is that cognitive function diminishes drastically whenever you get drowsy. It's no good to work all night if somebody else has to work all the next day correcting your mistakes.

But suppose the neurobiology underlying sleep could be tweaked, to maintain sharp thinking during emergencies or other times demanding sustained wakefulness. A clue to how to do that emerges from a new study, discussed on Page 8 of this issue by Tina Hesman Saey.

In fruit flies, the study shows, a molecule sensitive to the brain chemical dopamine plays a key role in sleep's importance for learning. Lots of evidence suggests that sleep is necessary for effective learning and remembering, and the new work supplies at least a partial molecular explanation for that need. What's more, the experimenters find that activating the dopamine-sensitive molecule allows learning even without the usually required sleep.

So all of a sudden, it's possible to contemplate designing a drug to substitute for sleep. That's maybe not everybody's idea of fun, but it surely would benefit soldiers or rescue workers who need to maintain peak mental performance for extended periods of time.

True, as Tina points out, this small step for a fruit fly does not necessarily portend a future human society of sleeplessness. After all, chemical methods of fending off sleep are already available, like caffeine. Sooner or later, though, the need for sleep triumphs. And sleep is important for things other than learning and memory — such as a time to dream of new things for science to do.

Nonetheless, the notion of a future in which sleep is optional cannot be totally dismissed. And if that dream does come true, the current fruit fly finding will be listed as one of the initial insights leading to that achievement. It's the same with much of the rest of current news from science — the significance often lies not so much in the news itself, but in what the future might build upon it.

—Tom Siegfried, Editor in Chief

Uncover the Cosmic Clues to Our Amazing Universe

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Who has not gazed with wonder at the night sky, especially from a dark site far away from city lights? The great canopy of stars stretching overhead suggests that our world is part of a vastly larger cosmos. But how large is it? Where do we fit in? And how did it all begin?

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Dr. Alex Filippenko is Professor of Astronomy at the University of California, Berkeley, where he is a five-time winner of "Best Professor" on campus. In 2006 he was named one of four national Professors of the Year by The Carnegie Foundation for the Advancement of Teaching, and in 1998 his international team of astronomers was credited with the top "science breakthrough of the year" for their discovery that the expansion of the Universe is speeding up.

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26. The Earth, Third Rock from the Sun
27. Our Moon, Earth's Nearest Neighbor
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29. Of Mars and Martians
30. Jupiter and Its Amazing Moons
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68. Structure of the Milky Way Galaxy
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70. The Dark Side of Matter
71. Cosmology—The Really Big Picture
72. Expansion of the Universe and the Big Bang
73. Searching for Distant Galaxies
74. The Evolution of Galaxies
75. Active Galaxies and Quasars
76. Cosmic Powerhouses of the Distant Past
77. Supermassive Black Holes
78. Feeding the Monster
79. The Paradox of the Dark Night Sky
80. The Age of the Universe
81. When Geometry Is Destiny
82. The Mass Density of the Universe
83. Einstein's Biggest Blunder?
84. The Afterglow of the Big Bang
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Scientific Observations

"If you want to become a fossil, you actually need to die somewhere where your bones will be rapidly buried. You then hope that the earth moves in such a way as to bring the bones back up to the surface. And then you hope that one of us lot will walk around and find a small piece of you. So it is absolutely surprising that we know as much as we do know today about our ancestors." **—FOSSIL HUNTER LOUISE LEAKEY, SPEAKING ABOUT DIGGING FOR EVIDENCE OF HUMAN ORIGINS IN A VIDEO POSTED ON TED.COM.**

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LIFE

Watch a slide show about recent fossil finds in an ancient Antarctic lake bed in "Time to chill." Writer Sid Perkins reports on mosses, tiny crustaceans and beetle fragments that suggest that 14 million years ago the site's average summer temperature was 17 degrees Celsius warmer than it is today.

BODY & BRAIN

A new study finds that professional basketball players watching a shot can more accurately predict the ball's fate than coaches or sports journalists. Watch some of the clips shown to participants in the study and make your own forecast in "Never bet against a pro," by Tina Hesman Saey.

Science Past: 50 Years Ago

From *Science News Letter*, August 30, 1958

NO "SAFE" RADIATION DOSE — There is no period of safety after exposure to harmful radiation, a geneticist reports. Radiation has been found to affect the primitive germ cell from which

the sperm develops. Chromosome abnormalities may be transmitted to offspring in dangerous numbers for a long time after irradiation of the male. This also is important evidence that there is no such thing as a "minimum permissible dose of radiation," says Dr. A.B. Griffen of the Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Me. Until now many scientists had believed the effects of irradiation on the male sex organs were not long-lasting.... A pilot study using mice indicates, however, that "for the mouse, and presumably for man, there is no period of safety after irradiation" and visible, detectable breaks in chromosomes or aberrations can be passed on to offspring.

Science Future

September 14

Secrets of the Dinosaur Mummy premieres on the Discovery Channel. Visit dsc.discovery.com

October 5–9

International Banana Conference in Mombasa, Kenya. Visit www.banana2008.com

October 18

Climate Change: The Threat to Life and Our Energy Future opens at the American Museum of Natural History in New York City. Visit www.amnh.org

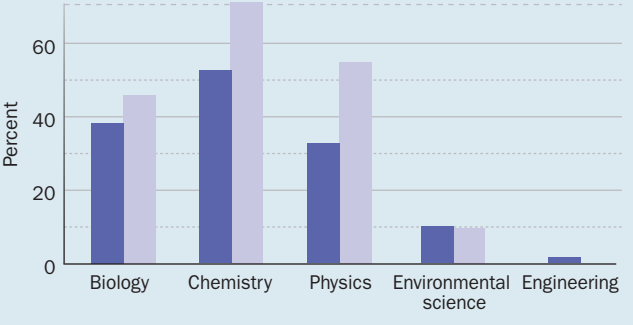
On the Web

Crazy-haired chemist Martyn Poliakoff of the University of Nottingham in England and his colleagues lead a virtual tour of the periodic table at **www.periodicvideos.com**. With 118 video clips — one for each element — there's enough light, smoke, flames and laughs to keep even the reluctant dabbler entertained for a few hours. Check out the demonstrations for H, Na and Hg. But a word of warning: Don't try these at home.

Science Stats

IN THE CLASS

Percent of U.S. high school graduates in 2005 completing advanced science and engineering courses ■ Public □ Private



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ANNE PURKISS; ADAM LEWIS; LOUISE LEAKEY COURTESY OF ROYCE CARLTON INC.

“Although we may be weird, we’re by no means unique.” —EDWARD THOMMES, PAGE 11

In the News

STORY ONE

Team toys with ions to simulate quantum world

Manipulations could help design better materials

By Davide Castelvecchi

If the Matrix really existed, it would probably have to be a quantum simulator. The fictional computer in the movie with the same name can create virtual worlds indistinguishable from the real one and project them into people’s minds. But the real world includes quantum phenomena, something ordinary computers can’t fully simulate.

Now physicists have created a rudimentary prototype of a machine that simulates quantum phenomena using quantum physics, rather than using data kept in a classical computer. While the new device can’t make people fly like the Matrix does, it demonstrates a technique that could enable physicists to create, in the virtual world, materials that don’t yet exist in nature and perhaps figure out how to build, in the real world, superconductors that work at room temperature.

Tobias Schätz of the Max Planck Institute of Quantum Optics in Garching, Germany, and his collaborators built a model of one of the smallest solid objects imaginable — made of just two atoms — by suspending two ions in a vacuum. The researchers used laser light to vary the electrical repulsion of the ions to simulate the magnetic interaction of atoms, harnessing one force to simulate the other.

SCHÄTZ *ET AL.*

Ions can simulate quantum phenomena that exist, and even some that don’t. In this vacuum chamber, metal wedges produce electric fields that trap ions for lasers to manipulate.

In a paper published online July 27 in *Nature Physics*, the researchers describe how their system reproduced the magnetic alignment of atoms that takes place when certain materials are exposed to magnetic fields.

“This is pretty important that they’ve been able to demonstrate the principle,” says John Chiaverini of Los Alamos National Laboratory in New Mexico.

“The experiment is an important initial step in the emerging field of quantum simulation,” says David Wineland of the National Institute of Standards and Technology in Boulder, Colo., whose group in 2002 pioneered a more limited quantum simulation technique by trapping ions. The new experiment “demonstrates important tools that can potentially be implemented on much larger systems whose simulations are intractable by classical means,” he adds.

The late physicist Richard Feynman pointed out in 1982 that ordinary computers can’t possibly simulate true quantum behavior of a large number of particles because the phenomenon of superposition allows a particle to be in two states at once. For example, the spin of an atom — the quantum version of a bar magnet’s orientation — can point simultaneously up and down. To simulate the spin states of an object made of two atoms, a computer has to keep track of four possible combinations of spins: up-up, up-down, down-up and down-down. For three atoms, eight possibilities exist, and the number keeps growing exponentially. For n atoms, the number is 2^n, which gets very large very quickly. “This 2^n — that’s what kills classical computers,” Schätz says. »

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» Chiaverini says even state-of-the-art supercomputers quickly get overwhelmed with all the calculations required to predict how all those spin states will evolve in time. "You run out of steam at about 40 spins," he says.

Simulating just 100 atoms would require keeping track of 2^{100} combinations, more than the number of protons in the visible universe. But a system of quantum objects, unlike a classical computer, is itself able to exist in a number of different states that grows exponentially. Several different teams of physicists are developing techniques for quantum simulation. The two leading approaches are to use ions in an electrostatic trap, as Schätz and colleagues have done, or to use atoms in an optical trap, which holds things in place using the pressure of light.

Last year, David Weiss of Pennsylvania State University in University Park and his colleagues demonstrated an optical trap able to hold hundreds of atoms in a cubic array, to image and manipulate the atoms individually, and to make them interact with one another. The researchers even took videos of glowing atoms staying in place or, occasionally, jumping from site to site along the array. "It took a couple of days until I could get my graduate student and my postdoc to stop taking pictures and actually start the experiment," Weiss said in March in New Orleans at a meeting of the American Physical Society.

The trapped-ion approach Schätz's team followed was first proposed by his Garching colleagues Diego Porras and Ignacio Cirac in 2004. In the experiment, the team suspended two magnesium ions in a vacuum, keeping them in place with electric fields. The positive ions were just a few micrometers apart — close enough to feel mutual electrostatic repulsion, but far enough not to feel each other's spins.

The researchers then used a laser to simulate the application of an external magnetic field, which could give the ions any initial state. "It's much better than a real magnetic field because, for example, you can individually address your atoms. It would be hard to have a real magnetic field 'on' on one atom, and 'off' on the other," Schätz says.

Using the laser, the researchers tuned the electrostatic interaction of the two particles. In the future, more-complex experiments could, for example, create a model of a superconductor and then selectively change the physical parameters to understand how the material conducts electricity with minimal loss of energy.

Such control would be impossible in a real solid material, such as a superconducting crystal. "If you tell a solid-state physicist, 'reduce your spin-spin interaction by a factor of two because I want to see the physics,' he can't do it," Schätz says.

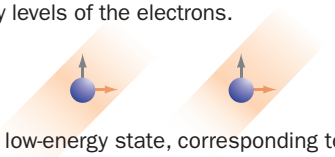
Together with his colleague Warren Lybarger Jr. and others, Chiaverini is working on a similar setup, also based on Porras and Cirac's idea. And the team is developing an alternative approach that would use radio frequency fields, instead of lasers, to manipulate the ions' states.

Two ions, of course, don't make a real solid object, but researchers say that in the future they may be able to scale up the Garching device to larger arrays. Currently, researchers who want to experiment with new materials, such as potential superconductors, have to first create actual crystals in the lab and then test their properties. Quantum simulations could make that task a lot easier. "Some day, hopefully, we can apply this to making designer materials from the ground up," Chiaverini says.

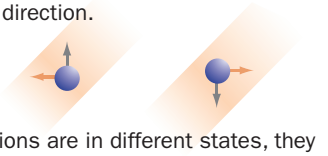
Feynman envisioned that eventually a general purpose, programmable quantum computer could carry out quantum simulations. But such machines are still decades away, while machines designed only for the simulations may be available sooner. ■

Mimicking magnetic forces

Lasers in a quantum simulator push ions in different directions depending on the energy levels of the electrons.



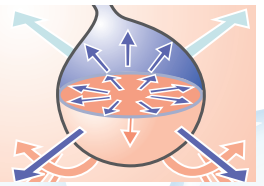
In the low-energy state, corresponding to parallel spins, both ions are pushed in the same direction.



If the ions are in different states, they are pushed in different directions as if the ions are attracting or repelling each other.

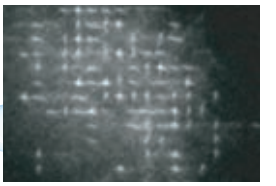
Back Story Going virtual: A variety of phenomena have been used to simulate other phenomena

Building design
Munich's stadium, built for the 1972 Olympics, was designed in part by modeling soap bubble interactions.



Smashing universes
Colliding bubbles of superfluid helium were recently proposed as a model for parallel universes smashing together.

Black hole's horizon
Slow-moving sound waves in an accelerating fluid can model the event horizon of a black hole.



Atomic core
Atoms trapped by light may someday help physicists understand the forces inside the atomic nucleus.

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Body & Brain

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To learn without sleep, fruit flies need a proper dose of dopamine

Finding suggests pills could someday replace naps

By Tina Hesman Saey

To boost their brain power, dumb flies (and perhaps people) may need a little more shut-eye — or a shot of dopamine.

Fruit flies need sleep in order to learn, a study in the Aug. 5 *Current Biology* shows. Keeping *Drosophila* up for hours after their normal bedtime impairs the flies' ability to learn a complex task.

But activating a particular molecule sensitive to the chemical messenger dopamine in a brain structure called the mushroom bodies erases the learning deficits, researchers from Washington University in St. Louis find.

The study raises the possibility that learning is impaired not because sleep sneaks up on us when we should be paying attention, but because staying awake too long erodes some biological brain process critical for learning and forming memories, says experimental psychologist David Dinges of the University of Pennsylvania School of Medicine in Philadelphia.

Such hard evidence for a direct link between sleep and learning has eluded researchers studying people and other animals, says sleep researcher Marcos Frank, also of Penn. The new research is the first to show that specific molecular changes in the brain can influence a sleep function, he says.

If the same process is at work in humans, the discovery suggests that drugs may one day substitute for sleep. Researchers don't envision long-term use of such drugs but say medications could keep soldiers alert during extended military operations and help emergency workers stay sharp after natural disasters.

