SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

MAY 5, 2007 PAGES 273-288 VOL. 171, NO. 18

shaping sensor networks

1/year osteoporosis R_x

mercury is molten to the core

evolving gestures

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place in the sun

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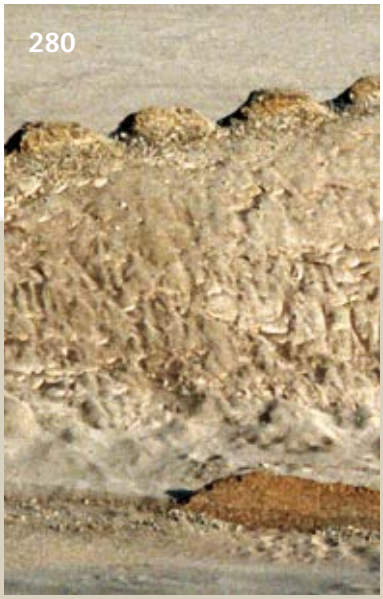

Features

This Week

Of Note

Departments

Cover Researchers have identified these 13 towers at the ancient Peruvian settlement of Chankillo as the oldest known solar observatory in the Americas. The towers, which date from 2,300 B.C., are seen from a vantage point to the west, from which they span the progression of sunrises from summer solstice to winter solstice. (Courtesy I. Ghezzi) Page 280

THIS WEEK ONLINE
http://blog.sciencenews.org/

MathTrek Why do plants' spiral patterns grow along lines that reflect the ancient Greeks' golden ratio?

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Less Is More (Bone)

Yearly osteoporosis drug reduces fractures

Older women with osteoporosis who received yearly infusions of a drug that prevents bone loss had far fewer fractures than did peers who didn't get the drug.

Over 3 years, the women who received zoledronic acid intravenously had about one-third as many spine fractures as did women who received a placebo. The drug-treated group also had significantly fewer fractures of the hip, wrist, and other bones.

"I think [the findings] will change clinical practice, particularly for the oldest people, who are most at risk" for fractures, says Dennis Black of the University of California, San Francisco. He led the study published in the May 3 *New England Journal of Medicine*.

Most current osteoporosis drugs must be taken orally every morning or once a week on an empty stomach and with a full glass of water. To avoid esophageal irritation, patients must remain upright for 30 minutes after taking their pills.

Black says that about 70 percent of people prescribed oral bisphosphonates fail to follow that strict regimen. However, with an annual infusion of drug, "you'll have 100 percent adherence for a year," he says. "And that means the clinical effect, the real ability to reduce fractures, goes way up."

The Food and Drug Administration approved intravenous zoledronic acid in 2002 for the prevention of the spread of certain cancers to bones. Almost immediately, physicians began administering the drug intravenously for osteoporosis, says Andrew Stewart of the University of Pittsburgh Medical Center. "This study is good news for doctors who thought they were doing the right thing" when recommending zoledronic acid beyond the uses listed on its label, he says.

Bisphosphonates work by seeping into the mineral lattice of bones. After intravenous administration of the drug, "the bone serves as its own reservoir and releases [the drug] continuously over the year," says Stewart. Taken orally, however, only 1 to 2 percent of the drug finds it way into the bone, so patients have to take it frequently.

The 3-year study—funded by the maker of zoledronic acid, Novartis—followed nearly 8,000 women with osteoporosis. Half received yearly 15-minute infusions of zoledronic acid, and half received saline infusions.

At the end of the study, 92 women receiving the drug and 310 women receiving saline had cracks in their vertebrae revealed by X rays. Fifty-two women in the drug group and 88 in the saline group had suffered hip fractures. Bone density increased in the drug group but not in women getting the placebo.

Zoledronic acid's reduction of fractures is comparable to or slightly better than the effect seen with the three other bisphosphonates approved for osteoporosis, both Stewart and Black say.

One of these drugs can be taken in a monthly oral dose, but zoledronic acid is the first such drug studied as a yearly infusion. The success of the regimen makes it attractive for patients who have difficulty following an oral-medication schedule, the researchers assert. Says Black, "Some people will say, 'This is great. I can go to my doctor once a year, and I don't have to think about it again.'" —B. VASTAG

Talk to the Hand

Language might have evolved from gestures

Chimpanzees and bonobos can communicate with greater flexibility using hand gestures than they can with facial expressions or vocalizations, new research shows. Their use of hand motions to convey different meanings in different circumstances suggests that gestures may have played an important part in the evolution of language.

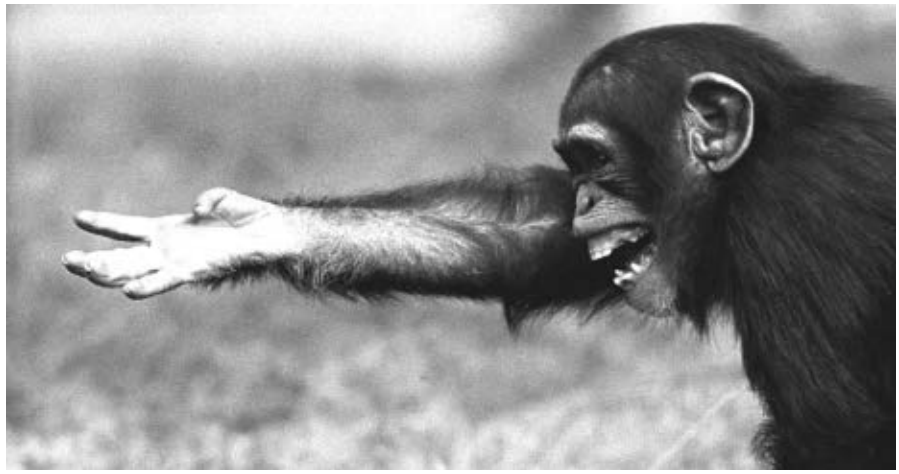
Researchers speculate about how prehuman species developed the capacity for complex language. One theory suggests that humans' apelike ancestors first communicated through gestures. Once the neural circuits for gesture-based language had evolved, those same brain areas could have switched over to verbal communication. Indeed, research has shown that modern apes use the same area of the brain to interpret hand signals as humans use to process spoken language.

Working at the Yerkes National Primate Research Center in Atlanta, Frans B.M. de Waal and Amy S. Pollick observed communications among 34 captive chimpanzees and among 13 captive bonobos, also known as pygmy chimpanzees. The researchers logged every hand gesture, facial expression, and vocal cry that one animal directed at another. They also noted the social context—playing, grooming, fighting, having sex, eating, and so on—in which each signal occurred.

Individual facial expressions and vocalizations were closely tied to a single context, showing little flexibility in meaning or usage, the scientists found. But the apes could use the same hand gesture in multiple contexts, the team reports online and in an upcoming *Proceedings of the National Academy of Sciences*.

For example, reaching out with an upturned palm while eating appeared to be a request for more food, but in fighting situations, the same gesture signaled a desire for support.

"Gesturing is a stepping-stone toward symbolic communication," in which the form of the signal bears no relation to its meaning, says Pollick, now at the Washington, D.C.–based Association for Psychological Science. Using a gesture to convey a meaning that varies with context implies a capacity to redefine signals. "There



DE WAAL/YERKES NATIONAL PRIMATE RESEARCH CENTER

REACHING OUT This hand gesture can mean either "I would like some of that food" or "Please help me," depending on the context.

isn't such a strict connection between a gesture and an emotional context as there is with [an ape's] scream," Pollick says.

Bonobos and chimpanzees are the two closest evolutionary cousins to people. The human lineage diverged from the bonobo-chimpanzee lineage about 6 million years ago, and the last common ancestor of bonobos and chimps lived about 2.5 million years ago. Any similarities in how the two ape species use hand gestures were probably inherited from that common ancestor, giving scientists a window into the past.

"I think this is the best kind of evidence that you'll find" for how language evolved, comments Susan Goldin-Meadow, who studies human gesture and language at the University of Chicago. Fossils reveal almost nothing about how people's distant ancestors communicated, so scientists can infer the past only by looking at modern humans and other primates, she says.

For example, all apes use hand motions to communicate, but monkeys and other animals don't. And gestures are ubiquitous in human communication. "In every single culture, we gesture as we talk," Goldin-Meadow says.

