SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

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new view on black holes

acid blockers harm bones?

prehistoric leaf bug

fish rolling their eyes

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the other bees

NO HIVES, NO HONEY

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JANUARY 6, 2007 VOL. 171, NO. 1

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This Week

Of Note

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Cover Two female *Megachile pugnata* bees perch at the center of a purple coneflower. This native North American species is one in which each bee has its own, private home. A solitary lifestyle is actually more common among bees than is the better-known social life of the honeybee. (Pitts-Singer) Page 11

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Bad to the Bone

Acid stoppers appear to have a downside

Popular heartburn pills taken to block the production of stomach acid seem to increase the risk of hip fractures in older people, according to an analysis of medical records.

Proton-pump inhibitors (PPIs), available by prescription or over the counter, include drugs such as Prilosec and Nexium. They are more potent than other medications such as Zantac or Pepcid that suppress acid production through a different biological mechanism.

QUOTE

"The results … raise caution about long-term use." *PETER VESTERGAARD, Aarhus University Hospital*

Earlier studies had hinted at an increased risk of broken bones among PPI users. To explore that possibility, researchers tapped into a British database of medical records and identified 13,556 people age 50 or older who had suffered a broken hip. The scientists also scanned the records of roughly 135,000 people in that age group who hadn't had such an injury. The researchers noted who had used PPIs, Zantac-type heartburn drugs, or neither type of medication.

The analysis revealed that people taking high doses of PPIs for more than a year were 2.6 times as likely to break a hip as were people not taking an acid blocker. Those taking even modest doses of PPIs regularly for 1 to 4 years were 1.2 to 1.6 times as likely to break a hip as were people not taking an acid-suppressing drug. Fracture risk rose with duration of use. The Zantac-type medications also increased fracture risk, but not to the extent that PPIs did.

The researchers report their findings in the Dec. 27, 2006 *Journal of the American Medical Association*.

PPIs become activated only in highly acidic environments, a design that drug developers expected would confine the compounds' effect to the stomach, says study coauthor David C. Metz, a gastroenterologist at the University of Pennsylvania School of Medicine in Philadelphia. When activated, PPIs switch off cells' acid-making machinery.

But while reducing heartburn and acid-reflux disease, the pills might disrupt other processes. Stomach acid may be necessary to dissolve calcium compounds so that the calcium can be used elsewhere in the body, Metz says. The higher fracture rate observed in the new study, he suggests, may result from PPIs and, to a lesser extent, the other acid blockers limiting the calcium available for the body to maintain bone structure.

But some studies suggest that stomach acid isn't required for calcium absorption, says endocrinologist Robert P. Heaney of Creighton University in Omaha, Neb. If that's the case, the new finding may indicate that PPIs interfere with the continuous breakdown and rebuilding of bone. Cells called osteoclasts produce acid to dissolve old or damaged bone, and if PPIs limit that acid production, fatigued bone may not be replaced, Heaney says.

Earlier in 2006, a team led by Peter Vestergaard, a physician at Aarhus University Hospital in Denmark, reported results of a shorter study that showed a similar association between PPI use and fractures. Together, the two studies "may not definitively say that PPIs are dangerous to your bone, [but] they raise caution about long-term use," he says.

Metz says that while doctors should monitor bone density in elderly patients using PPIs, "we don't want to deny these drugs to people who benefit from them." —N. SEPPA

Loopy Light

Rings that delay photons may advance microchips

By linking loops of silicon on a microcircuit, researchers have taken a major stride toward using light to shuttle information within computer chips. The new approach may lead to circuitry that can manipulate exceptionally large amounts of data and introduce the delays often required for a chip to coordinate calculations and communications.

Computer manufacturers are currently cramming multiple electronic-computing modules, or microprocessors, onto individual chips of semiconducting material. For instance, the powerful electronic brain of the Sony PlayStation 3 video game controller jams nine microprocessors onto a single chip. As the number of modules per chip continues to multiply in the coming decade, the data traffic is expected to outstrip the information-handling capacity of the electronic microcircuits that carry and route the traffic, says Yurii A. Vlasov of IBM's T.J. Watson Research Center in Yorktown Heights, N.Y.

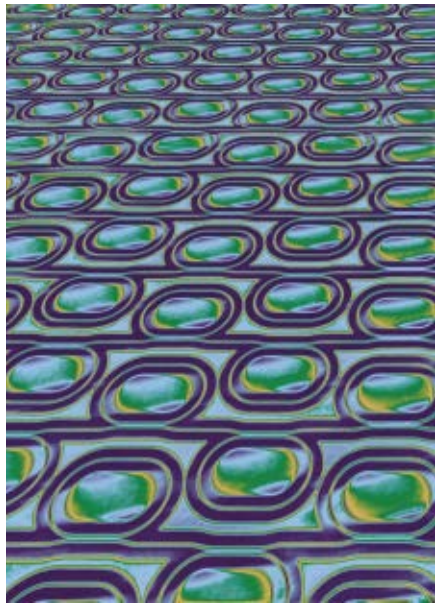
Light-manipulating, or photonic, components might rescue those overburdened electronic circuits, Vlasov predicts. By developing photonic components in silicon, chip makers stand to exploit their existing infrastructure and know-how for working with that material, he notes.

Light can travel within thin ridges left untouched between etched channels in a silicon surface. Light conducted along such ridges can transport far more information than electrons within ordinary copper wires do.

Now, Vlasov and his colleagues Fengnian Xia and Lidija Sekaric, also of the IBM center, have unveiled a promising new type of photonic component—chains of up to 100 oblong loops. Made of extraordinarily precise silicon ridges, the arrays transmit pulses of light from end to end. That's a feat in itself, given that in previous research, pulses typically died out even in short chains, Vlasov says.

The new arrays of chained loops take up less than 0.1 square millimeter, so they're suitable for chips, he adds.

The chains, described in the January *Nature Photonics*, delay more data than other chip-scale light-slowing technologies do, Vlasov says. The prototype components achieve delays by forcing pulses to circle each loop more than 50 times before proceeding to the next one.



IBM

ROUND TRIP **This false-color electron micrograph shows an array of loops, each 12 micrometers across in the shorter dimension. The loops are linked into a snaking chain that manipulates light pulses carrying data. Photons travel along the ridges of silicon centered between the dark channels that define the loops and the paths between them.**

"This is a beautiful result," comments photonics specialist Masaya Notomi of NTT Basic Research Laboratories in Atsugi, Japan.

"It shows the first practical steps toward being able to store optical bits of data," says electrical engineer Keren Bergman of Columbia University. The IBM loops can store up to 10 bits of high-speed data so far, but they'll need to store 10 to 100 times as much to be useful, she adds.

More than a year ago, another IBM team led by Vlasov reported retarding light in silicon by a different means—passing it through ultrathin slabs of the semiconductor punctuated by arrays of holes (*SN: 11/5/05, p. 292*). Such a structure, known as a photonic crystal, remains a potentially useful component for manipulating light on chips, Vlasov says.

Indeed, Notomi, Takasumi Tanabe, and their colleagues at NTT report, also in the January *Nature Photonics*, that they've developed a new photonic crystal that retards light more than 170 times as much as the 2005 IBM crystal did.

That's "a great achievement," Vlasov says.

Scientists are continuing to pursue both the photonic-crystal and silicon-loop approaches to find the most advantageous combination of light retardation, information capacity, and ease of integration with chip production. —P. WEISS

Paleotrickery

A lengthy lineage for leaf-mimicking insects

For at least 47 million years, some insects have escaped predators by looking like foliage and moving like swaying leaves, a new fossil find suggests.

Many creatures elude predators by blending into their surroundings. But the 3,000 or so species in an insect group called the phasmids take camouflage to an extreme, says Sonja Wedmann of the Institute for Paleontology in Bonn, Germany.

Most modern-day phasmids have bodies and legs that look like sticks and twigs, but at least 37 known species are shaped like the tree leaves that they eat or frequent during daylight hours, she notes. To complete the deception, phasmids occasionally move back and forth to mimic the motion of a leaf or twig in the breeze.

Paleontologists have found precious few phasmid fossils, and they had never previously unearthed one of a leaf insect. Wedmann and her colleagues describe their discovery of such a fossil in a report posted online Dec. 29, 2006 for an upcoming *Proceedings of the National Academy of Sciences*.

