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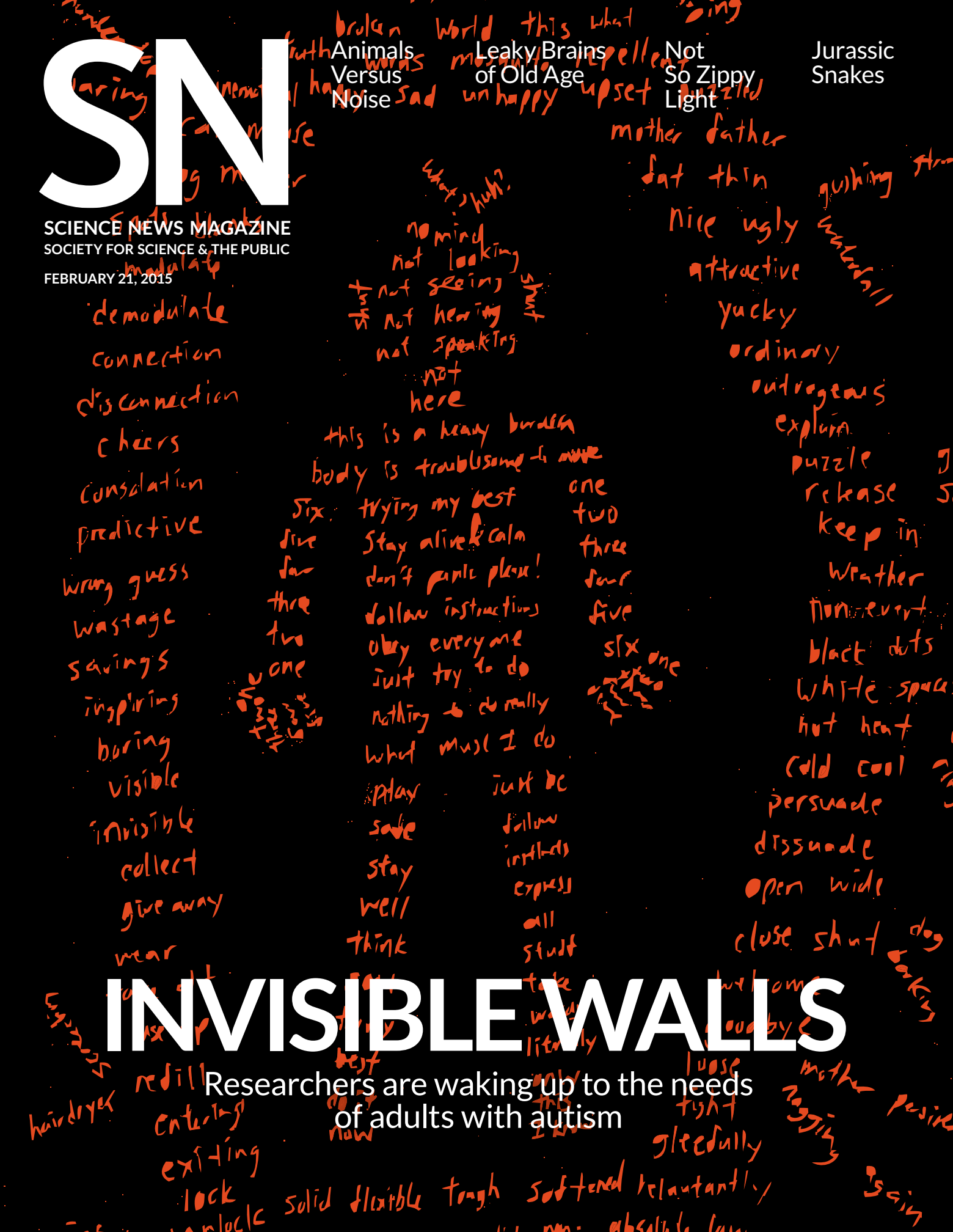
FEBRUARY 21, 2015

Animals Versus Noise

Leaky Brains of Old Age

Not So Zippy Light

Jurassic Snakes



INVISIBLE WALLS

Researchers are waking up to the needs of adults with autism

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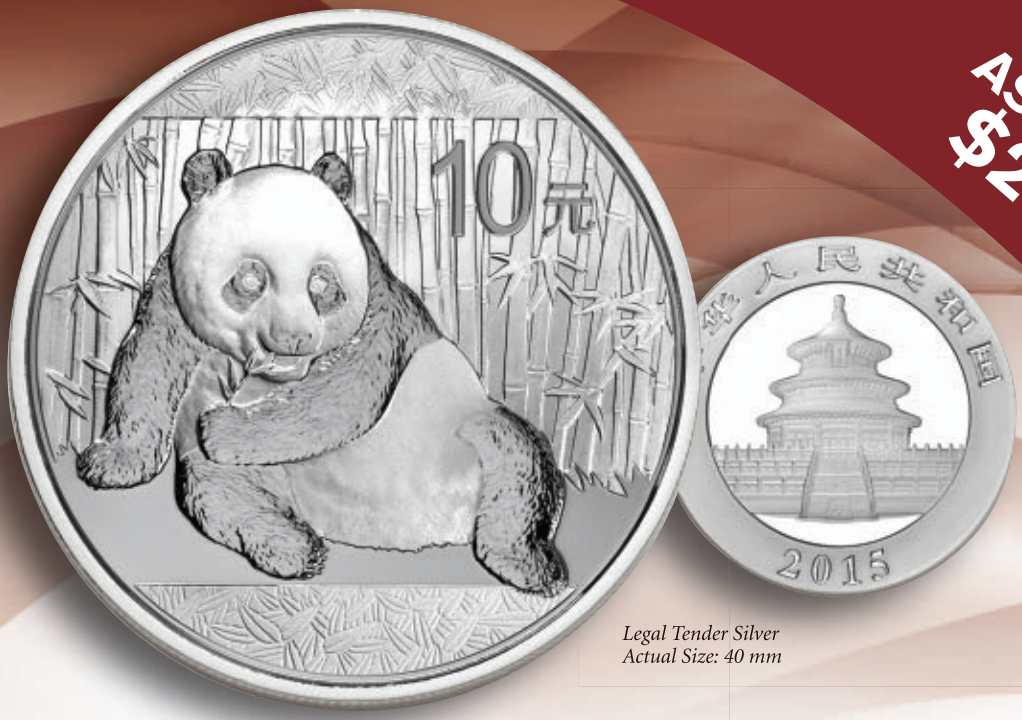

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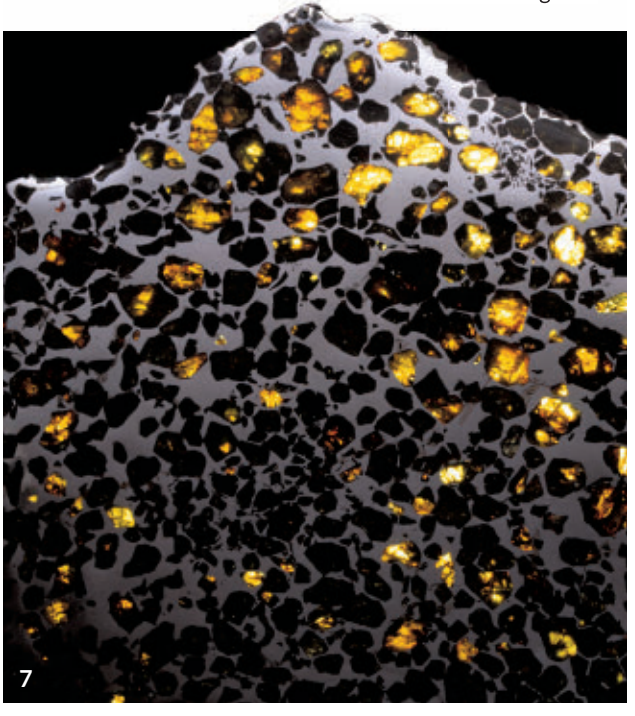
ScienceNews

22

Features

News



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Departments

COVER "Armour of Words" was created by a Singapore artist and author with autism who publishes his work at iautistic.com. *Eric Y. Chen*

Finding joy and inspiration in the pursuit of knowledge

When I was young, my great uncle Joseph Seruto (a Sicilian immigrant, chemist and father of five) drew diagrams to emphasize just how important it was to apply myself in school. He drew arrows leading from "knowledge" to "power" to "happiness." Studying, he said, was the key to building the knowledge that would throw open the gates to possibility and a contented life.

As freelancer Siri Carpenter writes on Page 16, it's clear that a lack of knowledge about how to best help adults with autism leaves caregivers and professionals feeling powerless. As the number of children diagnosed with autism spectrum disorders rises, finding ways to assist them with the transition to adulthood and building meaningful lives takes on a new urgency. Luckily, scientific studies are now beginning that should point to ways to help adults with autism navigate the challenges they face. Knowledge *is* power.

Of course, as we learn in every issue, knowledge is not written in stone. It's a shifty beast, and pursuing it is at least half the fun. On Page 6, for example, readers will learn that comets are not the dirty snowballs once imagined, but complex objects with stories to tell. On Page 7, we learn that the speed of light should be considered a speed *limit* of light, not always its actual velocity, even in a vacuum. On Page 8, the highly protective blood-brain barrier takes a hit: Its breakdown with age might play a role in dementia.

An inspiring tale about creating new knowledge is hidden on Page 13, in a story about the latest wrinkle in the search for primordial gravitational waves. The amazing discovery announced last year, it seems, is not. At least not yet. There's not enough evidence to conclude that those ancient gravitational waves exist. Dust mimics the signal, as we have reported before. But this is not all bad news. This is how science is supposed to work. Two teams — one that had claimed the discovery, and one that had questioned it — worked together to find the truth, through rational evaluation of the evidence. Their cooperation is a model for the rest of us. It speaks to the human capabilities we engage whenever we use logic to build knowledge. As my Uncle Joe would say, that's powerful. — *Eva Emerson, Editor in Chief*

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SANDY SCHAFFER

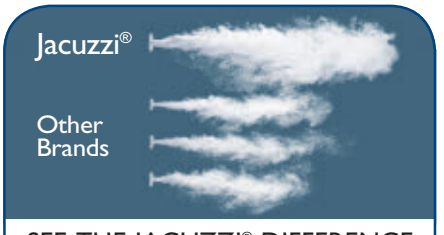
Technology Breakthrough | Safe, comfortable bathing from Jacuzzi®

Enjoy A Bath Again… Safely and Affordably

The Jacuzzi® Hydrotherapy Walk-In tub is luxurious, feature-packed and affordable

There is nothing like the simple pleasure of taking a warm bath. The cares of the day seem to fade away, along with the aches and pains of everyday life. Unfortunately for many aging Americans with mobility issues, slipping into a bath can result in slipping onto the floor. The fear of falling has made the simple act of bathing and its therapeutic benefits a thing of the past until now. Jacuzzi®, the company that perfected hydrotherapy, has created a walk-in tub that offers more than just safe bathing, peace-of-mind and independence, it can actually help you feel better.

Unlike traditional bathtubs, this Walk-In Tub features a leak-proof door that allows you to simply step into the tub rather than stepping precariously over the side. It features a state-of-the-art acrylic surface, a raised seat, and the controls are within easy reach. No other Walk-In Tub features the patented Jacuzzi® PointPro® jet system. These high-volume, low-pressure pumps feature a perfectly balanced water to air ratio to massage thoroughly yet gently. Some swirl, some spiral, some deliver large volumes of water and others target specific pressure points. They are all arranged in precise locations designed to deliver a therapeutic massage, yet they are fully adjustable so that your bathing experience can be completely unique.



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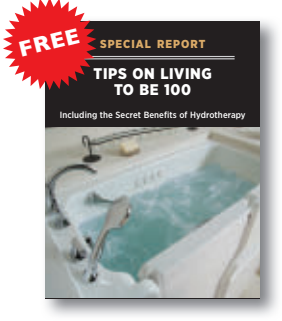

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Excerpt from the February 20, 1965, issue of *Science News Letter*

50 YEARS AGO

Carbon traces changes

Fallout from nuclear bomb tests is allowing University of California at Los Angeles scientists to develop a new method for tracing vital chemical and physical changes in the human body. Radioactive carbon increased by "dirty" H-bombs of 1961–62 opens up a way for measuring the metabolic turnover rate of tissue in the brain, heart, liver and blood stream, without endangering the human subject.... The new technique may give life scientists a new and simple way of studying the formation and decay of tissues and cells.

UPDATE: Doctors routinely use radioactive atoms to check for cancer, heart disease and other illnesses. The best-known example is positron emission tomography, or the PET scan. Patients swallow a tracer — a radioactive carbon, nitrogen, oxygen or fluorine fastened to a carrier molecule — or have it injected. A scanner tracks this tiny amount of radioactive material through the body, creating images that reveal how organs and tissues are functioning.

IT'S ALIVE

Fairly bad pitcher traps triumph in the end

Incompetent, says who? Carnivorous pitcher plant traps rarely catch much, but their lackadaisical hunting turns out not to be so lame after all. Ask the ecologist who set up hospital IV drips to test *Nepenthes rafflesiana* traps in the shrubbery of Brunei.

Biologists have observed that pitcher plants "have pretty lousy traps," says Ulrike Bauer of the University of Bristol in England. Captured nutrients give them the edge in difficult environments, but "most of the time when you look into a trap, there's hardly anything there."

Interest in poor trap performance intensified in 2004, when researchers reported being at the right pitcher at the right time. As it began to rain, ants that had been safely scurrying over the fat, nectar-rich collars along the rim of a pitcher started slipping into the

MYSTERY SOLVED

Earth's magnetic field guides sea turtles home

Loggerhead sea turtles traverse entire oceans in search of jellyfish and other food. But at nesting time, they always find their way back to the very stretch of coast where they hatched.

Now scientists know how the turtles (*Caretta caretta*) accomplish the feat: They recognize their home turf using Earth's magnetic field, which varies across the globe.

Although long suspected, this hypothesis had been challenging to test. J. Roger Brothers and Kenneth Lohmann of the University of North Carolina at Chapel Hill realized that if turtles homed in on beaches' unique magnetic signatures, their nests should migrate in response to subtle natural changes in the geomagnetic field. Over 19 years, the scientists found that the nests of sea turtles in Florida shifted along with gradual changes in magnetic fields: The nests clustered more densely in places where magnetic signatures got closer together and spread out where signatures drifted apart, the researchers report in the Feb. 2 *Current Biology*. — *Julia Rosen*

FROM TOP: U. BAUER; J.R. BROTHERS

digestive lake within. The colorful collar, long considered just a lure, actually creates an efficient death trap — when wet.

Young plants with only a few pitchers have an additional slippery surface just below the collars of their traps. But in many *Nepenthes* species, adult plants with abundant pitchers lose the waxy backup and rely entirely on their iffy collars.

Biologists had mused that inefficient traps might exploit the social habits of ants, allowing scouts to taste the nectar, escape and bring back nest mates for a massacre, rain permitting. To test the idea, Bauer set up slow-release tubing to drip water on 46 selected traps of *N. rafflesiana*. "You can believe it looked quite funny to have all these hospital drips out in the field," she says.

When she added up the ants captured during her study, pitchers allowed to dry out naturally caught almost 2½ times as many ants as tumbled into artificially wet traps, Bauer and her colleagues report in the Feb. 22 *Proceedings of the Royal Society B*. A few rainy-day mass captures in natural traps made the difference.

When pitcher plants' traps are dry, ants can swarm over them without slipping in (left).

Trap surfaces that work only when wet also evolved in North American and Australian pitcher plants. Yet "they're about as closely related to the Asian species as you and I are to a flatworm," Bauer says. "Whatever works, nature has discovered at least twice." —*Susan Milius*

SAY WHAT?

Bag of chips effect \BAG uhv CHIHPS ih-fekt\ n.