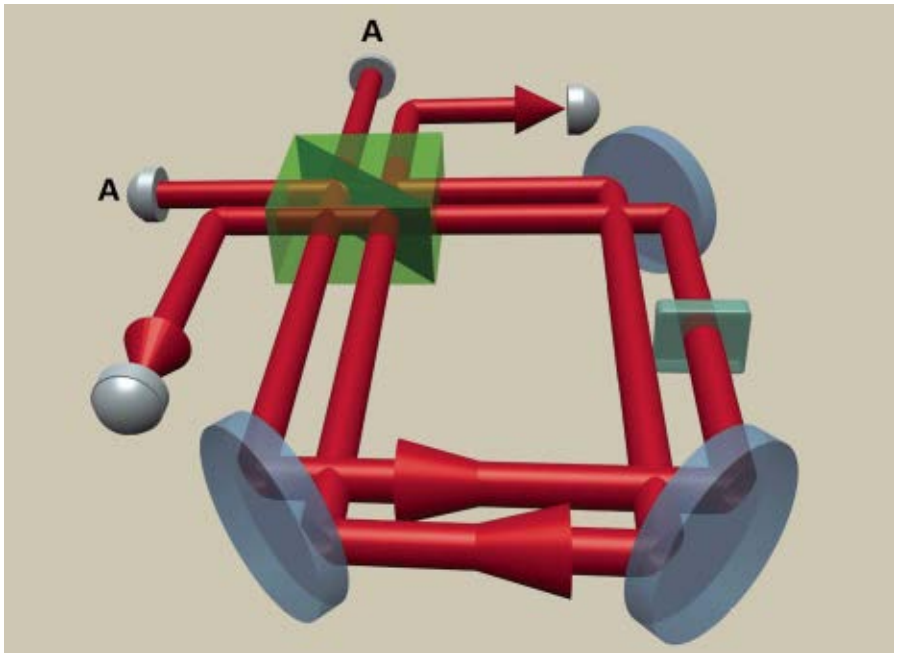
Scientists don't agree on whether and how gestures influenced the evolution of language. For example, Goldin-Meadow suggests that hand motions could have developed in parallel with vocal sounds rather than coming first. —P. BARRY

Quantum Loophole

Some quirks of physics can be good for science

Quantum theory notoriously sets limits on how precisely we can make measurements. But the quirks of the quantum realm can also be turned to advantage. Physicists have now demonstrated a way to almost double measurement precision when using photons to gauge distances.

Like markings on a ruler, the orderly waves of laser light can be used to measure lengths. In an interferometer, a laser beam is split into two beams that take two different paths. The beams bounce off mirrors and converge at the other end of the instrument, where their crests and troughs add together or cancel, depending on how these features line up. The resulting interference pattern reveals tiny differences in how far the two beams traveled. For example, a small displacement of one mirror will cause the interference pattern to shift.



ENHANCED VISION Four photons fed into an interferometer in pairs at the two entry points (A) split and form entangled quadruplets circulating in opposite directions, bouncing off mirrors (gray disks). The interference pattern that the photons produce (in the green box at left) precisely reveals the thickness of a glass plate (small square at right).

The precision of such a measurement depends on the wavelength of the light used. In the 1990s, physicists proposed that they could improve the sensitivity of interferometers by employing sets of photons in the same quantum state, or entangled, as if they formed a molecule of light. When several photons are coaxed into such molecules, the scientists predicted, an interferometer would respond as if the combined photons had a wavelength smaller than that of the individual photons.

Physicists first demonstrated the effect with pairs of photons in 2002. That strategy could increase sensitivity by about 40 percent over the sensitivity of two nonentangled protons.

A Japanese-British team has now done even better using four photons at a time. In their setup, the physicists feed the two pairs into an interferometer. Each photon then splits, taking two paths simultaneously in what's called a quantum superposition of states. The result is one set of four photons forming an entangled state that circulates around the interferometer in one direction, accompanied by another entangled quadruplet circulating in the other direction.

Each four-photon set, acting as a single quantum persona, "behaves as if it had a shorter wavelength," says team member Jeremy O'Brien of the University of Bristol in England. This is potentially like using a ruler with spacing four times as fine, he explains. In the case of four nonentangled photons, the improvement over using a single photon is only twofold.

In their experiment, the researchers arranged for one of the paths to cross a glass plate, which has the same effect as altering the length of the path. Interference between the two entangled states measured that length difference with the expected increase in precision. The results appear in the May 4 *Science*.

Paul Kwiat of the University of Illinois at Urbana-Champaign says that this experiment is an interesting demonstration, but that to get dramatic improvements, physicists would need to get many more photons to cooperate. "We don't yet know how to make sources that have [a quadrillion] entangled photons," he says.

Jonathan Dowling of Louisiana State University in Baton Rouge says that the four-photon method could be useful in some applications, such as using laser light to etch circuits on computer chips to provide features smaller than those that can be achieved now. —D. CASTELVECCHI

Automatic Networking

Brain systems charge up in unconscious monkeys

Anesthetized monkeys may be dead to the world, but their brains remain surprisingly lively. Organized patterns of

N. TOMOHISA/SCIENCE

activity continually course through neural networks that during waking life control the animals' eye movements and other critical functions, a new brain-scan investigation finds.

Unconscious monkeys also display a type of spontaneous brain activity that until now had been observed only in people at rest, say neuroscientist Marcus E. Raichle of Washington University in St. Louis and his colleagues. Some researchers suspect that this so-called default network supports the capacity to imagine the future, daydream, and think about oneself and others (*SN: 2/17/07, p. 104*).

"These findings are consistent with the perspective that the [primate] brain is governed primarily by internal dynamics," the researchers conclude in the May 3 *Nature*. If they're correct, events external to the individual play only a supporting role in ongoing brain activity.

Raichle's team used functional magnetic resonance imaging in a new way to investigate spontaneous fluctuations of neural activity in the brains of 11 anesthetized macaque monkeys. This technology measures blood-flow changes in the brain, which reflect cells' activity.

The scientists first looked for correspondences between spontaneous neural activity in a section of the frontal brain, known as the frontal eye field, and in regions in the rest of the brain. A few areas displayed rises and falls in activity that correlated with those in the frontal eye field.

Earlier studies had indicated that this set of correlated regions is anatomically interconnected and belongs to a system that controls eye movements in alert monkeys. The network is active when monkeys perform learned eye movements.

Raichle and his coworkers also observed two other networks active in anesthetized monkeys. One network is within the somatomotor system, which contributes to movement and touch. The other is in the visual system. Earlier studies showed that conscious animals activate these networks when performing tactile or visual tasks.

The researchers also found correlated activity among three parts of the outer brain layer, or cortex, in the anesthetized animals. These three interconnected areas resemble the default network reported for people at rest. It's not yet known whether this network performs the same mental functions in nonhuman primates as it does in people.

The new report shows for the first time that spontaneous, organized activity in specific brain networks is "neither restricted to the human brain nor tied to a conscious state," say Mark A. Pinsk and Sabine Kastner, neuroscientists at Princeton University, in a comment published with the new report.

Unconscious forms of such activity may bolster brain-cell connections needed for effective network functioning, Pinsk and Kastner theorize.

"The demonstration that anatomical connections among brain regions powerfully shape spontaneous fluctuations in neural activity is a major advance," remarks neuroscientist Olaf Sporns of Indiana University in Bloomington.

In related research, Sporns and his coworkers have developed a computational model of neural activity in macaques at rest, including simulated blood-flow alterations in interconnected structures.

When experimentally prodded, the model generates fluctuating, correlated activity patterns in related structures that resemble those previously reported for conscious macaques. This coordinated activity disintegrates when the researchers alter structural links in the model. The work from Raichle's group may send Sporns' model in new directions. —B. BOWER

Liquid Center

Mercury has a molten core, radar reveals

Mercury is hot stuff. That's the conclusion of a new radar study demonstrating that the core of the solar system's innermost planet is at least partially molten. The finding settles a long-simmering debate about the least studied of the planets. It may also provide insight about how the solar system created its planets.

With Mercury averaging just a third as far from the sun as Earth is, it might seem clear-cut that Mercury's core would be molten. But sunlight has a negligible effect compared with the heat left over from the planet's formation. And considering Mercury's small size, only 40 percent the diameter of Earth, astronomers calculate that the planet ought to have cooled and solidified long ago.

That thinking was challenged in 1974, when the Mariner 10 spacecraft found that Mercury has a magnetic field. The magnetic field of a rocky planet—such as Earth—is usually generated by the sloshing of charged material within a liquid core. It's also possible, however, that the magnetic field is a remnant in the crust, frozen in place when Mercury's core solidified.