FAKING IT Researchers recently discovered a 47-million-year-old fossil of an insect (*Eophyllium messelensis*) that, like its modern-day relative (inset), has a leaflike shape and measures about 6 centimeters long.

The 6-centimeter-long, almost-complete leaf insect was preserved in fine-grained sediments. They were laid down in a broad, shallow lake that formed about 47 million years ago inside a volcanic crater in what is now Germany. Portions of the creature's antennae and legs are missing, but its abdomen is the size and shape of some fossil leaves retrieved from the same strata, says Wedmann. The genitalia of the fossil insect are almost identical to those of modern leaf insects, a sign that subsequent species changed little in the millions of years that followed.

"This creature has all the features you'd expect of a primitive leaf insect," says Conrad C. Labandeira, a paleontologist at the Smithsonian Institution's National Museum of Natural History in Washington, D.C.

Unlike some modern leaf mimics, the newly discovered *Eophyllium messelensis* didn't have flattened projections on its front legs that made them look like small bits of leaves. The legs, like those of most living phasmids, were slightly curved where they joined the body. When the modern insects aren't on the move, they often extend their front legs forward, hold them together, and tuck their heads down into a position that helps them blend into their environment.

Many scientists suspect that ancient animals behaved quite differently than their modern-day relatives do, says Michael S. Engel, an entomologist at the University of Kansas in Lawrence. However, "fossils such as *Eophyllium* provide direct evidence to the contrary," he notes.

Other fossils unearthed from the same rocks include remains of fish, birds, bats, and small primates called lorises. The shape and variety of fossil leaves collected suggest that the lake was surrounded by a rich tropical ecosystem—the same type of environment in which leaf insects are found today, says Wedmann. —S. PERKINS

Better Blood

New tool removes agent of brain disease

Scientists have developed a device that filters from blood the mutant proteins that cause the human form of mad cow disease. This new tool could boost the safety of donated blood.

Infectious proteins called prions cause mad cow disease, scrapie in sheep, and variant Creutzfeldt-Jakob disease (vCJD) in people. Since the early 1980s, doctors have diagnosed more than 200 cases of the fatal human disease worldwide, most of which seem to have resulted from eating beef tainted with prions. However, there's evidence that at least three people contracted the disease from blood transfusions that carried prions.

Scientists are working to reduce the risk of obtaining prions from beef. Researchers in the United States and Japan reported online Dec. 31, 2006 in *Nature Biotechnology* that they have engineered cattle that are free of the proteins that mutate to cause mad cow disease.

However, Robert Rohwer of the Veterans Affairs Medical Center in Baltimore, who studies vCJD and other prion-related diseases, notes that if these cattle enter the food supply, disease risk won't drop right away. Prions can linger in a person's blood from beef that they ate years ago.

"This is a disease with a very long incubation period during which people infected with vCJD appear completely normal," Rohwer says.

To develop a way to extract prions from blood, Rohwer and his colleagues searched a library of millions of chemicals for ones that stick tightly to prions. The team coated tiny beads with each chemical and incubated the beads with prions isolated from people, hamsters, and other animals. After excluding those chemicals that were too expensive or too toxic or that stuck too readily to other blood components, the researchers narrowed their focus to a compound that they call L13.

PNAS

For testing how well L13 traps prions in blood, Rohwer and his colleagues used hamster blood spiked with prions that cause scrapie. The scientists first passed the blood through a filter that removes white blood cells because previous research had shown that about half of blood-borne prions stay in or around those cells.

The team then ran half the blood through another filter embedded with beads coated with L13.

When the researchers injected blood that hadn't gone through the second filter into 99 hamsters, 15 contracted scrapie. However, of 96 hamsters injected with the L13-filtered blood, none became ill with the disease.

Rohwer's team reports its results in the Dec. 23/30, 2006 *Lancet*.

Marc Turner, who studies prions in blood at Edinburgh Blood Transfusion Center in Scotland, calls the new report "very promising work." Filtering disease-causing prions from blood could keep the blood supply safer if people infected with vCJD donate blood, he says. —C. BROWNLEE

Rocky Finding

Evidence of extrasolar asteroid belt

Astronomers report that they've obtained the best evidence yet for an asteroid belt beyond the solar system. Such a belt would suggest that the star Zeta Leporis, which lies just 70 light-years away, possesses not only asteroids but rocky planets like Earth.

The new measurements pinpoint the location of a disk of warm dust that surrounds Zeta Leporis. The dust lies about the same distance from the star as the solar system's asteroid belt lies from the sun, Margaret M. Moerchen and Charles M. Telesco of the University of Florida in Gainesville and their colleagues report in an upcoming *Astrophysical Journal Letters*.

Most previously observed disks have been cool and lie much farther from their parent stars, in the region that corresponds in the solar system to the locale of Pluto and the reservoir of comets known as the Kuiper belt.

The close-in dust around Zeta Leporis probably arose when several asteroids bumped into each other, grinding rock into a fine spray of particles, or when a large asteroid, perhaps 100 kilometers in diameter, suffered a cataclysmic wallop, Moerchen and Telesco say.

"The [precise] measurement of the Zeta Leporis disk is a very exciting result," says Charles Beichman of NASA's Jet Propulsion Laboratory in Pasadena, Calif. "We now have direct evidence for structures around other stars that are directly analogous to the asteroid belt in our solar system."

Zeta Leporis entered the limelight in the 1980s, when a satellite revealed that the star and its surroundings emitted much more infrared light than was expected from the star alone. That's a sign that dust swaddles Zeta Leporis.

In 2001, Christine Chen and Michael Jura of the University of California, Los Angeles observed the star with one of the telescopes at the Keck Observatory on Hawaii's Mauna Kea. They found that the dust is probably confined to a disk with a radius no larger than 6.1 astronomical units (AU)—slightly greater than Jupiter's distance from the sun (*SN: 6/16/01, p. 375*).

In February 2005, the team led by Moerchen and Telesco viewed Zeta Leporis with the Gemini South telescope atop Cerro Pachon in Chile. Those observations for the first time enabled researchers to precisely gauge the size of the dust disk.

The team finds that most of the dust is concentrated at a distance of 3 AU from Zeta Leporis. That's similar to the location of the solar system's asteroid belt, which stretches between 2.1 and 3.3 AU from the sun.

Because asteroids are leftovers from the planet-making process in the solar system, the new study "supports the thought that Earthlike planets may exist" outside the solar system, says Jura. Compared with our sun, Zeta Leporis is a youngster, but it's still old enough to have formed planets.

Moerchen's team is planning further observations to reveal the Zeta Leporis disk's shape. If it's circular and uniform in density, the disk probably formed by the slow grinding of asteroids over thousands of years. A more distorted shape would suggest that the dust was generated by a collision between two large chunks of rock only about 100 years ago, Telesco says.

"For years we've been studying Kuiper belt–like disks; now, we're investigating the architecture of the inner asteroidal regions" around stars. "This is kind of new territory," Telesco says. —R. COWEN

Message Songs

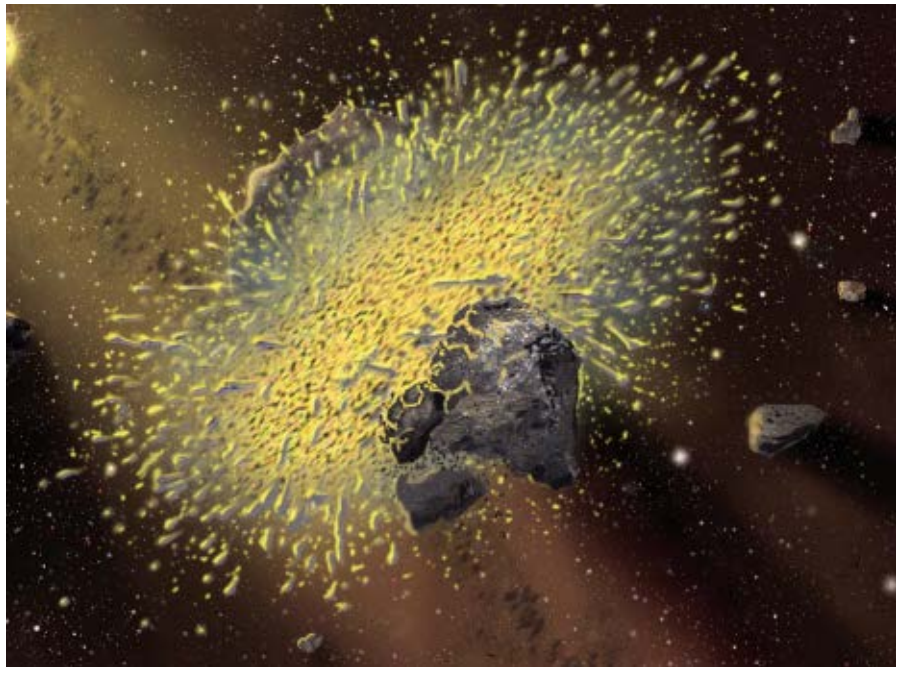
Wild gibbons warble with a simple syntax

Southeastern Asian forests harbor a small-bodied line of apes, known as gibbons, that sing like rainforest Pavarottis. These animals' full-throated refrains reverberate through dense vegetation.