In the new study, Paul Shaw and his colleagues deprived fruit flies of sleep by handling them gently or by forcing the flies to walk on a fruit fly treadmill. After the fruit flies were kept up for six to 12 hours past their usual bedtimes, the researchers tested the flies' ability to learn to avoid light. Fruit flies are normally attracted to light, but the researchers wanted to see if the insects could learn to resist. The scientists placed filter paper soaked in quinine — a substance that fruit flies don't like — in the lighted arm of a T-shaped maze. The dark arm had no quinine and lower humidity, making it the more pleasant choice.

Flies that got normal amounts of sleep learned to stay away from the lighted arm and wander down the dark alley instead, but sleep-deprived flies had difficulty learning to suppress their natural instinct.

If the same process is at work in humans, drugs may one day substitute for sleep.

Sleepy people experience similar control problems, Shaw says. Toddlers who miss naps can't seem to behave, and groggy adults may have trouble controlling their tempers.

"When you're sleepy, you might snap at your coworker," even though the person is being no more annoying than usual, Shaw says. "Sleep deprivation has a really profound effect on behavior inhibition."

The learning deficit depended on the length of time flies were awake, with the impairment getting worse the longer the flies went without sleep.

Although the study convincingly shows that sleep deprivation disrupts learning in fruit flies, even Shaw's "thorough" and "clever" experiments can't determine exactly what is happening in the fruit flies' brains, other sleep researchers say. Sleep may intrude at times when the flies are trying to learn, or the flies may just not be paying attention as well when they are sleep deprived.

The team's "arguments are strong but not watertight," says Robert McCarley, a sleep researcher at Harvard University and the Veterans Affairs Boston Healthcare System in Brockton, Mass.

Brain scans indicate that some parts of the human brain are more vulnerable to effects of sleep deprivation than others. In the fruit flies' brains, Shaw and his colleagues traced the learning problem associated with sleep deprivation to the mushroom bodies, structures involved in learning and forming memories, along with other functions. Furthermore, the group showed that a receptor for the neurotransmitter dopamine in the mushroom bodies was important for helping fruit flies learn to avoid light.

Fruit flies, rodents, humans and other animals have multiple types of receptors for dopamine. Using drugs that block specific types of dopamine receptors, the researchers determined that the dopamine D1-like receptor designated dDA1 is the critical link in the learning chain that is disrupted by sleep deprivation. Activating the dDA1 receptor only in mushroom bodies erased the learning problems in sleep-deprived fruit flies.

It's unlikely that the fruit fly findings will translate directly into advances in human sleep research. Already scientists know that many more brain chemicals are involved in human learning and sleep and that sleep involves many parts of the brain. But the new study does suggest that dopamine may play a more important role in sleep and learning than previously suspected, says Ritchie Brown, also of Harvard and the VA Boston Healthcare System.

Students famously use drugs, such as amphetamines and caffeine, to stay awake while studying. "Up until now we've said that's not a good idea because you're losing sleep," Brown says, but drugs that affect only a subset of dopamine receptors might override some of the effects of sleep loss.

Still, people on amphetamines or caffeine experience side effects and crash eventually. "You can't really cheat the system," Dinges says. "It's still true that there's no chemical substitute for sleep."

Molecules

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Carbon tubes leave nano behind

Colossal filaments could offer practical advantages

By Davide Castelvecchi

Take solace, all ye who've grown weary of carbon nanotube promises: The latest tubes are anything but nano.

While trying to grow better, longer nanotubes, researchers accidentally discovered a new type of carbon filament that's tens of thousands of times thicker. Christened "colossal carbon tubes," they aren't quite as strong as nanotubes but are 30 times stronger than Kevlar per unit weight, and are potentially easier to turn into applications, suggests a study to appear in *Physical Review Letters*.

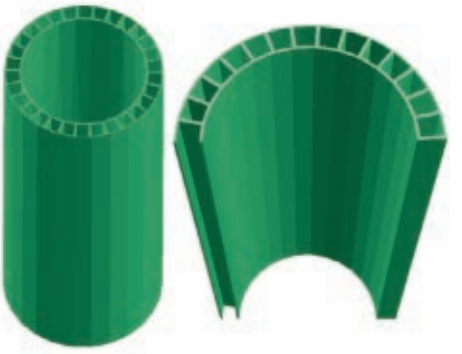
Though exceptionally strong, nanotubes are hard to weave into larger fibers that could be used in futuristic products, such as ultralight bulletproof vests.

Recently at Los Alamos National Laboratory in New Mexico, materials scientist Huisheng Peng and colleagues were trying to grow "forests" of long nanotubes from carbon gas in a vacuum oven. When Peng opened the door, he saw a scene that could be compared to a barbershop floor: Thin, black hairs were scattered everywhere.

"At first, I thought they were a lot of carbon nanotubes bonded together," says Peng, who recently moved to Fudan University in Shanghai, China.

Tests revealed that the filaments, which were centimeters long and 0.1 millimeter thick, were not clumps of nanotubes, but "colossal" tubes which had the same type of carbon bonds as nanotubes. The atoms were also arranged in the same hexagonal webs resembling chicken wire.

Instead of being simple cylindrical structures, the colossal tubes have two concentric layers. The researchers believe that each layer is made of many chicken wire sheets sandwiched together. Walls that are 100 nanometers thick connect the layers and divide the space between the layers into canals that run along the entire length of the tubes — similar to the gaps inside corrugated cardboard.



Newly discovered colossal carbon tubes are bigger than nanotubes, with some similarities.

The tubes are easily bent and stretched, and are at least twice as strong as the strongest fibers made from carbon nanotubes to date, the researchers report. The larger tubes are also good electrical conductors.

László Forró of the Ecole Polytechnique Fédérale in Lausanne, Switzerland, believes that the authors may have rushed to publication with results that are too preliminary. "At this stage it is only a cookbook," he says. "Basically, they do not know anything about the structure."

More research is needed to understand how the tubes form and grow, admits senior author Quanxi Jia of Los Alamos.

Fingerprints go high-tech

New tests can reveal signs of explosives, drugs

By Davide Castelvecchi

Fingerprints can tell a lot more about people — what they've touched, what they've eaten, what drugs they've taken — than just their identities. A new analytic tool could make it easier to spot terrorists and diagnose diseases from telltale chemical markers.

The method, described in the Aug. 8 *Science*, can map a fingerprint based on the presence of virtually any water-soluble chemical. "It's the difference between a black-and-white picture and a full-color picture," says chemist Graham Cooks of Purdue University in West Lafayette, Ind.

Cooks' team singled out traces of chemicals such as the explosive RDX and cocaine.

The researchers used a technique called DESI, pioneered by Cooks and collaborators in 2004. In DESI, researchers spray microscopic droplets of water onto a sample. The first droplets that hit the sample form a film that dissolves chemicals on the surface. When additional droplets splash onto the liquid film, some droplets bounce back and are sucked into a tube.

There the droplets are dried to isolate any chemicals in the sample. Mass spectrometry then identifies molecules according to their molecular weights.

Traditional mass spectrometry requires samples to be analyzed in a vacuum, while DESI can be used in the field.

"DESI is extremely powerful and promising," says chemist Facundo Fernandez of Georgia Tech in Atlanta.

DESI might also be useful for medical diagnosis. Fingerprints may contain chemicals that are not found with blood or urine tests and that indicate a disease's presence.

D.R. IFA *ET AL.*/*SCIENCE*; H. PENG *ET AL.*

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Ancient gadget charts game time

Antikythera mechanism kept a calendar of the Olympics

By Ron Cowen

Chalk up another Olympian feat to a gadget discovered more than a century ago in a 2,100-year-old shipwreck.

Scientists over the past decades have determined that the device was used to perform complex astronomical calculations, including predicting solar and lunar eclipses and planetary movement.

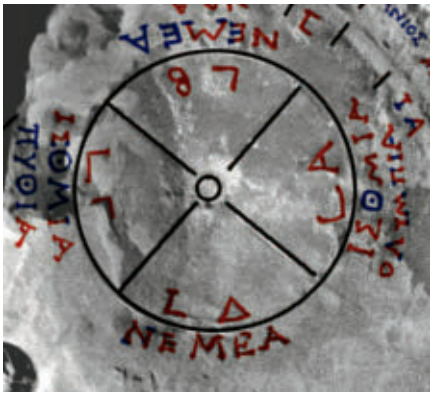
Known as the Antikythera mechanism, for the small Greek island near which sponge divers recovered it in 1901, the mechanical device is split into 82 fragments and is an agglomeration of disintegrating bronze gears and teeth, encrusted dials and hard-to-read inscriptions.

Using 3-D X-ray imaging, researchers have now revealed more of the inscriptions and determined that the gadget charted the four-year cycle of the Olympics and the cycles of other ancient Greek games.

These results and other new findings "link the cycle of human institutions with the celestial cycles embedded in the mechanism's gear-work," says Tony Freeth of the Antikythera Mechanism Research Project in Cardiff, Wales, and Images First Ltd in London.

The first clue suggesting a link to the games came when researchers deciphered the word *Nemea* near a small subsidiary dial on the mechanism. This represents the Nemean games, part of the Olympiad cycle. Next, Freeth and his colleagues deciphered *Isthmia* and *Pythia*, for the games at Corinth and Delphi, and *Olympia*, for the Olympics. The team reports the findings in the July 31 *Nature*.

The newly revealed inscriptions also identify 12 month names on the back of the mechanism, showing a sophisticated 19-year calendar — and providing the first concrete evidence for the use of a calendar described by the Greek astronomer Geminos. In this system, months have 30 days with one day omitted every 64th day for the correct average month length.



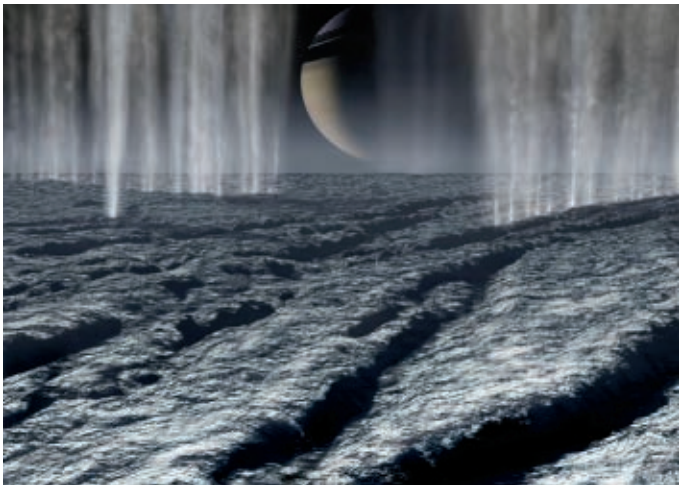
CT scans of one fragment of the Antikythera mechanism revealed inscriptions (outlined on the scan above), suggesting the ancient gadget charted the four-year Olympic cycle.

"Historians of astronomy had until now doubted that this scheme had been actually used in civil life," says François Charlotte, an independent scholar and expert on the mechanism. "But the evidence from the Antikythera mechanism now proves them wrong."

Freeth's team found that the names of the months correspond to those used in Corinth, and the team suggests that the device may have originated in Syracuse, Sicily, and may be linked to scientific instruments developed by Archimedes.

"Establishing a calendar is very tricky," comments Diomidis Spinellis of the Athens University of Economics and Business. Time has to be divided into logical units that follow heavenly bodies' movements, and the calendar should align with the tropical year, which determines the seasons, without annual intervention from astronomers, he says.

Such a calendar was employed by the Romans, but the new details suggest Greek civil calendars followed the accurate cycle by about 100 B.C. The findings further bolster the notion that the Antikythera mechanism is at least 1,000 years more advanced than other known mechanical devices from the same time period.



More hints of ocean on Enceladus

The Cassini spacecraft has found what may be the strongest evidence yet that Saturn's tiny moon Enceladus (shown in an artist's rendition) has an ocean beneath its icy surface. If the finding is confirmed, it would suggest that the moon may be a promising place to search for signs of life. Enceladus is already known to vent geysers of water ice and vapor that contain complex organic compounds. New evidence for an underground ocean comes from the detection of sodium in Saturn's E ring, the band of ice particles believed to be fed by the moon. Sascha Kempf of the Max Planck Institute for Nuclear Physics in Heidelberg, Germany, reported the finding in June at a Cassini project science group meeting in Rome. Jonathan Lunine of the University of Arizona in Tucson says a subsurface ocean is the best way to account for the sodium, but others remain more skeptical. — *Ron Cowen*

1,000° Celsius The temperature to which TEGA ovens heat soil samples from Mars

A solar system like few others

Conditions for formation were perfect, study says

By Ashley Yeager

Goldilocks isn't the only one who demanded everything to be "just right." Earth and its fellow seven planets also needed perfect conditions to form as observed, and those conditions occur rarely, a new computer simulation shows.

The simulation, described in the Aug. 8 *Science*, is the first to trace from beginning to end how planetary systems form from an initial gas disk encircling a baby star.

"The really striking result of the new model is how chaotic and even violent the average story of a planet's birth is," says Edward Thommes, now at the University of Guelph in Canada.

This illustration shows a star's dusty rings, which could coalesce to form planets.

All this violence seems to reduce the chances of forming a sedate solar system similar to Earth's, Thommes and his colleagues from Northwestern University in Evanston, Ill., conclude.

Based on data from the 307 exoplanets discovered to date, the simulation finds that if the disk that nurtures the protoplanets has a lot of gas, the system comes out containing a high number of "hot Jupiters." Too little gas in the disk produces smaller, rocky planets, with a few Neptunes. Solar systems with a mix of the two form only with a medium amount of gas. A few such systems showed up in 100 simulations.

"Although we may be weird, we're by no means unique," Thommes says.

Shigeru Ida of the Tokyo Institute of Technology says: "It is too early to say 'the solar system is special.'"

Mars lander confirms water ice

Phoenix also samples unexpected chemical compound

By Ashley Yeager

The Phoenix Mars Lander has finally confirmed the presence of water ice on the Red Planet, mission scientists have reported. This result, along with other successes, has led NASA officials to extend the mission of the lander, which touched down on Mars on May 25.

After two failed attempts to deliver a sample to one of the lander's Thermal and Evolved-Gas Analyzer ovens, the Phoenix team decided to put a sample of soil taken from just above the ice layer into the instrument. The soil contained ice.

Detecting the water ice in this sample was a surprise, William Boynton of the University of Arizona in Tucson said during a July 31 press briefing.

"Now, we have finally touched and tasted ice on Mars," said Boynton, a Phoenix coinvestigator and the lead TEGA scientist. "And I can say it tastes very fine."

One of the lander's instruments has also "tasted" an unexpected chemical compound in the soil. The compound, perchlorate, is an oxidizing agent found in rocket fuel and is considered hazardous to human health. Initial reports suggested that perchlorate's presence on Mars would have made life there unlikely.