In the new research, Jean-Luc Margot of Cornell University, Stan Peale of the University of California, Santa Barbara, and their colleagues bounced radio waves off Mercury's surface to measure small variations in its spin.

Peale had proposed 3 decades ago that a close study of Mercury's spin could determine whether the planet has fluid in its core. Mercury completes three rotations about its spin axis for every two 88-day revolutions around the sun. In that lockstep configuration, the sun's gravity causes the spin of the slightly out-of-round planet to vary. Solar gravity has a greater effect on a planet's spin if the core is at least partially liquid.

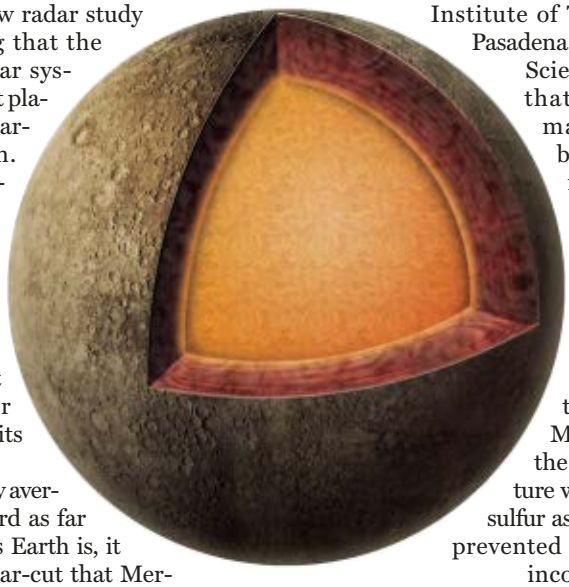
After 6 years of recording radar echoes from Mercury back to Earth, the researchers found that variations in the spin were about double what would be expected if Mercury were solid.

The most likely explanation is that, at minimum, the outer core of Mercury—the boundary between the heart of the planet and its overlying mantle—must be liquid, Margot, Peale, and their collaborators report in the May 4 *Science*.

"It is clear that Mercury is not solid throughout," comments planetary scientist David Stevenson of the California Institute of Technology in Pasadena.

Scientists propose that Mercury remains molten because sulfur infiltrated the planet's iron core and lowered its melting temperature.

But at the distance from the sun where Mercury formed, the high temperature would have kept sulfur as a vapor and so prevented it from being incorporated into the planet. That suggests that Mercury, and perhaps other planets, grabbed sulfur and other material from beyond their immediate surroundings, Margot says.



CORE FINDING The center of Mercury, shown as yellow in this illustration, is at least partially molten, new radar measurements indicate.

N. FULLER/NSF

To provide further information about the planet's core, scientists are now looking to NASA's MESSENGER spacecraft, which will

settle into orbit around Mercury in 2011, and a Japanese-European mission scheduled to arrive at the planet in 2019. —R. COWEN

More Than Bit Players

Snippets of RNA might sway pancreatic cancer

Cancer of the pancreas is one of the most discouraging diagnoses that a person can receive. The cancer is difficult to detect, so many patients are diagnosed too late for surgical treatment. The majority die within a year of getting the bad news, and only 5 percent survive for 5 years.

Researchers now find that small pieces of genetic material called microRNAs might provide a preview of a tumor's aggressiveness and offer targets for combating the disease.

While the majority of genes supply blueprints for protein assembly, a few hundred contain the instructions for making microRNAs. Within cells, these molecules switch genes on or off.

The purpose of this regulatory function is still poorly understood. However, several studies have linked microRNAs to cancer (*SN: 4/22/06, p. 254; 6/11/05, p. 371*).

In the new research, scientists analyzed the microRNA profile of pancreatic tissue of three kinds: normal, inflamed by pancreatitis, and cancerous. The tissue samples had been obtained from 65 patients who, years earlier, had had biopsies followed by surgery to remove pancreatic cancer. Despite treatment, the patients had survived only 15.5 months, on average, after being diagnosed.

The researchers gauged the activity patterns of dozens of genes known to encode microRNAs to see whether any were especially busy or idle in the tumor tissue. Ten were active in cancerous cells but not in either of the benign cell types, the researchers report in the May 2 *Journal of the American Medical Association*. Two of these—*miR-21* and *miR-155*—had been previously implicated in other cancers, says study coauthor Mark Bloomston, a surgical oncologist at Ohio State University in Columbus.

Bloomston and his colleagues then cross-checked the activity of the microRNA genes against each patient's survival time. Patients whose tumor cells had an active gene for the microRNA called *miR-196a-2* tended to succumb particularly rapidly.

Bloomston cautions that the new findings are only associations, not proof of cause and effect. "But this early data gives us some targets to start looking at," he says.

To diagnose the disease, doctors might eventually test for telltale microRNA profiles in individuals at elevated risk. Pancreatic cancer risk has been tied to smoking, pancreatitis, and a family history of the cancer.

The survival data in the new study hint that microRNAs might also shed light on a patient's prognosis, says clinical pharmacologist Scott Waldman of Thomas Jefferson University in Philadelphia. A different treatment strategy might be recommended when a doctor knows that a patient has an aggressive form of cancer, he says.

Scientists studying microRNAs "have uncovered a previously unanticipated level of regulation … in the machinery inside a cell," says Waldman.

The best outcome of microRNA research might be in therapeutics. If some microRNAs can be shown to promote cancer, "then drugs or other agents might disrupt these molecular mechanisms," Waldman says. "Particularly in pancreatic cancer, anything added to the armamentarium that allows us to intervene is welcome." —N. SEPPA

Not-So-Clear Alternative

In its air-quality effects, ethanol fuel is similar to gasoline

Switching the nation's vehicles from gasoline to mostly ethanol will not reduce air pollution, a new study finds. The work joins other evidence questioning the benefits of ethanol fuel.

Mark Z. Jacobson, an atmospheric scientist at Stanford University, created a model that takes into account how the chemicals emitted in car exhaust transform through reactions in the atmosphere. He combined the resulting chemical profile with population and health-effects data to determine the risks associated with each of the fuels.

Jacobson looked at emissions from E85, the 85 percent ethanol, 15 percent gasoline blend considered a potentially large-scale replacement for gasoline. He examined a scenario based on expected emissions in 2020, the first year that he says that E85-ready cars might dominate the roads.

Jacobson's calculations predicted health effects in response to ozone and carcinogens attributable to an all-gasoline fleet or an all-E85 fleet. He found that E85 use may increase asthma, hospitalizations, and death caused by ozone exposure by about 9 percent in Los Angeles and by 4 percent, on average, across the nation. The rise in ozone-related problems partially stemmed from larger releases of two ozone precursors—acetaldehyde and formaldehyde—from E85 as compared with gasoline.

Acetaldehyde and formaldehyde are also two of the four major human carcinogens in E85 and gasoline exhaust. E85 use lowered atmospheric concentrations of the other two major carcinogens—1,3-butadiene and benzene—as compared with gasoline use. The results regarding cancer "somewhat cancel each other out," notes Jacobson, "so there's not much difference between E85 and gasoline.

"The bottom line is, you aren't getting an improvement in air quality," Jacobson says. Although the ozone effects suggest that E85 could pose a larger health risk to the public than gasoline, he hesitates to emphasize that result because of the uncertainty inherent in some of his projections. His study appears online and in an upcoming *Environmental Science & Technology*.

Jacobson says that other renewable energies offer a better solution. "To solve global warming and air pollution health problems, we need to focus on technologies we know are addressing these problems," he says.

Timothy E. Lipman, a research scientist working on energy at the University of California, Berkeley, agrees. "There are other ways to substitute for petroleum that are likely to yield better greenhouse-gas and air-quality benefits," he says.

The study "should remind policy makers and others to be really skeptical about claims that E85 will improve air quality," comments Jana B. Milford, an environmental engineer at the University of Colorado at Boulder. The atmospheric-chemistry model that Jacobson developed is well regarded, she says, although he has examined only one scenario.

"It's a solid study," Milford says, "but it won't be the last word." —A. CUNNINGHAM

Are You Happy? Sad? Jealous?

Understand the importance of our emotions in 24 lectures from an award-winning professor

Far from being routine, emotions are "the key to the meaning of life," says distinguished philosopher and author Robert C. Solomon, who in these 24 lectures takes you on a tour of his more than three-decade-long intellectual struggle to reach an understanding of these complex phenomena. Some of his conclusions are surprising and very much against the current of common sense.

