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SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC

JULY 9, 2016

More
Spacetime
Ripples

A Shot
Against
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First
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Fire

Hobbit
History

DRAWN TO TERROR

How sacred values and
group identity spark
commitment to violence





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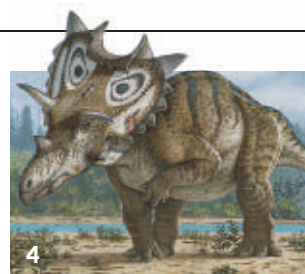
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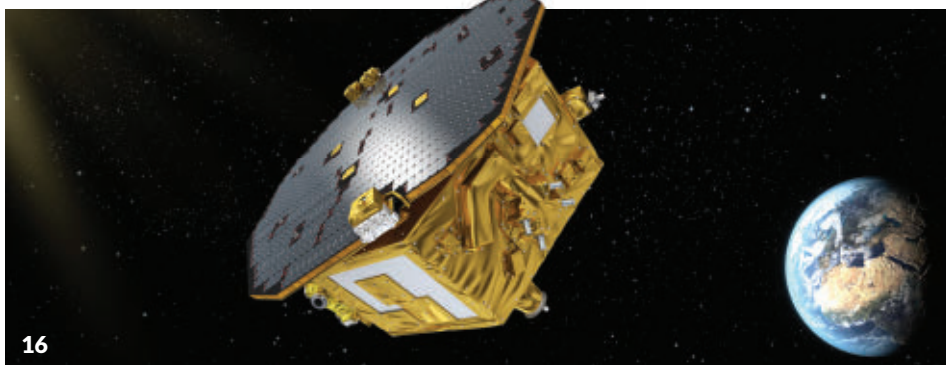
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Science advocates help underserved students

COVER An October 2014 explosion rocks the Syrian city of Kobani during a suicide car bomb attack by Islamic State militants. *Gokhan Sahin/Getty Images*



CLOCKWISE FROM TOP: PAUL FAITH/AP IMAGES; MIKE SKREPNICK/ESA; C. CARREAU



Problem-solving insights enable new technologies

Fire was one of our ancient ancestors' first forays into technology. Controlled burns enabled early hominids to ward off cold, cook and better preserve game. New evidence places fire-making in Europe as early as 800,000 years ago, much earlier than previously thought (Page 10) and closer to scientists' best estimate for hominids' first use of fire, about 1 million years ago in Africa.

It's unclear how early *Homo* species came to master fire, but it was perhaps an attempt at problem solving — capturing a natural phenomenon and harnessing it for use. That tradition has persisted in human cultures. It thrives today among scientists, especially those engaged in problem solving related to society's most pressing issues.

Take drug addiction, a vexing problem that has grown in urgency in the last decade as more and more people have become dependent on opioids — not only street drugs like heroin but also prescription pain meds like OxyContin and fentanyl. Opioids can be extremely difficult to give up because of their strong addictive pull. So scientists are trying to develop vaccines that would block the effects of heroin and other drugs of abuse, as Susan Gaidos reports on Page 22. Eliciting a strong immune response, researchers theorize, could stop the drug from reaching the brain, preventing the high that fuels addiction. Success with such biotechnology, now being tested only in lab animals, would offer hope to many battling to stay off drugs.

Another modern scourge is terrorism, and anthropologists like Scott Atran have been exploring the psychological and cultural factors that drive some individuals to extreme acts of violence. There is no technology to prevent people from committing such acts — at least not yet. Basic explorations must always precede any practical use of new knowledge: Hominids could not use fire until they understood its nature and limits — which things burn, which do not; water and sand douse flame, oil and fat fuel it. Mapping terrorism's contours is just a beginning on a long journey toward developing tactics for undercutting its power.

So it is with many other reports in this issue about basic explorations that may well precede the birth of new technologies. A few favorites:

- A report on insights into how the microbial denizens of the gut influence weight gain and obesity (Page 7). Scientists have now revealed a molecule made by microbes that sends a signal to the brain, influencing fat storage and appetite.
- An intriguing study of mice with genetic mutations similar to those found in some people with autism (Page 13). The findings suggest a role in the disorder for nerve cells involved with touch, as well as a new way to think about autism that may one day identify a target for novel therapies and interventions.
- News of a second detection of gravitational waves from LIGO (Page 8). It's less dramatic and showy than the first black hole merger detection, announced in February. But it is nonetheless a further sign that a new era, one in which astronomers probe the heavens by watching for violent if subtle wakes in the fabric of spacetime, is upon us. — *Eva Emerson, Editor in Chief*

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Lindell has been featured on numerous talk shows, including *Fox Business News* and *Imus in the Morning*. Lindell and MyPillow have also appeared in feature stories in major magazines and newspapers across the country. MyPillow has received the coveted "Q Star Award" for *Product Concept of the Year* from QVC, and has been selected as the Official Pillow of the National Sleep Foundation.