A circumstance in which the sound of one individual eating alerts others to the location of food. Now researchers have found that hungry bats find dinner by listening for their peers zeroing in on prey. When greater mouse-tailed bats (*Rhinopoma microphyllum*) spot a meal of flying ants with echolocation, they emit a "feeding buzz" made up of many short cries. The bats can hear an insect 10 meters away but can detect a feeding buzz from 100 meters away, a sound that, like a rustling bag of chips, gives away the location of a snack. Then the bats swoop over near a munching fellow and help themselves to other flying ants, researchers report in the Jan. 19 *Current Biology*. —*Kate Baggaley*

FROM TOP: U. BAUER; YALCIN SONAT/SHUTTERSTOCK

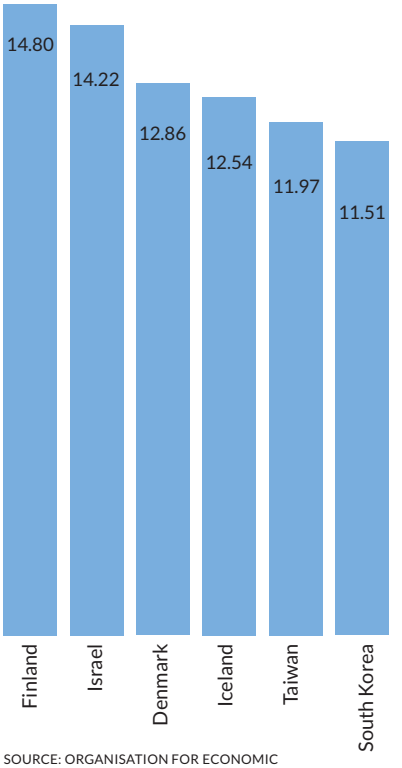
SCIENCE STATS

U.S. research workforce lags by some measures

China and the United States have impressive armies of science and engineering researchers. In 2011, the most recent year for which data are available, the two countries boasted the largest numbers employed in these fields, with 1.32 million researchers in China and 1.25 million in the United States.

But some small countries punch far above their weight, with researchers representing a higher fraction of all people employed. At the top, Finland's 40,000 researchers make up 1.48 percent of its whole workforce. The best performer per capita in East Asia is Taiwan, followed closely by South Korea. Ranked by this measure, the United States falls to 17th overall and China to 35th.

Top countries ranked by science and technology researchers per 1,000 employed, 2011



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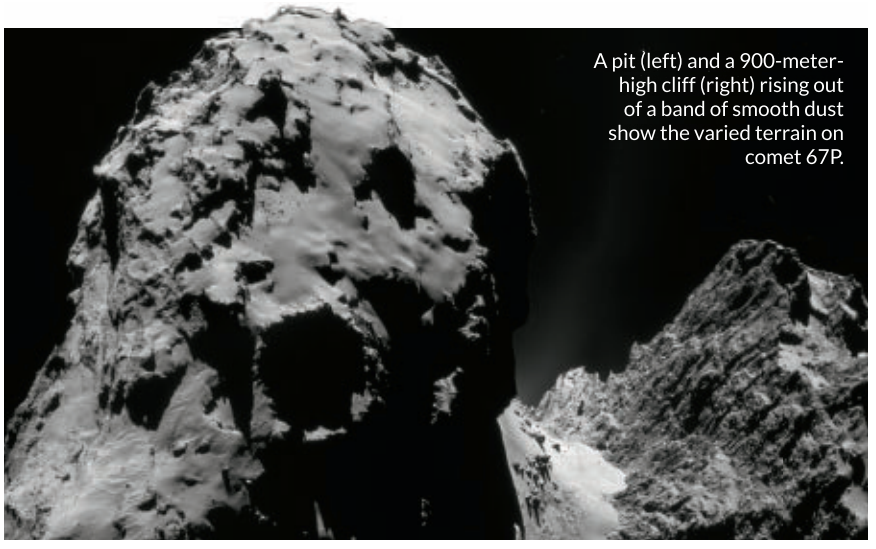
ATOM & COSMOS

Rosetta reveals a complicated comet

Simple 'ice-and-dust' model dashed by images of diverse terrain



A pit (left) and a 900-meter-high cliff (right) rising out of a band of smooth dust show the varied terrain on comet 67P.

BY CHRISTOPHER CROCKETT

It's time to stop thinking of comets as dirty snowballs. The Rosetta spacecraft's first look at comet 67P/Churyumov–Gerasimenko shows a diverse, complex world, shaped by eruptions and erosion, that may hint at what the solar system was like 4.6 billion years ago.

A panoply of textures and structures indicates that comet 67P is not a loose collection of ice and dust, the prevailing image of comets for decades.

"Rosetta has blown the dirty snowball idea out of the water," says planetary scientist Nicolas Thomas of the University of Bern in Switzerland and a member of the Rosetta team.

Previous missions had already hinted that comets were more complex than that. Rosetta, the first spacecraft to orbit a comet, shows a patchwork of terrains weathered by blowing dust and gas eruptions.

The data, presented in seven new papers in the Jan. 23 *Science*, reveal a thin layer of organic compounds dusted over the comet's surface. There's no evidence of surface ice, except for the occasional shiny nugget tucked away in a nook. Smooth plains of dust blanket a fractured, brittle crust, while towering cliffs expose layered bedrock. The entire landscape is littered with circular pits up to 300 meters across — and nearly as deep — carved by gas jets.

Rosetta launched in 2004 and spent 10 years in space before arriving at comet 67P last August (*SN: 9/6/14, p. 8*). In November, Rosetta released its lander, Philae, which subsequently bounced twice on the comet before settling in the shadow of a cliff and shutting down for lack of sunlight to power it (*SN: 12/13/14, p. 6*). Rosetta will monitor the comet during its closest approach to the sun in August.

Data collected through September 2014 are just "our first impression of the comet," says Matt Taylor, Rosetta's project scientist at the European Space Agency's Space Research and Technology Centre in Noordwijk, the Netherlands. This first look provides a reference point that will help researchers understand the changes that occur as the comet moves closer to the sun.

One question Thomas wants to answer is whether the varied terrain says something about how the comet formed. Comets, as well as asteroids and planets, are thought to have formed from tiny dust particles that swirled around the infant sun and stuck together. If the comet was assembled from debris that originated in different parts of the solar system, that might explain the assortment of terrains. But heat from the sun may have reworked the surface as well. With just a few months of data, it's too early to tell.

Thomas says he was surprised to see what appear to be dunes rippling across some of the plains of dust. Dunes are common on Earth and Mars. "But to see them on a comet where there's no atmosphere ... how the hell do you do that?" He wonders if the comet's gas jets, driven by ice heated by the sun and turned into a gas, create winds that can shift dust around.

"You don't get these kinds of landforms on a snowball," says Jessica Sunshine, a planetary scientist at the University of Maryland in College Park. Unlike asteroids, comets appear to be shaped by vaporized ice and occasional gas eruptions, which can remove material entirely or just drop it somewhere else on the surface. "This is a much more complicated beast that we're trying to understand," Sunshine says.

It's great to see all this diversity up-close, says Peter Thomas, a planetary scientist at Cornell University. If comet 67P "were just a fuzzy tennis ball vaporizing, it would be less interesting." The cliffs, for example, appear to cut into the comet's interior, exposing bedrock that may have built up in layers. "This opens up a lot of ways to tease out the history," he says.

Figuring out how that history unfolded will have to wait. Rosetta hasn't seen the entire comet yet; the south pole is still hidden from the sun and won't see light for several more months. Over the coming year, Rosetta will watch the comet change as it heats up, which should let researchers better understand how various terrains formed.

"They picked a really good comet to go to," says Don Brownlee, a planetary scientist at the University of Washington in Seattle. Following 67P as it approaches the sun, he says, "is going to show us how comets really work." ■

MATTER & ENERGY

Speed of light not so constant after all

Structure of pulses can slow down photons, even in a vacuum

BY ANDREW GRANT

Light doesn't always travel at the speed of light. A new experiment reveals that focusing or manipulating the structure of light pulses reduces their speed, even in vacuum conditions.

A paper reporting the research, published online January 22 in *Science*, describes hard experimental evidence that the speed of light, one of the most important constants in physics, should be thought of as a limit rather than an invariable rate for light zipping through a vacuum.

"It's very impressive work," says optical physicist Robert Boyd of the University of Rochester in New York. "It's the sort of thing that's so obvious, you wonder why you didn't think of it first."

Researchers led by optical physicist Miles Padgett of the University of Glasgow demonstrated the effect by racing photons that were identical except for their structure. The structured light consistently arrived a tad late. Though the effect is not recognizable in everyday life and in most technological applications, the new research highlights a fundamental and previously unappreciated subtlety in the behavior of light.

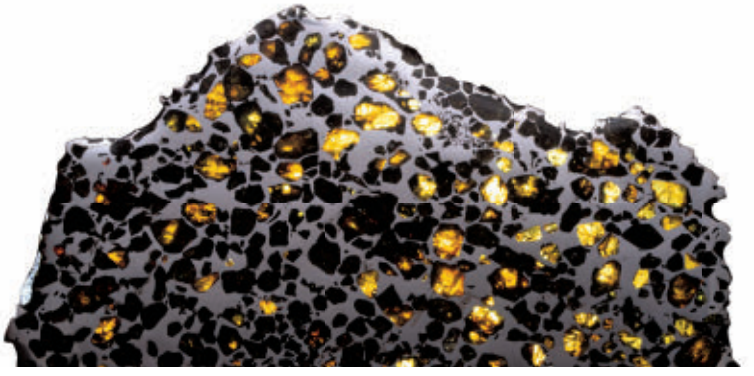
The speed of light in a vacuum, usually denoted c, is a fundamental constant central to much of physics, particularly Einstein's theory of relativity. While measuring c was once considered an important experimental problem, it is now simply specified to be 299,792,458 meters per second, as the meter itself is defined in terms of light's vacuum speed. Generally, if light is not traveling at c, it is because it is moving through a material. Light slows down when passing through glass or water, for example.

Padgett and his team wondered if there were fundamental factors that could change the speed of light in a vacuum. Previous studies had hinted that the structure of light could play a role. Physics textbooks idealize light as plane waves, in which the fronts of each wave move in parallel, much like ocean waves approaching a straight shoreline. But while light can usually be approximated as plane waves, its structure is actually more complicated. For instance, light can converge upon a point after passing through a lens. Lasers can shape light into concentrated or even bull's-eye–shaped beams.

The researchers produced pairs of photons and sent them on different paths toward a detector. One photon zipped straight through a fiber. The other photon went through a pair of devices that manipulated the structure of the light and then switched it back. Had structure not mattered, the two photons would have arrived at the same time. But that didn't happen. Measurements revealed that the structured light consistently arrived several micrometers late per meter of distance traveled.

"I'm not surprised the effect exists," Boyd says. "But it's surprising that the effect is so large and robust."

Greg Gbur, an optical physicist at the University of North Carolina at Charlotte, says the findings won't change the way physicists look at the aura emanating from a lamp or flashlight. But he says the speed corrections could be important for physicists studying extremely short light pulses. ■



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ATOM & COSMOS

Asteroids generated long-lasting magnetism

Ancient meteorites reveal that young asteroids may have generated powerful magnetic fields for hundreds of millions of years longer than once thought. The finding could explain long-lasting magnetism elsewhere in the early solar system, such as on the young moon (*SN Online: 12/4/14*).

James Bryson of the University of Cambridge and colleagues examined two South American meteorites (one shown) chipped off from asteroids roughly 400 kilometers wide. While forming billions of years ago, tiny pockets of iron and nickel in the meteorites aligned with their parent asteroid's magnetic field, providing a datable snapshot of the magnetism. Inspecting the iron and nickel using X-rays, the researchers discovered that each asteroid parent produced a strong magnetic field for well over 100 million years.

This is longer than can be explained by heat mixing an asteroid's molten interior and generating a magnetic field, which would last at most 10 million to 50 million years until the rock cooled.

The team proposes in the Jan. 22 *Nature* that as an asteroid's core solidifies, lighter elements such as sulfur push outward and form swirling patterns. The swirling can sustain the magnetic field for as much as 350 million years after the asteroid has cooled too much for thermal convection. — *Thomas Sumner*

BODY & BRAIN

Brain's protective barrier disintegrates as people age

Accelerated deterioration of blood-brain wall may play role in memory loss, learning problems

BY ASHLEY YEAGER

Time can wear down the sturdiest walls, even the one that protects the brain from bad stuff in the blood. This blood-brain barrier breaks down with age, possibly playing a role in Alzheimer's disease, a new study suggests.

Images in the Jan. 21 *Neuron* show direct evidence that aging influences the breakdown of the blood-brain barrier and that accelerated deterioration could contribute to learning and memory problems later in life.

Researchers in California detected the deterioration in high-resolution MRI scans of the brains of living people. Younger brains weren't as leaky as older brains, specifically in regions crucial for learning and memory. The images also revealed that older people with slight memory and learning difficulties had substantially more blood-brain barrier deterioration than healthy people of similar ages.

"This is a major advance," says neuroscientist Costantino Iadecola of Weill Cornell Medical College in New York City. Previous studies had suggested that the breakdown in the blood-brain barrier was linked to aging and memory problems, but that connection had not been shown in the brains of living people. "Now it has, and we have to put this thing back up on the board as a factor contributing to dementia," Iadecola says.

The blood-brain barrier is made up of sets of cells that zip tightly together around blood vessels in the brain. This firmly sealed layer creates a nearly impenetrable fortress that keeps potential toxins in the blood out of the brain. Tracking whether certain compounds breach the seal offers clues to the barrier's leakiness.

A group led by neuroscientist Berislav Zlokovic of the University of Southern California in Los Angeles tracked the chemical element gadolinium in MRI brain scans. Imaging the brains of healthy people ages 23 to 91 showed that the blood-brain barrier's leakiness begins in the hippocampus, a region crucial for learning and memory, and was greater in older brains. In people ages 55 to 85 who had mild learning and memory difficulties, the disintegration of one region in the hippocampus was 53 percent greater than in healthy people of similar ages.

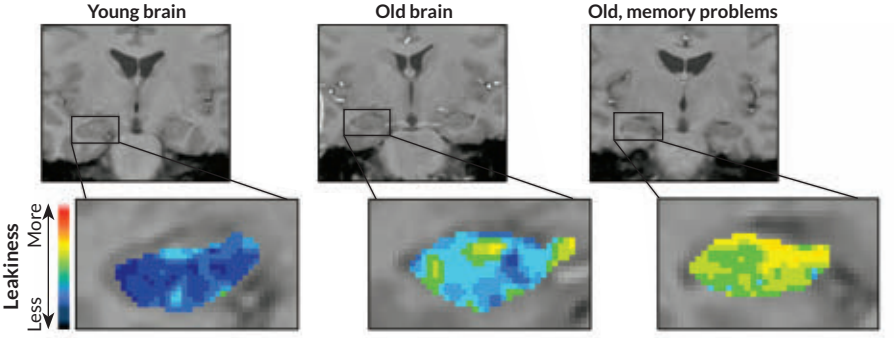
"Focusing on the damage of the blood-brain barrier shows that it is an important factor possibly initiating changes in the brain that lead to dementia," Zlokovic says.

His team's images also showed that the breakdown of the barrier was linked to damage to pericyte cells, which are part of the blood-brain wall. These cells rely on a protein called platelet-derived growth factor beta to divide and safeguard the brain. More leakage in the blood-brain barrier was associated with more of the protein in the brain, suggesting that damaged pericytes didn't collect the protein, but let it pass into the brain instead. People with mild memory and learning problems had 115 percent more of the protein in their brains than healthy people of similar ages.

Cultures of pericyte cells also shed the protein when exposed to a lack of oxygen or high levels of peptide plaques called amyloid-beta, which have both been linked to Alzheimer's disease. The results suggest that aging may lead to damage to pericytes, which may ultimately cause the disintegration of the blood-brain barrier.

"This is very important work," says Gary Rosenberg, a clinical neuroscientist at the University of New Mexico in Albuquerque. What still needs to be determined, he says, is at what stage in the development of dementia due to Alzheimer's disease these changes in the blood-brain barrier may occur.

It's now the classic chicken-or-egg problem, Iadecola says. Alzheimer's disease could lead to the buildup of amyloid-beta and damage the blood-brain barrier. Or the barrier could break down first, contributing to the buildup of the plaque and the development of dementia. The next step, he says, would be to look at the blood-brain barrier's deterioration in people at different stages in Alzheimer's and see if changes happen before or after the accumulation of amyloid plaques associated with the disease. ■



A. MONTAGNE *ET AL*/*NEURON* 2015

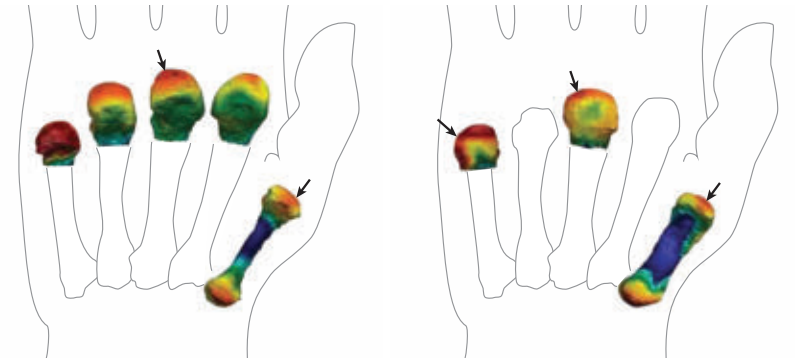
Crossing over The barrier that protects the brain from toxins in the blood deteriorates with age, new MRI scans reveal. In older people, the blood-brain barrier is leakier (indicated by green and yellow) in the hippocampus than it is in younger people. And for older people with mild memory impairment, the wall is even leakier in this brain region, which is important for memory and learning. This breakdown of the barrier may contribute to Alzheimer's disease, scientists say.