Professor Solomon's lectures unfold as a rich dialogue with other philosophers, including Plato, Aristotle, the Stoics, Descartes, Adam Smith, Nietzsche, William James, Freud, Heidegger, and Sartre. He also relates these views to contemporary work in the cognitive sciences on emotions. And he discusses the portrayal of emotions in writers and artists including Homer, Shakespeare, Melville, Dostoevsky, and Picasso.

Emotions Have Intelligence

By probing the ideas of these thinkers and presenting his own views, **The Passions: Philosophy and the Intelligence of Emotions** will lead you to a remarkable conclusion: Emotions have intelligence and provide personal strategies that are vitally important to our everyday lives of perceiving, evaluating, appraising, understanding, and acting in the world.

This idea runs counter to the widespread view that draws a sharp distinction between the emotional and the rational, and that views the emotions as inferior, disruptive, primitive, and even bestial forces. For Professor Solomon, many emotions are distinctly human, and they are far more complicated than mere "feelings." They are rational judgments—sophisticated strategies for survival.

One of the fascinating features of this course is that you get to see a philosopher wrestling with the ideas of his predecessors in a demonstration of the intellectual honesty required to make progress in tackling a profound philosophical problem.

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About Your Professor

Dr. Robert C. Solomon is the Quincy Lee Centennial Professor of Philosophy at The University of Texas. A recipient of both the Standard Oil Outstanding Teaching Award and the President's Associates Teaching Award, he is the author of more than a dozen books in philosophy and psychology.

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6. Noble? Or Deadly Sin? Pride and Shame
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8. Nastier—Resentment and Vengeance
9. A Death in the Family—The Logic of Grief
10. James and the Bear—Emotions and Feelings
11. Freud's Catharsis—The Hydraulic Model
12. Are Emotions "in" the Mind?
13. How Emotions Are Intelligent
14. Emotions as Judgments
15. Beyond Boohoo and Hooray
16. Emotions Are Rational
17. Emotions and Responsibility
18. Emotions in Ethics
19. Emotions and the Self
20. What Is Emotional Experience?
21. Emotions across Cultures—Universals
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PERU'S SUNNY VIEW

Solar observatory dates back 2,300 years

BY RON COWEN

When Ivan Ghezzi first visited the ancient Peruvian settlement of Chankillo 6 years ago, the world was reeling from 9/11. It seemed appropriate to view the site, already famous for its thick walls, parapets, and restricted gates, solely as a fortress. Ghezzi, then a Yale University graduate student, had in fact received a grant to investigate just that possibility at the 2,300-year-old coastal-desert site.

However, he soon became fascinated with a 300-meter-long array of 13 towers arranged like a row of giant prehistoric teeth along an adjoining ridge. Archaeologists had proposed that these structures might have defended the area as the other Chankillo features had. Some researchers, however, had noted a hint of astronomical symbolism, as 13 is the number of lunar cycles in a year. But no one had followed up.

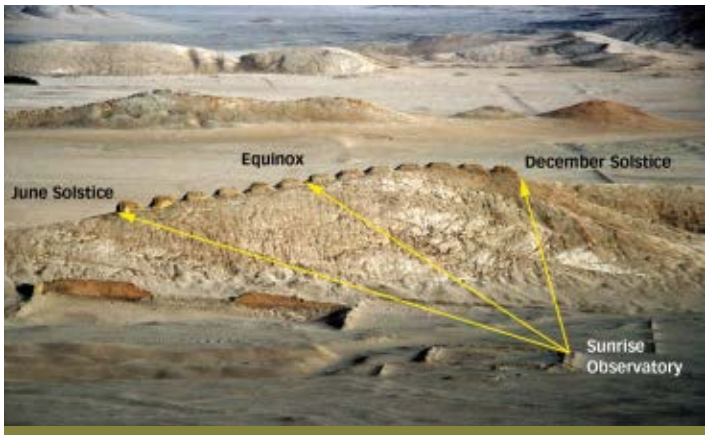
During his 2001 visit, Ghezzi revisited the idea that the towers might be an astronomical tool. Surveying the region around the ridge, he identified two structures—one just to the east and the other to the west of the string of towers—that seemed to be sites for observing the towers. Viewed from those sites, the placement and span of the 13 towers mark sunrises and sunsets from solstice to solstice. Ghezzi suggests that the towers served as a calendar accurate to within 2 to 3 days per year.

The 13 towers of Chankillo are the earliest known solar observatory in the Americas, according to a report in the March 2 *Science* by Ghezzi, now at the Pontificia Universidad Católica del Perú in Lima, and Clive Ruggles of the University of Leicester in England.

The Incas used solar calendars in another part of Peru during the 16th century, but the Chankillo towers were built 1,800 years before them, the authors say.

"The site seems quite unusual and is clearly earlier than other sophisticated [observing] sites in the Americas," comments astronomy historian Owen Gingerich of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass.

The intricacy of the tower structure, as well as the dual observing sites, suggests that the design relies on as-yet-undiscovered solar observatories that date to an even earlier time, says Ghezzi.



SUN CHART — Illustration of how the towers, viewed from the west, mark the position of sunrise over a year. Arrows show the sun at three notable times of the year.

GHEZZI

SUNRISE, SUNSET In a north-south line along the ridge, the flat-topped stone towers are evenly spaced, about 5 m apart. Though called towers, the structures are squat, varying in height from 2 to 6 m. Their rectangular tops are 11 to 13 m long and 6 to 9 m wide. Each tower has two sets of narrow stairs that lead to its top. From there, the eye takes in a landscape of foothills and mesas.

But it's the view from two sites elsewhere in Chankillo that astonished Ghezzi. Soon after making basic measurements of the towers in 2001, he began to suspect that they served an astronomical function that would be apparent only from other vantage points. During the next 2 years, he conducted excavations nearby, and by 2004, he had uncovered two intriguing sites—one to the west and one to the east of the towers.

Each of the sites has a commanding view of the towers. Ghezzi suspected that by viewing the towers and noting the locations of sunrise and sunset, ancient observers kept track of the seasons.

One of the observation sites is located at the open end of a 40-m-long walled corridor that runs outside a building about 200 m west of the towers. Both the corridor and the building had been carefully constructed. A wall restricts the entrance to one end of the corridor. At the other, open end of the corridor, Ghezzi noted an abundance of pottery, shells, and tools that hadn't been found at any other Chankillo entranceway.

The observation point 200 m east of the towers is an open-sided room in a building that stands apart from several others. A low wall restricts access to the room. Not far from the building, Ghezzi found scattered remains of offerings including ceramic panpipes and oyster shells. Nearby middens contained remains of serving vessels, panpipes, and maize.

Using modern technology—a handheld Global Positioning System device—Ghezzi determined the coordinates of the towers and each observing point. The results revealed that the sun's full range of motion 2,300 years ago, from the summer solstice to the winter solstice, matches the breadth of the line of towers.

From the western site, an observer could mark the progression of sunrises as they move north to south for half the year and then back again during the other half. The gaps between towers near the center of the array correspond to 10-sunrise intervals, while the gaps between the outermost towers correspond to longer periods.

Similarly, from the vantage point that Ghezzi discovered to the east, observers could chart sunsets throughout the year. From this site, spaces between most of the towers correspond

to 11-to-12-sunset intervals. Because the placement of the towers doesn't follow an exact north-south alignment, the gaps between towers differ as observed from the eastern and western sites.

TOWERING ACHIEVEMENT By 2005, Ghezzi had accumulated a large set of radiocarbon dates, which he used to determine the ages of the Chankillo site. He then contacted Ruggles, an astrophysicist who focuses on ancient astronomy.

Ruggles was initially skeptical when Ghezzi suggested that the 13 towers at Chankillo served as an astronomical observatory. After visiting many other sites proposed as observatories, "I am used to being disappointed," Ruggles says. Chance alignments of stars with human-built structures are common, he notes.

The view from the twin sites, however, convinced Ruggles of Chankillo's place in history as an ancient solar observatory. Ruggles own studies then confirmed Ghezzi's results.

From either observing site, Ruggles and Ghezzi conclude in their report, "the various towers and gaps would have provided a means to track the progress of the sun up and down the horizon to within an accuracy of 2 to 3 days."