"Now we have finally touched and tasted ice on Mars, and I can say it tastes very fine."
WILLIAM BOYNTON

But the perchlorate finding is yet to be confirmed, and its presence would not rule out the possibility that Mars could harbor some form of life, scientists said during a press briefing on August 5.

"These compounds are quite stable," said Arizona's Peter Smith, the principal investigator of the mission. "They are not likely to tear apart organic material, and so their presence does not limit the search for habitability in the icy soil of Mars."

Because of the direct detection of water ice, scientists can move away from proving its existence and focus on whether the soil-ice layer could ever have supported life, said Michael Meyer, chief scientist for NASA's Mars Exploration Program, headquartered in Washington, D.C.

Meyer announced during the July briefing that NASA would provide $2 million to extend the life of the lander through September 30. The original mission was to end in late August.

"Phoenix is healthy and the projections for solar power look good, so we want to take full advantage of having this resource in one of the most interesting locations on Mars," Meyer said.

NASA, JPL-CALTECH

Life

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Tissue found in dino fossil may be biofilm

New study questions analyses of *T. rex* remains

By Sid Perkins

Three years ago, a team of scientists rocked the paleontology world by reporting the recovery of flexible tissue resembling blood vessels from a 68-million-year-old dinosaur fossil. Now, another group suggests that such pliable material could be something more mundane: a modern-day film of bacterial slime.

The techniques used to assess such pliable materials are new to paleontologists, comments Matthew T. Carrano of the Smithsonian Institution in Washington, D.C. "It will take a while for paleontologists to sort through the arguments," he adds.

After dissolving and analyzing parts of a fossilized *Tyrannosaurus rex* leg bone, scientists — including Mary H. Schweitzer, a paleontologist at North Carolina State University in Raleigh — reported in 2005 (*SN: 3/26/05, p. 195*) that the fossil contained small bits of collagen, a fiber-forming protein that's the largest non-mineral component of bone.

But analysis of other fossils now suggests that soft tissue in fossil bones could just as likely be modern contamination.

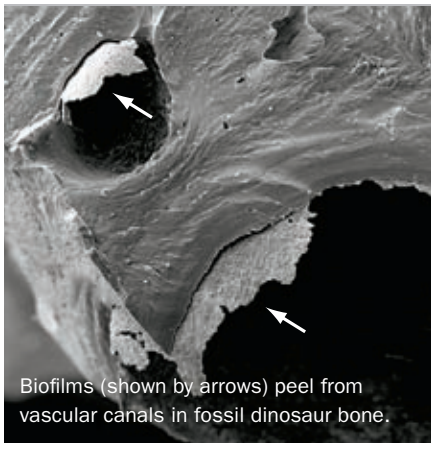
Rather than dissolving fossil fragments and analyzing the residue, Thomas G. Kaye, a paleontologist at the University of Washington's Burke Museum of Natural History and Culture in Seattle, and his colleagues cracked open dozens of old bones to see whether soft tissue was visible. Some of the specimens were 65 million years old and from the same rock formation as the *T. rex* that Schweitzer and her colleagues studied.

Kaye and his colleagues suggest in the July 30 *PLoS ONE* that the small, blood-cell–like spheres in the bones they studied are tiny enigmatic structures called framboids, named for the French word for raspberry. Framboids are typically made of iron sulfides, but those riddling the fossils analyzed by Kaye's team — as well as Schweitzer's team in the *T. rex* leg bone — were instead made of iron oxide.

A variety of evidence suggests that pliable material found in fossils may be biofilms of modern-day bacteria rather than ancient cells and blood vessels. Many of the fossils analyzed by Kaye and his colleagues contained such material. Carbon-dating analyses of some samples indicate that the material is very recent, forming after 1950, Kaye says.

Recent studies, Kaye's team reports, also show that some bacteria sport a collagen-like surface protein, which might trick a biochemical test designed to detect collagen.

Schweitzer and her colleagues take issue with the findings. "There really isn't a lot new here, although I really welcome that someone is attempting to look at and repeat the studies we conducted," she notes.



Biofilms (shown by arrows) peel from vascular canals in fossil dinosaur bone.

Schweitzer and her team dismissed bacterial biofilms as a cause of the tissues she and her team observed. Such coatings probably would be thicker along the lower surfaces of the vascular spaces, but the flexible structures her team recovered had walls with an even thickness, she says. Also, there's no reported evidence that biofilms can produce branching, hollow tubes like those noted in her study.

Furthermore, says John M. Asara, an analytical chemist at Harvard Medical School in Boston and a colleague of Schweitzer's, the type of collagen found was bone-specific and isn't a common protein contaminant.

Nevertheless, the interpretation that the soft tissue in fossils is actually modern-day biofilms "is a reasonable alternate hypothesis," Carrano says.

HEDGES; KAYE

Smallest known snake

A newly named species from Barbados could be the world's smallest kind of snake. Adults of this threadsnake average only 100 millimeters long, says evolutionary biologist Blair Hedges of Pennsylvania State University in University Park. He is naming it *Leptotyphlops carlae* in honor of his wife, Carla Ann Hass, he says in a report published online in *Zootaxa*. The new species edges out threadsnake cousins for smallest honors by only a matter of millimeters. Its eye-to-tail stripes, narrow head, scale pattern and DNA segments mark it as a species new to science, Hedges says. He studied five adult Barbados threadsnakes, including a female that will be the reference specimen for the new species. Hedges and Hass found her on the eastern side of Barbados in June 2006. —*Susan Milius*

16 millimeters The length of the smallest known lizards, *Sphaerodactylus ariasae* and *S. parthenopion*

Spider eats trees, not bugs

Small jumping species steals lunch from ants

By Susan Milius

A little eight-legged pickpocket that darts around acacia trees could be the first known vegetarian spider.

Bagheera kiplingi belongs among the big-eyed, athletic predators in the family of jumping spiders and gets its name from a panther in a Rudyard Kipling story. Yet a population of these spiders in Mexico mostly eats bits of acacia trees, says Christopher Meehan of Villanova University in Pennsylvania.

A few other species do taste vegetable matter now and then, says Yael Lubin of Ben-Gurion University's Sede Boqer campus in Israel. Male crab spiders will sip nectar for a little energy boost. And some baby spiders eat spores that have stuck to a web. But on hearing about spiders specializing in stealing vegetarian food, "I was absolutely floored," Lubin says.

This spider, which may be the first-known vegetarian species, collects protein and fat bodies from the tips of leaflets on acacias.

These arachnid herbivores are no wimps. "The tree is full of biting, vicious ant guards," Meehan said August 11 at Cornell University during the 12th International Behavioral Ecology Congress. The spider spends its life dodging patrols of ants to steal their (vegetarian) lunches. The spiders perch on leaf tips and nest in mature leaves, which are less heavily guarded.

Acacia trees and their resident ants are a textbook example of a mutually beneficial partnership. Tree thorns grow swollen bases that shelter ants. Glands at the base of the leaves ooze nectar for refreshment, and leaflet tips sprout nubbins rich in protein and fat. In defending their homes, ants rid the trees of invaders that might chew the trees.

Meehan, along with his Villanova colleague Robert Curry, watched videos of 140 spider meals. The researchers counted 136 acacia protein-fat snacks with a few nectar sips. On four occasions the spiders turned to meat, tugging ant larvae away from a passing nursemaid and eating the youngsters. But concentrations of a heavy form of nitrogen in spider tissue suggest meat moments don't happen often.

In Costa Rica, Eric Olson of Brandeis University in Waltham, Mass., found that this spider also frequents acacia trees and specializes in stealing ant food.

Man yawns, best friend follows

Contagious jaw-stretching jumps species barrier

By Susan Milius

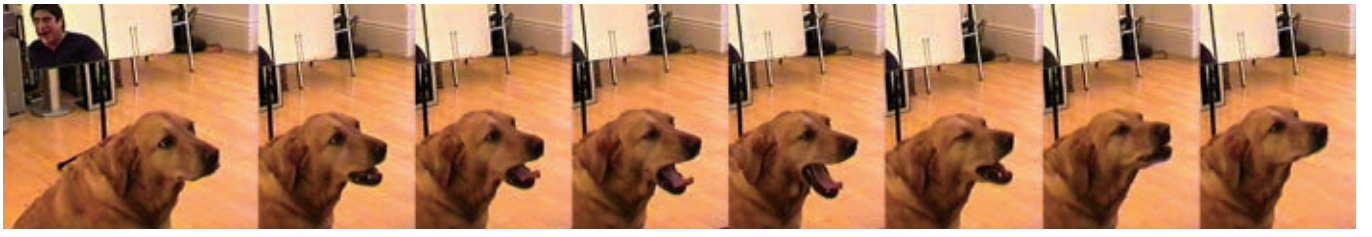
It's not just Frisbees and sticks. Dogs catch yawns from people, too. Dogs watching a person repeatedly yawn will yawn themselves, report Atsushi Senju of Birkbeck, University of London and his colleagues in an upcoming *Biology Letters*.

One of Senju's students, Ramiro Joly-Mascheroni, spent five minutes catching the eye of subjects ranging from dachshunds to Dobermans and giving wide, sighing yawns. For a control, Joly-Mascheroni opened his mouth quietly and less dramatically.

Of the 29 dogs, 21 yawned at least once. But none of the dogs yawned while watching the control mouth movements.

"If the study can be replicated, it strongly suggests dogs may have a primitive empathic capacity," says Gordon Gallup Jr. of the State University of New York at Albany. Empathy, or the ability to grasp what someone else feels, knows or intends, may depend on some of the same neural circuitry triggered by contagious yawning, Gallup adds.

Though it's not clear why the yawns spread, studies do suggest that domesticated dogs have evolved superior powers to read and react to the waves and shouts of the primates that fill the food bowls.



JOLY-MASCHERONI; R. CURRY

Genes & Cells

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Take two and run farther in the morning

Drugs improve muscular endurance in lab mice

By Patrick Barry

It's not quite exercise in a bottle, but it's pretty close. Building on research that produced a genetically altered "marathon mouse" in 2004, scientists have shown that a drug called AICAR can boost the running endurance of mice by about 45 percent — exercise not required.

Different mice given a second drug did even better, besting the running time and distance of their drug-free, exercising peers by up to 75 percent, researchers reported in the Aug. 8 *Cell*. But this drug, called GW1516, worked only if the mice regularly exercised while taking it.

All this just in time for the Olympics.

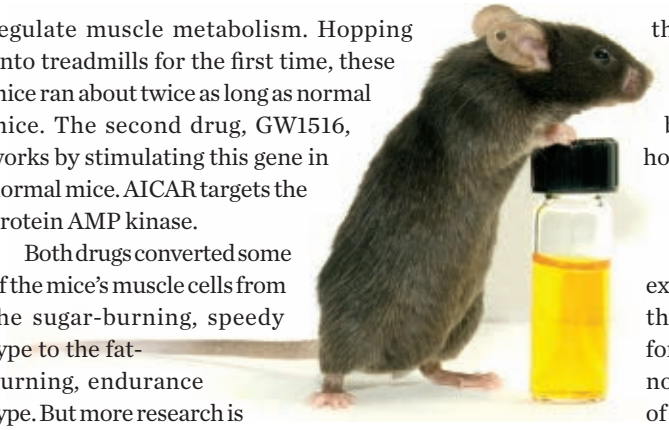
"I wouldn't be surprised if there are some athletes who already have" acquired GW1516, says lead scientist Ronald Evans of the Salk Institute for Biological Studies in La Jolla, Calif. The drug is already made in India "by the bucket load," Evans says, and United Kingdom pharmaceutical company GlaxoSmithKline has tested it in clinical trials as a cholesterol drug.

Evans says he has already provided sensitive tests for both drugs to the World Anti-Doping Agency, the group based in Montreal, Canada, that oversees drug testing for the Olympics.

Illicit use by athletes isn't the only potential use for these muscle endurance–boosting drugs. "Perhaps you can treat people who are disabled or who are unable to exercise," comments Erik Richter, a muscle physiologist at the University of Copenhagen in Denmark. "They would benefit from this type of drug."

Evans made headlines in 2004 after genetically engineering mice with extra copies of the gene *PPAR-delta*, which helps regulate muscle metabolism. Hopping onto treadmills for the first time, these mice ran about twice as long as normal mice. The second drug, GW1516, works by stimulating this gene in normal mice. AICAR targets the protein AMP kinase.

Both drugs converted some of the mice's muscle cells from the sugar-burning, speedy type to the fat-burning, endurance type. But more research is needed to show whether the drugs induce any of the other benefits of exercise, such as cardiovascular fitness, bone strength and hormonal changes.



A shot of a drug called AICAR boosted the running endurance of mice.

Richter says he doubts a single pill will soon replace exercise. "If you think that exercise is good for you," he says, "why not just do it instead of sitting on the couch and popping a bunch of pills?" ■

T cells get tough against HIV

In mice, RNA 'scissors' keep the AIDS virus at bay

By Patrick Barry

I pity the fool who messes with these T cells.

Delivering molecular "scissors" into T cells in mice makes the immune cells downright hostile to HIV. Not only do the cells reject the virus's advances, but copies of the virus already inside the cells get snipped up.

The technique is the first to deliver these HIV-fighting scissors — called small interfering RNAs, or siRNAs — into T cells in living animals, Premlata Shankar of Texas Tech University Health Sciences Center in El Paso and her colleagues report in the Aug. 22 *Cell*.

"They've shown very nicely that you can ... target T cells and knock down the virus," comments John Rossi, an AIDS researcher at City of Hope's Beckman Research Institute in Duarte, Calif. "It's a nice proof of principle that I think could be developed into a viable therapy."

Previous research on cells in lab dishes showed that customized siRNAs can snip the molecules that enable HIV to enter and kill T cells. Cell death leads to the immune deficiencies characteristic of AIDS. In the new experiments, done when Shankar was at Harvard Medical School, custom siRNAs were injected into mice that had their blood cells replaced with human ones. The siRNAs prevented T cell loss.

"It could become a very good adjunct therapy," Shankar says.

Existing drugs also inhibit HIV from replicating inside T cells. But unlike those drugs, siRNAs can be quickly modified to target viral mutations that make HIV resistant to conventional drugs.

An siRNA is a short molecule only 20 to 25 "letters" of genetic code long. If that code matches up with a gene segment, the siRNA blocks production of the protein encoded by that gene. Shankar's team used an siRNA that targets the gene for a protein called CCR5, which sits on the surface of T cells. To enter the cells, most HIV variants first bind to CCR5, so blocking its production slams the door on HIV.

The researchers delivered this siRNA, along with two others that target the genetic code of the virus itself, by coupling the molecules to an antibody that binds to a protein on the T cell surface.