HUMANS & SOCIETY

Scans push back origins of tool use

Ancient fossils contain inner signs of humanlike hands

BY BRUCE BOWER



High concentrations of spongy bone (red, indicated by arrows) in *A. africanus*' knuckles are similar to that of humans, suggesting that the capacity for toolmaking evolved by 2.8 million years ago.

Members of the human evolutionary family possessed hands capable of making tools at least 200,000 years before the earliest evidence of stone implements.

Fossil hand bones of *Australopithecus africanus*, dating to as early as 2.8 million years ago, display an inner structure associated with grips needed for wielding tools, anthropologist Matthew Skinner of the University of Kent in England and his colleagues report in the Jan. 23 *Science*. *A. africanus* lived in South Africa from roughly 3 million to 2 million years ago.

The oldest known stone artifacts come from a 2.6-million-year-old site in East Africa. Either *Homo habilis* or another species called *Australopithecus garhi* may have created those cutting implements. Due to the skill involved in making those tools, anthropologists generally assume that toolmaking originated considerably earlier than that.

"We finally have evidence of what was long suspected, that australopithecines used humanlike hand proportions to handle objects in humanlike ways," comments anthropologist Brian Richmond of the American Museum of Natural History in New York City.

The problem in proving this suspicion has been finding ways to identify fossil markers of the potential for toolmaking. Skinner's team used a scanning device to analyze the 3-D structure and density of spongy trabecular tissue that grows beneath bones' hard outer layers. Spongy tissue gets molded by pressure produced during manual activities.

The team compared scans of *A. africanus* with scans of apes and more modern peoples. Humans and Neandertals had hands capable of holding items between the thumb and fingertips and gripping objects with the thumb and palm.

A. africanus fossils have concentrations of spongy bone at the base of the thumb and in the knuckle of the third finger, a pattern found in humans and Neandertals. Modern apes show a different pattern, consistent with tree climbing and knuckle-walking. ■

GENES & CELLS

Environment steers immune system

Genes play lesser role in influencing variations in immunity

BY TINA HESMAN SAEY

Environmental factors shape the immune system's reactions more than genes do, a study of twins suggests. As people age, the effect of the environment on their immune systems grows even stronger, researchers report in the Jan. 15 *Cell*.

In the study, 58 percent of the variation measured in immune system responses was almost completely determined by nonheritable factors, such as exposure to microbes.

The study may improve understanding of how genes and the environment interact, and why some people get asthma, allergies or autoimmune diseases.

"It's not negating that genetics can play a big role," says immunologist Mark Davis of Stanford University. "We're saying that inherited influences, genes, are not the whole story."

Genes can predispose people to develop immune disorders, such as asthma and type 1 diabetes. But not everyone who inherits a genetic susceptibility develops the disorder. This study and others suggest that it also takes an environmental trigger, such as an infection, to set off the disease, says immunologist Janko Nikolich-Zugich of the University of Arizona in Tucson.

Davis and colleagues studied 210 healthy twins ranging in age from 8 to 82. Twins are often used to determine how much influence genes have on traits. Identical twins have nearly identical genetic makeup, while fraternal twins, like nontwin siblings, share about 50 percent of their genes. When a characteristic is more similar in identical twins than in fraternal twins, it indicates genetics plays a bigger role than environment.

The team measured 204 immune system characteristics, including numbers of various types of immune cells, levels of immune chemicals and proteins in the blood, and reactions to flu vaccines. Environment played the strongest role in 77 percent of the traits and is probably the sole determinant for 58 percent of them.

Genes had a larger impact on the immune reactions of younger identical twins. But environmental factors swamped that influence as twins aged and lived apart.

"The [study's] scale is absolutely stupendous," says Stephen Kingsmore, a geneticist at Children's Mercy Hospital in Kansas City. But there are caveats, he says. The team looked at healthy people. But genes may be more important in people who inherit autoimmune disorders. ■

M.M. SKINNER *ET AL*/*SCIENCE* 2015, ADAPTED BY E. OTWELL

MATTER & ENERGY

Spikes explain alkali explosions

Before a blast in water, metals bristle and electrons escape

BY BETH MOLE

Lights, camera, kaboom! With snapshots from a high-speed camera, chemists can finally explain why sodium and other alkali metals blow up in water.

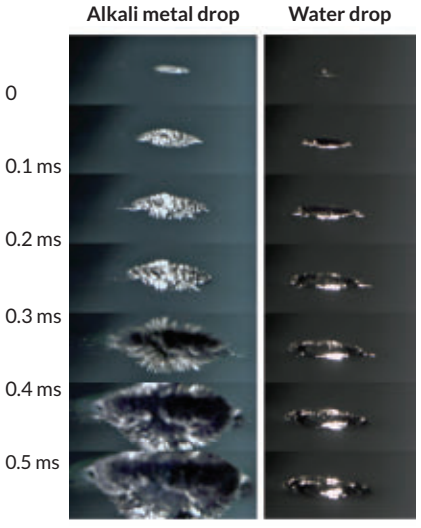
Just before the explosion, spikes burst from the metal's smooth surface, setting off a chain reaction that ignites the metal. The blast's film debut, appearing online January 26 in *Nature Chemistry,* offers a long-awaited explanation of a classic chemical reaction demonstrated in classrooms worldwide.

"What we found out is that there's a crucial piece of the puzzle that precedes the explosion," says Pavel Jungwirth, a chemist at the Academy of Sciences of the Czech Republic in Prague.

In textbooks, chemists describe the reaction in simple terms. Alkali metals, including potassium and sodium, are highly reactive. In water, the metals jettison electrons, generating heat. Once afloat, these electrons attack water molecules, breaking off hydrogen atoms to form explosive hydrogen gas. The gas then ignites in the newly generated heat.

For electrons to jump ship, the metal and water have to be in direct contact. But Philip Mason, a chemist working with Jungwirth, theorized that before enough heat could build to ignite the hydrogen gas, the extra warmth would also create steam from the surrounding water. A blanket of vapor on the metal would block fleeing electrons and halt the heat-up. The chemical reaction, Mason reasoned, should smother itself.

Mason, Jungwirth and colleagues filmed the explosion of an alloy of sodium and potassium with a camera capable of snapping over 30,000 images per second.



High-speed images show spikes forming on an alkali metal's surface 0.35 milliseconds after it hits water and explodes. For comparison, a water droplet plunges into water.

The researchers held a 100-milligram glob of the alloy a meter above a pool of water, then let it drop. At 0.5 milliseconds after the metal touched the

GENES & CELLS

New way to corral modified microbes

Engineered bacteria rely on human-made molecules to survive

BY KATE BAGGALEY

Scientists have engineered a new way to genetically modify microbes so they are less likely to spread uncontrollably in the wild and wreak havoc. By creating bacteria that require molecules not found in nature to survive, the scientists have set the stage for a safer way to use genetically modified bacteria to make medicines, fuels and other chemicals.

Two teams of researchers separately used *E. coli* as a test case, engineering the bacterium to depend on human-made versions of amino acids, the researchers report online January 21 in *Nature*. Amino acids link together to form proteins.

The new method drastically cuts the likelihood of genetically engineered bacteria escaping into the environment, says Floyd Romesberg, a synthetic biologist at Scripps Research Institute in La Jolla, Calif. The dependence on synthetic amino acids "really creates a firewall between the cell's life and its natural environment."

> The technique may boost genetically modified bacteria's usefulness.

One research group, led by Farren Isaacs of Yale University, engineered bacteria to build proteins necessary for survival only when exposed to a human-made amino acid. Bioengineer Christopher Voigt of MIT says the microbes' reliance on the synthetic molecule is like a car's dependence on tires — it can't run without them.

Bacteria engineered by the other group, led by George Church of Harvard (*SN: 1/12/13, p. 22*), have proteins that cannot fold into their proper shape without the human-made amino acid holding them together. In this case, it's like taking the tires off a car and replacing them with tank treads, Voigt says. "You fundamentally change what it's running on."

Both groups tested their doctored *E. coli* in cultures that lacked the synthetic amino acid, observing them over time to make sure the bacterial colonies could not grow. In neither case did the researchers find detectable amounts of bacteria.

Isaacs' group went a step further and exposed *E. coli* to soil and blood, which the microbes might encounter if used outside the lab. Again, the bacteria failed to thrive.

Church's group mingled engineered *E. coli* with wild *E. coli* to make sure the genetically modified bacteria could not steal DNA that would break their dependence on human-made amino acids.

Previous attempts to keep genetically engineered bacteria in check include "kill switches" that wipe out the bacteria

P.E. MASON *ET AL./NATURE CHEMISTRY* 2015

Watch a video of metal blowing up at **bit.ly/SN_explosion**

water, the explosion was in full swing. But just before that — at 0.35 milliseconds — something weird happened: The metal's smooth surface became spiky, like an angry hedgehog.

The spikes shooting from the surface are pieces of positively charged metal, the chemists say. Once electrons abandon the metal's surface, they leave behind positively charged atoms, which repel each other and create spikes as they leap away. This creates gaps in the surface, exposing underlying atoms to the water. These atoms then lose electrons, creating more positive atoms that form spikes upon spikes. As the metal continually unloads electrons, the heat needed to ignite the hydrogen gas builds up before steam can stifle the explosion. Computer simulations support this explanation.

"It makes sense," says organic chemist Rick Sachleben of Momenta Pharmaceuticals in Cambridge, Mass. He hopes the new finding makes its way into chemistry classrooms and laboratories. ■

when researchers are finished with them. But even with kill switches, altered bacteria have the potential to spread beyond the lab by mutating or swapping DNA with wild bacteria. Engineering bacteria to rely on synthetic compounds "significantly reduces the threat of them ever causing trouble," Romesberg says.

By removing that concern, the new technique may boost genetically modified bacteria's usefulness. "Bacteria have been engineered to produce pharmaceuticals, materials and fuels," says biomedical engineer Karmella Haynes of Arizona State University in Tempe. "Now that bacteria can be designed to stay put in an industrial environment, these new bioproduction technologies can be scaled up."

The new research also lays a foundation for broader uses of genetically engineered bacteria, Isaacs said in a news briefing. The microbes could be used away from controlled industrial environments to boost food production, fight disease or clean up oil spills and landfills. ■

M. CALDWELL

LIFE & EVOLUTION

Snakes crawled among Jurassic dinos

Fossils indicate flexible skulls evolved before legless bodies

BY KATE BAGGALEY

Just call it the Jura-*sssss*-ic period. Newly identified fossils suggest that snakes slithered through much of the golden age of the dinosaurs, a finding that pushes back the fossil record for snakes by about 70 million years.

Ancient skulls with features similar to modern snakes tipped paleontologists off to the new timeline, published January 27 in *Nature Communications*.

The fossils also indicate that snakes evolved their flexible skulls before they stretched out and lost their legs.

"One of the major ideas about the evolution of snakes is that the long body evolved first because it allows constriction, an ancient predation strategy. The highly mobile skull came later," says Krister Smith, a paleontologist at the Senckenberg Museum in Frankfurt, Germany. "The authors challenge this and present a new head-first hypothesis."

Before the new finds, the earliest known snakes lived about 100 million years ago, during the Cretaceous period.

Michael Caldwell, a paleontologist at the University of Alberta in Canada, identified the first of the new fossils while perusing lizards from the earlier Jurassic period in England. Among the remains were a few bones that were in fact very old snakes, he says.

Wondering if other ancient snakes had been mislabeled or overlooked, he and his team spent the next 10 years sifting through museum fossil collections. Ultimately, they identified four new species of snake from what are now England, Portugal and Colorado. The fossils date from 167 million to 143 million years ago, from the mid-Jurassic to early Cretaceous periods.

While alive, the snakes probably had four limbs and shorter bodies than their modern relatives, Caldwell says. "These things had specialized features of snake skulls 167 million years ago. That probably indicates that ... the snake innovation was about the skull and feeding ecology, not becoming long and legless."

The skulls share a number of features with later snake fossils and living snakes. These include teeth that curve backward and that sit in sockets, as opposed to sitting in a single shallow groove like lizard teeth. The fossils also sport bones in the roof of the mouth that can shift, allowing the jaws to spread apart for bulky meals. And the fossils lack bony protrusions that hold the upper jaw in place, as seen in lizards (and in other four-limbed animals).

"Snakes have very mobile skulls," says Caldwell. The skulls from the ancient snakes aren't as flexible as those seen in some living snakes, resembling the more fixed and rigid skulls of boas and pythons.

Most of the identified bones are skulls, so the researchers cannot be certain what the rest of the snakes' bodies looked like. But some snake fossils from about 70 million years later still have hind limbs, suggesting that the essential "snakeness" of the skull was already in place before the animals lost their legs.

"With only bits of skeleton to work with, it's easy to make a mistake," says Nicholas Longrich, a paleontologist at the University of Bath in England. "But I think Mike [Caldwell] and his team make a good case for these fossils being related to snakes." ■

Jurassic snake fossil

Modern python

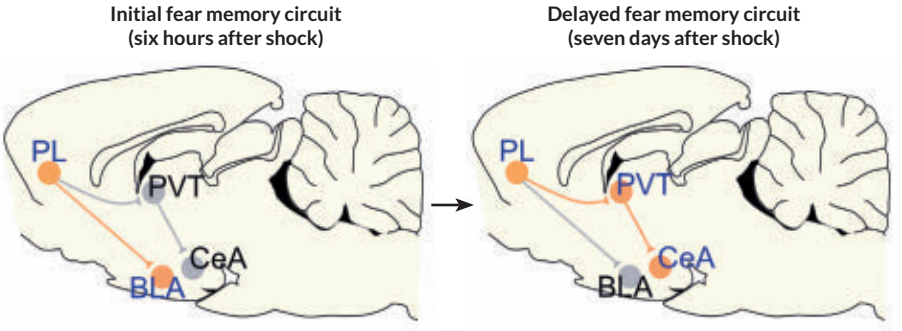
The fossil (top) from the Jurassic period shows that ancient snakes had teeth that sat in sockets and curved backward, just like a modern snake (bottom).

BODY & BRAIN

Memories of fear shift in the brain

Newfound neural circuit may shed light on anxiety disorders

BY ASHLEY YEAGER



In rats, a memory of a shock is initially recalled through connections between brain cells in the prefrontal cortex (PL) and the basolateral amygdala (BLA). A week later, the same fear memory is remembered through a different circuit that connects neurons in the paraventricular nucleus of the thalamus (PVT) with neurons in the central amygdala (CeA).

A newly identified set of brain connections plays an important role in how fear memories are stored and recalled, studies of rodents suggest. The discovery may lead to a better understanding of post-traumatic stress disorder and other anxiety problems.

Two teams of researchers independently found the brain-cell circuit while studying rodents' ability to recall a fear memory. The circuit that initially recalled the memory differed from the circuit that retrieved the memory days later, the researchers report in two papers online January 19 in *Nature*. It is the first time scientists have shown that a memory can be on temporary hold in one area of the brain and later released to a completely separate spot.

"This may be the tip of the iceberg in understanding these types of brain events, suggesting that our concept of memory storage in broad terms may require revision," says Aryeh Routtenberg, a neuroscientist at Northwestern University in Evanston, Ill.

> "Our concept of memory storage in broad terms may require revision."
>
> ARYEH ROUTTENBERG

Storing and remembering a memory requires nerve cells, also called neurons, to talk to each other. Neurons send messages using molecules and electrical signals, linking different brain regions in a setup similar to an electrical circuit.

The idea that memories shift within regions of the brain is not new. Observations of the famous amnesiac Henry Molaison, known as H.M., and other patients suggested that where memories were stored in the brain changed with time (*SN Online: 1/28/14*). In the new research, scientists pinned down precisely when and where a specific memory moved, discovering the previously unidentified circuit in the process.

One team, led by neuroscientist Gregory Quirk of the University of Puerto Rico School of Medicine in San Juan, trained rats to fear a tone that came with a mild shock. Tracking which neurons later turned on in response to the tone revealed which brain circuits the rats used to remember the shock.