Ghezzi and Ruggles propose that the relics found at the two viewing sites indicate that ceremonial feasts and rituals took place there in conjunction with viewing the rising and setting sun. The blocked access indicates that the observations may have been controlled by an elite group, perhaps a governing body at Chankillo.

The archaeological evidence of ritual use, most apparent at the better-preserved, western site, distinguishes these places from other sites at Chankillo, says Stephen McCluskey, a historian of science at West Virginia University in Morgantown. "That was, for me, the clincher" for a solar observatory, he adds.

VIEWS OF THE PAST Astronomer Ed Krupp, director of the Griffith Observatory in Los Angeles, says that he's impressed by the sophistication that Ghezzi and Ruggles describe at Chankillo. With twin observing sites, residents had two chances each day—sunrise and sunset—to mark the location of the sun.

"Most horizon calendars only permit a sunrise or a sunset observation," he notes. "The Chankillo horizon calendar provides [much] more observational flexibility."

With the variability of coastal weather, a second opportunity each day to mark the calendar would be critical. "An overcast morning might otherwise mean waiting a whole day," he says.

"There are many ways to devise calendars, but the purpose is coordination of goods and services," Krupp says. Societies keep calendars to enhance survival. Planting crops only after the last frost has passed and knowing when to harvest, especially in a region of highly changeable weather, is essential, he notes. Other activities, including navigation, may also be seasonally modulated.

SUNUP — As seen from an observing site to the west of the 13 towers during the summer solstice of 2003, the sun rose between the northernmost tower and an adjoining hill. Sunrise has shifted slightly to the right since 300 B.C., when the observing site was originally used.

Krupp says that groups retained power by maintaining calendars that scheduled ceremonies and other seasonal events.

Some calendar functions could be accomplished by simply tracking the phases of the moon. "But because the sun is also obviously behaving seasonally, people may figure you need to integrate its behavior with the moon to ensure doing the right thing in the right way at the right time," Krupp says.

For example, Southern California's Chumash tribe and most other California Native American groups employed a moon-based calendar when anthropologists interviewed them in the 19th century. Nevertheless, these people "observed the sun on the horizon at the solstices to establish their occurrence for major rituals," says Krupp. That activity may have dated to a few thousand years earlier.

"Solar observations are required to establish the solstices," Krupp notes. "People use the solstices as references for ceremonies and rituals that fortify social cohesion through cooperative interaction with the cosmos."

STAIRWAY TO HEAVENS — A staircase leads to the summit of one of the Chankillo-observatory towers.

Some temples in ancient Egypt, built about 3,500 years ago, aligned with sunrise at winter solstice, Krupp adds. One of the symbols in Egyptian iconography shows the sun lodged in a mountain notch, "and this argues for a very old tradition of horizon-based sun watching."

Among the Incas, evidence of sun worship dates to at least the 1500s, notes Ghezzi. An Inca king considered himself an offspring of the sun, and chroniclers described "sun pillars" in a pattern radiating from a central sun temple in Cusco, Peru.

These pillars reportedly marked planting times and marked seasonal observances. But the pillars vanished without a trace.

More recently, in the late-19th and early-20th centuries, the Hopi of Arizona and other Pueblo tribes of the southwestern United States used hillside markers to chart the passage of the sun, McCluskey says. "These records are sufficiently detailed that we can document the nature and precision of their observations," he notes.

However, Krupp says that he doesn't know of any other example of the dual-observation system seen at Chankillo.

Ghezzi proposes that charting the yearly migration of the sun in the Americas is probably much older than even the Chankillo towers. The knowledge of the heavens embodied by the towers and twin observing sites didn't accumulate overnight, he notes.

People today can still use the towers as a sun calendar. Earth's tilt varies by a few degrees in a 41,000-year cycle, and this shifts the exact positions of solstice sunrises and sunsets. The difference is small, however, so the vista today is nearly the same as that viewed by the residents of Chankillo in 300 B.C.

"You can bring someone here, and they can have the same experience as someone 2,300 years ago," says Ghezzi.

"I don't know of anyplace else where you can do that," he adds. "This is truly remarkable." ■

GHEZZI

SENSOR SENSIBILITY

The mathematics of shapes is illuminating the structure of wireless sensor networks

BY ERICA KLARREICH

Imagine a future in which billions of tiny computers are embedded into buildings, streets, fields, or even our bodies. These devices might monitor weather, traffic, crop conditions, the progression of diseases, or a host of other variables. The tiny computerized sensors would spontaneously organize into networks that could adjust their structures and functions in response to the information that they pick up.

That future might be just around the corner. Researchers have already deployed networks with dozens of matchbox-size sensors in a wide range of applications. Sensor networks are tracking the movement of zebras in Kenya and determining bullet trajectories in military field tests. Coming soon, many engineers predict, are cheap sensors the size of dust particles. Those high-tech specks will measure temperature, vibration, noise, light, and more. The question, the engineers say, is not whether these smart-dust sensors will someday pervade our environment, but when.

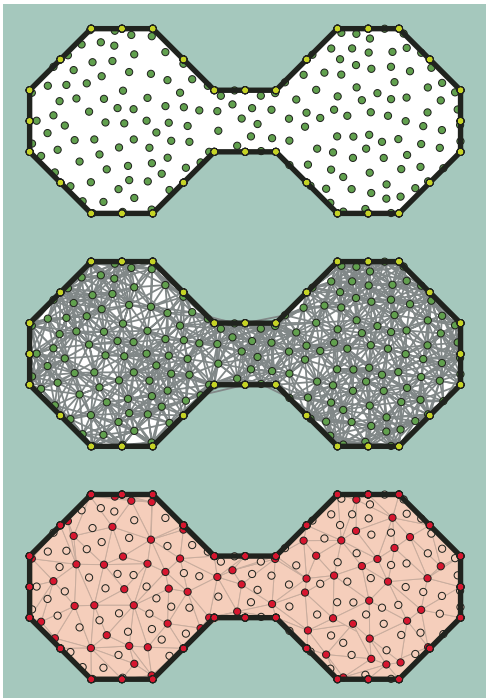
For smart dust to be useful, however, engineers must figure out how to build a global view from the information provided by millions or billions of individual sensors.

For example, suppose that agricultural researchers scatter a million battery-powered, smart-dust sensors by helicopter to monitor water levels across a cornfield. Without knowing where each sensor has landed, how would the researchers determine whether the sensors' combined range leaves gaps? Or imagine that engineers have deployed a sensor network to keep track of boats in a harbor. If each sensor reports how many boats it detects, how can the engineers keep an accurate tally without knowing how many sensors have counted the same boat?

To tackle these questions and others, researchers are drawing on techniques from topology, the study of shapes. Analyzed by mathematicians for more than a century, topology has until recently had few real-world applications.

Yet topology, which pieces together the global structure of a space from local snapshots, is exactly what sensor-network engineers need, argues Robert Ghrist, a mathematician at the University of Illinois at Urbana-Champaign.

"Topology is good for finding hidden features inside a space that you can't see very well, that you don't have all the information about," Ghrist says. "Figuring out the structure of wireless sensor networks is the kind of problem topology was meant to solve."



POWER SAVER — Given a sensor network (top), mathematicians can analyze a theoretical shape known as the Rips complex (center) to reveal which sensors (bottom, red dots) must be active for full coverage of the area and which may be turned off. In this example, 101 of the network's sensors are essential and 111 may be put into sleep mode.

GHRIST AND DE SILVA

SIMPLEX COMPLEXITY Unlike geometry, topology focuses on qualitative features—those that don't change when a shape is stretched and its geometry distorted. This viewpoint may sometimes seem fanciful: For example, to a topologist, a doughnut and a coffee cup represent the same shape since each has one hole. Nevertheless, topologists have developed a powerful arsenal of numerical and algebraic tools that enable them to extract important features from a shape whose precise geometry is unknown.

One of the most famous of such tools is the Euler characteristic, which in its simplest version assigns a number to any polyhedron—a surface, such as that of a cube, made up of polygons that meet along lines and at corner points. The Euler characteristic is easy to compute: Just add up the number of polygons, subtract the number of lines, and add the number of corner points. For example, a cube is made up of 6 square faces, 12 line edges, and 8 corners, so its Euler characteristic is $6 - 8 + 12 = 2$.

The Euler characteristic is, remarkably, the same for all shapes with the same topology. For example, a hollow cube, tetrahedron, and dodecahedron each has an Euler characteristic equal to 2.