More research to check for toxicity is needed, Rossi says. Further tests on monkeys are also needed before the treatment can be tested in human clinical trials. ■

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Matter & Energy

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Invisibility is almost within sight

Two new materials show promise for cloaking devices

By Davide Castelvecchi

At this rate, Harry Potter skeptics may soon be left with no place to hide. Two new materials that bend light backward suggest that invisibility cloaks like Harry's could someday become feasible.

The two materials, described in separate papers published online by *Nature* and in the Aug. 15 *Science*, use different approaches to bend light in the opposite direction than it would bend when encountering an ordinary material, says Xiang Zhang of the University of California, Berkeley, senior author of both papers.

For example, light bends at the surface of a pond, such that fish in the water look larger and closer than they are. If water bent light the opposite way, fish would instead appear to float above the surface.

In 2000 scientists first described materials that could do the reverse bending trick. The first demonstrations worked for microwave radiation. Last year, the first materials that could bend visible light backward began to appear.

But those materials had many drawbacks, letting very little light through, for instance, or working only for a particular polarization of light. The Berkeley materials, while not completely transparent, remove some of those limitations.

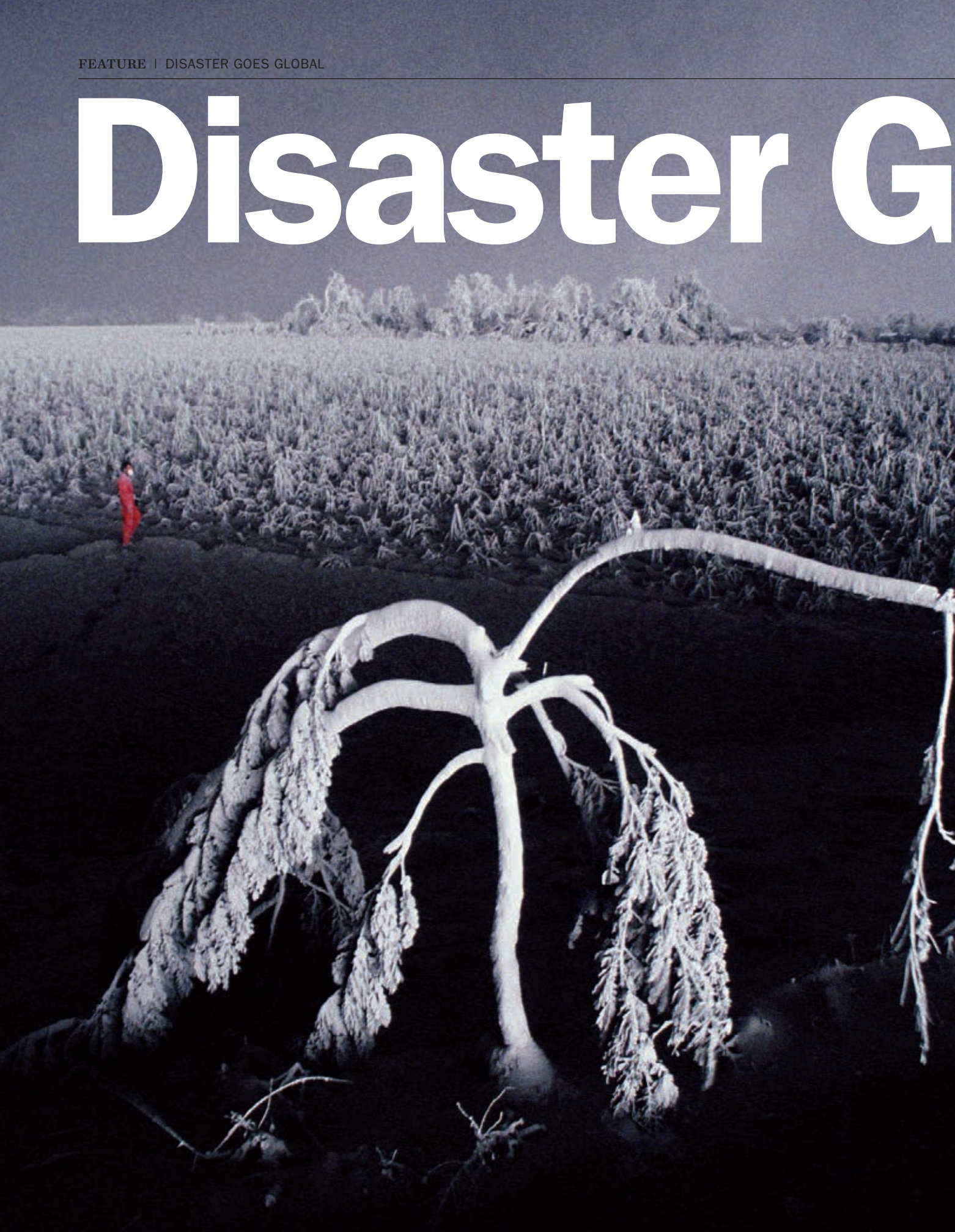
In *Nature*, the authors describe a film of about 20 alternating layers, each just tens of nanometers thick, of silver and magnesium fluoride. In the *Science* study, researchers embedded 60-nanometer-thick silver wires in an aluminum-oxide sheet just 0.01 millimeter thick.

In principle, a material that bends light backward could be fashioned into a spherical shield that would hide what's inside by making light flow around it (*SN: 7/15/06, p. 42*). Neither new material is ready for full-fledged cloaking status, "but the Berkeley team made an important step," says theoretical physicist Ulf Leonhardt of the University of St. Andrews in Scotland.

Both materials bend light at different angles depending on its wavelength, while a real invisibility cloak should bend light equally across the spectrum.

Such materials could be used, though, in microscopes to beat the limits of ordinary optics. For microscopy, it would be sufficient to use one wavelength at a time, so it would not be necessary to bend all wavelengths by the same angle.

Disaster G



The eruption of Mount Pinatubo in 1991 covered surrounding areas in ash. It also caused the global average temperature to briefly drop by 0.4 degrees Celsius.

PHILIPPE BOURSEILLER/CORBIS

oes Global

The eruption in 1600 of a seemingly quiet volcano in Peru changed global climate and triggered famine as far away as Russia

By Sid Perkins

Small disturbances can eventually have immense consequences. In the namesake example of the butterfly effect, the vortex spun from a butterfly's wing creates tiny changes in the atmosphere that result in a hurricane half a world away. While that's theoretically possible, no one has yet tried to blame the insect world for triggering a cyclone.

But a strong link does exist between the small particles suspended high in Earth's atmosphere, such as those spewed from erupting volcanoes, and the overall climate down at the planet's surface. High-altitude aerosols, especially in large numbers, block sunlight from reaching the ground and scatter it back into space, thereby cooling the planet for months or even years (*SN: 2/18/06, p. 110*). The 1991 eruption of Mount Pinatubo in the Philippines, for example, caused the global average temperature to briefly drop about 0.4 degrees Celsius. The eruption of Indonesia's Tambora in 1815 triggered agricultural failures in North America and Europe, caused the worst famine of the 19th century and cooled the planet so much that 1816 became known as "the year without a summer."

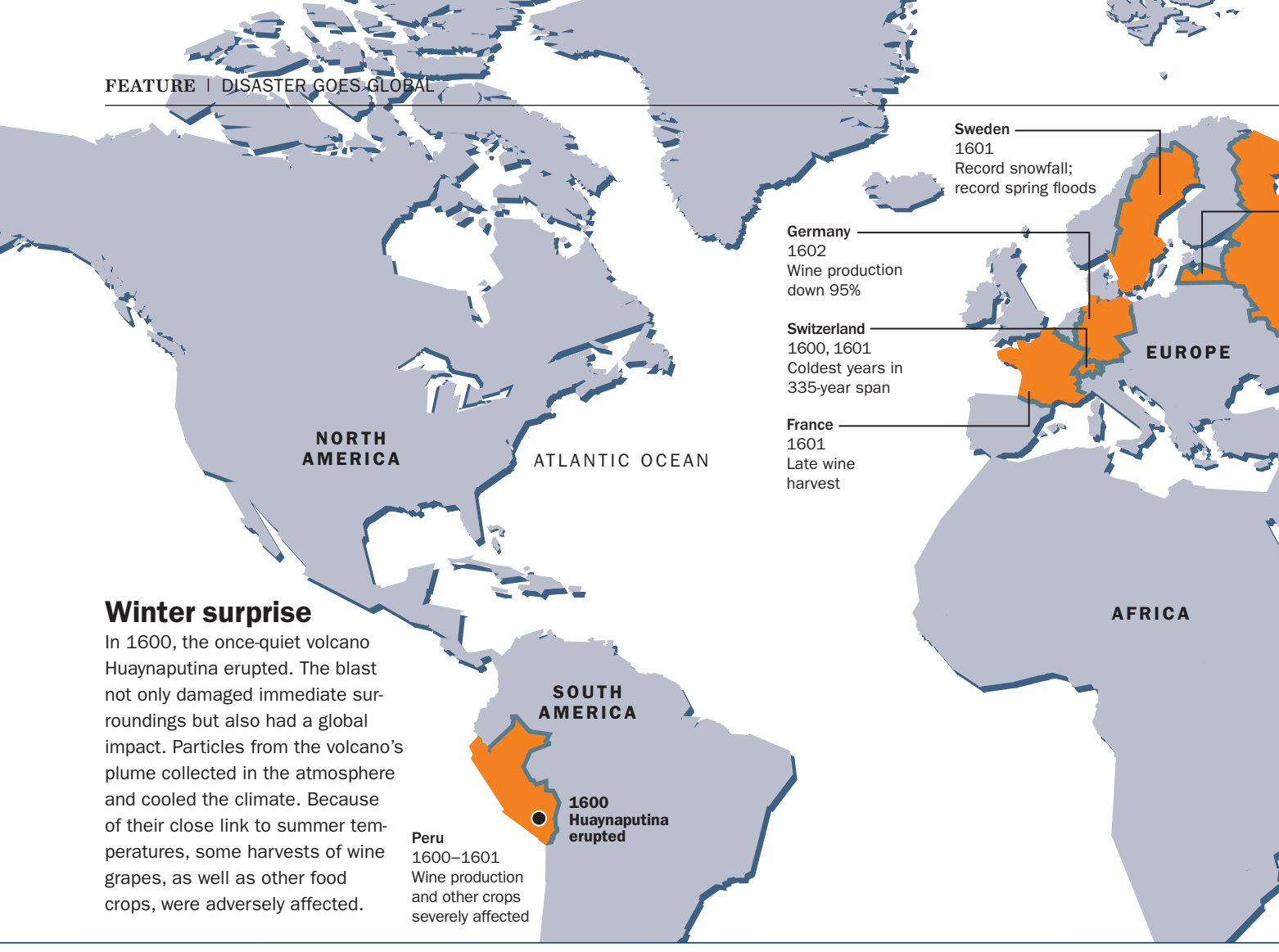
While many eruptions in historic times caused real climatic changes, previously only Tambora had been linked to significant social disruptions, says Kenneth Verosub, a geophysicist at the University of California, Davis. Now, however, analyses by Verosub and colleague Jake Lippman suggest a connection between the 1600 eruption of Huaynaputina, a little-known peak in Peru, and one of the greatest famines ever to strike Russia.

"People have long known about the eruption and have long known about the famine, but no one has previously linked the two," Verosub says.

Other volcanic eruptions of approximately Huaynaputina's size or larger have occurred more recently, including Pinatubo in 1991 and Indonesia's Krakatau in 1883, but they didn't cool Earth as much and didn't trigger societal upheavals. The reason, researchers say, may stem from the immense volumes of sulfur-rich fluids that fueled Huaynaputina's eruption, which released an exceptional amount of planet-cooling aerosols.

Krakatau and Pinatubo also took place in a more industrialized world in which nations were more connected than they were when Tambora blew its top. So perhaps technology and globalization have rendered modern society more resilient to the effects of a worldwide catastrophe such as a massive volcanic eruption.

Unfortunately, though, overpopulation and humanity's consumption of a large fraction of the world's biological productivity mean that even today a large eruption could deal humanity a significant blow, some scientists say.



Winter surprise

In 1600, the once-quiet volcano Huaynaputina erupted. The blast not only damaged immediate surroundings but also had a global impact. Particles from the volcano's plume collected in the atmosphere and cooled the climate. Because of their close link to summer temperatures, some harvests of wine grapes, as well as other food crops, were adversely affected.

Trouble down south

The Andes, the world's longest mountain chain, stretch along the western edge of South America and are chock-full of volcanoes. In February 1600, Huaynaputina, a relatively inconspicuous peak in southern Peru with no known history of eruption — in the local language, the name means "new volcano" — catastrophically exploded. The eruption, the largest in South America in written or oral history, lasted at least two weeks and belched as much as 12 cubic kilometers of ash, much of that spewing into the atmosphere during the first two days.

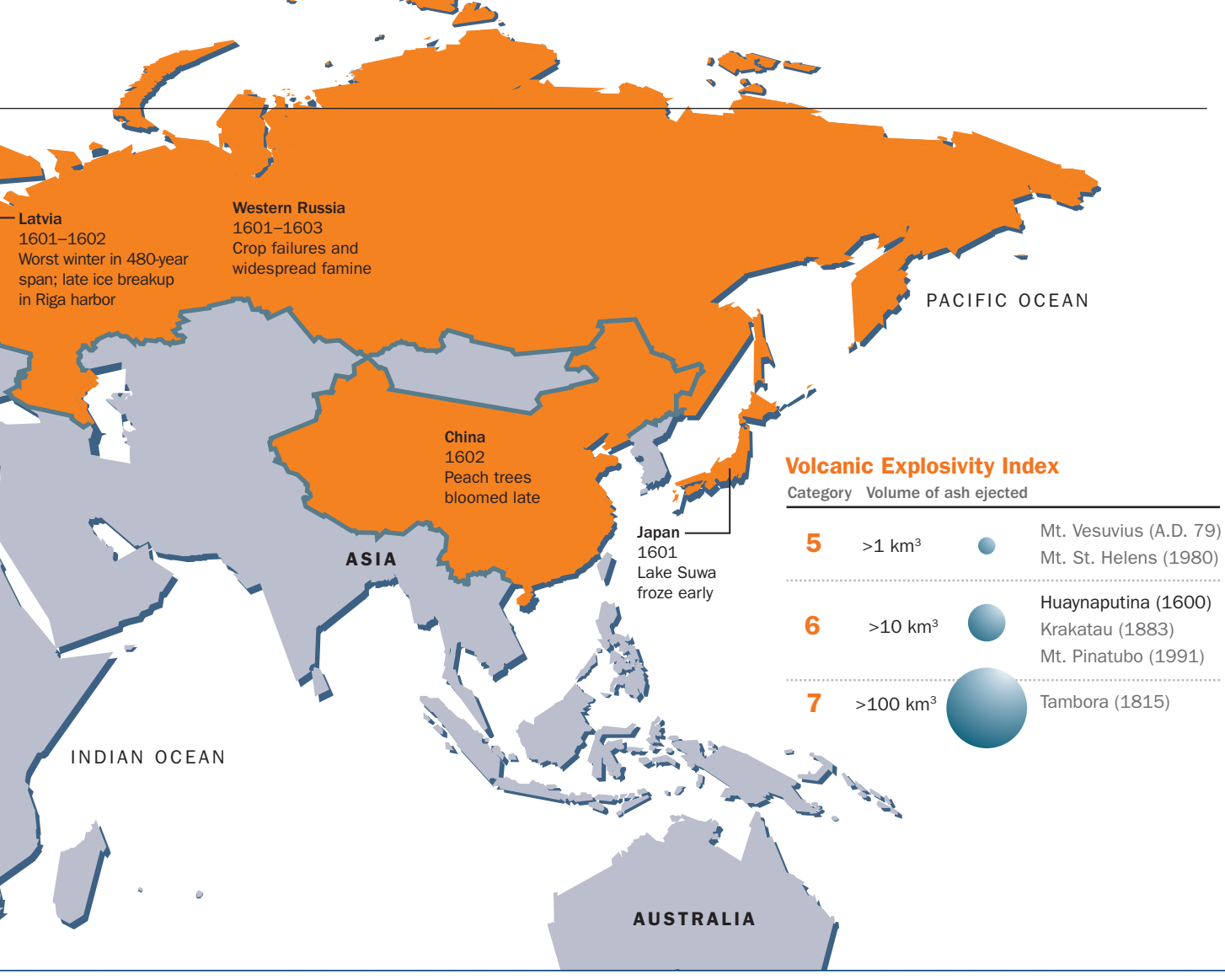
Avalanches of volcanic ash and hot boulders spilled east and southeast of the peak, and lahars — flows of ash and mud with the consistency of wet cement — destroyed several villages on the way to the Pacific coast, about 120 kilometers away. Significant quantities of ash smothered the region, says Charles Walker, a historian at UC Davis. "Some people didn't see the sun for months, and agricultural production was devastated for the next two years," he notes.