Initially the rats' brains recalled the memory by turning on neurons in the brain's frontal lobe, which controls actions and complex thoughts. A set of frontal lobe neurons activated another set of neurons located in a subsection of the amygdala, the brain's fear-processing center. That circuit, however, was not involved in retrieving the memory the next day. Instead, the memory was recalled through a circuit that links the frontal lobe to a region that plays a role in sensing and sleep. This region, located near the brain stem and called the paraventricular nucleus of the thalamus, or PVT, turned out to have a strong connection to a distinct group of neurons in the amygdala.

The scientists then used optogenetics, a technique for controlling neurons with light, to switch off the PVT neurons linked to the amygdala. If the PVT neurons were switched off six hours after storing a fear memory, the rats could still remember their fear of the shock. But if those neurons were turned off seven days after storing the memory, the rats could not recall their fear. The results show that neurons in the PVT-amygdala circuit help to solidify and maintain fear memories, Quirk says.

A second team, led by neuroscientist Bo Li of Cold Spring Harbor Laboratory in New York, used mice to confirm the discovery of the new fear memory circuit. Li and colleagues had previously shown that learning and remembering fear is rooted in the neurons of the central amygdala. Finding that neurons in the PVT region became active and communicated with the central amygdala as mice learned or recalled fear suggested that the region could be important in understanding anxiety disorders.

Li and colleagues wanted to see if a particular brain chemical influences fear memories. Previous research has shown that abnormalities with the protein brain-derived neurotrophic factor, or BDNF, plays a role in post-traumatic stress and other anxiety disorders. Tracking the brain protein in mice showed that it allows neurons in the PVT region to exert control over those in the amygdala, ultimately triggering a response to fear.

Linking how the brain protein and the newly identified fear circuit work together to establish and retrieve fear memories could provide a new target for treatment of post-traumatic stress disorder and other anxiety disorders, Li says. ■

G. QUIRK/UNIV. OF PUERTO RICO SCHOOL OF MEDICINE

ATOM & COSMOS

Elderly solar system detected

Small rocky worlds formed throughout universe's history

BY CHRISTOPHER CROCKETT

Some planets were already billions of years old when Earth was a mere twinkle in our sun's eye.

The Kepler space telescope has unearthed the oldest known solar system. Five tiny rocky worlds snuggle up to an 11.2-billion-year-old cool red star called Kepler 444, which is more than twice as old as our sun. Because planets form at the same time as the stars they orbit, the discovery implies that the universe has been churning out rocky planets throughout its entire history, providing ample time for alien life to develop and perhaps flourish (*SN: 2/7/15, p. 7*).

Kepler 444 itself, however, is not the best place for life to get going. The star's planets, all between the sizes of Mercury and Earth, are too close to the star for liquid water to endure on their surfaces. The longest year for any of the planets is less than 10 days, astronomers report in the Feb. 1 *Astrophysical Journal*.

"Planets this small have never been found around a star this old," says study leader Tiago Campante, an astronomer at the University of Birmingham in England. Old stars don't have as many of the elements essential for planet formation — such as carbon, silicon and iron — as stars that formed later. Astronomers once thought that planets could form only around stars rich in these ingredients. But researchers last year found a mega-Earth — a rocky planet about as massive as Neptune — around the roughly 10.4-billion-year-old star Kepler 10 (*SN: 7/12/14, p. 10*). Kepler 444 now confirms suspicions that Earth-sized planets can form around a variety of stars.

Campante and colleagues discovered the planets, which sit about 116 light-years away in the constellation Lyra, by sifting through data from the Kepler space telescope (*SN: 2/7/15, p. 9*). Kepler spent four years staring at about 150,000 stars, looking for the silhouettes of planets as they pass in front of their suns.

To nail down Kepler 444's age, the team measured the frequency of waves rippling across the surface of the star, which show up as tiny fluctuations in starlight. As stars age, the frequency of these waves drops. By comparing the frequency of the flickering light with calculations that describe star evolution, the team deduced that Kepler 444 is 11.2 billion years old.

Finding planets around a star that old isn't terribly surprising, says Joshua Winn, an MIT astrophysicist. "It's not like there's any kind of theoretical objection to having planets form so quickly." What's groundbreaking, he says, is the precise measurement of the star's pulsation. Before Kepler, astronomers could make these measurements only for giant stars. "It's probably the case that many known planets are this old," he says.

The discovery shows that a necessity for life was present early in the universe: a solid surface to call home. "Once you have the rocky planet and the ingredients for life," says Lisa Kaltenegger, a Cornell astronomer, "then you could have life." While the known planets around Kepler 444 are inhospitable, planets with temperate climates may have been forming around other stars at the same time. "We just need to find them now," she says. ■

ATOM & COSMOS

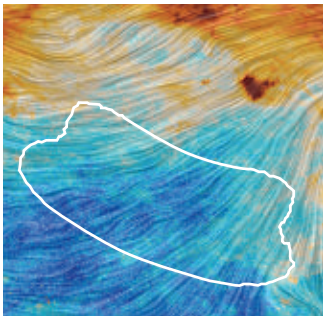
Gravitational wave claim bites dust

Spacetime ripples might exist, but search will need to continue

BY ANDREW GRANT

An elusive signal from the dawn of the cosmos is officially still elusive.

Galactic dust accounts for much of the signal that scientists interpreted as ripples in spacetime imprinted on the universe's first light. A new study, by the BICEP2 team that claimed the discovery and scientists with the Planck space telescope, nullifies a result that would have been the first direct evidence of cosmological inflation, a brief period after the Big Bang when the universe ballooned in size.



The Planck satellite analyzed the same patch of sky, outlined in white, that BICEP2 measured. Yellow and red areas contain the most dust.

Announced January 30, the analysis does not mean that inflation is wrong or that the primordial ripples, called gravitational waves, don't exist. But after properly factoring in dust, the scientists agree that the evidence doesn't support the original claim.

"It's perfectly plausible that there are primordial gravitational waves," says cosmologist Raphael Flauger of Carnegie Mellon University. "But experiments right now are just not accurate enough."

Last March, researchers proclaimed that BICEP2, an Antarctic telescope, detected swirling patterns in the alignment of light waves, known as the cosmic microwave background, that were emitted 380,000 years after the Big Bang (*SN: 4/5/14, p. 6*). The patterns, the team said, were imprinted when the fabric of space rapidly stretched.

Shards of carbon and silicon in our galaxy, however, emit light imprinted with a swirl that is indistinguishable from the signature of gravitational waves.

The BICEP2 team joined Planck scientists to take a careful look at the slice of sky measured by BICEP2. BICEP2 measures light at one frequency; Planck captures a wider spectrum, allowing scientists to isolate the influence of dust, which preferentially emits light at particular frequencies. The latest survey confirms that BICEP2 underestimated the effect of galactic dust. ■

PLANCK COLLABORATION/ESA. ACKNOWLEDGMENT: M.-A. MIVILLE-DESCHÊNES/CNRS

HUMANS & SOCIETY

Murals unveil Maya literary practices

Discoveries peg ritual specialists as central to making books

This reconstructed mural depicts Maya ritual specialists called *taaj*. Researchers say a high-ranking *taaj* (depicted at far right) was buried near the mural.

BY BRUCE BOWER

Excavations at a more than 1,200-year-old Maya settlement in Guatemala suggest that ritual specialists made sacred books in a room where they also painted murals and astronomical tables on the walls. The findings offer a rare glimpse of the people who created Maya books.

At least two men buried near the mural room, located in a city called Xultun, took part in making bark-paper, stucco-coated books known as codex books, say archaeologist Franco Rossi of Boston University and colleagues. One man was interred in an addition to the mural room built when the room was filled in with limestone and mud, Rossi's group reports online January 5 in *American Anthropologist*.

"The mural room was sealed off and turned into this individual's mausoleum," Rossi says.

Two pendants found with the man's skeleton identify him as an important ritual specialist depicted in the murals, the researchers propose. On one painted wall, the man — wearing one of the pendants hanging from his neck and the other attached to his headdress — sits below hieroglyphics that dub him a senior *taaj*. Two smaller men sitting next to him bear the title of junior *taaj*. Only those designated as *taaj* would have had the knowledge to calculate and write the calendrical tables in the mural room and, presumably, in codex books, Rossi says.

Several other Maya sites from the same time contain written references to ritual specialists known as *taaj*, but their duties are poorly understood, Rossi adds.

In a related paper in the February *Antiquity*, Boston University archaeologist William Saturno, Rossi and others describe who and what was portrayed in the Xultun murals. Images painted on the room's stucco walls show members of a *taaj* order celebrating a new year's ritual with their ruler, the researchers say.

Saturno's group previously reported that writing and numbers painted on the mural room's walls referred to lunar and planetary cycles (*SN: 6/16/12, p. 10*). One wall includes three sets of inscriptions repainted over added layers of stucco, suggesting walls were used as scratch pads to construct astronomical tables.

New analyses find that astronomical writing in the mural room corresponds to passages from three of four surviving codex books. Those bark-paper books were created at least 400 years after Maya civilization fragmented around A.D. 900.

Another clue that codex production occurred in the mural room lay beneath the floor, where researchers found a tool that was used to pound fig-tree bark into paper. Known as a bark beater, this item was apparently placed beneath the floor as a ceremonial offering.

A grave excavated in an adjoining patio contained a man's skeleton holding another bark beater and a round tool for smoothing plaster, such as that used to coat the mural room's walls and the pages of codex books. This man was an artisan but not a *taaj*, Rossi says.

It's unclear why the two Xultun graves contain no paint pots, since Maya hieroglyphics depict scribes with these tools of their trade, remarks anthropologist David Freidel of Washington University in St. Louis. Some Maya rulers were buried with paint pots, raising the possibility that royals claimed sole status as scribes, perhaps to enhance their status, Freidel says. ■

This ancient Maya man, buried with pottery and two pendants, may have been a high-ranking ritual specialist involved in making books.

CLOCKWISE FROM TOP: HEATHER HURST (© 2014); H. HURST, L. HAMMON, F. ROSSI; AVIVA CORMIER; ALL: COURTESY OF SAN BARTOLO-XULTUN ARCHAEOLOGICAL PROJECT

LIFE & EVOLUTION

Cone snails deploy insulin to slow speedy prey

Fish-hunting cone snails release insulin that can work as a weapon, sending nearby prey's blood sugar plummeting and making the groggy fish easy for a less-than-speedy snail to catch. It's the first discovery of insulin in the complex venom brews that cone snails produce, says Helena Safavi-Hemami of the University of Utah in Salt Lake City. She and colleagues found the insulin during a standard screen of venom genes from two cone snail species (*Conus geographus* and *C. tulipa*). Instead of being a version of the compound that regulates mollusk metabolism, the insulin seemed to be a version more likely to affect fish, the team reports online January 20 in the *Proceedings of the National Academy of Sciences*. The researchers released the cone snail's fishy insulin into water where zebrafish larvae swam, causing them to become lethargic. Injecting the same insulin into adult fish caused their blood sugar levels to drop. The snails probably secrete the insulin as part of a preliminary barrage of venom components, called the nirvana cabal, that quiets fish enough for the snails to pull the prey into their elongated funnel-shaped mouths and inject more venom. — *Susan Milius*

GENES & CELLS

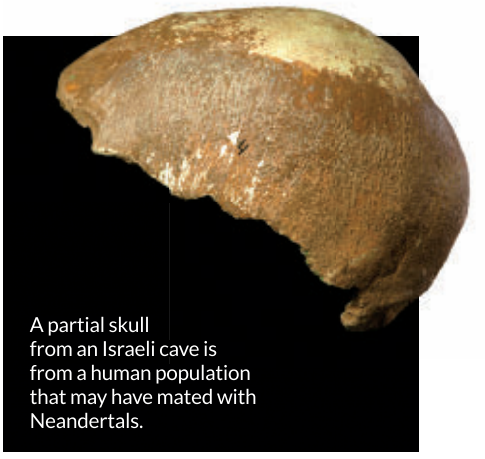
Bacteria-killing viruses linked to inflammatory bowel disease

When it comes to inflammatory bowel disease, the enemy of my friends is my enemy, too, a new study suggests. Bacteriophages — viruses that infect and kill bacteria — are more diverse in people with Crohn's disease or ulcerative colitis. Herbert "Skip" Virgin, an immunologist at Washington University in St. Louis, and colleagues report the finding in the Jan. 29 *Cell*. In particular, *Caudovirales* bacteriophages were more diverse in people with the diseases than in healthy people living in the same households, the researchers found. The viruses may kill friendly bacteria in the intestines, leading to inflammation and disease. Scientists already knew that people with Crohn's and colitis tend to have fewer types of beneficial bacteria in their gut microbiomes. What researchers hadn't understood is why the bacterial diversity decreased. The new results suggest some viruses may damage health not by infecting human cells, but by altering the microbial mixes in the body. The findings may also explain why fecal transplants from healthy people generally haven't cured inflammatory bowel diseases; lingering viruses may destroy newly introduced bacteria before they can do a patient any good. — *Tina Hesman Saey*

ATOM & COSMOS

When entering black hole, fasten seat belt

As if someone falling into a black hole wouldn't face enough problems, new research reveals that the approach could get bumpy. Interacting ripples in spacetime can create turbulence in the vicinity of a black hole, scientists report in a paper to appear in *Physical Review Letters*. Their study builds on previous research suggesting that in the vacuum of space, gravity could imitate the flow of fluids. Turbulence — the random, chaotic motion best known for jarring air travelers — is ubiquitous on Earth but always occurs in fluids, such as air or water. Astrophysicist Aaron Zimmerman of the Canadian Institute for Theoretical Astrophysics in Toronto and his colleagues wondered whether gravitational waves, ripples in spacetime generated under some conditions by massive objects such as black holes, could also generate similar chaotic motion. Zimmerman and collaborators mathematically determined that if a black hole spins quickly enough, it could emit long-duration bursts of gravitational waves that run into each other and stir up turbulence. Future gravitational wave detectors may be able to identify signatures of this phenomenon, the researchers say. Zimmerman says that he is unsure whether a person would feel the turbulence. But he's confident it would represent a minor inconvenience compared with imminent death by spaghettification (*SN: 5/31/14, p. 16*) for travelers falling toward the center of the black hole. — *Andrew Grant*



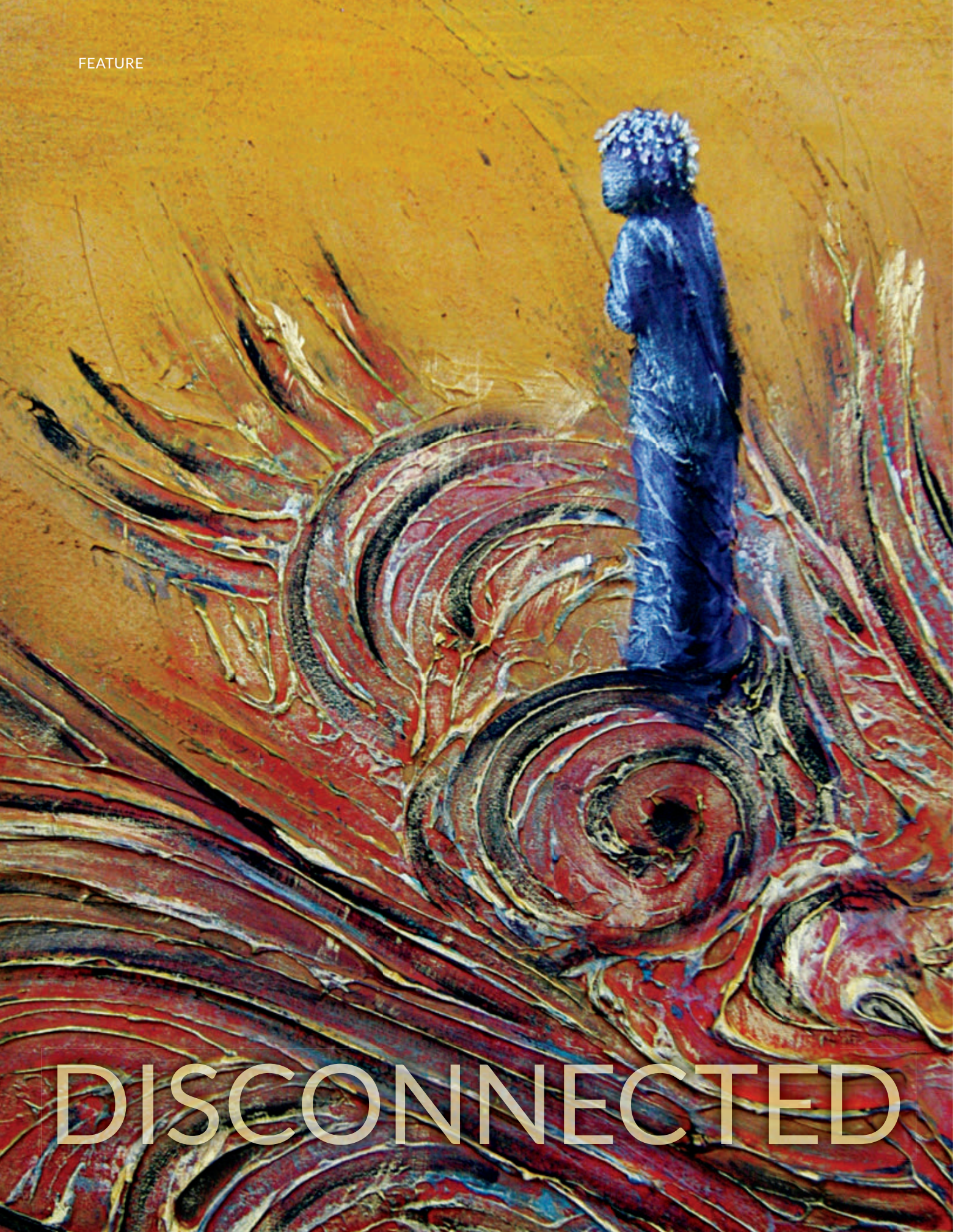
A partial skull from an Israeli cave is from a human population that may have mated with Neandertals.