Mathematicians are now finding that the Euler characteristic and a more complex topological tool called homology can solve many problems about wireless sensor networks. Homology calculates how many holes a shape has and distinguishes between holes of different dimensions—a pinprick in a sheet of paper as compared to the interior of a balloon, for example. It also sheds light on how pieces—triangles or tetrahedrons, for instance—with different dimensions fit together to form an overall shape.

Like the Euler characteristic, homology works best on shapes built up out of what topologists call simplices, namely, corner points, lines, polygons, and their higher-dimensional analogs—objects that are hard to visualize but can be precisely described using mathematical formulas. Accordingly, to apply the power of

these topological tools to wireless sensor networks, Ghrist and his collaborators put simplices together into a theoretical shape, called the Rips complex, that captures the intricacies of how the sensors communicate with each other.

In the Rips complex, named after mathematician Eliyahu Rips of the Hebrew University in Jerusalem, each sensor is represented by a corner point, and two points are connected by a line if their sensors are within communication range of each other.

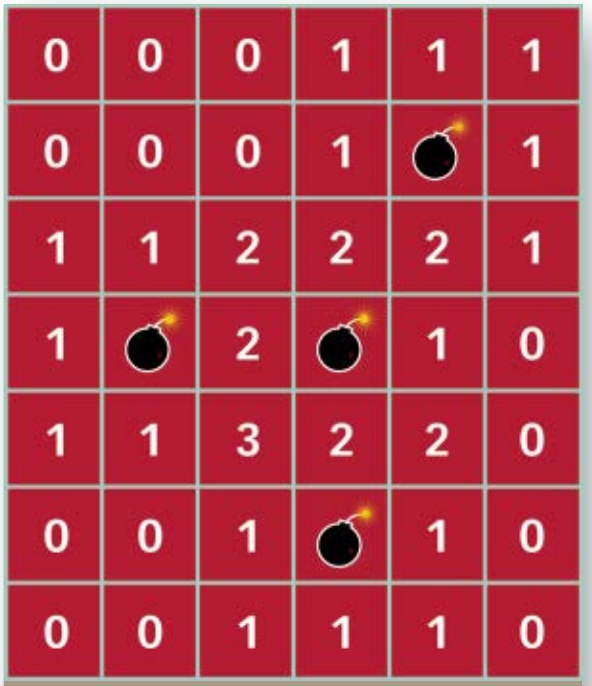
When three sensors are within range of each other, the Rips complex includes a triangle with the three sensors at its corners. Similarly, when four sensors are within range, the Rips complex includes a tetrahedron. More generally, when n sensors are within range, the complex includes an $(n–1)$-dimensional simplex with those n corners.

In this way, the Rips complex contains all the information about clusters of sensors that can talk to each other. Its topology, researchers are finding, can uncover the hidden structure of wireless sensor networks.

TRIANGULAR COVERAGE Ghrist and his collaborator Vin de Silva of Pomona College in Claremont, Calif., have used the Rips complex to tackle a basic question about sensor networks: If you scatter a bucket of smart-dust particles over a field, how do you know whether their combined sensory range covers the entire region?

Today, engineers typically deal with this problem by equipping each sensor with a global-positioning device that can report its location. This approach works well for the small-scale networks currently in use, which might number a few hundred sensors. But developing miniature global-positioning devices for large-scale networks may be prohibitively expensive.

"We're trying to prepare for the day—and it's coming very soon—when we have millions of sensors distributed," Ghrist says.



MINESWEEPER MATH — Eight neighbors count each land mine, so the sum of the counts, 32, divided by 8, yields the number of land mines, 4. Real-world situations are more complex, with some objects getting counted by more sensors than others are. But topological methods can make each object contribute equally to the total, leading to straightforward solutions of counting problems.

Many sensor-network engineers, Ghrist says, have assumed that it's impossible to deduce the structure of a network without knowing where every sensor is. "If you don't have the sensors' coordinates, at first, it doesn't seem as if you can do much," Ghrist says.

Yet in the Dec. 1, 2006 *International Journal of Robotics Research*, Ghrist and de Silva showed how to use the homology of the Rips complex to figure out whether a network has full coverage. They needed to know only which sensors were within range of each other, not where each sensor was.

For the purposes of network coverage of, say, a field of corn, the researchers considered the triangles of the Rips complex. Each triangle represents a patch of the field that is completely within range of the three sensors at the triangle's corners. The researchers asked, "When the triangles are pieced together, does the resulting quilt cover the field or leave holes?"

For a field whose perimeter is marked by sensors that are within range of their neighbors, Ghrist and de Silva have shown that unless the two-dimensional homology computation for the Rips complex comes out to zero, the triangles fully cover the field. In this case, the homology calculation not only guarantees coverage but also describes the most economical collection of triangles that covers the field. Only the sensors at the corners of the triangles in that collection need operate. Any other sensors are redundant and may be put in sleep mode, saving precious battery power.

"This is a big deal because if you have millions of sensors, you want to conserve their batteries as long as you can," Ghrist says.

If the network has small gaps in coverage, the homology computation flags the sensors that border the gaps. Engineers then have various options, such as moving sensors into the gap or turning up the power of nearby sensors so that they each report on a larger area. "We can tell you exactly which sensors need to ramp up power, and by how much, to guarantee that the holes are filled," Ghrist says.

Unlike the Euler characteristic, homology is far from straightforward to calculate. Ten years ago, Ghrist says, the homology calculations necessary for large sensor networks would have been impossible. However, with recent advances in homology algorithms and computer speed, a standard laptop can now compute the homology of a network of 10,000 sensors in less than a second.

Ali Jadbabaie, an engineer at the University of Pennsylvania in Philadelphia, has recently taken these homology algorithms a step farther. With his method, the sensors themselves compute the network's homology by communicating with their neighbors, rather than by relaying information to a base station. "This is part of a drive toward more and more autonomy for sensor networks," he says.

Jadbabaie's algorithm can even handle situations in which the sensors' positions are changing—if they are attached to animals, for instance, or blown about by the wind. "We can verify on the fly, in real time, whether you're covering all the holes," he says.

The topological approach currently makes several assumptions that don't usually hold true in the physical world, cautions Gaurav Sukhatme, who studies sensor networks at the University of Southern California in Los Angeles. For instance, the approach often assumes that a sensor detects a circular region with a sharp boundary. Real-world sensors are frequently blocked by obstacles in some directions, and their sensing ranges tend to die off gradually rather than end abruptly.

"That said, you have to begin somewhere," Sukhatme says. "It's not unreasonable to start with these simplified models and then chip away at the constraints to see which can be removed. I think it's an incredibly promising start."

COUNTING GAMES Topology is also being applied to handle the data that sensor networks generate. For example, imagine that engineers are monitoring boat traffic because they want to know how many vessels are in a harbor at any moment. The engineers are using simple sensors that can keep track of how many, but not what kinds of, boats that they see. "If you've got two nearby sensors that each see three targets, you don't know if they're seeing the same three [boats] or, say, two the same and one different," Ghrist says.

Ghrist likens the counting problem to that faced by players of

E. ROELL

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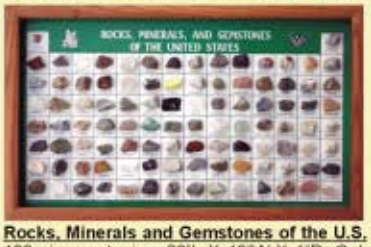

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Minesweeper, a popular computer game in which land mines are hidden in certain squares of a grid. Clicking on a square displays the number of mines in adjacent squares, unless the square itself hides a mine, in which case the player has lost the game.

In the Minesweeper scenario, it's easy to calculate the total number of mines from the individual counts contributed by the squares. Eight neighboring squares count each mine, so the total number of mines is the sum of all the counts divided by eight. This method works as long as no mines border each other or the outer edges of the grid.

Real-world counting problems are considerably more unruly. Instead of each target triggering the same number of nearby sensors, different targets may have different impacts. In the harbor scenario, for example, a giant cruise ship might get counted by hundreds of sensors, while a dinghy might get counted by just a few.

Ghrist and Yuliy Baryshnikov of Bell Labs in Murray Hill, N.J., are using topological techniques to make inroads into this problem. "Our results are extremely robust," Ghrist says. "We make very few assumptions about the system's capabilities."

Their theorem makes only one assumption about the targets: that the region from which a given target is visible is always a contractible shape, meaning that it could shrink to a single point without tearing or otherwise changing the shape's topology.