A research team has now gone behind the music and gleaned the first evidence that singing gibbons rearrange notes to communicate with their comrades. This simple system, or syntax, for recombining sounds to convey messages represents a step toward human language that had not previously been demonstrated in apes, says psychologist Esther Clarke of the University of St. Andrews in Scotland.

Researchers have traditionally held that syntax arose only as the vocabulary of prehistoric people grew large and unwieldy. "We're finding the opposite in gibbons," says psychologist Klaus Zuberbühler, also of the University of St. Andrews. "One way of escaping the constraints of their limited vocal abilities is to combine signals into more-complex sequences, which carry meaning."

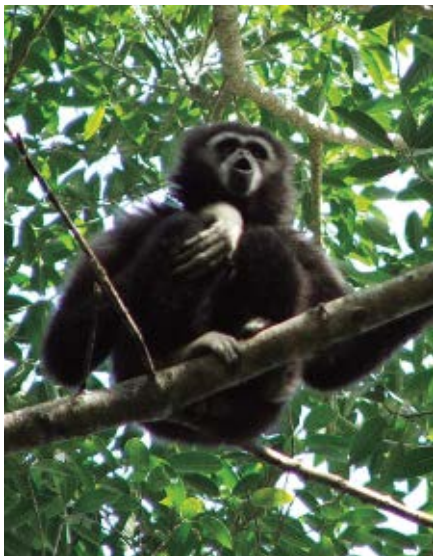
Gibbons evolved complex vocal skills as a tool for finding long-term mates in a com-



J. LOMBERG/GEMINI OBSERVATORY

CRASH CREATION? **Collisions of asteroids, as in this artist's depiction, might have created the warm dust in the belt around the nearby star Zeta Leporis.**

petitive social scene, the scientists theorize. In the December 2006 *PLoS ONE*, a new online journal, Clarke, Zuberbühler, and a colleague outline basic rules for gibbon songs stimulated by a predator's presence versus those crooned with a mate.



SOCIAL SINGER A new study suggests that gibbons in Thailand, such as the one shown here, communicate by rearranging tunes that they croon.

From April 2004 to August 2005, the researchers studied 13 groups of white-handed gibbons living in Thailand's Khao Yai National Park. Each group consisted of two to six members—usually an adult pair, its offspring, and occasionally another adult male.

Clarke elicited predator songs by placing realistic models of threatening animals in trees where an entire group of gibbons could see them. Models included a fur–wrapped sack representing a leopard and a painted, papier-mâché, crested serpent eagle covered in feathers.

The team recorded predator-induced songs, which began with series of soft "hoo" notes and included many instances of another note. Each predator tune lasted roughly 30 minutes.

Pairs of adult males and females that mate for life perform duets, often adjusting the tunes over time. In the new experiment, adult pairs of each group spontaneously produced duets that were captured by the audio recordings. These songs lacked introductory "hoo" notes and the repeated extra note of the predator songs, and duets lasted only 10 minutes.

Gibbons within earshot of singing comrades discriminated between duets and predator songs. Nearby females emitted a characteristic brief call after hearing any song, but they delayed this response for 2 minutes or more following predator tunes. All members of neighboring groups responded to predator-induced crooning by loudly repeating the sequence of notes.

Although a substantial gap separates human language from ape communication, the new study shows that "in gibbons, the difference in degree of vocal complexity and sophistication is not as large as some have been tempted to think," remarks biological anthropologist Barbara J. King of the College of William and Mary in Williamsburg, Va.

Biologist Dorothy Cheney of the University of Pennsylvania in Philadelphia recommends that recordings of the two song types be played to gibbons in the same setting. She adds that syntax in gibbon songs falls short of that in language, which uses words to serve specific functions in sentences as well as to refer to features of the world. —B. BOWER

Guys Roll Eyes

Fish show some eyeball to their rivals

Male fish in the Colorado River roll their eyes to flash a novel "Back off, punk" signal at other males, researchers say.

The razorback suckers' gesture—dipping the eyeball to expose its upper third—ranks as the first documented eye roll among territorial signals, says vision specialist Inigo Novales Flamarique of Simon Fraser University in Burnaby, British Columbia. What makes the communication even more unusual, he says, is that it gets much of its punch from ultraviolet (UV) light.

People don't see UV wavelengths, but biologists have in recent years found that certain fish, birds, and other animals do.

Flamarique had puzzled over the UV vision in a razorback relative, a white sucker that spends most of its life in water too deep for the UV wavelengths of sunlight to reach. Then Flamarique got an e-mail from Gordon Mueller of the U.S. Geological Survey in Denver that described another deep-dwelling fish, the razorback sucker (*Xyrauchen texanus*), that swims to the shallows to breed. Mueller had noticed bright flashes from the eyes of males staking out breeding territories.

Flamarique says, "All of a sudden, I connected the dots." He hypothesized that those flashes included a UV signal that fish detected in shallow waters.

In lab tests, Flamarique and his colleagues confirmed that razorbacks have UV receptors. They're located where the retina receives light from below and would pick up a signal as one fish swam above another.

During razorback's breeding season, the researchers visited one of the few remaining populations in the Colorado River in Arizona. Flamarique and a colleague anesthetized seven razorbacks, moved their eyeballs to the rolled position, and dipped them in the Colorado River.

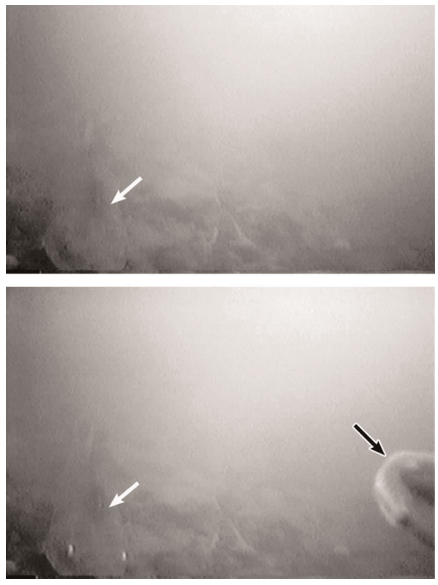
The rolled eyeballs reflect sunlight brilliantly, Flamarique reports. Compared with the rest of the reflection's spectrum, the UV part offers the strongest contrast to surrounding light and so would make a dramatic signal.

To see how fish react to glinting eyeballs, the researchers set a fake fish with LED eyes on each side of a big tank and loosed razorbacks in the middle. Male fish shied away from whichever model flashed its eyes.

Because female fish didn't noticeably react, eye flashes probably warn off intruding males, Flamarique, Mueller, and their colleagues say in an article now online for the *Proceedings of the Royal Society B*.

Yellow-bellied slider turtles also roll their eyes, but as a different kind of communication, says Jeffrey E. Lovich of the U.S. Geological Survey in Flagstaff, Ariz. He's seen eye rolling only in willing females being courted.

For creatures in water shallow enough for UV light to penetrate, those wavelengths seem useful as intimate signals, notes Molly Cummings of the University of Texas at



FISH-EYE VIEWS A male razorback sucker barely shows up in river murk (top, arrow) until he rolls his eyes (bottom, white spots below white arrow) at an intruder (dark arrow).