CLARA AMIT, ISRAEL ANTIQUITIES AUTHORITY

HUMANS & SOCIETY

Fossil recasts history of first Europeans

Excavations in Israel's Manot Cave have unearthed the first fossil — a partial skull — of a modern human who lived outside Africa between 60,000 and 50,000 years ago. Interbreeding between *Homo sapiens* and Neandertals probably occurred during that time (*SN: 11/29/14, p. 8*), after which the humans migrated to Europe, researchers led by paleoanthropologist Israel Hershkovitz of Tel Aviv University report in the Jan. 29 *Nature*. If so, Neandertal-like skeletal traits of Stone Age humans in Europe were probably inherited from Middle Eastern *H. sapiens*, not through interbreeding with European Neandertals. Features of this ancient partial skull suggest that it must have come from a population of African *H. sapiens* that had recently arrived in the Middle East. Some features also indicate that this human population occasionally mated with Neandertals who lived in the region. Several traits shared by European Neandertals and *H. sapiens*, including a bony projection at the back of the skull, appear on the Israeli fossil. That raises the possibility that the Manot people were among the first human colonists of Europe, around 45,000 years ago, and that they passed a few Neandertal skeletal traits along to future generations of Europeans. If DNA can be extracted from the fossil, researchers can look for direct evidence of interbreeding with Neandertals, Hershkovitz says.
— *Bruce Bower*



DISCONNECTED

Adults with autism are left alone to navigate a jarring world

By Siri Carpenter

"I don't look like I have a disability, do I?" Jonas Moore asks me. I shake my head. No, I say — he does not. Bundled up in a puffy green coat in a drafty Starbucks, Moore, 35 and sandy-haired, doesn't stand out in the crowd seeking refuge from the Wisconsin cold. His handshake is firm and his blue eyes meet mine as we talk. He comes across as intelligent and thoughtful, if perhaps a bit reserved. His disability — autism — is invisible.

That's part of the problem, says Moore. Like most people with autism spectrum disorders, he finds relationships challenging. In the past, he has been quick to anger and has had what he calls "meltdowns." Those who don't know he has autism can easily misinterpret his actions. "People think that when I do misbehave I'm somehow intentionally trying to be a jerk," Moore says. "That's just not the case."

His difficulty managing emotions has gotten him into some trouble, and he's had a hard time holding onto jobs — an outcome he might have avoided, he says, if his coworkers and bosses had better understood his intentions.

Over time, things have gotten better. Moore has held the same job for five years, vacuuming commercial buildings on a night cleaning crew. He attributes his success to getting the right amount of medication and therapy, to time maturing him and to the fact that he now works mostly alone.

Moore is fortunate. His parents help support him financially. He has access to good mental health care. And with the help of the state's division of vocational rehabilitation, he has found a job that suits him. Many adults with autism are not so lucky.

Scientists are beginning to take note, but their understanding of how best to help adults with autism is paper thin. Of the more than $400 million that the United States spends each year on autism research, the vast majority is for two avenues of study: genetics research to find the causes and a cure, and studies on early diagnosis and intervention in children. Few studies have examined treatments for adults.

Accepted approaches for treating children with autism range from brief interventions for addressing specific challenges like recognizing facial expressions to comprehensive behavioral training programs that involve parents, teachers and peers.

"When you look at early intervention for autism, there are lots of different models, and we have a pretty good sense of evidence-based practices for young children with autism," says Leann Smith, a developmental psychologist at the University of Wisconsin–Madison, whose research focuses on adolescents and adults with autism plus their families. "There isn't anything analogous to that for adults," she says.

Activists like Temple Grandin and others are making the case that adults with autism bring important qualities to society. And in the last few years, public and private agencies that fund autism research have begun funding a growing cadre of researchers to develop and test therapies for adults with autism — particularly high-functioning adults.

"I really do expect to see huge changes in terms of what we know about how to support adolescents and adults with autism over the next 10 years or so," says Julie Lounds Taylor, a Vanderbilt University developmental psychologist who studies the transition to adulthood for people with autism. "I would not have said that two years ago."

Finding their place

The term "autism spectrum disorder" includes a suite of neurological conditions that range in severity and include impairments in communication and social interaction, difficulty with regulation of emotions and repetitive or obsessive behaviors and interests. About half of children diagnosed with an autism spectrum disorder are "high functioning" like Moore, meaning they have average or above-average intelligence. No drugs have been approved to treat the core symptoms of autism in children or adults, though many people with autism take medications for conditions that can occur alongside autism, such as depression, anxiety and irritability.

There are no reliable estimates of the number of adults with autism. But the prevalence of children diagnosed with autism has spiked in the last two decades. In 2000, the U.S. Centers for Disease Control and Prevention estimated that 1 in 150 children had an autism spectrum disorder. The agency's 2014 estimate is a startling 1 in 68. The reasons for the increase aren't fully understood, but researchers believe it is partly due to improved detection.

Those children will eventually reach adulthood and will still need support services as they try to find their place in the world.

One might expect that people with autism who are most

Jonas Moore, who has autism, bowls in a winter league, a social activity he calls "good therapy." His high score is 201.

OPPOSITE: D. WILLIAMS; THIS PAGE: ALYSSA SCHUKAR

Australian artist Donna Williams chronicles her life with autism in paintings like "To Dare" (left).

high functioning would fare best in the adult world. But paradoxically, those without an intellectual disability are most likely to falter at the precipice of adulthood, partly because they often lose support services after age 21 and partly because social difficulties may frustrate college and career ambitions. (In some states, only more severely disabled people are eligible for assistance, such as Medicaid-funded services.)

Into the abyss

Spend time talking with autism researchers or with families of adolescents or adults with autism, and it doesn't take long for the phrase "falling off a cliff" to come up. The new environments, people and expectations for independence that come with entry into adulthood can be tricky for any young person. For someone with impaired abilities to communicate and manage relationships, solve problems flexibly and regulate emotions, this period can be harrowing. And the end of adolescence means the end of federally mandated special education services — just when the need for support may be greatest.

In a study of 242 teens transitioning to adulthood, Taylor and Marsha Mailick at Wisconsin–Madison found that young people's autism symptoms and behaviors such as repetitive habits, withdrawal and self-harm often improved during adolescence. But progress typically slowed markedly, or even stopped, after students left high school.

More than half of young adults with autism were "completely disengaged" from any employment or postsecondary education in the two years after leaving high school.

Paul Shattuck directs the Life Course Outcomes program at Drexel University's Autism Institute in Philadelphia. He has spent much of the last five years dissecting data from a nationally representative survey of adults who received special education services during high school, including students with autism.

Shattuck's results are bleak. Within just a few years of leaving high school, almost 40 percent of the young adults in his sample were receiving no medical, mental health, case management or speech or language services, he and colleagues reported in *JAMA Pediatrics* in 2011.

In a separate study published in 2012 in *Pediatrics*, Shattuck's team found that more than half of young adults with autism were "completely disengaged" from any employment or postsecondary education in the two years after leaving high school. Young adults with learning disabilities, intellectual disabilities or speech or language impairment were much more likely to have some engagement with work or school after high school.

Poor employment outcomes are especially dismaying because good employment may make a world of difference for autistic adults' personal development. In a 2014 study, Taylor, Smith and Mailick found that the more independence adults had at work, the more improvement they showed over the next five years in social interactions, communication skills, repetitive behaviors, self-harm, socially offensive behavior and activities such as housekeeping and making meals.

Those results, published in the *Journal of Autism and Developmental Disorders*, shouldn't be surprising, Taylor says. "We see that in typically developing people all the time. If you're in a job that's a good fit for you or where the expectations are high, oftentimes you rise to that. Why wouldn't we expect the same thing for somebody with autism?" The findings, she says, suggest that "we don't have to go in and 'fix' everything for somebody with autism before we put them in some sort of job setting."

It may seem obvious that as children with autism mature, most will continue to need support and services. But the body of research on best practices for supporting adults is flimsy.

In 2013, a review published in the *Journal of Autism and Developmental Disorders* of 1,217 studies, conducted from 1950 to 2011, found only 13 that assessed interventions (all psychologically based) for adults with autism. The review, by researchers at the University of Pittsburgh, found that most research followed single cases or involved very few participants. Only four of the studies randomly assigned adults to treatment versus control groups.

One of the few randomized controlled trials that the review included was a study published in 2012 in the same journal and led by clinical psychologist Elizabeth Laugeson of UCLA. She enrolled 17 high-functioning young adults diagnosed with autism spectrum disorders in a 14-week course that provided participants with concrete rules of social behavior. Participants also practiced social skills such as entering and leaving conversations, organizing get-togethers, handling teasing and resolving disagreements. Separately, parents and other caregivers received guidance about how to coach their young adults without compromising their independence.

The misconception about people with autism, Laugeson says, is that they're asocial and perfectly happy being alone. "Most adults with autism will tell you that they want to make friends and have relationships, but they don't know how. As a result, they often experience tremendous loneliness." Adults going through her program demonstrate better overall social skills, improved social responsiveness and more social engagement. But perhaps best of all, she says, they no longer feel as lonely and isolated.

Like Laugeson's program, most of the adult-intervention studies that the Pitt researchers reviewed had positive results. But the small number of studies and wide variability in their methods and in the size of their effects make it difficult to draw conclusions about the effectiveness of any given intervention, says doctoral student Lauren Bishop-Fitzpatrick, the study's lead author. More than anything, she says, the results of the review highlight the need for rigorously studied behavioral treatments for adults with autism.

The tide does appear to be shifting, in part due to the

community of parents who successfully agitated for more funding for autism research in the 1990s. "There's a second wind coming to this movement," Shattuck says. Many pioneer activists, their children now grown, "are raising money for research and activating around experimental new approaches to help people have a decent quality of life as adults."

In the last several years, both the federal government and private organizations have upped their investment in adult intervention research. In September, the National Institute of Mental Health awarded three grants totaling nearly $760,000 to support development and testing of new intervention programs for adults with autism. The research and advocacy organization Autism Speaks has likewise begun investing in research in this area, says Rob Ring, the organization's chief scientific officer. Of the $2.73 million Autism Speaks has spent on adult-focused research since 2010, only about $650,000 has been for treatment studies. But Ring says investment in such research is bound to rise. "As we become more acutely aware of the tidal wave of individuals who are transitioning into adulthood, we're becoming very much aware of the needs that are out there for adults," he says.

Much of the emerging research focuses on helping adults with autism strengthen social communication skills and learn to understand what some autism experts call the hidden curriculum — the unstated rules and customs that govern social behavior, such as "don't hug your boss at the office" or "don't ask a coworker how much money she makes."

Social beings

The ability to function socially, which many people take for granted, is actually very complex, says Edward Brodkin, director of the Adult Autism Spectrum Program at the University of Pennsylvania School of Medicine.

With one of the NIMH grants, Brodkin is developing a training program that he hopes will help adults with autism learn to interact with others more comfortably, form meaningful relationships and navigate the social world in the ways that are necessary for school or job success. In group sessions, participants will learn and practice fundamental skills such as making appropriate eye contact, ending conversations smoothly and gathering information about other people at a distance by reading their body language.

Brodkin's program will also place participants in volunteer work teams, something that he believes will not only strengthen new skills and provide concrete work experience, but will also carry an important psychological benefit. "People with disabilities are often in the position of needing and receiving help," Brodkin says. "There's something about giving help that we think will be empowering."

Other experimental treatment programs focus on social skills. In a recent pilot study led by speech-language pathologist Lindee Morgan of Florida State University's Autism Institute in Tallahassee, 24 high-functioning adults diagnosed with autism spectrum disorders were randomly assigned to participate in a three-month interview-preparation program or be put on a waiting list. The weekly group sessions covered greetings, nonverbal communication, hygiene, emotion management and closing interviews. They included a mix of discussion, role play, video feedback, peer review and games.

Morgan's team compared participants' performance on mock job interviews before and after the intervention. Those in the treatment group — but not those in the waiting list control group — showed substantial improvement on outcomes, the researchers reported last September in the *Journal of Autism and Developmental Disorders*. The mock interviewers noted improvement in numerous facets of participants' presentations, including their grooming, the smoothness of their greetings and the richness of their responses to questions.

Getting along

Many aspects of work life can present major challenges for people with autism. A few examples:

Making small talk

"Can you believe this weather?" Or, "How about that basketball game last night?" Small talk, inane as it can be sometimes, is an essential social skill. But it is one that many people with autism aren't wired for. At work, someone who has difficulty responding smoothly to seemingly inconsequential questions like "How was your weekend?" might be perceived as aloof or unintelligent.

Interpreting body language and facial expressions

Communication is about a lot more than words. Deciphering nonverbal behavior is just as important. A person with autism may miss or fail to understand subtle but important cues. For example, gestures or furrowed brows might signal that two coworkers are in the midst of a conflict and that it would be best to steer clear.

Following unspoken social rules

If social rules of behavior are not made explicit, a person with autism may not realize he or she is committing a faux pas by doing something that is outside the norm in a work setting, such as talking about personal matters or talking too loudly.

Remembering and following instructions

It can be difficult for people on the autism spectrum to follow multistep verbal instructions, especially if they're given quickly. Breaking instructions down into smaller steps and putting them into writing can make a big difference.

Adapting to changes

A shift in routine or an unexpected event that might appear small to someone without autism, such as an adjustment to work hours or a change in supervisor, can be difficult for someone with autism to cope with.

Planning and organizing

No one's memory is infallible — that's why many people keep checklists and calendars to keep track of commitments and designate specific places for their keys or cellphone. Most people adopt such organizational tricks intuitively, without much thought. But for many people with autism, doing so does not come naturally. "Prospective memory strategies," as they are called, must be explicitly taught.

"At the beginning, it was as if a lot of the participants didn't really understand that in a job interview you're supposed to sell yourself," Morgan says. "We taught them to market themselves, and their ability to convey to the potential employer what they would bring to the job really improved."

Morgan also points out a more intangible benefit. "More than half of high-functioning adults with autism report not having any friends," she says. "One of the by-products of participating in this class was that these guys really got to know each other and enjoyed each other."

Social skills are key to getting and keeping a job. But they're not the only skills that adults with autism often struggle with, notes research psychologist Mary Baker-Ericzén at Rady Children's Hospital–San Diego and director of the Intricate Mind Institute, which provides therapeutic services for people with neurodevelopmental disorders.

In a program she's developing, participants will practice social skills such as deciphering "hidden" meanings, handling compliments and criticism and reading body language. But her program will also target another common aspect of autism: impairments in what psychologists call "executive functioning." The term encompasses an array of cognitive and problem-solving skills such as paying attention to and remembering instructions, using organizational tools like to-do lists and calendars, planning and preparing for the future and thinking flexibly enough to generate a "Plan B" when circumstances change.

The intervention is based on research involving people with traumatic brain injuries, dementia and schizophrenia — populations that, like people with autism spectrum disorders, tend to have difficulties with executive functioning. "Our theory is that if we develop these cognitive functioning skills, those are going to be related to functional skills like being able to get up on time or retain what their boss tells them," Baker-Ericzén says.

The larger community

Few adults with autism forge their way in the world on their own. For most, family members are an important, even daily, source of support. That reality is the cornerstone of a program Leann Smith is testing in Wisconsin. She first became interested in autism during college, when she worked as an in-home therapy provider for a young boy with autism. "It was so amazing and beautiful and powerful to me to see how families can rally and do what needs to be done to provide educational opportunities and interventions for their loved ones," she says.