The trick to counting the targets is to figure out a way to integrate all the sensors' counts so that each target contributes equally to the total, just as each land mine contributes eight counts to the total in Minesweeper. Ghrist and Baryshnikov find that this can be accomplished without knowing how the targets vary in size or shape.

The Euler characteristic holds the key. Any contractible shape, for instance, the area from which a boat is visible, has an Euler characteristic of 1. Thus, adding up all the Euler characteristics gives the total number of boats. At first glance, this may seem circular because the number of boats isn't known.

However, Ghrist and Baryshnikov have shown that it's possible to calculate this sum using a variation of the Euler characteristic that counts the points, lines, and other simplices in the Rips complex not just once each but according to how many boats that each sensor can see. For example, if a given sensor can see five targets, it gets counted five times. Other simple rules apply to the lines and higher-dimensional simplices of the Rips complex.

> "We want to make sure that when these networks come into existence, the math is there and ready to use."
>
> — ROBERT GHRIST, UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

This Euler-characteristic sum yields the total number of targets. The sensors can collectively carry out the calculations by comparing boat counts with those of their neighbors and by performing some straightforward arithmetic.

"There's no complicated homology computation here," Ghrist says. "This should be very implementable using simple sensors."

Topological methods are expected to be useful to a host of other sensor-network problems. "I think mathematicians are really starting to take seriously the possibility that they could help us," says Daniel Koditschek, who studies robotics and sensor networks at the University of Pennsylvania. "It's extremely exciting."

Sensor networks complicated enough to require topological analysis are right around the corner, Ghrist predicts.

"The field of sensor networks is changing very rapidly, with the kinds of stuff we're able to build growing at an exponential rate," he says. "We want to make sure that when these networks come into existence, the math is there and ready to use." ■

OF NOTE

COMPUTERS

Lost in transportation

Online map programs such as MapQuest or Google Maps have made it easier for many people to plan road trips. But to handle large numbers of requests for driving directions, such systems often don't search the entire range of possible routes, says Dominik Schultes, a computer scientist at the University of Karlsruhe in Germany. For example, the systems may overlook shorter routes for the sake of following major highways, he says.

Schultes and his collaborators have now invented an algorithm that can efficiently deliver the best directions with mathematical certainty—save for traffic jams—the researchers say.

Schultes says that the new algorithm exploits a common-sense observation no other algorithm had used before: Each route into or out of a city typically passes through one of a handful of major intersections.

The new algorithm works out the location of such traffic nodes. It then plots individual routes by calculating how to get to the most convenient node from a specified starting or finishing point. The result appears in the April 27 issue of *Science*.

Andrew Goldberg of Microsoft Research in Mountain View, Calif., agrees with Schultes' group that the new algorithm could improve map programs for travelers. —D.C.

AGRICULTURE

Bugged wines

An Asian ladybug with an appetite for bruised grapes has been spreading throughout the United States since 1988. Canadian researchers confirm that the foul-smelling chemicals that these bugs secrete can easily spoil an entire vintage. The researchers also describe a treatment that they're investigating for such ladybug-tainted wine.

Chemists had suspected that the ladybugs' recently identified stinky ingredients, called methoxypyrazines, were mingling with grape juice at harvest time, giving wine the taste and aroma of peanuts, bell peppers, and asparagus—a mixture unlikely to captivate oenophiles. Lesser quantities of the chemicals are also present in "green" wines made from immature fruit.

In an upcoming *Vitis*, researchers at Brock University in St. Catharines, Ontario, report finding that just 200 to 400 ladybugs (*Harmonia axyridis*) per metric ton of harvested grapes can foul a batch of wine. Depending on the bugs' methoxypyrazine output, an infestation of as few as two beetles per grapevine can destroy the harvest, notes team leader Gary J. Pickering.

The Ontario group has now found a protein additive that binds with methoxypyrazines to create a substance that can be removed from a wine vat. The prob-

lem, Pickering explains, is getting the system to operate efficiently in the presence of wine's alcohol and acidity—"quite an aggressive environment for a protein." An effective methoxypyrazine-removal system could, however, salvage "millions of liters of green or bad vintages" in North America each year, Pickering says. —J.R.

ANTHROPOLOGY

Kin play limited role in chimp cooperation

Male chimps collaborate in a variety of ways and, like people, often find partners outside of their immediate families for cooperative ventures, according to a long-term study of these creatures in the wild.

Kevin E. Langergraber of the University of Michigan in Ann Arbor and his colleagues spent a total of 20 months between 1999 and 2005 observing cooperative acts between pairs of adolescent and adult male chimps living in a large community in Uganda's Kibale National Park. Observed collaborative behavior among the 36 to 41 animals in the group at various times included hunting, sharing meat, mutual grooming, and defending territory against males from other groups.

The researchers also conducted extensive genetic analyses of each animal to determine which males were maternal or paternal siblings.

A majority of collaborating male-chimp pairs consisted of unrelated or distantly related individuals, the researchers report in an upcoming *Proceedings of the National Academy of Sciences*. When male chimps did cooperate with immediate family members, they almost always chose a maternal brother. —B.B.

EARTH SCIENCE

Lake Superior is warming faster than its local climate

In recent decades, the waters of Lake Superior have warmed significantly faster than have air temperatures at nearby sites onshore—a trend caused at least in part by a long-term decrease in the lake's winter ice cover, scientists say.

Between 1979 and 2006, the average summertime air temperature at 31 sites within 500 kilometers of the center of Lake Superior rose about 1.5°C, says Jay A. Austin, a geophysicist at the University of Minnesota in Duluth. During the same period, however, the average summertime temperature of the lake's surface water, as measured by instruments on three buoys, jumped about 2.5°C. "It is a remarkably rapid rate of change, and it is surprising," Austin notes.

At least two factors have conspired to boost the lake's temperature, he and his colleagues report in the March 28 *Geophysical Research Letters*. First, the area of Lake Superior that was covered by ice between Dec. 1 and May 31 dropped, on average, about 0.42 percent per year between 1979 and 2005. Because dark, open waters absorb more solar radiation than ice does, the date on which surface water reaches 4°C—the temperature at which it reaches maximum density and sinks, thereby mixing the lake's waters—comes nearly 2 weeks earlier now than it did in 1979. Afterward, layers remain stable and surface waters begin to warm.

The second major factor has been warmer summertime air temperatures. The earlier onset of lake-water turnover combined with warmer air have brought about the surprisingly rapid surface warming in the lake, the researchers suggest. —S.P.

ZOOLOGY

Spider blood fluoresces

Fluorescence under ultraviolet light seems to be a widespread trait among spiders, say researchers who have done the first broad survey of spiders for this property.

The researchers tested blood from representatives of 10 diverse families and found that while under ultraviolet (UV) illumination, all samples glowed blue to human eyes, says Susan Masta of Portland State University in Oregon. In a wider survey of 19 spider families, at least one species from each family displayed glowing hairs or some other external fluorescence.

SPECIAL GLOW ***Enoplognatha ovata*** **glows when bathed in ultraviolet light.**

Masta says that the project began serendipitously when she and her colleagues turned off the lights while calibrating an instrument that illuminated a spider with UV light. The UV made bits of the spider's body fluoresce—that is, absorb one wavelength and emit another. Some of the emitted wavelengths fell within the range of human vision, and Masta noticed spider hairs glowing in the dark.

Masta and her colleagues found that hemolymph, the spider version of blood, fluoresced even in species that have no external fluorescent body parts. Previous studies by other researchers had found fluorescence in only a few species (*SN: 2/10/07, p. 94*)

The external patterns varied widely. Emitted wavelengths, in UV as well as in visible light, differed among species, suggesting that spiders carry a variety of fluorescing compounds and that some individuals have more than one compound, Masta says.

Many spiders have limited vision, so Masta doubts that the light communicates much among them. Masta says that it's too early to tell whether the fluorescence makes them more or less conspicuous to predators.

The team reports its findings online and in an upcoming *Biology Letters*. —S.M.

PLANETARY SCIENCE

A solar forecast

Solar activity, which waxes and wanes in an 11-year cycle, will most likely begin its next round in March 2008 and peak sometime between late 2011 and mid 2012, predicts the National Oceanic & Atmospheric Administration's (NOAA) Space Environment Center in Boulder, Colo.