CLARKE; MUELLER

Austin. She has documented UV-reflecting decorations that boost the sex appeal of fish. Because those decorations and the eyeball rolls aren't visible far away underwater, they can signal a nearby fish without alerting more-distant predators. —S. MILIUS

Learn the Story Behind the Greatest Story

The Story of the Bible details the ancient wisdom and lasting treasures in 24 fascinating lectures

Since the invention of the printing press, the world's consistently best-selling book has been the Bible. Since 1815, it has been printed an estimated five billion times. By the end of 2005, it had been translated into 2,043 languages. In the Western world, the Bible is easy to find: In most hotel rooms, it is handier than the Yellow Pages.

And yet, what do many of us know about this ancient and influential text? Compiled over centuries, the Bible is considered to be both a divinely inspired message and the work of human authors. Throughout its history, it has grown from a collection of stories and teachings shared through oral tradition to a founding text for three of the world's great religions. It has been copied and recopied into countless manuscripts, pronounced from the pulpit, studied in universities and synagogues, and read in private. Translated and distributed all over the world, it bears the mark of the many cultures that have debated its meaning and prized its wisdom.

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About Your Professor

Dr. Luke Timothy Johnson is the Robert W. Woodruff Professor of New Testament and Christian Origins at Emory University's Candler School of Theology. He is the author of more than 20 books, including *The Real Jesus: The Misguided Quest for the Historical Jesus and the Truth of the Traditional Gospels,* and *The Writings of the New Testament: An Interpretation,* which is used widely as a textbook.

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A NEW SPIN

X rays shed light on black holes

BY RON COWEN

For an object that wields such a powerful and complex influence, a black hole is amazingly simple. Although its gravity is strong enough to trap light and slow time until each second lasts an eternity, the basic astrophysical properties of a black hole can be described by just two properties: mass and spin rate.

Over the past 15 years, astronomers have made great progress in measuring the mass of big black holes, which may lurk at the center of every large galaxy. Astronomers have found that these black holes weigh millions to billions times the mass of the sun.

Spin rate has been more difficult to measure but has now yielded to astronomers' probes. Measurements of spin provide a critical new test of Einstein's general theory of relativity, which predicts that spinning black holes drag space-time along with them. The new observations lend support to the theory.

Spin measurements provide a new view of the Alice-in-Wonderland world of twisted space and warped time near a black hole. That's because the rotation permits material surrounding the heavyweight to safely orbit at closer distances, instead of getting sucked in, as it would if the hole were stationary.

"Spin imparts unique signatures on the structure of space-time around black holes," note theorists Ramesh Narayan of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass and Eliot Quataert of the University of California, Berkeley in a recent article.

Astronomers don't yet have a spacecraft to journey near a black hole and relay back information about its rotation. But a flotilla of Earth-orbiting X-ray telescopes is recording the fireworks emanating from the region immediately surrounding several supermassive black holes, which lie millions to billions of light-years away.

The new clocking of spin comes from several hundred hours of observations from a recently launched Japanese X-ray telescope called Suzaku. Studies with Suzaku are also fleshing out two proposed sets of structures surrounding black holes: a close-in disk and an outer region of gas.

After years of predictions, "we're just at last starting to see the effects of strong gravity around a black hole," says Andrew Fabian of the University of Cambridge in England.

IRON FINDINGS The Suzaku discoveries rely on the detection of a wavelength of X-ray radiation emitted by hot iron atoms in the gas surrounding a black hole. In the absence of gravity and movement, radiation from the iron atom would produce a single spike on the craft's spectrograph, corresponding to an energy of 6.4 kiloelectron volts.

The mind-bending physics of black holes, however, makes the spectrum recorded by Suzaku much broader, more like a mountain range than a sharp peak. A wide, asymmetric feature, known as the broad iron K line for its appearance on the spectrograph, contains a wealth of information about the interplay between black holes and their surroundings, says Fabian.

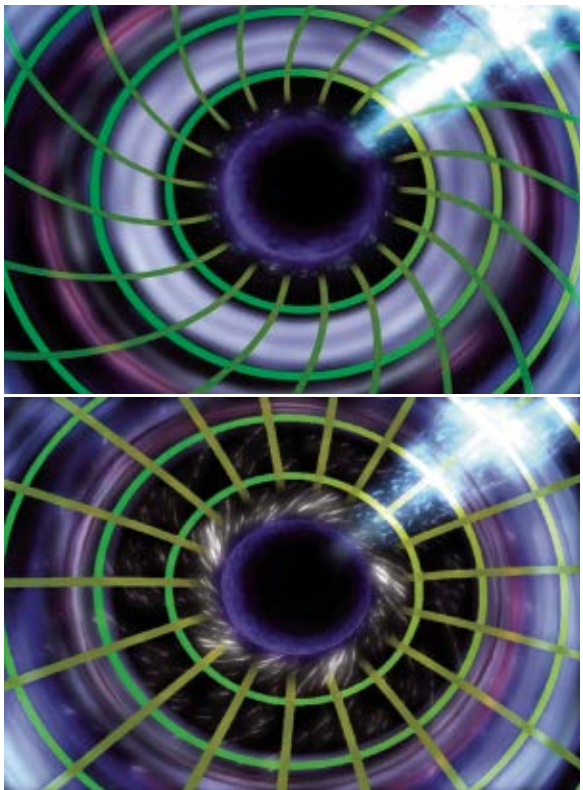
Just as a police officer uses a radar gun to record the speeds of passing cars, Fabian and his colleagues employ the spectrograph reading to clock the velocity of material whirling around black holes. From that speed, they deduce how close to the hole that material resides.

Consider that distant Pluto orbits the sun much more slowly than innermost-planet Mercury does. Similarly, distant material orbits a black hole more sedately than nearby material does. The broad X-ray spectrum recorded by Suzaku implies fast-moving, and therefore close-in, material.

Fabian's team has also used the new X-ray data to demonstrate that the gravity of the black holes has slowed time, stretching the radiation to longer wavelengths.

The observations, which the researchers describe in an upcoming *Publications of the Astronomical Society of Japan*, are providing new evidence that the pattern of X-ray emission from iron atoms around a black hole originates from two different processes. The first is the rotation of the disk, while the other is the strong gravitational pull of the black hole.

Most material drawn toward a black hole doesn't dive directly



DISKO DYNAMICS — Because a spinning black hole (top) drags space-time with it, it pulls the disk of material (white ring) feeding the hole closer. In contrast, the disk of a stationary black hole (bottom) lies farther out from the gravitational maw.

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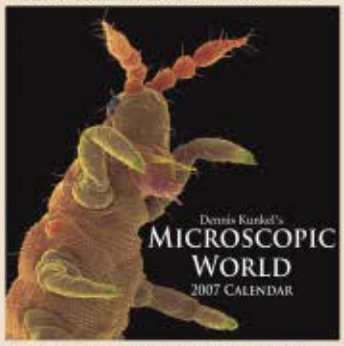

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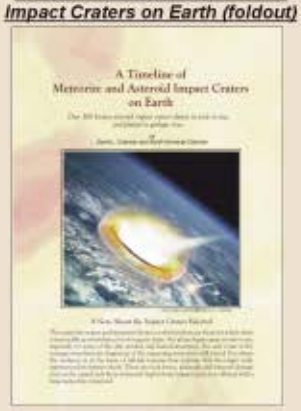

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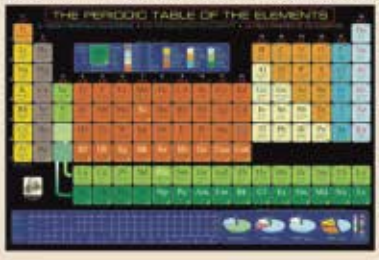

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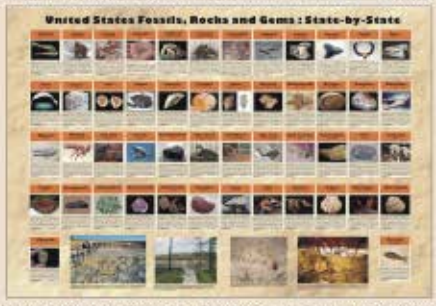

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in but forms a swirling disk, called an accretion disk, around the hole. That disk continuously feeds the voracious monster.

When a disk is viewed edge-on from Earth, material heading toward the back side of the black hole recedes from our planet, while material spinning toward the front approaches us. Like the changing pitch of a wailing ambulance as it moves past an observer, X rays emitted by the approaching material are shifted to shorter, or bluer, wavelengths, while those from the receding material get shifted to longer, or redder, wavelengths.