As many volcanic eruptions do, Huaynaputina lofted immense amounts of sulfur dioxide into the atmosphere. That gas reacts with water vapor in the air and then condenses into Earth-cooling droplets of sulfuric acid, which can destroy high-altitude ozone. Eventually the droplets are cleansed from the air by natural processes. The amount of sulfur-bearing compounds deposited on ice in Greenland and Antarctica in the months after the eruption suggests that Huaynaputina spewed between 16 million and 32 million metric tons of sulfur into the air, says Hannah Dietterich, a geologist at Pomona College in Claremont, Calif.

Most of that sulfur came not from the lava, but rather from pressurized fluids that accumulated in the volcano's magma chamber before the eruption, she and her colleagues proposed in December 2007 at a meeting in San Francisco of the American Geophysical Union. Geochemical analyses of trace elements in the apatite minerals recovered recently from rocks made of Huaynaputina's ash suggest that the magma could have contained no more than 4.1 million metric tons of sulfur. The tests also hint that as much as 5 percent of the material that erupted from the peak could have been fluid rich in sulfur dioxide, carbon dioxide and water — substances that, as they rose to Earth's surface, would have violently expanded and fueled the eruption.

The big chill

Several studies indicate that the sulfur dioxide emissions from Huaynaputina



were roughly comparable to those of Tambora. Therefore, says Verosub, the climatological consequences of the two volcanoes should be similar. Indeed, the chilling effects of Huaynaputina's eruption in 1600 were substantial and were felt worldwide, he and Lippman report in the April 8 *Eos*.

To wit: Tree ring data gathered throughout the Northern Hemisphere indicate that 1601 was, on average, the coldest year out of the last 600. In Switzerland, 1600 and 1601 were among the coldest years between 1525 and 1860. In Estonia, the winter of 1601–1602 was the coldest in a 500-year period. In Latvia, the late date of ice breakup in the harbor at Riga indicates the winter was the worst in the 480 years before today. In Sweden, record amounts of snow in the winter of 1601 were followed in the spring by record floods. People around the world felt the effects of Huaynaputina's changes to climate.

Through a chance meeting on an airplane, Verosub found that Huaynaputina may have triggered substantial social upheaval as well. While he chatted with a seatmate about his research on the effects of volcanic eruptions, a fellow seated in the row behind — Chester Dunning, a historian specializing in Russian history at Texas A&M University in College Station — overheard the conversation and introduced himself.

"So," Verosub asked Dunning later in the chat, "did anything interesting happen in Russia in 1601?" The reply: "Oh, yeah. That was a terribly cold time in Russia." That cold spell was just the beginning of the nation's woes, Dunning continued.

Large portions of Russia received heavy rains in the summer of 1601, and by the end of the growing season it was clear that most crops would fail. In that age, Dunning explains, most farmers expected to occasionally experience a bad year and stockpiled accordingly, so farmers and their families didn't suffer immediately. However, another agricultural failure the following year led to widespread starvation in both 1602 and 1603.

This lengthy famine — Russia's worst, says Dunning — claimed the lives of an estimated 2 million people, or about one-third of the population, and more than 100,000 died in Moscow alone. Government inability to alleviate both the calamity and the subsequent unrest eventually led to the overthrow of Czar Boris Godunov, a defining event in Russian history.

Many volcanoes, besides killing local residents during their eruptions, have caused indirect deaths by triggering famines in the surrounding regions,

REDMAL/ISTOCKPHOTO

says Lee Siebert, a volcanologist at the Smithsonian Institution in Washington, D.C. In 1783, for example, the clouds of volcanic ash and poisonous gases lofted during the eruption of Laki in Iceland killed more than half of the nation's livestock, which in turn led to a food shortage that resulted in the death of about one-quarter of the population there. Also that year, an eruption of Asama, one of Japan's most active volcanoes, may have contributed to a local famine that lasted four years and killed between 300,000 and 1 million Japanese, Siebert says.

The local and regional effects of volcanoes are common and often well-documented. However, the purported long-distance link between Huaynaputina and the subsequent famine and social unrest in Russia marks the only instance besides Tambora in which a specific volcano has been blamed for causing global misery, Verosub says.

Future shock?

In general, the larger the volcanic eruption, the bigger the cooling effect and the longer that effect lasts, sulfur content of its aerosols notwithstanding. Scientists categorize eruptions according to the Volcanic Explosivity Index, a parameter that depends on factors such as how much material is thrown from the peak and the height of the ash plume that's produced.

The Huaynaputina eruption of 1600 falls into VEI category 6, which denotes an eruption with an ejecta volume greater than 10 cubic kilometers and a plume height that exceeds 25 kilometers. By comparison, Tambora has been tagged as a VEI category 7 eruption, which signifies an eruption that produces a similarly lofty ash plume but generates more than 100 cubic kilometers of ejecta.

Since 1601, there have been five category 6 eruptions, including Laki (1783), Krakatau (1883) and Pinatubo (1991). However, none of these events spawned adverse societal effects on a global scale as Huaynaputina did. In part, Huaynaputina's sulfur-rich plume could have rendered the peak's eruption inordinately powerful.

Climate at the time could have played a role as well, says Verosub: In 1600, the world was in the midst of the Little Ice Age, typified by harsh winters, springs and summers much cooler and wetter than normal, and shorter-than-average growing seasons. A large volcanic eruption during that period would have depressed average temperatures even further — adding insult to injury, as it were.

> **…people then "were used to living on the margin. Everybody knew hunger …and the idea that you should plan for a bad year was ingrained in these societies."**
>
> CHESTER DUNNING
> TEXAS A&M UNIVERSITY

The demographics of the era also played a role, Dunning speculates. During the 1500s, the population in many regions had doubled, and as the century progressed, the proportion of young males had grown even faster. As a result, many of the younger sons of the late 1500s ended up not receiving their fathers' land, jobs or titles, producing what Dunning terms "a surplus population of angry young men." And in general, food production wasn't keeping up with population growth.

By the 1590s, Dunning notes, many parts of the world were experiencing a wave of starvations, rebellions and unrest. Then, he adds, "at this most excruciating moment, this other thing comes along to take things where they'd never gone before." None of the countries of early modern Europe were equipped to deal with such crises, Dunning says.

Is the situation any better today? Would modern technology and an increased global interconnectedness enable 21st century humans to better survive an immense, Earth-chilling eruption? Surprisingly, the answer to both questions may be no.

In the past, Verosub notes, most of a society's foodstuffs were grown locally and in wide variety, so not every crop required the full growing season to mature. Therefore, any event that shortened a region's growing season didn't necessarily doom the entire harvest. Staples that formed the bulk of the diet were, for the most part, homegrown.

Today, on the other hand, most large-scale agricultural production focuses on a single crop that's chosen to take full advantage of a region's climate in order to realize maximum output — a severe disadvantage if the growing season is significantly trimmed by, say, a volcanic eruption.

Not only were preindustrial farming practices possibly more resilient to total agricultural failure, people then "were used to living on the margin," Dunning says. "Everybody knew hunger ... and the idea that you should plan for a bad year was ingrained in these societies."

Today, by comparison, the world's surplus food supply would last only about 90 days, a number that's steadily dropping as population increases. Additional pressure on food, water and other resources in some nations, such as China, stem from a rapidly increasing standard of living and the resulting changes in dietary preferences (*SN: 1/19/08, p. 36*).

Humans are consuming an ever-increasing fraction of the biological productivity at the base of Earth's food chain, in some regions almost two-thirds of the biomass that would be available if humans weren't clearing forests, farming or otherwise occupying the land (*SN: 10/13/07, p. 235*). Rising population, plus the shift in some areas to divert agricultural production to produce inedible commodities such as ethanol, has led many to suggest a modern-day food crisis is at hand.

"What happens if another major eruption happens today?" Verosub asks. "If we lower the growing season globally, are we looking at a food crisis? ... We've got a really stressed system, and if we hit it hard, is it going to collapse? I think that's worth thinking about." ■

Explore more

■ Chester Dunning. *Russia's First Civil War: The Time of Troubles and the Founding of the Romanov Dynasty*. Pennsylvania State Univ. Press, 2001.

Are you missing the luxury of warm, relaxing baths? Well, grab your towel!

NEW Lifetime Warranty*

By John Fleming

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Recent changes in hearing-related genes may have

Evolutio

Imagine, for a moment, that you are smaller than a speck of dust and in the mood for some teeny-tiny sightseeing. It's a perfect opportunity to take a scenic trip to the inner ear.

First, stroll up the ear canal. This is a fantasy, so no waxy buildup blocks the way. At the end of the fleshy tunnel, squeeze around the huge, circular membrane better known as the eardrum. Gingerly sidestep the precariously balanced, oddly shaped middle ear bones and proceed into the inner ear. Up ahead, rising like skyscrapers from a flat landscape, looms a cluster of stereocilia. These slender, interconnected projections sit atop the basic sensory elements of hearing — the inner ear hair cells. Bundles of gently waving stereocilia serve as receptacles for sound waves delivered from hair cells, transforming those waves into electrical signals that travel to the brain to be interpreted.

But the inner ear is more than just the mediator of hearing. As a core player in the human system for receiving and creating spoken language, it's a hotbed of recent evolutionary change as well.

In a new study, anthropologist John Hawks of the University of Wisconsin–Madison finds that eight hearing-related genes show signs of having evolved systematically in human populations over the past 40,000 years. Some alterations on these genes took root as recently as 2,000 to 3,000 years ago.

"Hawks makes a compelling case that not only is human evolution ongoing in the past 10,000 years, but it has sped up," says anthropologist Clark Larsen of Ohio State University in Columbus.

Seven genes identified by Hawks produce proteins that make stereocilia and the membrane that coats them. The eighth gene assists in building middle ear structures that transmit sound frequencies to the inner ear.

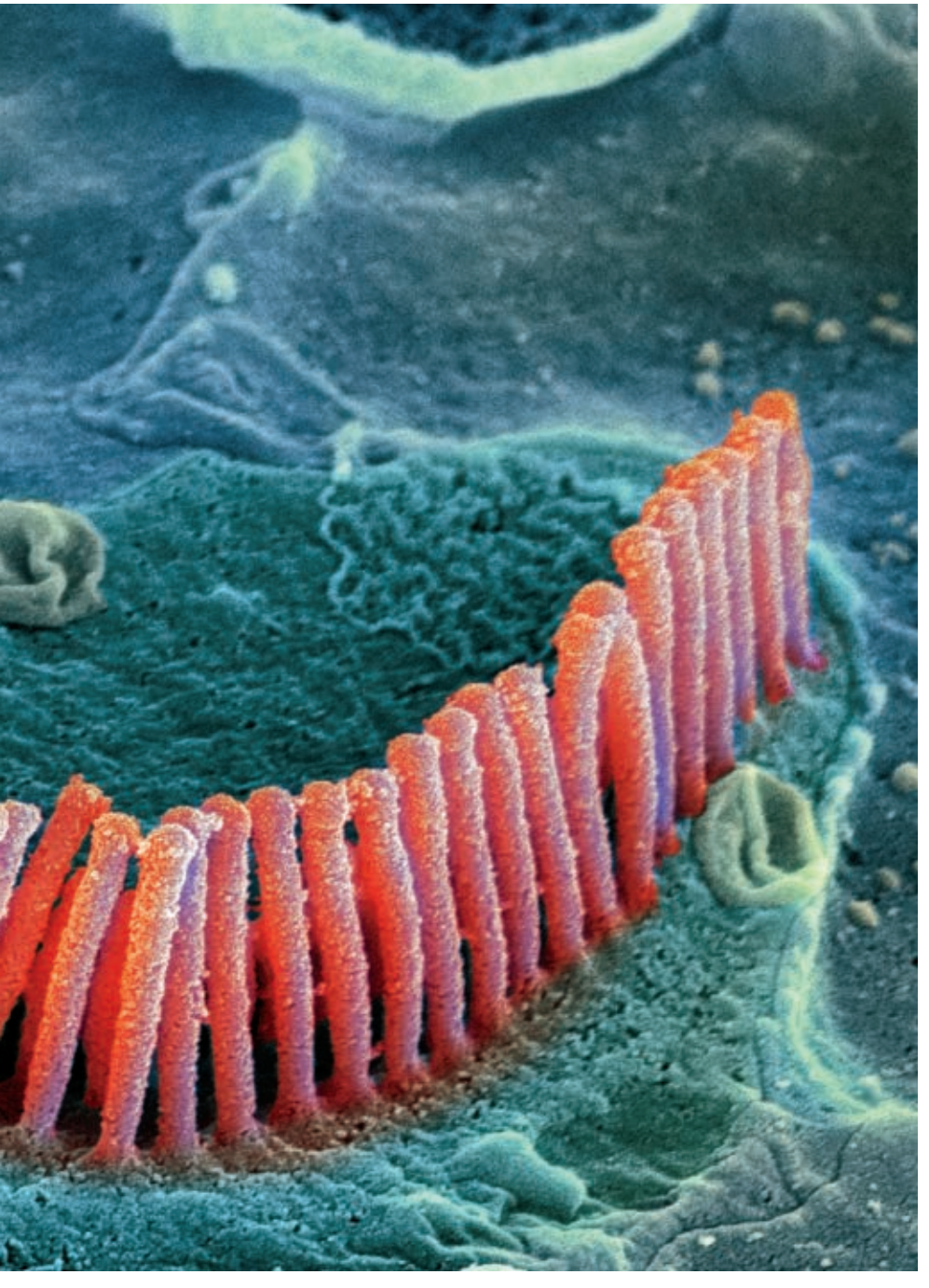
It all points to the evolutionary sensitivity of at least one part of the human language system in the post–Stone Age world, Hawks reported in April in Columbus at the annual meeting of the American Association of Physical Anthropologists. Language depends not

This scanning electron micrograph shows sensory hair cells in the cochlea of the inner ear. As sound enters the ear, waves cause the stereocilia (orange) on the hair cells to move. This movement is converted to an electrical signal, which passes to the brain.

influenced language development

By Bruce Bower

on's Ear



SPL/PHOTO RESEARCHERS

just on a vocal tract capable of making certain speech sounds but on ears designed to hear particular sound frequencies, as well as on a variety of other brain and body features. Relatively recently in evolutionary history, genetic revisions within populations have upgraded ear structures needed for discerning what other people say, he proposes.