But the caregiver role takes a psychological toll. "Although parents work very hard in supporting their children [with autism], it is not an easy road," Smith says. She is recruiting participants to test an intervention focused on reducing stress for young adults with autism and their families. The hope is that stress reduction will in turn help the young people take on adult roles. Reducing stress and emotional intensity, she says, "has a stabilizing effect, which can help people be more empowered and able to maintain a job."

Smith's three-year study will involve 56 families randomly assigned to take part in the intervention immediately or after a six-month wait, thus forming a control group. Smith's team will meet individually with each person with autism and his or her family members to learn about personal and vocational goals and the challenges they're encountering. Then families will take part in eight weekly group sessions — adults with autism in one room, family members in another.

Smith's team will provide practical information, such as where to find local educational and vocational services and how to access them, networking strategies for finding friends and employment, and advice about financial planning and legal guardianship arrangements.

> Reducing stress and emotional intensity "can help people be more empowered and able to maintain a job."
>
> LEANN SMITH

Participants will also rehearse problem solving steps and learn a coping strategy that can help reduce stress for families of adolescents with autism: positively reinterpreting challenges or difficult events as opportunities for growth. "Even if you can't change the stressor, you can change how you think about it," Smith says.

Smith's emphasis on family counters what Shattuck says is the dominant approach to studying autism. Most autism research, he says, "presumes there's something defective with the person, and if we want the person to have a better outcome, we need to fix the person." Shattuck believes researchers should also seek ways to improve the wider social context for adults with autism, from strengthening housing and vocational support services to educating police departments about aspects of autism that might influence police encounters.

Toward that goal, Shattuck is teaming up with community-based programs that are testing innovative interventions for adults with autism. He plans to study how effective the programs are and how readily they could be scaled up to work elsewhere. "There's a lot of cool stuff happening," he says.

In Jonas Moore's experience, such services are badly needed. With the help of a good therapist, he has built a life that he finds fulfilling. "There are certain social situations I will not go into," he says. "But at least I have friends. Before I didn't want to have anything to do with socializing or friendship."

Knowing that research is happening makes Moore feel optimistic, he says. "It means that people like me are going to get more help. We're human beings too and we want to be treated with respect, want to be understood, want people to be patient with us and not to assume that we're trying to be difficult." ■

Explore more

- Temple Grandin, "The world needs all kinds of minds." TED2010: bit.ly/SN_Grandin.

Siri Carpenter is a freelance journalist based in Madison, Wis.

For a video interview with Jonas Moore, visit **bit.ly/SN_autism**

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Even if prairie dogs don't move their homes away from human noise, the distraction may take a hidden toll.

G. SHANNON

Hush, humans

We're trying to survive here

Prey and predators have their issues with noisy humankind **By Susan Milius**

I keep looking over my shoulder at the dark wall of roadside trees that passing headlights make slightly less black. Muggers are less of a worry than some suburban samaritan materializing out of the winter gloom to ask if everything's OK with a reporter down on her hands and knees in front of a parked car, caressing the pavement.

Explanation would not be easy. This is not an obvious place to pull over. The shadowed shoulder of a roaring commuter parkway looks as if it might pothole itself in shock at the footstep of a strolling pedestrian. But it's a pilgrimage destination for the acoustically curious, and it's not a bad place to contemplate looking over one's shoulder.

This 3.5-kilometer stretch of Fairfax County Parkway near Herndon, Va., is one of only three places in the state's northern sprawl where a driver can try to discern the subtle effects of two unusually textured road surfacings called "quiet pavement," or sometimes less ambitiously, "quieter pavement." These experimental road surfaces suggest that worries about the effects of human-made, or anthropogenic, sounds have reached the point to compel action.

In reality, the Virginia legislature probably approved these roads more out of concern that noise harms the health and voting behavior of humans than out of concern for local wildlife. But a surge of evidence is pushing the National Park Service, at least, to take steps to restore and preserve the natural soundscapes of the nation for all its residents (see Page 32).

The wildlife side of that burgeoning research has come a long way since studying anthropogenic noise meant exploring what Navy sonar might be doing to marine mammals or how city birds' songs differ from their country cousins'. Recent experiments have tackled the basic question of whether noise alone can cause ecological effects, separate from the lights or motion from whizzing cars. And researchers have expanded the study of human noise to consider its effects on what might be called the nonconversational ways that animals use sounds.

To people, "noise pollution" often brings to mind the vexations of words drowned out, of trying to have a soul-satisfying conversation in a clatteringly loud restaurant. Of course, wild creatures also need to convey the full nuances of their chirps, hums and howls. But creatures draw information from all sorts of other noises, many of them accidental, barely audible and of life-or-death importance.

Some examples related to food: Tiny tip-taps of beetle feet in the dark can mean a decent meal for a hungry bat. And the merest whisper of a cat's paw over a dry leaf can give a chipmunk one last chance to dodge. Milliseconds matter.

If road roar keeps a person from hearing foot-

steps in time to jump up from pavement-gazing, the main risk is embarrassment. But for the hunters and the hunted, the stakes are much higher.

Phantom evidence

To explore a basic question about wildlife and noise, Jesse Barber and his colleagues built what they call the phantom road.

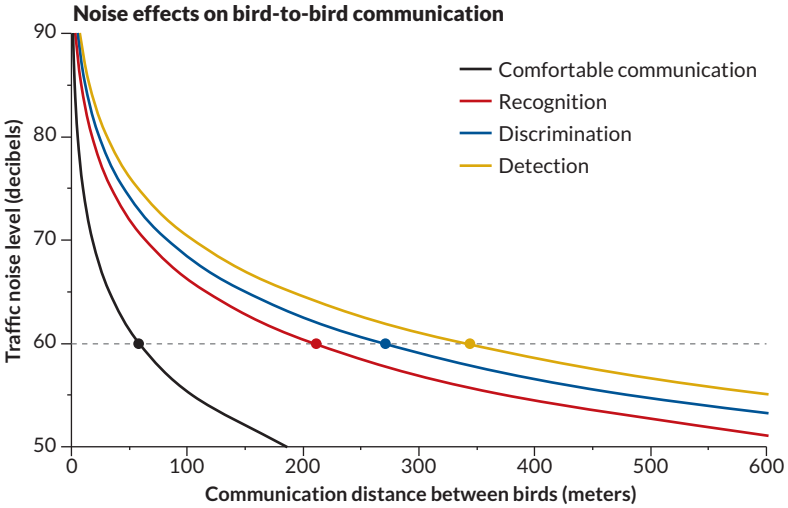
Earlier studies of noise effects often compared animals near roads or other clamorous human-made features with animals in rural landscapes. This approach left questions about how much of the difference came from noise instead of from artificial lights, exhaust fumes or other non-noisy aspects. Other research teams have turned to, of all things, gas wells to try to sort out the problem — by monitoring wildlife near wells equipped with thundering compressor motors versus otherwise similar wells without the noisy equipment. In Canada's boreal forest, songbirds didn't settle as densely near the monster motors, and in a New Mexico gas field, there weren't as many bird species at the loud sites. The impact rippled onward: Because the animals found in the neighborhood changed, plants' exchange of pollen and spread of seeds would change. Noise seemed to be the cause.

But for a direct test of sound effects, Barber, of Boise State University in Idaho, and his colleagues created a highway that was nothing but the noise. They broadcast recordings of cars from 15 pairs of speakers mounted in a row along a half-kilometer of ridge near Lucky Peak State Park in Idaho. "It sounded like a highway in the woods," Barber says. "But then you get up there and there's no road."

"Challenging" is his restrained word for the travails of the experiment. It took a month just to position the speakers and get the broadcast to sound realistic. And once the spectral road was running, lab members spent hours each day hiking out and back to replace batteries and take data because, of course, there was no real road to the site. But the effort was worthwhile, as revealed in the team's 2013 report in the *Proceedings of the Royal Society B*.

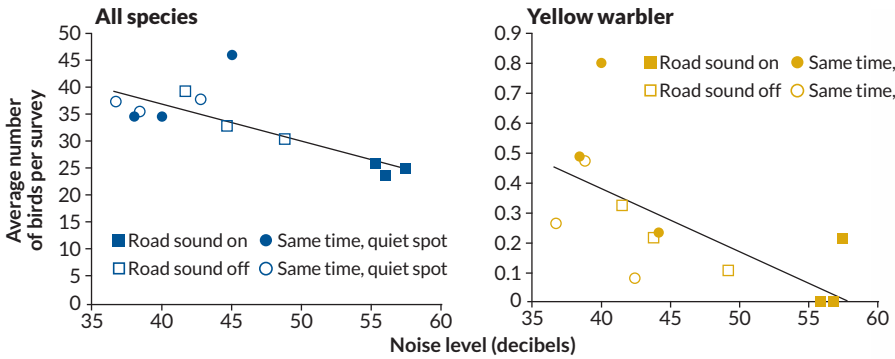
The ghostly road ran beside a major rest stop for migratory birds. Just beyond the ridge, the great Douglas fir forest of central Idaho frays into clusters of bitter cherry and chokecherry, and then the landscape opens into what small migratory birds would have every right to call challenging. They must cross miles of low-growing steppe vegetation with little cover but plenty of bird-eating raptors. Typical migrants "stop at the edge for a few days and fatten up and get ready for this dangerous and exhausting nocturnal journey," Barber says.

When the researchers turned on the speakers for four days of faux traffic, the numbers of birds stopping to rest dropped by more than a quarter on average. And during the alternating four-day stretches of silence, bird numbers bounced back. Noise matters, Barber and colleagues concluded.



Hear me now There is no single meaning for "too loud." Species vary in their ability to hear sounds against a background of noise. A typical bird can detect a sound (yellow line) coming from more than 300 meters away amidst a background racket of 60 decibels, roughly the intensity of human speech. For more delicate tasks like discriminating between sounds, however, birds need to be closer. As traffic noise increases, they need to be closer still. SOURCE: R.J. DOOLING *ET AL/PROC. INSTIT. ACOUSTICS* 2009

Noise on, noise off When speakers piped traffic noise into an Idaho forest, fewer migrating birds stopped to rest than in nearby quiet areas or when the noise was off. Yellow warblers showed a strong distaste for the noise. SOURCE: C.J.W. MCCLURE *ET AL/PROC. R. SOC. B* 2013



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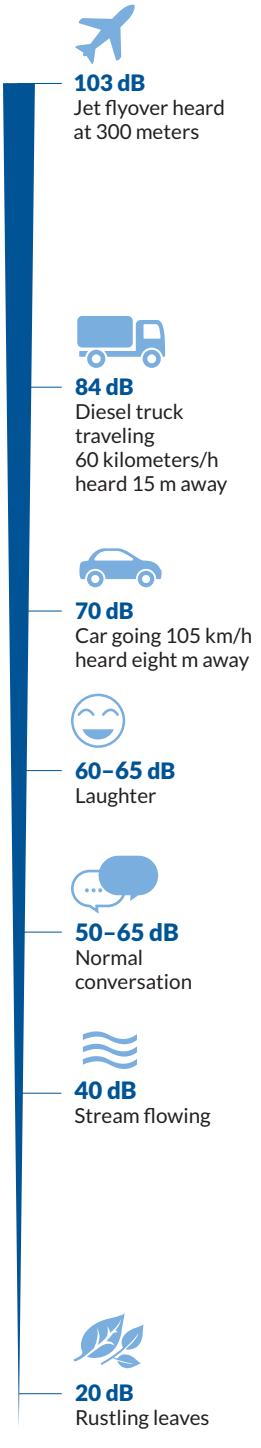


Noise log The decibel scale describing sound intensity increases by powers of 10. So the scale's upper end is much louder than the lower end. The common A-weighted decibels (above) reflect human hearing. SOURCES: NIDCD; E.H. BERGER *ET AL*/NOISE NAVIGATOR SOUND LEVEL DATABASE 2013

It can change animals' most basic stay-or-go assessments of habitat. It can prompt more than the usual number of birds on thousand-mile marathons to skip a chance to rest and refuel.

Wild sounds

Not that natural soundscapes are always quiet. Nature makes and uses noise in an intricate information network rich in content and as varied as caterpillar clicks and elephant rumbles, snow hush and thunder.

To go back to food, barn owls and gray mouse lemurs can locate prey by listening for rustlings in fallen leaves or shrubbery. The sound of worming through soil can tip off robins to their dinner. And from the opposite side of the eat-or-be-eaten struggle, female túngara frogs shy away from recordings of seductive males if researchers add wingbeat sounds of a frog-eating bat. Recordings of footsteps of birds called pied currawongs shush the nestlings of one of their prey species, the white-browed scrub wren. And maybe it's not strictly an approaching predator, but the crackling noises of fire will send African reed frogs rushing away.

When Megan McKenna campaigns for humankind to quiet down and let nature's soundscapes thrive, she gets pushback. "People say to me, 'But thunder and lightning are loud.'" Species evolved with their local noises, responds McKenna, an acoustic specialist in the National Park Service's Natural Sounds and Night Skies Division in Fort Collins, Colo.

What's worrisome about anthropogenic noise is its sudden arrival, evolutionarily speaking, and its confusing properties. Navy sonar, for instance, shares acoustic qualities with the calls of killer whales, as noted by Peter Tyack at Woods Hole Oceanographic Institution in Massachusetts. The accidental similarity may help explain why beaked whales, one of the killer whales' prey species, apparently stop feeding and hide at the sound of sonar signals or even flee so frantically that they sometimes die stranded in shallow water.

And vehicles rolling by the burrows of Stephens' kangaroo rats may tap into the animals' communication system. The small, largely solitary animals drum their feet to others in neighboring burrows and also, it seems, in response to the noise of passing cars. Playing recordings of the low-frequency vibes of traffic caused alert postures and drumming bouts similar to those that followed broadcasts of the low-frequency foot drummings, Debra Shier of the San Diego Zoo Institute for Conservation Research and her colleagues reported in 2012.

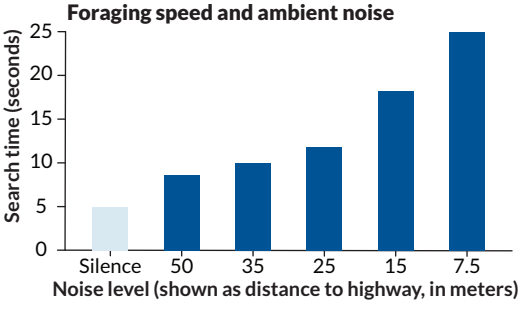
Mixing unfamiliar, artificial noises into the natural soundscape isn't just confusing the wildlife. These evolutionarily novel human noises may just drown out what animals need to hear. "Drowning out" and "hearing," however, can mean a variety of things depending on the species of the animal and its needs, cautions avian acoustics researcher Robert Dooling of the University of Maryland in College Park. For too loud, "there is no one number," he says. A person can identify sounds with about 50 percent accuracy despite a buzz of junk noise five decibels louder than the important tones. In one sense that's hearing, and it might do for noticing smartphone ring tones, but it's hardly enough for conversation.

Will listen for food

And it may not be enough for hunting, at least for some predators.

Greater mouse-eared bats of Europe, like other gleaning species, listen for their supper. Gleaners pick up the faint rustles of beetles, spiders or centipedes moving along the ground at night and then swoop down for the attack. To mimic that kind of hunting in the lab, the late Björn Siemers of the Max Planck Institute for Ornithology in Seewiesen, Germany, and colleague Andrea Schaub filled a room with 64 little platforms, each with its own speaker. When a speaker broadcast the faint patter of beetle feet, bats needed only about five seconds

Can't hear the food Gleaners, such as the pallid bat below, use sounds to hunt prey at night. In a gleaner lab study, greater mouse-eared bats took longer to detect prey sounds during playback of close-up highway noise. SOURCE: B.M. SIEMERS AND A. SCHAUB/*PROC. R. SOC. B* 2011



BOTTOM: J.R. BARBER *ET AL*/*TRENDS IN ECOLOGY & EVOLUTION* 2010

to dart to the right platform and pick up a mealworm treat. During the same experiment against a backdrop of noise approximating a nearby highway 7.5 meters away, the bats took almost five times as long to find the right platform, the researchers reported in 2011.

Bats that catch their prey in the air hunt by ear in a different way. And some of them might also have trouble in human-loud spots, Boise State's Jessie Bunkley, Barber and colleagues suggest in the January *Global Ecology and Conservation*. These bats attack insects in midair, locating prey by pinging into the night and listening to the subtleties of the echoes. Bunkley took bat detectors, which record ultrasonic bat squeaks, to gas wells in New Mexico to eavesdrop on aerial sonar. Echolocation happens at frequencies higher than a lot of motor noise. Yet at the noisy wells with big compressor motors, she found 40 percent less activity among Mexican free-tailed bats (*Tadarida brasiliensis*).