> "We're just at last starting to see the effects of strong gravity around a black hole."
>
> — ANDREW FABIAN, UNIVERSITY OF CAMBRIDGE

These blue and red shifts broaden the spectrum of X rays emitted from the iron atoms in the accretion disk. The greater the speed of the disk, the more spread out the spectrum becomes. Specifically, the width indicates the speed of the innermost part of the disk—the gas that's moving around the black hole the fastest.

"The Suzaku observations are beautifully confirming the models [of spin] that we have been applying" from earlier data, says theorist Chris Reynolds of the University of Maryland at College Park.

Fabian and his colleagues recently trained Suzaku on a galaxy called MCG-6-30-15. The width of the X-ray spectrum indicates that the galaxy's central black hole is whirling around at 90 percent of its maximum possible rate of rotation. Had the black hole been rotating any slower, it couldn't have whipped nearby spacetime into quite as strong a tornado, and the inner part of the accretion disk couldn't have extended quite so close to the event horizon—the boundary between the black hole's maw and the outside world. Instead, the material would have plunged in.

With the extensive data that they collected, Fabian and his colleagues, including Giovanni Miniutti of the University of Cambridge, could distinguish a second factor that contributes to the broadness of the X-ray radiation emitted by the iron atoms. It's a shift distinctive from the red and blue shifts attributed to material speeding toward and away from Earth. Known as gravitational redshift, the effect is caused by the black hole's powerful gravity, which slows time and causes light waves to lose energy. The loss in energy causes the light waves to have longer wavelengths. Previous studies hadn't demonstrated this redshift as clearly.

In the case of MCG-6-30-15, the gravitational redshift is so extreme, says Fabian, that most of the emission must be coming from the gas and dust extremely close to the black hole. The team calculates that the inner edge of the disk is only twice as far away from the hole's center as is the event horizon. That proximity of the disk is another indicator that the black hole is a whirling dervish, spinning so rapidly that outside material can orbit within a hair's breadth of ultimate doom.

From previous X-ray measurements, astronomers hadn't been certain that they were seeing the effects of strong gravity from a black hole, notes James Reeves of NASA's Goddard Space Flight Center in Greenbelt, Md., and Johns Hopkins University in Baltimore. But the Suzaku measurement "leaves little doubt," he adds.

Scientists now have sufficient data to measure black hole features other than spin. For example, they've calculated the orientation of an accretion disk. In a galaxy called MCG-5-23-16, Reeves' team determined that the accretion disk is angled at 45° to the black hole's axis of rotation.

The angle of the accretion disk indicates how much gas and dust an Earth-orbiting telescope must look through as it views a black hole. With this information, scientists can more accurately determine a black hole's gravity, energy, and other features.

OUTER LIMITS The new observations are also solving a puzzle about the material surrounding black holes. Although the accretion disks emit X rays, computer simulations have indicated that the disks around black holes are, in astronomical terms, cool and thin. The gas is warm enough to generate visible and ultraviolet light but not the billion-degree temperatures required to generate X rays.

Theorists propose that outside the accretion disk lies a cloud of highly ionized gas—the corona. Just as the sun's corona, or outer atmosphere, is hotter than the surface of the sun, the black hole's corona would be hotter than the closer-in accretion disk. Some of the radiation produced by the corona would shine on the disk, exciting the gas within it. That extra energy would trigger iron atoms in the disk to fluoresce and generate the X rays that produce the broad iron K line.

The corona seems responsible not just for the X rays but also for wild variations in X-ray intensity that Fabian and his collaborators have observed in the vicinity of some black holes. The team proposes that the changing intensity isn't the result of variations in the amount of light emitted by the accretion disk.

"The corona is dancing around," says Reynolds, and when the corona gets closer to the hole, more of its light is trapped by the hole, less falls on the accretion disk, and the X rays appear dimmer. When the corona moves farther from the hole, more of its light travels freely into space, and the corona appears brighter.

HOLE ENERGY — Strong magnetic fields (shown as loops) may permit energy from a black hole to escape to the surrounding disk of gas and dust.

NASA

The great intensity of the X-ray emissions measured can't be completely accounted for by the gravitational energy of supermassive black holes. The X-ray power could be a sign that magnetic fields extend outward from the hole and thread around the spinning accretion disk. The fields could then act to extract rotational energy from the hole and transfer it outward.

Some of this energy might be funneled into the giant jets of high-speed gas often observed to be blasting out from the neighborhoods of supermassive black holes. If correct, this magnetic model would solve a long-standing puzzle of how these jets are powered, Reynolds notes.

Suzaku observations by Reeves' team are also revealing that the broad iron K line "is quite common," emanating from many massive galaxies, says Fabian. The detailed observations that the craft has made in a handful of cases may therefore apply to supermassive black holes across the universe.

"All these effects have been very elusive," says Fabian, adding that the Suzaku observations "take us into a new regime." ■

MOST BEES LIVE ALONE

No hives, no honey, but maybe help for crops

BY SUSAN MILIUS

Theresa Pitts-Singer and Cory Vorel give us such friendly smiles that it's almost impossible not to believe them. But their advice on getting a close look at their bees seems nuts. They've led a small group of visitors around a back corner of the home of their bee lab. Dark blurs zip past us as the bees settle down for the night. Vorel passes out otoscopes. For prime viewing, she urges us to position our eyes and a bright light just an inch away from the stinging end of a resting bee, as if we're ear doctors gone off the deep end.

At first we're skeptical. But, in the 20 minutes that we shine our otoscopes into the bees' bedrooms, no one is stung. We're impressed, but Pitts-Singer isn't surprised. These are special bees. This lab in Logan, Utah, is the only one of the United States Department of Agriculture's five bee laboratories that doesn't work on honeybees.

Instead, she and her colleagues keep alfalfa leaf-cutting bees (*Megachile rotundata*). These bees and others classified as solitary bees operate independently and don't have hives or honeycombs. Each leaf-cutting bee in the lab lives in a paper drinking straw stuck in one of many holes in a plastic block. Solitary bees, Pitts-Singer tells us, don't sting as readily as honeybees do because they aren't defending a family nest.

Loner bees may seem unusual, but honeybees are actually the oddballs. At least 75 percent of the 4,500 bee species in the United States and Canada live solitary lives.

This unsung majority has attracted new attention as concern rises that populations of honeybees, and perhaps other pollinators, may be declining. In October 2006, a National Research Council report on pollinators called for new attention to solitary bees. They may offer alternatives to honeybees as pollinators for crops. And research is starting to reveal their importance in the wild.

Regardless of what uses people find for them, solitary bees offer a variety of charms. Some gleam like blue pearls; some grow fur tufts; some sleep in flower blossoms. And it's hard not to like a bee that's slow to sting.

PITTS-SINGER

HONEYBEES SUBS — The alfalfa leaf-cutting bee, a stowaway from Europe and Asia, has settled into North America. It pollinates these purple alfalfa flowers more efficiently than honeybees do.

HONEYBEE HIATUS The job market's great for honeybees these days, says James Cane of the Utah lab. Commercial beekeepers rent their hives to farmers, who rely on the bees to pollinate some 100 commercial crops in North America.

The 2-million–plus honeybee colonies traveling the farm circuit represent a shrinking labor force. It's down by a third since 1981, according to the USDA's statistics. Pesticide use, Africanized bees, parasites, and diseases have taken their toll. In 2005, California almond growers became the first U.S. farmers since 1922 to get emergency permission to import honeybees from outside the United States.

The new National Research Council report notes a "demonstrably downward" trend not only for honeybees but also for some wild-living pollinators, such as several bumblebees and bats.

Out of 115 crops worldwide examined in a study that the *Proceedings of the Royal Society B* has posted online for the Feb. 7 issue, 87 rely fully or partly on animals for pollination. That represents a third, by volume, of all crop production, report Cane, Alexandra-Maria Klein of the University of Göttingen in Germany, and their colleagues. For example, cantaloupes, watermelons, and cocoa are almost exclusively dependent on insects.

ALTERNATIVE FARMERS While honeybees pollinate many crops, they shirk that duty for some, such as alfalfa. Pitts-Singer demonstrates the problem by plucking a little pompom of flowers from a field of alfalfa.