"It takes a long time for a biologically complex system like language to evolve," Hawks says. "We're still genetically adapting to language."

His findings challenge the influential idea that the way humans now talk emerged full-blown about 50,000 years ago thanks to a single genetic mutation that improved vocal articulation. Hawks' results instead play into a growing appreciation that rapid population growth toward the end of the Stone Age, followed by the rise of agriculture and village life around 10,000 years ago, triggered cultural changes that prompted genetic accommodations.

Speak up speedup

Speech-related genes must have succumbed to evolutionary pressures for improved communication in the expanding populations of the late Stone Age and at the dawn of farming, Hawks reasons.

He wanted to test whether certain genes that foster the ability to hear what others say might have become more common as more and more people lived year-round in one place.

To do that, Hawks analyzed a database of 3.9 million single nucleotide polymorphisms — regularly occurring variations of individual DNA letters within genetic sequences — that researchers had earlier identified in 90 Europeans, 90 Africans, 45 Chinese and 45 Japanese.

These single letter mutations are passed down as part of a larger chunk of DNA, a section of chromosome with a characteristic pattern of other nearby DNA alterations. These sections, along with their sets of mutations, break down over time due to the remixing of DNA that occurs each time a sperm and egg fuse during conception. It's thus possible to estimate how long ago a specific

mutation arose based on the pattern of accompanying mutations.

Consider a gene necessary for forming filaments that join stereocilia into sound-transmitting bundles. A particular mutation of this gene appears frequently in Chinese and Japanese people and probably originated in the past 10,000 to 15,000 years, Hawks says.

Other common variants of genes required for making stereocilia occur either in Europeans or Africans. These DNA changes emerged as early as 40,000 years ago and as late as 2,000 years ago.

"I have no idea why certain variants show up in some populations and not in others," Hawks remarks.

It nonetheless appears that evolution has increasingly promoted genes that mediate the ability to hear speech sounds. Hawks suggests that as social life became more demanding in the late Stone Age, these particular gene variants must have aided survival and reproduction. People who inherited them may have developed special proficiency at detecting subtle emotions conveyed by a speaker's vocal tone or recognizing familiar voices in a chattering crowd.

Hawks initially suspected that the need to counteract hearing loss in aging populations spurred much recent evolution in genes involved in hearing. But to his surprise, genes that have been implicated in aging-related hearing loss showed no evidence of systematic change in the past 40,000 years.

In contrast, the systematic changes of the hearing- and speech-related genes echo those of a 2007 paper in which Hawks and his colleagues — using the same genetic database from Europeans, Africans and Asians — concluded that late–Stone Age population surges spurred a bevy of rapid evolutionary changes. The pace of such changes has sped up ever since, the researchers propose.

About 1,800 genes, roughly 7 percent of the human total, show signs of survival-enhancing change in the past 80,000 years, Hawks' team estimates. Around 80,000 years ago, human groups left Africa and adapted to a series of new habitats and climates. In a second wave of change, the agricultural revolution reshaped physical and cultural environments with particular vigor.

That may explain the researchers' finding that gene variants related to several forms of disease resistance have spread through populations in different parts of the world. Agricultural groups witnessed sharp increases in mortality from contagious epidemic diseases, including smallpox, malaria, yellow fever and tuberculosis, Hawks notes.

Similarly, a switch to milk drinking by farmers fostered the spread of a gene variant involved in efficiently metabolizing lactose, a sugar found in milk. This lactose-tolerance gene flourished independently in Europe and in Africa, allowing its inheritors to drink milk without unpleasant side effects.

Other recent evolutionary changes defy explanation. For instance, Chinese, Japanese and Europeans display systematic alterations to a couple of serotonin transporter genes. These genes produce a protein necessary for regulating serotonin, a mood-related chemical messenger in the brain. Any emotional or behavioral consequences of tweaks to these genes remain unknown.

Although apparently adaptive mutations such as these arose in the past 10,000 years, some geneticists doubt that the agricultural revolution jump-started the pace of genetic evolution. Accurate techniques for identifying and dating the single DNA letter variants characteristic of certain populations are still being developed. Hawks and his associates' analysis may have missed many ancient instances of genetic evolution, leading them to overestimate the pace of recent evolution, remarks geneticist Sarah Tishkoff of the University of Pennsylvania in Philadelphia.

"We have to be cautious in making inferences about the rate of selective change in human populations," she says.

Fossil talk

Hawks sees a greater need for caution in evaluating the recent suggestion, based on fossil discoveries, that humanlike speech emerged long before modern *Homo sapiens* did about 200,000 years ago.

Throat and ear bones of a Neandertal ancestor that lived at least 530,000 years ago in northern Spain point to a remarkably advanced speech capacity, say paleontologist Ignacio Martínez of the University of Alcalá near Madrid, Spain, and his colleagues.

In the January *Journal of Human Evolution*, the scientists describe two hyoid bones from this ancient *Homo* species, a possible common ancestor of later European Neandertals and modern humans. A cave in Spain's Atapuerca mountains yielded the fossils. The hyoid, a horseshoe-shaped bone in the neck, supports the tongue and larynx and is the only bone in the skeleton not connected to any other bone.

Some researchers regard hyoid shape in humans as an indicator of a vocal tract designed for speaking. Others argue that the hyoid contains no reliable clues to vocal tract functions.

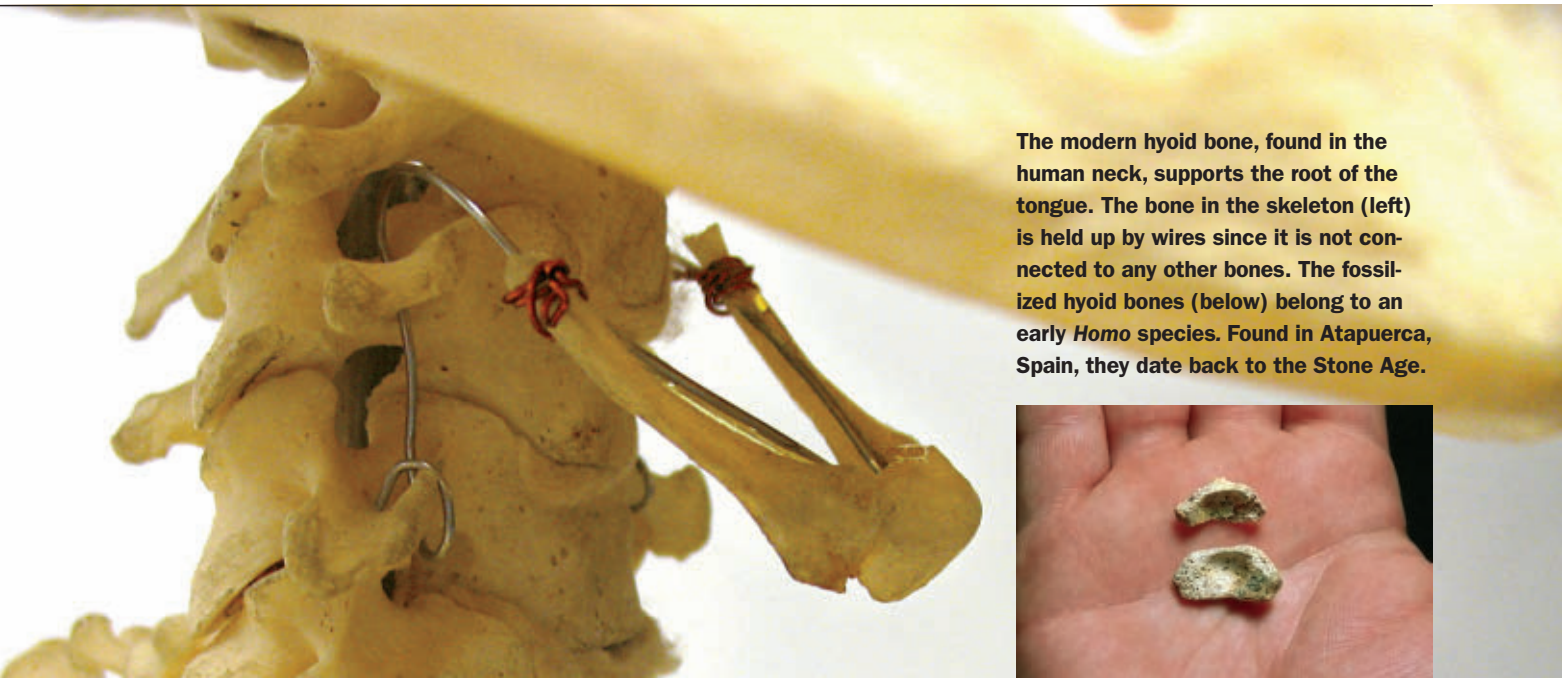
What's beyond debate is that the Atapuerca hyoids look like those of people today, the researchers say. But hyoids from chimpanzees, gorillas and 3- to 4-million-year-old human ancestors differ substantially from the Spanish fossils.

Human-looking hyoids alone don't prove that Atapuerca folk gabbed with one another a half million years ago. But add earlier finds of humanlike outer and middle ear structures in five skulls from the same site and the possibility of ancient speech at Atapuerca gains some traction, according to Martínez's group.

Neandertal ancestors in northern Spain had ears specialized for transmitting midrange sound frequencies used in speech today, the Spanish scientists reported in 2004.

But skeletal similarities such as these tell a limited story about language evolution, Hawks argues. Recent genetic modifications to nonfossilizing stereocilia in the inner ear suggest that modern humans produce and hear speech differently than ancient Atapuercans did, in Hawks' view.

Anthropologist Robert McCarthy of Florida Atlantic University in Boca Raton agrees. McCarthy studies head



The modern hyoid bone, found in the human neck, supports the root of the tongue. The bone in the skeleton (left) is held up by wires since it is not connected to any other bones. The fossilized hyoid bones (below) belong to an early *Homo* species. Found in Atapuerca, Spain, they date back to the Stone Age.

KAREN E. PETERSEN/UNIV. OF WASHINGTON, SEATTLE; JAVIER TRUEBA/MADRID SCIENTIFIC FILM/PHOTO RESEARCHERS, INC.

and neck fossils in order to reconstruct the vocal tracts of ancient members of the human evolutionary family.

Neandertals and other Stone Age species must have spoken, only not as clearly as people now do, he says. At the physical anthropology meeting, McCarthy played synthesized re-creations of what a Neandertal speaker would have sounded like making vowel sounds, based on earlier reconstructions of vocal tracts.

The combination of a long face, short neck, unequally proportioned vocal tract and large nose would have decreased the intelligibility, at least to modern human ears, of Neandertals' vowel sounds, according to his analysis.

A transition to facial and neck traits needed for modern speech occurred in *H. sapiens* between 100,000 and 40,000 years ago, McCarthy estimates.

Even then, languages continued to change and assume different structures. For instance, Asian languages came to rely on musical-sounding tonal shifts for meaning and some African tribes adopted clicking sounds in place of vowels.

In a volatile linguistic world, it makes sense to McCarthy that language-related hearing genes still attract evolutionary adjustments. "Hawks has done a nice job of showing that all kinds of genes have been changing at a faster rate in the last 50,000 years, so it's not surprising that genes related to hearing are on that bandwagon," he says.

Cultivating problems

The biggest bandwagon in human evolutionary history started rolling around 10,000 years ago, when sedentary farming rapidly replaced nomadic hunting and foraging, the anthropologists agree. On the plus side, the spread of agriculture and animal domestication provided enough food for growing populations. On the minus side, farming's rise caused many people to suffer marked declines in health and well-being, says Ohio State's Larsen.

Larsen's unpleasant picture of the agricultural lifestyle stems from analyses of human skeletons excavated at a variety of prehistoric farming villages. Crowds of villagers acted as petri dishes for infectious diseases. Water sources near villages became contaminated by parasites, which also infected people. Infants and young children died more frequently than they had at the height of the Stone Age.

A newfound emphasis on eating domesticated plants prompted deficiencies in nutrients formerly obtained from meat, such as iron, zinc, vitamin A and vitamin B12. As a result, people grew increasingly smaller and shorter. Size reductions of the face and jaw outpaced those of the teeth, often resulting in dental misalignments. To top it off, competition for fertile land encouraged the rise of organized warfare and mass slaughters.

A brave new agricultural world of deteriorating health must have provoked unprecedented adaptive changes in human genes, Larsen asserts.

Recent genetic evolution bolstered immune defenses in response to epidemic diseases that ravaged farming populations, hypothesizes anthropologist George Armelagos of Emory University in Atlanta.

Hawks agrees but adds that post–Stone Age evolution has not been solely a race against death and disease. The need to communicate in groups of expanding size and complexity sparked genetic changes in humans' ability to hear what others say, he maintains.

As genetic data from people around the world continue to accumulate, Hawks will keep his eye on the ear for further signs of language evolution. If you know how to listen, even DNA can talk. ■

Explore more

- John Hawks *et al*. "Recent acceleration of human adaptive evolution." *Proceedings of the National Academy of Sciences*. December 26, 2007.

The ultrasonic din of dying trees inspires a new kind of research to save

It turns out that a tree doesn't have to fall in the forest to make a sound. Upright trees make plenty of sounds, even though human ears can't hear them. But few aside from botanists would have known about the voices of the trees if two guys had not pounded an old meat thermometer turned ultrasonic microphone into a beetle-infested piñon.