It's not clear yet whether the noise bothered the free-tailed bats directly or just chased away many of the insects that bats eat. "Either way," says Barber, "it means less bat habitat."

Human noise doesn't always mean bad news for predators, though. Humming wind turbines in the seas have stirred debate on whether the noises of their construction and operation affect animals. Yet 11 harbor seals wearing tracking devices routinely foraged among drilling platforms and wind farms in the North Sea, Deborah Russell of the University of St. Andrews in Scotland and her colleagues reported last July in *Current Biology* (*SN Online: 7/21/14*). Three of the seals swam from turbine to turbine, presumably feasting on fish living around the brand new reefs that the utility infrastructure created.

By filtering out sensitive species and inviting tolerant ones, noise may be reshaping ecosystems. The resulting mix-and-match food webs and species combinations may not occur in the wild and may never have. "We're not studying noise," Barber says. "We're studying ecology."

Danger, danger

That filtering and jumbling effect, with noise-phobes and noise opportunists, appears among prey species, too.

Young European eels (*Anguilla anguilla*) didn't do so well in tests of vigilance when researchers played recordings of ships chugging through a harbor, Stephen Simpson of the University of Exeter in England and his colleagues report in the February *Global Change Biology*. Vigilance is especially important for these youngsters as they leave their oceanic nursery and confront the strange new menaces of harbors, rivers and lakes.

In a laboratory enclosure with a clear window, youngsters sometimes saw a looming, scary fish shape as they swam by the window. Little eels serenaded by ship noise were only half as likely as eels in quiet water to startle and twitch when they spotted the scary fake fish in the window. Even eels that startled took an unusually long time to do so. And a simulated predator that pursued them, actually a researcher with a net, swept up young eels more than twice as quickly if the ship noise was humming.

The noise effects probably didn't come from ship engines drowning out approach cues, because there are no audible approach cues; the fish shape stayed on the opposite side of the glass. Instead, Simpson says, tests on the young eels suggested they were stressed, which can dull performance. Or maybe the noise just distracted them.

Prairie dogs, in contrast, do pretty well on vigilance despite traffic noise. But vigilance around human-made noise may become a burden in itself.

Black-tailed prairie dogs (*Cynomys ludovicianus*) in free-ranging colonies in Colorado grew much

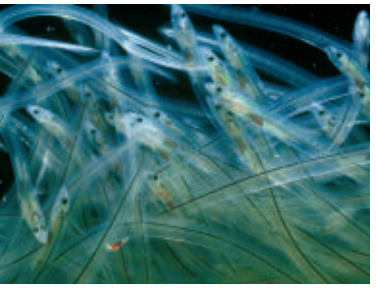
Quiet design

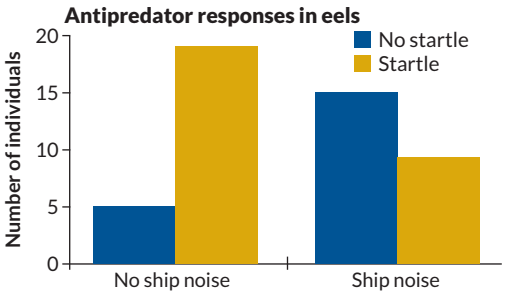
As the human-made world gets noisier, in some ways it's also — thanks to clever design — getting a bit quieter.

Aircraft design over the last three decades, for example, has taken some 20 decibels out of typical plane noise, says the 2010 report *Technology for a Quieter America* from the National Academy of Engineering. The roar comes not just from the engines but from the airflows, and several extreme initiatives have worked on concepts for drastic reductions. Through his Powering Imagination organization, Erik Lindbergh (grandson of Charles) is championing students at Embry-Riddle Aeronautical University in Daytona Beach, Fla., who are working on an all-electric airplane. He imagines it replacing the intrusive growls of tourism overflights with soft whirs soaring over splendid places like the Grand Canyon.

To reduce its workplace noise, NASA has initiated a "Buy Quiet" program. Improving the soundscape inside homes may be more difficult, cautions the engineering academy report. On the plus side, consumers are likely to attribute more overall quality to quieter versions of products such as appliances. Yet consumers aren't showing signs of paying a premium for that noise respite.

Sometimes a cost-effective measure for restoring some serenity can be simple. Visitors to California's Muir Woods National Monument made less racket on special quiet days and in designated quiet zones. All it took was a few posted signs. — *Susan Milius*





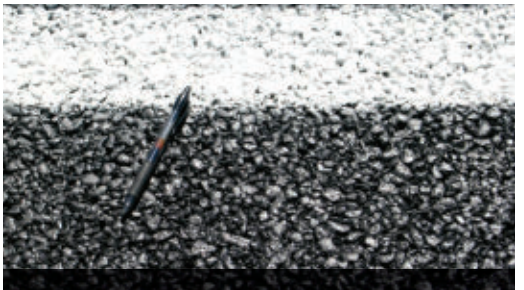
Foolish young eels
European eels were less likely to react to a looming, scary fish model in the lab if researchers played ship noise in the tank. SOURCE: S.D. SIMPSON *ET AL/GLOBAL CHANGE BIOLOGY* 2015

more watchful when researchers broadcast recordings of highway noise. Such heightened awareness meant less time for other important activities, says Graeme Shannon of Liverpool University. He and his colleagues created a little bit of phantom highway by setting up speakers near prairie dog colonies and broadcasting bouts of traffic noise as if a highway were 100 meters from the colony center.

"It wasn't that they heard the noise and ran," he says. But with road noises in the air, over the course of watching the colony, the researchers found that the number of prairie dogs foraging — presumably an important thing to do — declined 18 percent during the traffic broadcasts. Social interactions and resting declined by half, Shannon and colleagues reported last August in *Animal Behaviour*. Even though he revisited the same colonies twice a week for three months and played some noise, he saw no sign that the animals were getting used to it.

It's tempting to assume that animals staying near a highway aren't bothered by it, Shannon says. Just knowing that animals stay, however, doesn't reveal what their persistence costs them.

Settling in a loud neighborhood can have measurable benefits for tolerant prey species just as it does for certain predators. Nests of black-chinned hummingbirds and house finches were far more common near the very loud gas wells in New Mexico than near wells without any roaring compressors. And — possibly not a coincidence — scrub jays weren't raiding many nests in the noise zones, Clinton Francis at California Polytechnic State University in San Luis Obispo and his colleagues reported in 2009. Whatever the downsides of all that racket, it brought some protection.



Quieter pavement being tested in Northern Virginia is porous and looks like painted popcorn.

Where rubber meets the road

Noise "is about the most manageable pollutant we have," Exeter's Simpson says. And various projects are already under way to create a quieter world (see "Quiet design," Page 25).

Experiments with quieter pavement address what may seem counterintuitive to the driver. At speeds over about 35 miles an hour, the majority of highway noise typically comes not from engines but from tires hitting the road, says Kevin McGhee at the Virginia Center for Transportation Innovation and Research in Charlottesville.

To coax the rubber and the road to meet less noisily, engineers are making asphalt smoother with abundant pores. The dimples and holes are for noise to get lost in "like acoustic ceiling tile," McGhee says. But during mid-Atlantic winters, sand and deicers plus general grit clog the pores, and the road gets louder.

At experimental site 6, surfaced in 2012, on the Fairfax County Parkway, rush hour is tapering off. Four lanes of cars and light trucks whoosh, whoosh, whoosh by in irregular crowds, then leave the road darker and almost empty for maybe a minute before the next cluster rushes by.

I've stood by the side of regular pavement for several chilly, awkward minutes in preparation for appreciating the experimental stretch of rubberized asphalt mixed with coarse surface rock. It's the most promising of the pavements in the current test. But McGhee is right. After several winters, it's hard for the unaided ear to tell whether there's a real difference in noise or just some touristic wish fulfillment. It's still four-lane highway noise, just (maybe) muted a bit.

Down on my hands and knees at the quieter pavement, I can see and feel the difference from pavement just down the road. Here are pores galore, big, little and irregular. McGhee has described them as looking "like popcorn that has been painted black."

And in spite of the spookiness, no one walked up behind me. Or if somebody did, I didn't hear. ■

Explore more

■ Jesse R. Barber *et al*. "The costs of chronic noise exposure for terrestrial organisms." *Trends in Ecology & Evolution*. March 2010.

FROM TOP: PHILIPPE GARGUIL/SCIENCE SOURCE; VIRGINIA DOT

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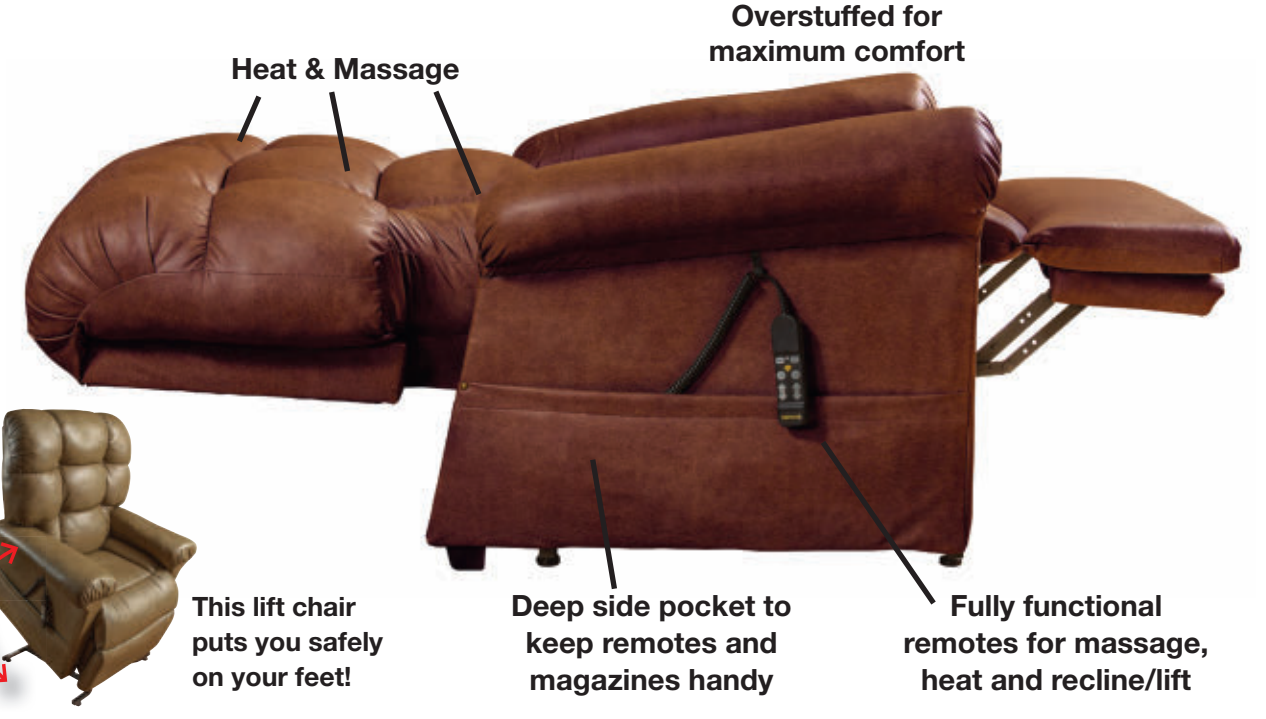

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Finalists chosen to compete in the 2015 Intel Science Talent Search

Teens from 18 states will soon face off in the finals of the 2015 Intel Science Talent Search, the nation's most prestigious science research competition for high school seniors. Prizes have been bumped up markedly this year: Each of the three top awards is $150,000 and, taken together, the prizes now total more than $1 million.

The 40 finalists will visit Washington, D.C., from March 5 to 11. There, they will present their research to judges and the public. During more relaxed times, the teens will tour a number of national landmarks. The climax of the week will be a black-tie awards gala at the National Building Museum.

Intel STS finalists "are some of the best and brightest young scientists in the nation," says Maya Ajmera, president and chief executive officer of Society for Science & the Public, which publishes *Science News*. "As an alumna of the Science Talent Search, I am especially proud to join with Intel in congratulating the finalists on their successes," Ajmera says.

As always, the finalists' research projects are diverse. One student invented a low-cost, portable device to detect blood diseases and parasites. Another developed advanced mathematical techniques to encrypt data. Yet another created computerized methods to search for promising treatments for diseases such as cancer and Ebola.

"This year's finalists engaged in leading-edge scientific research and the creation of new technology to address global challenges such as renewable energy, cybersecurity and infectious diseases," observes Justin Rattner. The teens' accomplishments "prove that with the right education and resources, young people can indeed change the world," he adds. Rattner is president of the Intel Foundation, based in Hillsboro, Ore.

Society for Science & the Public is a nonprofit membership organization dedicated to public engagement in scientific research and education. It has owned and run the Science Talent Search since the competition's creation in 1942. Intel became the title sponsor of the competition 17 years ago. Since then, annual awards and scholarships associated with this program have increased from $205,000 to more than $1.6 million.

Past finalists have gone on to distinguished research careers, earning more than 100 of the world's most coveted scientific accolades. Among those honors are eight Nobel prizes, two Fields Medals (for outstanding discoveries in mathematics), five National Medals of Science and 12 MacArthur Foundation Fellowships.

This year's crop of young researchers includes 19 girls and 21 boys from 36 high schools. Previously, judges had narrowed the field to 300 semifinalists from more than 1,800 entries.

Last year's top prize went to Eric Chen of San Diego. He used computer models to look for potential new drugs to fight influenza. Second-place honors went to Kevin Lee of Irvine, Calif. He developed a mathematical model to describe the shape of a beating heart. William Henry Kuszmaul of Lexington, Mass., claimed last year's third-place award. Results of his math project could help researchers in fields such as computer science and computational biology. —*Sid Perkins*

2015 Intel STS finalists

ARIZONA **Anvita Gupta**, BASIS Scottsdale, Scottsdale

CALIFORNIA **Augustine George Chemparathy**, Dougherty Valley High School, San Ramon; **Andrew Jin**, The Harker School, San Jose; **Somya Khare**, Lynbrook High School, San Jose; **Rohith Kuditipudi**, The Harker School, San Jose; **Kriti Lall**, Castilleja School, Palo Alto; **Janel Lee**, Amador Valley High School, Pleasanton; **Yelena Mandelshtam**, University High School, Irvine; **Jennifer McCleary**, Arnold O. Beckman High School, Irvine; **Saranesh Prembabu**, Dougherty Valley High School, San Ramon; **Tanay Tandon**, Cupertino High School, Cupertino; **Steven Michael Wang**, The Harker School, San Jose

COLORADO **Jesse Zhang**, Fairview High School, Boulder

FLORIDA **Catherine J. Li**, Lake Highland Preparatory School, Orlando

ILLINOIS **Ryan D'Mello**, Benet Academy, Lisle

MASSACHUSETTS **Noah Golowich**, Lexington High School, Lexington

MARYLAND **Michael Winer**, Montgomery Blair High School, Silver Spring; **Yizhen Zhang**, Richard Montgomery High School, Rockville

NEW JERSEY **Eswar Anandapadmanaban**, Dr. Ronald E. McNair Academic High School, Jersey City; **Nicole Eskow**, Academy for the Advancement of Science and Technology, Hackensack; **Brice Huang**, West Windsor-Plainsboro High School North, Plainsboro; **Alexander Lin**, Millburn High School, Millburn

NEW YORK **Samuel Epstein,** John F. Kennedy High School, Bellmore; **Kalia D. Firester,** Hunter College High School, New York City; **Charles Gulian,** Ossining High School, Ossining; **Ien Li**, Jericho Senior High School, Jericho; **Scott Massa**, Commack High School, Commack; **Max Pine**, Pelham Memorial High School, Pelham; **Tiffany Sun**, Roslyn High School, Roslyn Heights; **Crystal Zheng**, Jericho Senior High School, Jericho

NORTH CAROLINA **Emily Lorin Ashkin**, Providence Day School, Charlotte

OHIO **Emily Jane Spencer**, Hathaway Brown School, Shaker Heights

OREGON **Valerie S. Ding**, The Catlin Gabel School, Portland; **Anika Raghuvanshi**, Jesuit High School, Portland

PENNSYLVANIA **Shashwat Kishore**, Unionville High School, Kennett Square

TEXAS **Lily Liu**, Texas Academy of Mathematics and Science, Denton

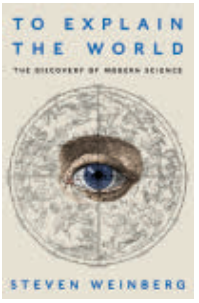
UTAH **Brandon Bicheng Cui**, Hillcrest High School, Midvale

VIRGINIA **Anya Michaelsen**, Lake Braddock Secondary School, Burke

WASHINGTON **Reesab Pathak**, Camas High School, Camas

WISCONSIN **Dhaivat Nitin Pandya**, Appleton North High School, Appleton

Finalists are listed by state, name, high school's name and city.