When she squeezes the bottom petal of an individual bloom with the tips of her fingers, several yellow, pinhead-size balls pop out. They barely tickle a human fingertip, but they bother honeybees, which "don't like getting smacked in the head," says Pitts-Singer.

Honeybee foragers generally avoid the drubbing. Most of them are looking for nectar rather than the pollen that's on the yellow balls. The bees get what they want by sidling up to alfalfa flowers and sipping slantwise. The blossom's spring doesn't trip to make the balls whop them, so the honeybees don't pick up pollen to transfer to other blossoms.

A female solitary bee, in contrast, needs pollen to pack away as food with the eggs that she lays in her few weeks of adulthood. If she visits alfalfa flowers, she collects pollen, even though she gets bumped on the head. So, in her short, urgent season of motherhood, she spreads lots of pollen among flowers.

Most U.S. alfalfa is grown for its greenery, to be used as animal forage, so only the suppliers of alfalfa seeds need pollinators. Decades ago, the seed farmers started taking advantage of solitary bees. They had noticed that their crop yielded extra seed when planted near salt flats pockmarked with nesting holes from alkali bees (*Nomia melanderi*).

However, because alkali bees nest in the ground, they couldn't be moved easily and so weren't supplied commercially in the way

that honeybees were. Farmers began creating new bee beds by planting blocks of soil riddled with bee nests dug from natural nesting zones. It was a struggle to mimic those areas' moisture and chemistry. The farmers even had to add salt to the surface, "which seems horrible for agricultural land," Cane says.

When alkali bees find a suitable stretch of barren land, each female excavates a shaft ending in a cluster of nursery chambers about the size of small table grapes. To make a wad of food for hatchlings, the female uses a few drops of nectar to pack together pollen she has collected from about 5,000 alfalfa flowers. She works 11-hour shifts to outfit about one chamber a day.

The pollen wad contains the only nectar a young bee will need. Because they don't feed a large nursery and workforce through the winter, solitary bees don't bother with honey.

In recent decades, an easier-to-handle solitary species has been supplanting the alkali bees. It's the species that Pitts-Singer studies—the alfalfa leaf-cutting bee. It offers a great advantage over alkali bees: It doesn't need ground for nesting.

Female leaf-cutting bees nest in holes that beetles have bored into trees or almost any other small cavity. Pitts-Singer says that the bees lay eggs in the grooves of wooden house siding and even in electrical outlets.

The bee's common name comes from the females' habit of snipping sections of leaves and lugging them home. The swatches can easily measure two-thirds of a bee's body length. The females work leaf pieces into position to line their nest holes. "They're agile little critters," says Vorel.

Commercial bee suppliers set out polystyrene blocks with rows of holes in them to serve as leaf-cutting–bee nests. A female bee moves into a hole and, starting from the rear, creates a line of nursery chambers.

The supplier punches out a string of egg chambers to ship to an alfalfa farmer, who buys a fresh supply of leaf-cutting bees each year. It's convenient, though Pitts-Singer sounds wistful when she says that the species has become a "disposable bee."

Other solitary species also hold promise as crop pollinators, says Cane. He tested the powers of the metallic-green-blue bees *Osmia aglaia* by caging them with raspberry plants. The berries turned out as plump and plentiful as those on bushes left uncaged for honeybees to work, he reported in the October 2005 *HortScience*.

An *O. aglaia* relative, the blue orchard bee (*Osmia lignaria*), has proved energetic in pollinating cherries and some other fruits. Cane says that he's now working with California growers to develop commercial orchard-bee sources for almond orchards.

Vorel describes *O. lignaria*, with its shining-blue body, as "about my favorite bee." The male cuts an especially dashing figure, with its white mustache and a vest of white body fur.

Squash bees also interest Cane. These native bees in the genus *Peponapis* collect pollen only from squash, gourd, and pumpkin plants. Males often spend the night in a closed blossom. They meet females working so early in the morning that they can pollinate the day's blooms before any honeybees show up.

WILD VOLUNTEERS Other solitary bees may also be pitching in to pollinate crops, especially the ones honeybees fumble, such as tomatoes, says Sarah Greenleaf of the University of California, Davis.

The tomato plant belongs to a diverse group of species that release pollen only when their little salt shaker–like pollen organs receive intense vibration.

The bee species that do pollinate tomatoes grip the flower and shiver their flight muscles without opening their wings. Although the honeybee may seem the embodiment of buzz, it doesn't show this behavior.

When Greenleaf surveyed fields on 14 organic farms in California, she found that *Anthophora urbana*, a wild, black-and-white solitary bee, accounted for 60 percent of 2,500 tallied visits to tomato plants. Wild bumblebees, which live in groups, logged about a third of the visits.

Both species gave flowers a strong buzz. "Each flower gets just a 'tzzt', a second or two," says Greenleaf.

She reports that flowers left open for bee buzzing grew into tomatoes six times as often as did flowers that researchers covered in bags sewn from wedding-veil material.

Buzz-pollinating bee species shiver at different frequencies, which an aficionado can identify. "It's like birding," Greenleaf says. "You can just stand in the tomato field and close your eyes and do beeing by ear."

Greenleaf and Claire Kremen of the University of California, Berkeley have also found that wild bees boost pollination in hybrid sunflowers, but in an indirect way. Although 30 or so wild bee species work sunflower fields, commercially supplied honeybees perform most of the pollination.

In the course of a survey, "I noticed some bizarre interactions going on. Bees were colliding with each other a lot," says Greenleaf. She also saw bees landing on each other as if objecting to a competitor's reaching the pollen first. All this mayhem stirred up the honeybees to switch flowers frequently, often by moving between rows of the hybrid's parent varieties.

Overall, the wild bees doubled the effectiveness of the honeybee pollination, she and Kremen reported in the Sept. 12, 2006 *Proceedings of the National Academy of Sciences*.

ALT BEES — The small native bee *Osmia aglaia* could work as an alternative pollinator of red raspberries and blackberries in the Pacific Northwest, according to recent tests. A relative, the blue orchard bee (*Osmia lignaria*), readily moves into holes in nesting blocks (upper right) and does a good job pollinating tree fruits such as cherries.

WILDFLOWER SPECIALISTS It's not just crops that need pollination help. Bees visit wild plants too, pollinating some 40,000 flowering plants, or nearly 17 percent of the known worldwide total, according to a 1996 estimate from ecologists Stephen Buchmann and Gary Nabhan in *The Forgotten Pollinators* (Island Press). That's twice the total number of species serviced by butterflies and moths and more than 40 times the number pollinated by birds. Only beetles do more pollinating.

DESERT OASIS — One of the solitary bees of the Southwest, this *Diadasia* specializes in visiting cactus flowers.

Major declines in wild pollinators could have "substantial" ecological consequences,

S. WERBLOW/HOMESTEAD; (INSET) PITTS-SINGER; MCINTOSH

but they could be "difficult to detect," says the National Research Council report on pollinators. Outside laboratories and crop fields, pollination turns into a complex business.

Most common, the report notes, are networks of pollinators and flowers, only some of which are specialized to rely on a few partner species. However, biologists have documented a few dramatic tales of plants nearing extinction after their specialized pollinator died off. Some wildflower communities depend on communities of specialist pollinators, says bee researcher Robbin Thorp of the University of California, Davis.

His favorite solitary bees are specialists, little, dark species that are often mistaken for flies by a casual observer. These bees, in the genera *Andrena* and *Panurginus*, nest near so-called vernal pools of accumulated winter rains. Adults emerge just for the 2 to 3 weeks of wildflower bloom: the goldfields, yellow carpets, meadow foams, and sky blues that provide some of the West Coast's most scenic, but also most endangered ecosystems.

Solitary bees have sometimes surprised biologists looking at bee-flower relationships. Margrit McIntosh of Tucson studies bees that collect pollen only from certain cactus species, which don't seem complex enough to require a specialist bee.

The flowers of *Ferocactus* barrel cacti look like kindergarten drawings: tufts with rows of petals around them. Pollination doesn't require a long hummingbird bill or a buzz-pollinator's muscles. A kindergartner trailing a coat sleeve could do the job.