During the peak of activity, eruptions such as solar flares and coronal mass ejections hurl X rays, ultraviolet light, and billion-ton clouds of charged particles into space. If these outbursts head toward Earth, they can disrupt the planet's ionosphere and pierce Earth's protective magnetic bubble, potentially knocking out power grids, disturbing satellites, and harming space-walking astronauts. An especially active solar cycle shows up as abundant sunspots—relatively cool blotches of concentrated magnetic activity.

A panel of solar scientists convened by NOAA initially expected that the next solar cycle, to be the 24th on record, would already have started by last fall. However, the current solar cycle has faded more slowly than predicted.

Although the panelists now concur on when the next cycle will begin, they disagree on how intense it will be. Half the panel, basing its prediction primarily on the intensity of the sun's polar magnetic field during the past few months of the current cycle, forecasts a moderately weak next cycle. The panel's other half, considering properties of the past few cycles such as the surface flow of the sun's magentic field, predicts a moderately strong cycle. The panel announced its split decision April 26 in Boulder at NOAA's annual workshop on space weather. —R.C.

A. COLEMAN-HULBERT

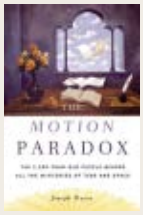
Books

A selection of new and notable books of scientific interest

THE MOTION PARADOX: The 2,500-Year-Old Puzzle behind All the Mysteries of Time and Space

JOSEPH MAZUR

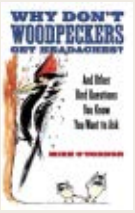
The Greek philosopher Zeno proclaimed in four famous paradoxes that motion is an illusion. To date, philosophers and scientists from Aristotle to modern-day string theorists have been unable to fully understand motion and its foundations: space and time. Mazur chronicles the conundrum that Zeno created and the theories that have arisen about the nature of the universe. He explains how Aristotle believed that heavy objects fall faster than lighter ones, only to be proved wrong by Galileo. The author explains discoveries about the motion of the planets and the development of coordinate geometry and calculus, which still didn't solve the mystery of motion. He also outlines the space-time revolution, Albert Einstein's theories of relativity, and the development of quantum theory and string theory. ***Dutton, 2007, 262 p., hardcover, $24.95.***



WHY DON'T WOODPECKERS GET HEADACHES? And Other Bird Questions You Know You Want to Ask

MIKE O'CONNOR

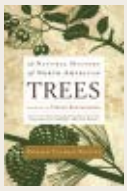
Where should I put my bird feeder? Do birds like peanuts? Do ostriches really bury their heads in the sand to hide? O'Connor, the author of the Cape Coder newspaper column "Ask the Bird Folks," tackles these and other serious and not-so-serious questions about birds. He addresses topics including backyard bird-watching, concerns about feeding, facts about familiar birds, and how to identify unusual birds. O'Connor helps amateur birdwatchers collect the appropriate gear—beginning with good binoculars—and offer the right food to attract and nourish feathered friends. The author gives advice on where to place birdfeeders, how to keep them clean, and how to fend off squirrels. He also answers basic questions about birds, including whether cardinals mate for life, why some birds sleep standing on one leg, and the difference between a downy woodpecker and a hairy woodpecker. ***Beacon, 2007, 211 p., b&w illus, paperback, $9.95.***



A NATURAL HISTORY OF NORTH AMERICAN TREES

DONALD CULROSS PEATTIE

Published in the 1950s, botanist and naturalist Peattie's two books on trees of North America contained some of the most influential nature writing of the time. This new book combines and updates those classics while maintaining the poetry of Peattie's original descriptions. More than offering a field guide, Peattie provides historical and cultural notes about the willows, oaks, elms, magnolias, and other trees that populate the United States. He describes California's majestic redwoods, detailing how Spanish settlers discovered those trees' wood to be perfect for the beams of churches and how the timber was eventually used throughout the United States. The book includes arcane details such as that Charles Darwin believed the oak tree to be the apex of plant evolution. Throughout the book, Peattie paints a picture of how trees influenced the early development of this country, and he laments the destruction and waste of America's forests. The book retains the detailed etchings that illustrated the original volumes. ***Houghton Mifflin, 2007, 490 p., b&w illus. hardcover, $40.00.***



100 BUTTERFLIES AND MOTHS: Portraits from the Tropical Forests of Costa Rica

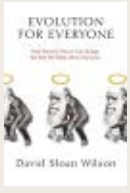
JEFFREY C. MILLER, DANIEL H. JANZON, AND WINIFRED HALLWACHS

From the authors of *100 Caterpillars: Portraits from the Tropical Forests of Costa Rica* (2006, Harvard) comes this new book dedicated to the moths and butterflies of the Guanacaste Area of Conservation. The reserve is a wild area in the northwestern portion of Costa Rica, equal in size to New York City and its suburbs. This book presents the site's winged beauties in vivid detail. Wings with striking colors and markings not only keep the insects aloft, but also transmit a variety of messages, serve as camouflage, and attract mates. The authors present a compilation of the 28 years of research that they've conducted in the conservation area with the aid of local lepidoptera collectors. Details emerge of moth and butterfly behavior, their metamorphoses, the conservation area's environment, and the effort that goes into identifying and classifying these animals in both their caterpillar and adult stages. The book also presents 100 moths and butterflies, one per page, set on black backgrounds that emphasize the insects' colors. ***Belknap Press, 2007, 256 p., color images, hardcover, $39.95.***

EVOLUTION FOR EVERYONE

DAVID SLOAN WILSON

Wilson, a professor of biology and anthropology, explains how the theory of evolution can explain behavior in contexts from biology to religion to politics. People are still under the influence of evolution, Wilson writes, and their behavior is the result of natural selection on ancestral species. Keeping in mind that adaptation routinely results in behaviors that are not benign and may seem at odds with environmental demands, Wilson uses evolutionary theory to explain many human experiences. For example, he cites research suggesting that a woman's morning sickness during pregnancy is an adaptation that protects her fetus from toxins. Even the seemingly negative behaviors of many inner city youths, such as early pregnancy and violent conflict, can be viewed as adaptive responses to the pressures of an urban lifestyle. ***Delacorte, 2007, 390 p., hardcover, $24.00.***



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LETTERS

Mere kats?

"Science behind the Soap Opera" (*SN: 3/3/07, p. 138*) shows that meerkats bear an uncanny resemblance to human beings. We, too, have an innate sense of responsibility for our group and individually commit acts of unspeakable violence.

JOHN HAGERHORST, FREDERICK, MD.

Just a dram

"Natural-Born Addicts: Brain differences may herald drug addiction" (*SN: 3/3/07, p. 133*) describes an elegant study. I found the 7 percent addiction-susceptible figure interestingly similar to the 10 percent of people who drink alcohol who become addicted. I wonder if similar percentages of other species are impulsive and vulnerable.

ELLEN WAGGENER, POUGHKEEPSIE, N.Y.

Back to the future

"Fixes for Fatty Liver" (*SN: 3/3/07, p. 136*) mentioned choline as a possible treatment. This is not a new idea, as I found while searching the *Science News* Web site: In the June 22, 1935, issue, choline is reported as "a new aid in controlling diabetes." Dr. C.H. Best, codiscoverer of insulin, reported the new finding.

DANIEL VANCE, CLEVELAND, TENN.

The worst part

Among estrogenic pollutants ("Traces of Trouble," *SN: 3/10/07, p. 152*), by far the worst offender is 17-alpha ethinyl estradiol, the most common estrogen in oral contraceptives used by tens of millions of women. This synthetic steroid is of necessity nonbiodegradable, at least by human liver. Otherwise, it would not work as a pill.

JOEL BRIND, CITY UNIVERSITY OF NEW YORK, NEW YORK, N.Y.

But are they sopranos?

A better title for "Mafia Cowbirds: Do they muscle birds that don't play ball?" (*SN: 3/10/07, p. 147*) might be "Mendelian Cowbirds." By reducing the number of successful hatches and subsequent offspring of any parent birds that kick the interlopers' eggs out of their nests, the cowbirds are (unintentionally) reducing the expression of that behavior in the next generation of potential foster families.

W. GREGORY STEWART, LOS ANGELES, CALIF.

Correction *"Not-So-Perma Frost"* (SN: 3/10/07, p. 154) *understated by half the energy needed to melt a particular quantity of ice. It takes about 160 times, not 80 times, the energy that's needed to raise the ice's temperature from –1°C to 0°C.*

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