BOOKSHELF

To Explain the World

Steven Weinberg

Nobel laureate Steven Weinberg is a legend of 20th century physics, one of the chief architects of the mathematical structure that describes nature's particles and forces. It's the confluence of predictions based on that math and the experimental observations confirming them that gives modern physics its preeminence as a way of knowing how the world works.

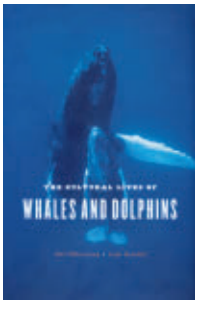
Science wasn't always like that. In ancient and medieval times, philosophical reasoning attempted to explain the heavens and the Earth, but the connection to experimental method was missing, Weinberg relates in *To Explain the World*. Not until the 17th century, with work by such towering figures as Galileo and Kepler, culminating in Newton's laws of motion and gravitation, did science in the modern — and powerful — sense arrive.

Weinberg tells this story in a way sure to make historians cringe. He admits that he comes "close to the dangerous ground" of flouting the notion that the past should be judged on its own terms. And in fact, Weinberg does often assess the past from the perspective of the present. From that viewpoint, he finds Aristotle (on one point) "careless or stupid"; Plato is "sometimes silly"; Descartes is "overrated."

But that is not his point. He cites the errors of "very intelligent individuals" from ages past to point out "how difficult was the discovery of modern science." His intent is to show that early "scientists" did not have a grasp on how science ought to be done.

Whatever you think of Weinberg's approach, his account of science's history is incisive, precise and thoroughly informed. It's not a full history of the efforts to understand nature that were made in the centuries before Copernicus shattered Aristotelianism, but a succinct and authoritative summary of the key steps in the path to modern methods and knowledge.

In an epilog, Weinberg defends the reductionist approach to science, in the sense that chemistry and biology are ultimately rooted in the workings of the laws of physics (while acknowledging, of course, that historical accidents play a key role in how biological history actually plays out). Weinberg is well-known for his reductionist views. On the other hand, it seems that he is a cat person. In criticizing Descartes' idea that animals are merely mechanical automatons, Weinberg writes: "On the basis of observation of several lovable pet cats, I am convinced that Descartes was ... wrong in saying that animals are machines without true consciousness." Who knew? — *Tom Siegfried*
HarperCollins, $28.99



BOOKSHELF

The Cultural Lives of Whales and Dolphins

Hal Whitehead and Luke Rendell

In 1987, a female orca in Puget Sound took to prodding around a dead salmon. Within weeks, the vogue had spread to the rest of her pod and two nearby pods. "Nearly everyone had their dead salmon toy," Whitehead and Rendell write in *The Cultural Lives of Whales and Dolphins*. "Then, just about as quickly as it arose, the fad stopped."

The trend is an example of culture, albeit an ephemeral one, say Whitehead and Rendell, who study sperm whales. The researchers argue that whales and dolphins are among a number of animals that have culture. Whitehead and Rendell define culture as behavior or information that animals learn from one another and share within a community.

After a few chapters defining terms, the meat of the book begins with the authors laying out the evidence for culture among whales. This includes widely observed behaviors such as humpback whale songs, which change and spread among the whales quickly within their lifetimes. "There is no way even the most outlandish scenarios can explain this pattern with genetics alone," Whitehead and Rendell write.

Another example of whale culture is groups of orcas learning distinct methods for tracking down food. Orcas, it turns out, are incredibly picky eaters and can hone their hunting skills to a particular prey: One orca group will slide onto a beach to snap up seals; another pins stingrays to the seafloor before gobbling them. It's believed that the whales learn which animals to eat, and how to hunt them, from other members of their group.

Some of the most vivid examples highlight individual animals. A dolphin held briefly in captivity learned to "tail walk" by watching performing neighbors and then later spread this behavior to dolphins in the wild. An orca raised in captivity and released into the wild proved unable to respond to the social overtures of wild whales.

The authors also convincingly dig into critiques and alternative explanations for whale and dolphin behavior, providing a detailed look at the debate over whether culture exists among the animals. Whitehead and Rendell pack the text with references, keeping the book scrupulously rooted in scientific evidence.

This makes for a slow read in places. But for readers who are curious about whales and dolphins in the wild, the book offers a thorough grounding. — *Kate Baggaley*
Univ. of Chicago, $35

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JANUARY 10, 2015

SOCIAL MEDIA

A river runs free

Demolishing two dams holding back Washington state's Elwha River (one shown below) has helped restore ecosystems (*SN: 1/10/15, p. 22*). The story prompted some readers on Facebook to call for other U.S. dams to come down.

"There's a dam in Oroville, Wash., that's doing nothing on the Similkameen River but blocking the salmon."
Rich White

"Very interesting. I wonder if they'll do something similar with what is left of Matilija in California, among others."
Stefan Brems

"That is great. Wish Oregon would do that, too."
Anita James

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A mineral by any other name

A rock from space helped researchers describe a common mineral found on Earth. In "A name for Earth's most abundant mineral" (SN: 1/10/15, p. 4), ***Thomas Sumner*** *explained that the form of magnesium iron silicate that makes up more than a third of the planet's volume is now officially called bridgmanite.*

The meteorite impact that forged the first naturally occurring bridgmanite sample generated pressures that reached 180,000 kilograms, about the weight of a blue whale, per square centimeter. "That comparison immediately set my bored mind to wandering about for other comparisons," **Jim Stars** wrote. Readers looking for another analogy could say that the pressures created by the impact equaled the weight of 360,000 gray squirrels or 1,384,615 chipmunks per square centimeter, he reported.

"How is it possible that scientists had any idea that such a thing as bridgmanite existed, if they had never seen or examined a piece of it?" asked **Carolyn Bredenberg** in an e-mail.

Bridgmanite may be sealed hundreds of kilometers below ground, but luckily nature provides a way to study Earth's innards, **Sumner** explains. Powerful earthquakes send vibrations through the planet. As these waves travel through regions with different densities and other properties, they change speeds slightly. By tracking many earthquakes across seismic stations, scientists confirmed the abundant mineral's existence and some of its properties.

Scientists also created synthetic versions of bridgmanite under extreme temperatures and pressures in laboratories, though the International Mineralogical Association doesn't consider artificial minerals worthy of naming.

Making methane in the city

Densely populated cities host a surprising amount of wildlife, as ***Kate Baggaley*** *reported in "The concrete jungle"* (SN: 1/10/15, p. 18). *Ants, fungi, bats and even coyotes can thrive in urban areas, sharing space with millions of human neighbors.*

Some nonhuman residents perform helpful services, like gobbling up dropped food that would otherwise get swept into garbage heaps, molder and release the greenhouse gas methane. "But isn't that methane produced eventually anyway when those animals, or those that eat them, decompose?" asked **Bruce Novak**. "Is there a net difference?"

When decomposition occurs in places without oxygen — such as when food waste is buried deep in landfills — it produces methane, **Baggaley** says. But when living organisms die in the open, their bodies break down on the ground or in the first few inches of soil. With plenty of oxygen around, decomposition releases water vapor and carbon dioxide, which are less potent greenhouse gases than methane.

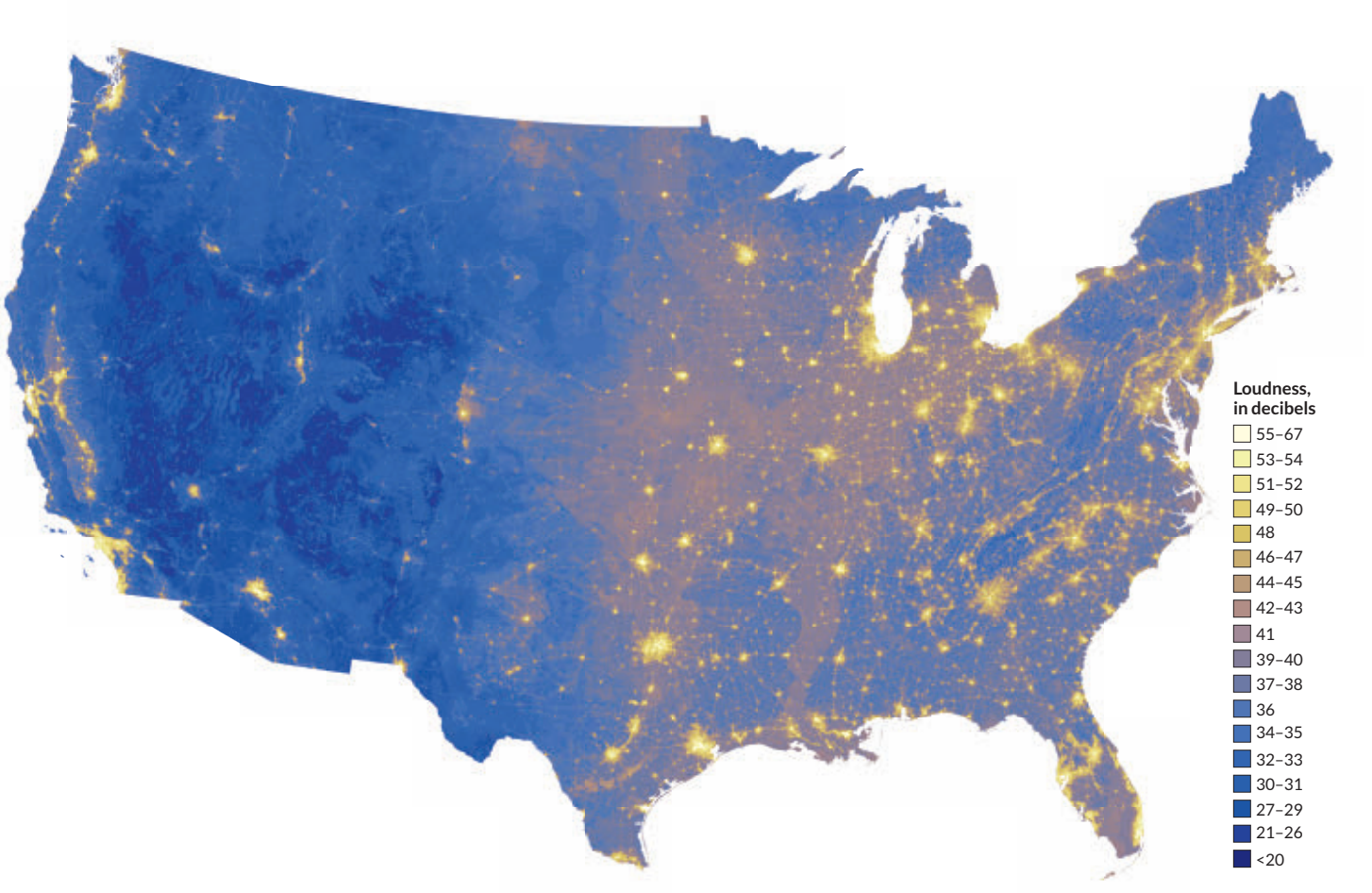
Examining mob math

Researchers have found patterns in the seemingly unpredictable behavior of crowds. ***Andrew Grant*** *described a new simulation that takes into account how people anticipate and avoid collisions in "Math depicts pedestrian behavior"* (SN: 1/10/15, p. 15).

Readers are intimately familiar with the problems of navigating within a throng of people. "I find lots of people just don't follow the 'keep to the right as you pass' rule. Phones are the major reason, I think," wrote commenter **Pacemaker4**. There are always outliers in data, noted **Ian McLaughlin**. "I think that's where your nonconformist pedestrians are coming in. I think most people do follow general body language rules when in large groups."

Norb Baumann would like to see simulations of more than just pedestrian behavior. "Having recently visited [Ho Chi Minh City] and [seen] the innumerable motorcycles throughout the city, I pondered how they avoid one another. It baffles me how they weave around one another without frequent accidents. Solving this mystery would be a real challenge for a model of motorcycle movement!"

JOHN GUSSMAN



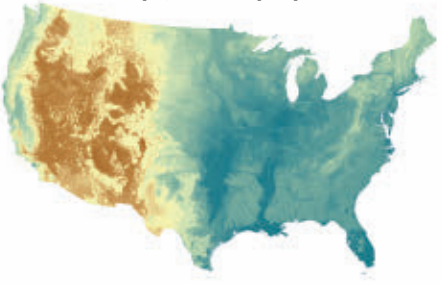
A cacophony of sounds on a summer's day

An ambitious National Park Service project exploits computer algorithms to predict the loudness of a typical summer day from coast to coast. The project's newest map (above, with yellow representing the loudest noise) includes natural sounds, but it's the human-made features that jump out.

The eastern half of the United States is louder than the West, according to the map, set to be released February 16 at the annual meeting of the American Association for the Advancement of Science in San Jose, Calif. The map shows an average volume, the sound level that's exceeded about half the time at particular spots. (Typical conversation registers at roughly 50 to 60 decibels.) Airplanes arcing high over the continent don't show up well, but cities and loud highways are clearly visible.

Researchers also predicted the loudness of a summer's day in an alternate universe without people (below). Again, the East is louder overall (green). Much of what drives this difference is water. Rivers rush and brooks babble, of course. But at least as significant to the noisescape are plants rustling in the wind and animals communicating and traipsing through ecosystems that are fueled by water (see Page 22).

U.S. soundscape, without people



Estimated loudness of natural sounds, in decibels

A corridor along the mighty Mississippi River stands out, as does verdant South Florida. As map coauthor Daniel Mennitt says, "Sound is life, right?"

Complete national sound monitoring is impossible, at least on the Park Service's budget. So researchers including Kurt Fristrup of the Park Service and Mennitt, of Colorado State University in Fort Collins, fed what data they could find, totaling about 1.5 million hours of acoustical monitoring, into a machine-learning computer program. For each location, the scientists included details such as average summer precipitation and weekly plane overflights. The program discerned patterns in all this geography and predicted where the noise is.

The findings should help urban planners, biologists and especially the Park Service, whose mission includes the arduous task of preserving some "natural quiet." —*Susan Milius*

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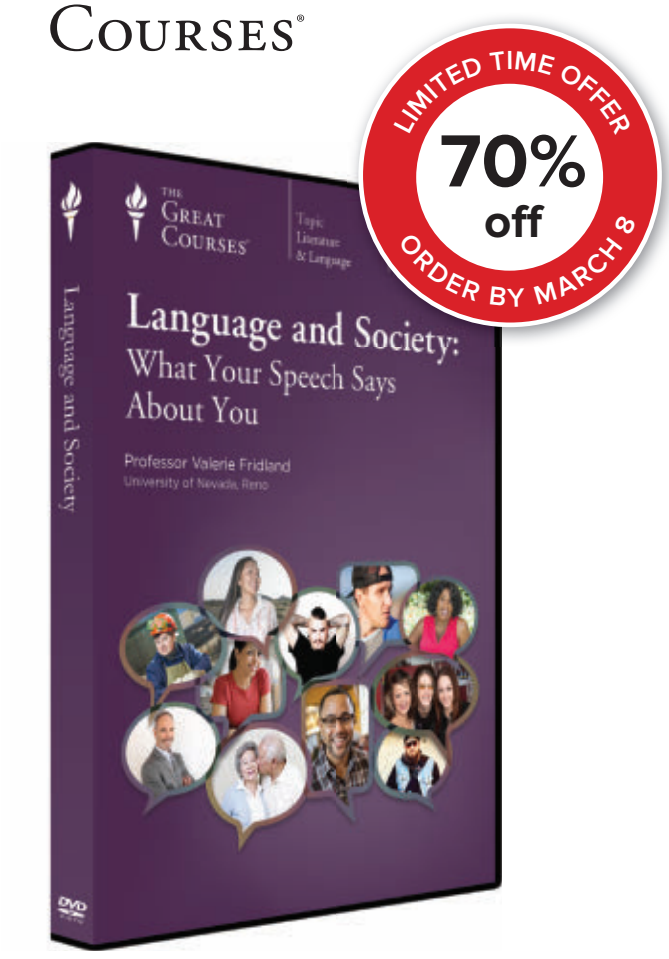

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