Yet although both solitary cactus bees and sweat bees visited two species of the flowers in the Sonoran desert during McIntosh's tests, only a cactus-bee visit transferred enough pollen from one flower to pollinate the next. McIntosh reported this result in the August 2005 *Functional Ecology*.

PEMBERTON

PERFUME BEE — ***Euglossa viridissima*** **bees collect flower scents that males deploy during courtship. This species, native to Mexico and Central America, is moving into Florida and apparently finding the local odors attractive.**

Another oddity about the barrel cactus flowers: "Honeybees don't like them," she says. "I don't know why, but they don't."

In contrast, a study of the first orchid bee to invade the United States documents flexibility in a pollinator despite a tough challenge. Since 2003, the metallic-green, solitary *Euglossa viridissima* from Mexico and Central America has been turning up around Fort Lauderdale, Fla., report Robert Pemberton and Gregory Wheeler of a USDA lab there. Male orchid bees depend on fragrances that they collect from orchids or other sources to supply just the right aroma for attracting a female.

Out of 55 scent ingredients identified in bees living in Florida, 27 scents matched those from nine orchids collected in the native range. The Florida bees had picked up the scents from different local plants. For example, the common garden basil holds 14 of those 27 compounds. Allspice and the leaves of the melaleuca trees offer bees other ingredients in the faux-orchid scent, the researchers reported in the August 2006 *Ecology*.

This tropical orchid bee hasn't moved north of Florida, but there's plenty of good solitary-bee viewing available elsewhere, even in built-up landscapes, says Thorp. He's been participating in a survey of solitary bees just within Berkeley, Calif.

"Eighty-two species and counting," says Thorp.

Of course, city people may mistake solitary bees for flies. Or honeybees. ■

OF NOTE

CHEMISTRY

For sweat's sake

Soldiers may someday find comfort as well as safety in chemical-protection gear, now that researchers have created a breathable, chemical-blocking composite material.

Manufacturers commonly make protective garments out of butyl rubber, which blocks vapors and liquids. But in warm conditions, a person "might sweat to death in it," says chemist Douglas L. Gin of the University of Colorado at Boulder.

To create a breathable barrier, Gin and his colleagues turned to a lyotropic liquid crystal, which has two different ends: one water loving, the other water repelling. The researchers placed the liquid crystals in water, which caused the water-loving ends to pack together and form nanometer-scale pores. Next, the scientists blended the mixture into liquid butyl rubber. Once cured, the material consisted of a three-dimensional network of rubber and pores that contain water.

Chemical warfare agents can't pass through the pores because such chemicals are generally water repelling, says Gin. In tests, a patch of the composite material stopped a mustard gas–like chemical even better than plain butyl rubber did. Yet the composite would allow enough water vapor to move through to meet military standards for comfort, the team reports in the Dec. 15, 2006 *Advanced Materials*. —A.C.

SCIENCE & SOCIETY

Longer work hours may warm climate

U.S. employees work an average of 16 percent more hours per year than most of their European counterparts do—often with no increased productivity—a new study notes. A longer workday requires more energy for heat, light, and power, and the atmospheric emissions from that extra energy use contribute substantially to U.S. releases of greenhouse gases, including carbon dioxide.

U.S. workers typically labor some 1,817 hours per year, compared with 1,560 hours per year among Europeans, who have shorter workdays and more vacation.

"If the United States had adopted European standards for work hours, U.S. carbon dioxide emissions in 2000 would have been 7 percent lower than its actual 1990 emissions," conclude report authors David Rosnick and Mark Weisbrot of the Center for Economic and Policy Research in Washington, D.C.

They note that other developed nations are moving toward U.S. labor habits. In Europe, this could increase energy consumption by 30 percent. Rosnick and Weisbrot calculate that "if, by 2050, the world works as many hours as do Americans ... [t]he additional carbon emissions could result in 1° to 2°C in extra global warming." —J.R.

ANCIENT TSUNAMI

Dating a massive undersea slide

Pieces of moss buried in debris deposits along the Norwegian coast have enabled geologists to better peg the date of an ancient tsunami and the immense underwater landslide that triggered it. Carbon dating of the newly unearthed moss suggests that the landslide occurred about 8,100 years ago.

Sometime after the end of the last ice age, the largest landslide known to geologists took place off the coast of Norway. Called the Storegga slide, this slump of seafloor sediments included about 3,000 cubic kilometers of material. That's enough mud to cover the entire United States to a depth of about 30 centimeters, says Stein Bondevik, a geologist at the University of Tromsø in Norway.

The tsunami created by the slide scoured coastal sites in Norway, England, Scotland, and Greenland, in some places to heights of 20 meters above sea level. Scientists have previously used carbon dating of seeds, twigs, and other organic material in sediment layers deposited by the tsunami to date the Storegga slide. However, the organisms in those samples could have been long dead when the tsunami occurred and therefore might have provided artificially old date estimates, says Bondevik.

Now, he and his colleagues report that they have unearthed material that was alive when the tsunami buried it. The pieces of moss, found within an 80-cm-thick layer of sand and broken shells at two sites along the western coast of Norway, were still green when the researchers uncovered them. Chlorophyll typically decomposes rapidly if it's exposed to light and oxygen, but sudden burial by the tsunami sealed off the material, say the researchers. Also, the acidity of the sediments was low because some shell fragments dissolved and released carbonate ions—another factor that preserved the chlorophyll. —S.P.

CLIMATE CHANGE

Glaciers give major boost to sea level

In today's warming climate, the significant melting of the ice sheets capping Greenland and Antarctica garners a lot of attention. However, the ongoing melting of glaciers and other small ice masses worldwide actually makes a larger contribution to the rise in sea level, a new study suggests.

MEETINGS

American Geophysical Union
San Francisco, Calif.
December 11 – 15, 2006

Sea level is now rising about 3 millimeters each year, says W. Tad Pfeffer, a glaciologist at the University of Colorado at Boulder. While some of that increase comes from the expansion of ocean water as it gets warmer, most of the boost is caused by meltwater from land-based ice. The melting of icebergs and of the floating ice shelves that fringe Antarctica doesn't raise sea level.

Net losses of ice from Greenland and Antarctica send about 250 billion tons of water to the sea each year, Pfeffer and his colleagues estimate. However, the team's analysis of satellite and field data also finds that other ice masses, including several hundred thousand glaciers, are losing about 400 billion tons annually. That amount of meltwater is enough to fill Lake Erie. Modest ice masses such as those in Montana's Glacier National Park and atop Tanzania's Mount Kilimanjaro may disappear entirely in the next few decades, scientists estimate (*SN: 10/04/03, p. 215*).

"We feel that ignoring the contributions of small glaciers and ice caps is dangerous because it affects the accuracy of predictions of sea level rise," says Pfeffer. —S.P.

ICE AGE REMNANTS

Scraping the bottom

A survey of deep waters in western Lake Superior reveals the tracks left when massive icebergs scraped the lakebed during the last ice age.

Scientists have previously seen iceberg scours on the bottom of Lake Superior, but those were found in a shallow region near Wisconsin's Apostle Islands. The newly discovered scrapes were detected with sediment-probing sonar in 200-meter-deep water far northeast of the islands, says Nigel J. Wattrus, a geophysicist at the University of Minnesota–Duluth. The tracks—some of them tens of meters across and as much as 6 m deep—are now buried by about 10 m of sediment that has accumulated on the lake floor since the icebergs plowed the region. No one has ever reported iceberg tracks that deep in Lake Superior, says Wattrus.

Because the lake's surface has never been more than 70 m below its modern level, the icebergs that formed the tracks must have reached at least 130 m deep. A piece of ice that big could have towered as high above water as a four-story building. Most of the kilometers-long tracks run along a line from west-northwest to east-southeast, a hint of the prevailing winds and currents at the time, says Wattrus.

Samples of lakebed sediment suggest that the tracks were formed near the end of the last ice age, about 10,000 years ago. At that time, the ice sheet that covered much of northeastern North America was retreating northward past Lake Superior, and rivers flowing into the lake were carrying distinctive reddish sediments that had eroded from nearby bedrock. —S.P.

SCIENCE AND SOCIETY

When budgeting for quakes, dig deep

If the earthquakes that have struck the United States since 1900 are any guide, the nation can now expect to suffer, on average, billions of dollars of seismic damage each year.