When they did, composer David Dunn and physicist Jim Crutchfield heard "sounds that went on, uninterrupted, for long periods of time. It was a constant ultrasound, and it didn't matter where you were, the sound was there," Crutchfield says. "It was bizarre."

The cacophony came from a tree besieged by drought — and from a frenzy of tree-invading beetles.

The duo's investigation began after Crutchfield's New Mexican piñon pine trees came under attack.

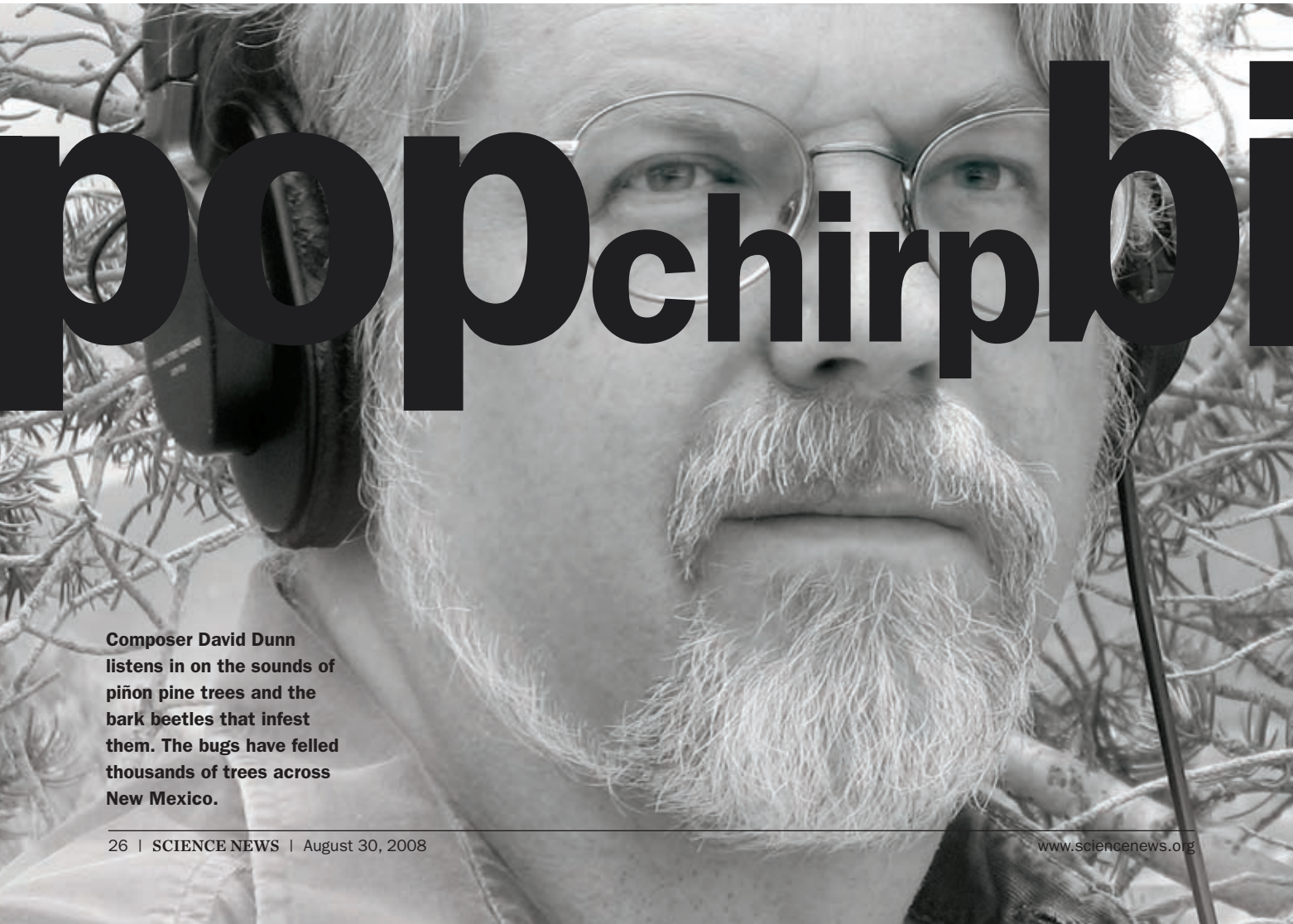
"I had to cut down 100 trees on my lot," he says, "and I wanted to know what killed them."

It was not the drought that ultimately destroyed the pines but the invasion of a specific type of bark beetle and its accompanying fungus. Crutchfield's neighbors turned to pesticides to thwart the insect attack, but had no luck. The trees still died.

The same destruction has been happening — en masse — elsewhere as well. The spruce bark beetle has already taken a Connecticut-sized bite out of Alaskan pine forest. And bark beetle outbreaks have desolated thousands of square kilometers of western North American forests, incidentally releasing thousands of tons of carbon into the atmosphere. The additional carbon is a concern because of its link to climate change.

But it was the tree deaths and the failure of the pesticides that first led Crutchfield, who models complex chaotic systems at the University of California, Davis, and Dunn to propose a radical solution to dampen beetle infestations: They want to play deceptive ultrasound to confuse the tree-devouring bugs, luring them away from vulnerable forests and keeping the insects from spreading to new territories.

Crutchfield says the noise could perhaps even stop the beetles from inadvertently adding so much carbon to the air that humans' contributions to global warming would become irrelevant.



J. CRUTCHFIELD

Composer David Dunn listens in on the sounds of piñon pine trees and the bark beetles that infest them. The bugs have felled thousands of trees across New Mexico.

forests from beetle attacks — and battle climate change **By Ashley Yeager**

The big crunch

The idea to use ultrasound as a beetle-defense tactic began percolating in the pair's minds about four years ago. As Crutchfield's trees were dying, Dunn, who is president of the Art and Science Laboratory in Santa Fe, N.M., was fabricating a device to listen to the ultrasonic sounds of nature. The environmental sound recordist had decided to create a high-frequency recorder while working at the Detroit Zoo, where he learned that endangered Tanzanian frogs used ultrasonic calls to find mates.

Dunn and Crutchfield got together to eavesdrop on pine trees and their invading beetles, which led the composer to an idea. He wondered if the beetles could, in any way, detect the ultrasound coming from the trees. As the pines' liquid-transporting cells dehydrate, the trees' water columns cave in, creating ultrasonic pops. Scientists believe that extended periods of dehydration and drought cause the water cells to implode and give off the pops, which are near the 100 to 300 kilohertz range. By comparison, the highest frequency a human can hear is 20 kilohertz.

Crutchfield suggests that the pops may help possible beetle invaders sense whether a tree is ripe for attack and whether they should chomp through to its inner living layers to lay eggs. Healthy trees have a defense against this invasion, he says. By secreting a sticky, toxic ooze, or resin, that flows into the holes beetles bore into the bark, the pines can "pitch out" the insects.

Drought-stressed trees affected by warming temperatures and consequent moisture loss, though, have trouble making the defensive resin to push the beetles out of the bark. And, water-deprived trees, Crutchfield says, generate more ultrasonic pops. So as the beetles successfully chew their way through a tree, they could pick up the sounds of the tree's cells collapsing.

Amid the popping, Dunn and Crutchfield also picked up on loud, piercing ultrasonic chirps — the beetles' cries — as well as crunches on the bark. Beetles passing by might hear the crackles, crunches and pops and drop by to get a bite of their own, the physicist says.

"This hypothesis, namely that trees send signals to beetles, needs a lot of experimental work to back it up," Crutchfield concedes. "It's

difficult to study because, to take one example, no one knows what the insect's hearing mechanism is or even if it is responding to ultrasound."

Wood-boring beetles do seem to sense which trees are more vulnerable to attack, but scientists do not yet know how. The mountain pine beetle reacts strongly to chemicals called pheromones that are produced by the insects during their attacks, as well as to kairomones, aromatic compounds produced by the trees, says James Powell, a mathematician from Utah State University in Logan who models the dynamics of beetle invasions in pine forests.

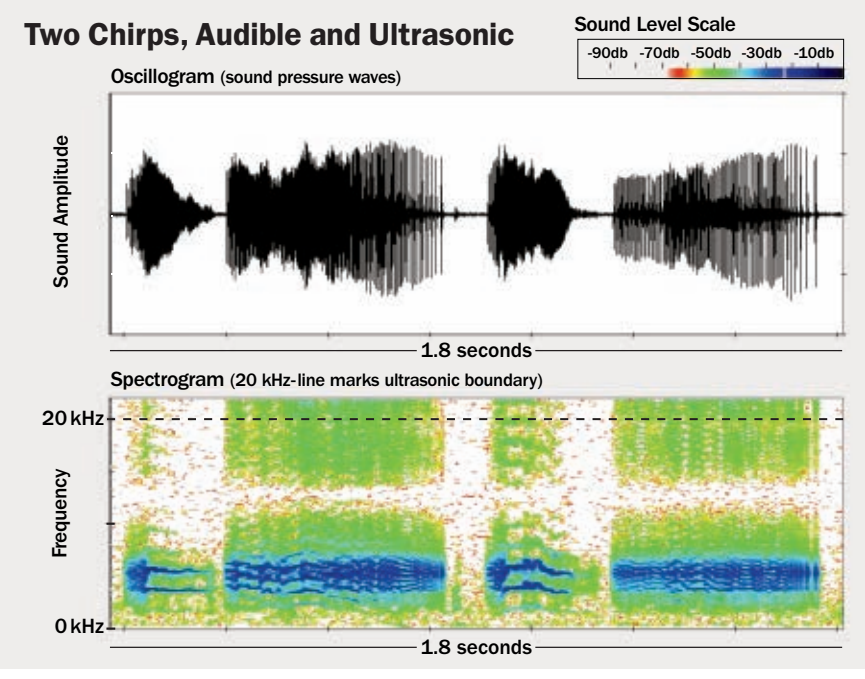
Most entomologists think beetles rely primarily on pheromones, not sound, to communicate, mate and possibly even rally the troops for invasion. Powell has studied the interaction between beetles and pine forests in the Rockies, and he says countering beetle outbreaks with chemicals is hit or miss. Some experiments in Scandinavia have actually shown that using pheromones to lure beetles away from vulnerable trees can exacerbate beetle invasion, Crutchfield says.

Crutchfield and Dunn published their "bioacoustic ecology hypothesis" in 2006 as a working paper on the website of the Santa Fe Institute, a center for interdisciplinary research. A revised version will appear in an upcoming *Leonardo*, a journal highlighting work of artists using science- and technology-based media.

Despite all the existing research on beetle communication, Crutchfield says, entomologists don't yet know how far each species's chemical or sound signals can travel.

It's also not known what actually kills a tree after a beetle infestation. Richard Hofstetter, Crutchfield's collaborator and an ecologist at Northern Arizona University in Flagstaff, has a beetle farm and looks at the interactions between beetles and the blue stain fungus *Ophiostoma minus*, which hitchhikes with the beetles into trees. Hofstetter studies whether it's the beetles' feeding frenzy, the associated fungal invasion or some combination of the two that kills a tree.

More important for testing the bioacoustic hypothesis, however, is figuring out the full range of sound signals that the beetles can produce and detect. For that, Crutchfield turned to Jayne Yack, a biologist at Carleton University in Ottawa, Canada.



Top image shows the short and long pulse of a piñon beetle chirp. The bottom shows chirps are loudest (blue) in the audible range but include an ultrasonic component.

D. DUNN, J. CRUTCHFIELD

Listening to bugs

Yack eavesdrops on insects, typically butterflies and moths, to decode their sound signals. Now she has turned her attention to bark beetles. But these insects, she says, are harder to study because they live under tree wood and are small — sometimes as small as the head of a matchstick.

"We really know very little about how they talk to each other and what signals they send," Yack says. But "these guys are highly acoustic. They talk to each other all the time, and so they have to have acoustic organs."

Scientists do know that the male or female in certain wood-boring beetle species has an organ called a pars striden, which looks like a set of ridges on the back or underside of the insect's head. An insect can "play" these organs by curling up and rubbing its head back and forth against the middle of its body, Yack says.

The beetles seem to make other auditory calls, too. Although Yack is not sure exactly what the sounds mean. She speculates that the calls could signal aggression if one beetle violates another's territory when the insects are mating. Or the signals, which she says can only travel about 10 centimeters, could alert incoming beetles that they need to spread out while laying eggs in a host tree. If beetle pairs disperse and lay eggs all over the tree, Yack says, there might be less competition for resources and space — at least for the beetles.

Whether the beetles have organs to sense sounds and, if so, whether they use those organs to find drought-stressed trees is still unknown, she says. Yack's team is now trying to determine if the beetles have sound receptors called tympanals, which can pick up ultrasonic vibration. "We have good candidates for these receptors," she says, but notes that the team has yet to confirm that the insects have the organs. She expects to submit her research on the question for publication soon.

Next, Yack plans to test if the beetles respond to a recording of the pine trees' ultrasonic vibrations. "We will put electrodes in certain regions of the beetles'

nervous system, play sounds and see if the nervous system reacts," she says.

While Yack's research focuses on understanding insects' sensory worlds, her work could have important practical implications. If scientists learn what sounds, coupled with what chemicals, beetles use to signal mating cycles and impending invasions, she says, the knowledge could lead to new ways to control the beetles.

A frenzied loop

Invasive beetles are beginning to move not only northward but also upward, to elevations above their usual habitats, Powell says. Certain species of wood-boring beetles, such as the mountain pine beetle and piñon beetles, are native to lower-altitude forest regions. The bugs help forests thrive by eating old trees and letting new ones grow, he notes. But as warmer temperatures and less rainfall lead to drought, the beetle population is pushed out of check. More trees become vulnerable to beetles, which spread to higher latitudes and altitudes.

Tree species found in these regions not native to the beetle invasions may not be as successful at pitching out beetles and their fungus, Powell says. Beetle attacks on these new, drought-stressed species could devastate forests and start to add large amounts of carbon dioxide into the air, says Werner Kurz, an ecologist at the Canadian Forest Service's Pacific Forestry Centre in Victoria, Canada. Infested pines ultimately take in less CO_2 than healthy trees. And dead trees take in none — as the wood breaks down, it releases carbon. So every time a tree is damaged or dies because of a beetle infestation, the bugs indirectly contribute more carbon to the atmosphere.