Analysts have often adjusted damage estimates from long-past quakes simply by taking into account monetary inflation. But by factoring in population and property-value changes since the old quakes occurred, planners could make damage and death-toll predictions that more accurately reflect today's conditions, says Kevin Vranes, a policy analyst at the University of Colorado at Boulder.

Only three of the United States' post-1900 quakes cost more than $1 billion when they happened. In today's dollar value, three more would have broken the billion-dollar barrier. Factor in current population and property values as well as inflation, and 13 of those temblors would have inflicted $1 billion or more in damages.

If the magnitude-7.9 quake that hit San Francisco on April 18, 1906, occurred in the same place today, it would rank as the United States' costliest natural disaster—with the possible exception of the Dust Bowl of the 1930s, says Vranes. Adjusted for inflation, the $524 million damage estimate from the 1906 event, which killed about 3,000 people, adds up to nearly $9 billion (*SN: 4/15/06, p. 234*). But by considering today's demographics, the researchers calculated that such a quake would now cost $328 billion and probably kill 24,000 people.

Altogether, quakes that struck the United States since 1900 would cost about $430 billion if they happened today. Quakes that occurred between 1970 and 2005, the period in which damage estimates are considered to be most complete and accurate, today would trigger average annual damages exceeding $2.5 billion, Vranes estimates. —S.P.

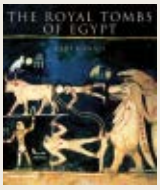
Books

A selection of new and notable books of scientific interest

THE ROYAL TOMBS OF EGYPT: The Art of Thebes Revealed

ZAHI HAWASS

Egypt's Valley of the Kings is the burial site of most of the pharaohs of the New Kingdom. Hawass, head of Egypt's Supreme Council of Antiquities, writes that

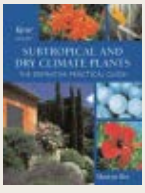


the tombs shed light on the deep religious views of the time. In this elaborately illustrated book, He explains how the ancient Egyptians' beliefs are represented in the architecture and adornment of the tombs of their kings. In an introduction, he explains why the valley was chosen as a royal burial ground. In the rest of the book, the author traces the ruling dynasties, explains how structures and adornments represented the gods, and explores people's beliefs about the netherworld. What supposedly awaited kings and queens in the afterlife was illustrated in both words and images inside the tombs. The book includes 30 foldout images, more than 300 color illustrations, and photos by Sandro Vannini. ***Thames & Hudson, 2006, 316 p., color images, hardcover, $65.00.***

SUBTROPICAL AND DRY CLIMATE PLANTS

MARTYN RIX

Gardeners who find themselves in the warm-and-wet climate of the southeastern United States or the dry heat of the Southwest have at their disposal a wide array of beautiful plant species, writes horticulturalist and gardening author Rix. She focuses on plants especially adapted to these environments,



thus requiring less maintenance and providing more enjoyment than other plants that gardeners might choose. In conjunction with the Royal Botanic Gardens in Kew, England, Rix introduces both novices and gardening experts to plants native to the subtropical and dry climates of the Mediterranean region, the West Indies, Australia, New Zealand, South America, and elsewhere. She demonstrates how the exotic plants from such places can be cultivated to thrive almost anywhere. The core of the book is a directory of more than 1,000 types of trees, shrubs, climbers, perennials, annuals, and cactuses. Each entry is illustrated and includes advice for cultivation. ***Timber Press, 2006, 256 p., color photos, hardcover, $44.95.***

OCEAN

AMERICAN MUSEUM OF NATURAL HISTORY

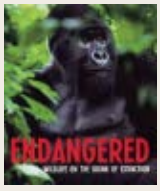
Staff of the American Museum of Natural History in New York City and other contributors present an elaborate reference to the underwater realm. Without the oceans, explains Fabien Cousteau in the book's introduction, Earth would be just another lifeless rock. This detailed book introduces readers to all aspects of the ocean. The opening explains phenomena such as the oceans' origins, sea-level change, tectonics, earthquakes, tsunamis, and the global water cycle. The next chapter is devoted to ocean

environments. It describes coastal landscapes around the world as well as the mostly hidden world of the deep ocean. Next, the book reviews the various organisms that live in the ocean or that rely on it for food, from bottom-dwelling bioluminescent plankton to the more familiar mollusks, bony fish, and marine mammals. Finally, an atlas of the world's oceans offers details such as areas, maximum depths, and currents. ***DK, 2006, 512 p., color images, hardcover, $50.00.***

ENDANGERED: Wildlife on the Brink of Extinction

GEORGE C. MCGAVIN

Extinction, like evolution, is a natural process. However, since the Industrial Revolution, increasing numbers of animals have become endangered not so much as a consequence of nature but as a result of



the actions of human beings. McGavin explores extinction and how it progresses. Life on Earth has been witness to five great mass extinctions—events that obliterated more than 50 percent of living things. McGavin, an Oxford University research lecturer, writes that human influence is now causing the sixth great extinction. McGavin details how people have learned to change their environments to suit their needs, yet their evolving methods of farming and hunting have led to the destruction of many other species. He details how the Industrial Revolution and accompanying pollution have contributed to climate change and its ongoing actions on animal species. Finally, McGavin reviews the actions that people can take now to stem the tide of destruction. ***Firefly, 2006, 192 p., color photos, hardcover, $35.00.***

DARK SIDE OF THE MOON: The Magnificent Madness of the American Lunar Quest

GERARD J. DEGROOT

Many people have fond memories of the moon landings of the 1960s and consider them heroic scientific achievements for the United States. However, DeGroot, a professor of history at the University of

St. Andrews in Scotland, claims that the race to the moon brought few dividends beyond a fleeting sense of pride and wonder. DeGroot examines what he calls the dark side of the space race. He reveals how Nazi scientists used slave labor to develop rockets and then were rewarded with work and security in the United States. The author claims that the first astronauts weren't chosen for their piloting or scientific skills. Once Russia orbited Sputnik and ignited panic in the U.S. government, few people questioned the logic of space exploration, and NASA became a big-budget agency with a nebulous mission. After Neil Armstrong's first step onto the moon, politicians and NASA leaders had even less of a sense of what to do about space, the author asserts. ***NYU Press, 2006, 321 p., hardcover, $29.95.***

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LETTERS

Gone with the heat?

"Feeling the heat of an extrasolar planet" (*SN: 10/28/06, p. 285*) made me wonder how long a gas planet is expected to survive when one of its faces is more than 1,000°C. The conventional model of our solar system assumes that gas planets can form and survive only in a cold region of space. This implies that Upsilon Andromedae b moved to its present position after it had formed and that it is now evaporating rapidly.

DONALD SHERNOFF, WHITE PLAINS, N.Y.

Reflecting on a problem

One solution to global warming suggested in "A Swarm of Umbrellas vs. Global Warming: Astronomer thinks small to save Earth" (*SN: 11/4/06, p. 291*) is stretching Mylar across the ground. How about designing reflective concrete to aid in this endeavor? We are already covering a large amount of Earth with pavement.

TOM E. KLASSEN, INDIANAPOLIS, IND.

Some 'No' votes

As a computer scientist, I appreciate that increased layers of hidden complexity only increase vulnerability to both innocent error and fraudulent manipulation ("Ballot Roulette," *SN: 11/4/06, p. 298*). As a voter, I thoroughly understand how to indelibly mark a paper ballot. The ballot can be machine read and tabulated even before I leave the precinct. It is as nearly perfect a vote-recording technology as I can imagine.

LEANDRA VICCI, SILK HOPE, N.C.

I'm quite sure that the source of the reliability and security problems in software controlled voting devices is the same that pervades all other software: hasty, sloppy systems engineering and programming, not any inherent difficulty of the problem.

BRUCE ZUIDEMA, ROBBINSVILLE, N.J.

Oregon has no voting equipment, new or old, having changed to 100 percent vote-by-mail in 1998. Your article might have mentioned this sensible system as an alternative to the expensive, complicated, and vulnerable electronic systems that have plagued the country since the 2000 election debacle.

TOM HOEBER, GOLD HILL, ORE.

Although Oregon voters mail in their ballots, all counties in the state tally votes with optical scanners. The article's graphic shows, by means of colors, which were the last Oregon counties to switch from punch-card readers to scanners for ballot counting. —P. WEISS

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The next step.

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QC2 headphones (left). New QC3 headphones (right).

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