Based on a model of the beetles' effect on western Canadian pine forests, Kurz and his colleagues predict that in about 20 years, beetle outbreaks could kill enough trees to release greenhouse gases with a warming effect equivalent to about 990 million metric tons of CO_2. In a single year, the beetles could add 73 million tons worth of these gases — equivalent to about 10 percent of Canada's total human-caused emissions for one year, Kurz and his colleagues reported in the April 24 *Nature*. Those extra gases, if not removed, could lead to further increases in temperatures, which could trigger more beetle population growth, movement to new locales and damage to trees. "We call this a feedback loop," a positive one, he says, because more beetles lead to more CO_2.

"The numbers the Canadians have are shocking, and that is just one class of beetle and one class of trees," Crutchfield says. "If other insects are doing the same thing — I am especially thinking of moths infecting deciduous, boreal forests in Siberia — imagine the damage." Echoing anthropogenic climate change, the beetles could have their own "entomogenic climate change," he says.

Buzzing the beetles

Kurz believes that recognition of the insects' potential impact on the environment could lead to new efforts to control the mountain pine beetle attacks in Canada. Managing beetle outbreaks at their outset, planting new trees and using the dead and eaten ones for wood products or energy, he says, are a few ways humans can keep forests, traditional carbon sinks, from ever becoming carbon sources.

Crutchfield is more skeptical that such efforts would keep temperatures low enough. According to his models, a continued increase in global temperature is likely, and the beetles' current reaction to this "early stage of warming" does not bode well for future forest health.

What adds to his concern, he says, is the fact that current countermeasures against the beetles are less than effective.

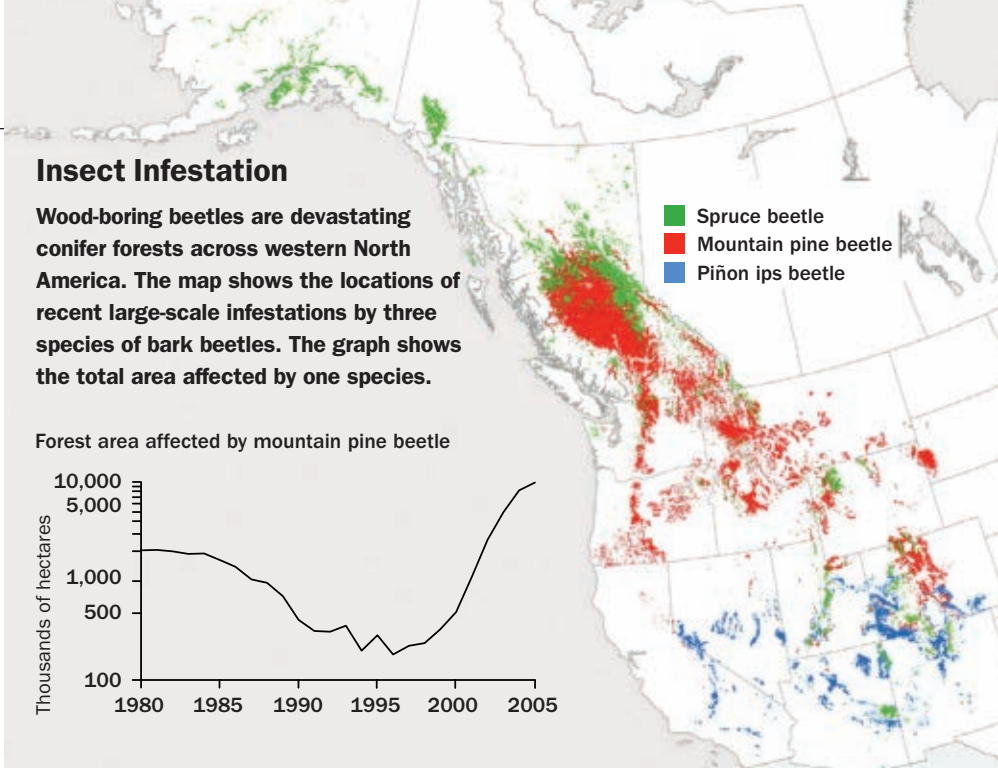
But, "there is a possibility that you could have an acoustic signal to break up or slow down a beetle infestation," Crutchfield says. In preliminary field work, he and Dunn played ultrasonic noise to interfere with the beetles' sense in this acoustic range. The tests, he says, were effective. "Again, the bioacoustic idea is still a hypothesis, one that has to be carefully tested in a lab." Right now, though, Crutchfield adds, "it is the only alternative I see."

The method is one that Powell admits might work. "The idea that beetles create sound passes muster with me, so using ultrasound to confuse beetles is possible, at least at short distances," he says.

And should ultrasonic beetle-blocking turn out to be a dud, Crutchfield says, "We better hope that the beetle-climate feedback loop does not kick in." ■

Explore more

■ D. Dunn and J. Crutchfield. "Entomogenic Climate Change." arXiv:0805.3851v1. May 25, 2008.



KENNETH RAFFA *ET AL., BIOSCIENCE* JUNE 2008

Feedback

> "It seems to me unfortunate and Earth-centric to assume that we can, based on but one example, conclude that a planet can or cannot support life."

A female benefit

Does the article "Two paths to longer life overlap" (*SN: 8/2/08, p. 14*) mean that, as a female, going on a calorie-restricted diet will not prolong my life? That is, does going on a calorie-restricted diet only help males live longer?

ALICE DREW, BETHESDA, MD.

First of all, there is still no proof that calorie restriction will prolong life in humans. It has been shown to work for yeast, roundworms, mice and dogs. But humans are longer-lived than all of these. Keep that in mind before considering a radical diet. For mice, at least, the effect of calorie restriction on the activity of the proteins mentioned in the article is greater than the effect of being female. So female mice still get a longevity benefit from calorie restriction, just less of one. —PATRICK BARRY

Life of a different sort

The article "Astronomers find distant stars with a whole set of superEarths" (*SN: 7/5/08, p. 7*) contains the statement: "The planets all lie too close to their parent star to support life." It seems to me unfortunate and Earth-centric to assume that we can, based on but one example, conclude that a planet can or cannot support life. No one, not even one of our top scientists, is in a position to know definitively how life might conceivably evolve in other environments, even those that would seem extreme to biologists who have out of necessity based their knowledge on our local example. Almost by definition, life in such environments would be unimaginable to us. Given the infancy of our knowledge about our own planet, let alone our solar system and the universe itself, it would be more accurate, and humbler, to always use the phrase "life as we know it" in these discussions.

MARK VANHOENACKER, LONDON, ENGLAND

Astronomers believe that life does not exist on any of these closely orbiting planets because the blistering heat from the parent star would evaporate any surface water and because the ionizing radiation from the star would likely damage organisms. But, of course, the astronomers cannot know for sure. —RON COWEN

Cite your source

I've been an avid reader of *Science News* for many years. It allows a specialist (I have a Ph.D. in ecology) tidy, intelligible summaries of work in other fields. My only request—and I've wanted this for a decade—is that *Science News* publish at the end of each article the full, original journal citations of the source articles. How about it?

MICHAEL GHIGLIERI, FLAGSTAFF, ARIZ.

Editor's note: Full references for journal articles and other readings are available for each article at www.sciencenews.org.

Surgery or anesthesia

In regard to "Sick and down" (*SN: 7/19/08, p. 26*), for more than two years I've been helping a friend deal with chronic and deep depression. Her second depression began after major neck surgery. The cause, we were told, was a reaction to anesthesia. I began hearing stories that open-heart surgery patients often develop depression. I wonder if perhaps the cause was instead a reaction of her cytokines to the surgery.

FRANK BRAUDIS, WAKEFIELD, MASS.

Shorter was better

You can count me and my son among the readers who do not like the new format. I read several other journals, and all of them are too thick and contain articles that are too long to finish in one sitting. I have always depended on *Science News* to fit that niche. I have typically taken it from the mailbox and read it immediately over my next meal. Interruptions would not matter because the shortness of the pieces allowed for that. Now I have another journal to add to the pile of journals with articles too long to finish right now. Longer articles are available everywhere. Only *Science News* had short, well-done, interesting pieces on all different science areas. I miss it.

SALLY ANN LEDERMAN, WAYNE, N.J.

Several readers have complained about articles being longer than in the pre-redesigned Science News. *In fact, article lengths have not substantially changed. Nearly all features now are in the same word-count range as in the old magazine, except for "Story One," which is actually a shorter feature at the front of the magazine. With occasional exceptions, news stories are generally about the same length as in the old magazine, or shorter. The short "Of Note" articles from the back of the old magazine now appear with other news articles as short stories, photo captions or briefs, often shorter than before.* —TOM SIEGFRIED

Maybe now isn't normal

In "Forest invades tundra" (*SN: 7/5/08, p. 26*), Janet Raloff writes: "Conifers here now reside where no living tree has grown in some 1,000 years." What caused the conditions that allowed trees to grow there 1,000 years ago, since it wasn't human-generated carbon combustion? Also, why do we assume the normal, "best" conditions are now and not what they were 1,000 years ago and older, when trees grew in today's Arctic tundra? Perhaps the past 1,000 years is the abnormal condition.

KEN LAPRE, CRANSTON, R.I.

No one knows what caused the Medieval Warm Period, which lasted from about A.D. 800 to 1300 and was followed by the Little Ice Age. Data suggest that temperatures were about the same as they were during the early 20th century. Though the warming was believed to be Europe-wide, there is debate about whether it was global. —JANET RALOFF

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All letters subject to editing.

Maria Mitchell and the Sexing of Science: An Astronomer Among the American Romantics

By Renée Bergland

Professor, astronomer, tourist attraction. Maria Mitchell held many titles, but she liked tourist attraction least. Soon after discovering her first comet in 1847, the American astronomer became a sought-after celebrity. Her popularity subsided when she moved away from her native Nantucket, Mass., and as men came to dominate science.

This book chronicles the astronomer's ascent to fame during the mid-1800s. During her era, girls and women of a certain class were encouraged to become educated. Science was ordered, and because women were near the bottom of the social hierarchy, "studying nature's hierarchies could only keep them in their place," writes Bergland, a professor at Simmons College in Boston.

Bergland follows Mitchell from youth to her professorship at Vassar College. There, Mitchell watched and protested as her female students were shut out of science. The field's controversial thinkers, such as Charles Darwin, changed science into a "highly theorized method of inquiry" that was "no longer the place to learn docile obedience and respect for hierarchy," and therefore no longer the place for women, Bergland notes.

Yet, Bergland tries so desperately to reiterate her central theme—science was not always dominated by men—that much of the meat of the book, Mitchell's story, is muddled in extraneous detail. The book is still a fun read, particularly for those captivated by romanticism, the role of women in science or the night sky. **—Ashley Yeager**

Beacon Press, 2008, 300 p., $29.95.

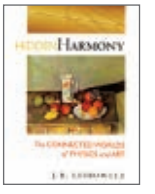
Bending Science: How Special Interests Corrupt Public Health Research

Thomas O. McGarity and Wendy E. Wagner

A report on how political and other attacks threaten public understanding of hazards.

Harvard Univ. Press, 2008, 384 p., $45.

Hidden Harmony: The Connected Worlds of Physics and Art



J.R. Leibowitz

A professor unites his two loves by exploring shared aesthetics and compositional demands.

Johns Hopkins Univ. Press, 2008, 160 p., $24.95.

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Alex Szalay

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Preserving digital data for the future of eScience

Libraries and other archives of physical culture have been struggling for decades to preserve diverse media — from paper to eight-track tape recordings — for future generations. Scientists are falling behind the curve in protecting digital data, threatening the ability to mine new findings from existing data or validate research analyses. Johns Hopkins University cosmologist Alex Szalay and Jim Gray of Microsoft, who was lost at sea in 2007, spent much of the past decade discussing challenges posed by data files that will soon approach the petabyte (10^{15} — or quadrillion — byte) scale. Szalay commented on those challenges in Pittsburgh during an address at this summer's Joint Conference on Digital Libraries and in a follow-up interview with senior editor Janet Raloff.

Scientific data approximately double every year, due to the availability of successive new generations of inexpensive sensors and exponentially faster computing. It's essentially an "industrial revolution" in the collecting of digital data for science.

But every year it takes longer to analyze a week's worth of data because even though the computing speed and data collecting roughly doubles annually, the ability to perform software analyses doesn't. So analyses bog down.

It also becomes increasingly harder to extract knowledge. At some point you need new indexes to help you search through these accumulating mountains of data, performing parallel data searches and analyses.

Like a factory with automation, we need to process and calibrate data, transform them, reorganize them, analyze them and then publish our findings. To cope, we need laboratory information-management systems for these data and to automate more, creating work-flow tools to manage our pipelines of incoming data.

In many fields, data are growing so fast that there is no time to push them into some central repository. Increasingly, then, data will be distributed in a pretty anarchic system. We'll have to have librarians organize these data, or our data systems will have to do it themselves.

And because there can be too much data to move around, we need to take our analyses to the data.

We can put digital data onto a protected system and then interconnect it via computer networks to a space in which users can operate remotely from anywhere in the world. Users get read-only privileges, so they cannot make any changes to the main database.

For the Sloan Digital Sky Survey data, we have been giving an account to anyone with an e-mail address. People with accounts can extract, customize and modify the data they use, but they have to store it in their own data space. We give them each a few gigabytes.

We currently have 1,600 users that are using [Sloan data] on a daily basis. Those data become a new tool. Instead of pointing telescopes at the sky, users can "point" at the data collected from some portion of the sky and analyze what they "see" in this virtual universe.

This is leading to a new type of eScience, where people work with data, not physical tools. Once huge data sets are created, you can expect that people will find ways to mine them in ways we never could have imagined.

But key to its success is the need for a new paradigm in publishing, where people team up to publish raw data. Perhaps in an overlay journal or as supplements to research papers. Users would be able to tag the data with annotations, giving these data added value....

Once huge data sets are created, you can expect that people will find ways to mine them in ways we never could have imagined.

The Sloan Digital Sky Survey was to be the most detailed map of the northern sky. We thought it would take five years. It took 16. Now we have to figure out how to publish the final data — around 100 terabytes [0.1 petabyte].

The final archiving of the data is in progress. There's going to be paper and digital archives, managed by the University of Chicago and Johns Hopkins libraries.

Today, you can scan one gigabyte of data or download it with a good computer system in a minute. But with current technologies, storing a petabyte would require about 1,500 hard disks, each holding 750 gigabytes. That means it would take almost three years to copy a petabyte database — and cost about $1 million.

We generally try to geoplex, which means keeping multiple copies at remote geographic locations. That way, if there is a fire here or a meltdown there, backup copies are unlikely to be affected. We're also trying to store data on different media. Eventually, I think we'll probably load data on DVDs or something, which can go into cold storage. We'll still have to recopy them periodically if we want digital data to survive a century or more.

This is something that we have not had to deal with so far. But it's coming — the need to consider and plan for curation as data are collected. And it's something that the National Science Foundation is looking at: standards for long-term digital-data curation. ■

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The Stauer Times

"It's About Time"

News Flash....

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