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Excerpt from the July 16, 1966 issue of *Science News*

50 YEARS AGO

Lightning seen as cause of puzzling chondrules

Lightning flashes in the huge cloud of primeval dust and gas from which the planets in the solar system condensed may have caused formation of the puzzling objects known as chondrules ... the tiny, rounded granules about the size of poppy seeds found in stony meteorites.... Dry lightning flashes could have been the source of the fast heating that, followed by quick cooling, [explains] the glassy structure of chondrules.

UPDATE: Chondrules are among the oldest pieces of planetary building blocks, formed roughly 4.6 billion years ago during the solar system's first few million years. How they formed is still up for debate. But the lightning hypothesis has mostly fallen out of favor. One leading idea is that chondrules emerged in the wake of shock waves that rippled through the planet nursery. Those shock waves may have been triggered by collisions of embryonic planets, gas waves spiraling around the sun or strong solar flares.



A shark's snout contains tiny pores, known as ampullae of Lorenzini, that can sense weak electric fields from prey. A jelly inside the pores turns out to be a highly efficient proton conductor.

Santa Cruz and colleagues squeezed jelly from the pores of one kind of shark and two kinds of skate and tested how well protons could flow through the substance. Good proton conductors, including a protein found in squid skin, occur in nature. But the jelly is the best biological proton conductor discovered so far. In fact, even humankind's best technology isn't wildly better. The most efficient proton conductor devised by people — a polymer known as Nafion — is a mere 40 times better than the stuff sharks are born with. — *Emily Conover*

MYSTERY SOLVED

Shark jelly is strong proton conductor

Sharks have a sixth sense that helps them locate prey in murky ocean waters. They rely on special pores on their heads and snouts, called ampullae of Lorenzini, that can sense electric fields generated when nearby prey move.

The pores were first described in 1678, but scientists haven't been sure how they work. Now, the answer is a bit closer.

The pores, which connect to electrosensing cells, are filled with a mysterious clear jelly. This jelly is a highly efficient proton conductor, researchers report May 13 in *Science Advances*. In the jelly, positively charged particles move and transmit current.

Marco Rolandi of the University of California,

THE -EST

Wine making goes way back in ancient Europe

Bottoms up, from the distant past. Thanks to a new method of analyzing the chemicals in liquids absorbed by clay containers, researchers have uncorked the oldest solid evidence of grape-based wine making in Europe, and possibly the world, at a site in northern Greece.

Chemical markers of red wine were embedded in two pieces of a smashed jar and in an intact jug discovered in 2010 in the ruins of a house destroyed by fire around 6,300 years ago at the ancient farming village of Dikili Tash.

After successfully testing the new technique on replicas of clay vessels filled with wine, then emptied, the scientists identified chemical markers of grape juice and fermentation in clay powder scraped off the inner surfaces of the Dikili Tash finds. None of the vessels

contained visible stains or residue, researchers report online May 24 in the *Journal of Archaeological Science*.

Remains of crushed grapes found near the ancient jar shards and jug had already indicated that Dikili Tash farmers made wine or grape juice, say chemist Nicolas Garnier of École Normale Supérieure in Paris and archaeobotanist Sultana Maria Valamoti of Aristotle University of Thessaloniki in Greece.

Previous reports of ancient wine have largely relied on chemical markers of grapes but not the fermentation necessary to turn them into wine, leaving open the possibility that containers held grape juice. The “juice versus wine” conundrum applies to roughly 7,400-year-old jars from Iran (*SN: 12/11/04, p. 371*), Garnier says. — *Bruce Bower*

The sound of gunshots may help solve crimes

The surveillance video shows a peaceful city streetscape: People walking, cars driving, birds chirping.

“Then, abruptly, there’s the sound of gunfire,” said electrical engineer Robert Maher. “A big bang followed by another bang.”

Witnesses saw two shooters facing off, a few meters apart — one aiming north, the other south. But no one knew who shot first. That’s where Maher comes in. His specialty is gunshot acoustics, and he’s helping shore up the science behind a relatively new forensics field.

In the case of the two shooters, surveillance cameras missed the action, but the sounds told a story that was loud and clear.

A distinctive echo followed the first gunshot but not the second. The first gunshot’s sound probably bounced off a big building to the north, causing the echo, Maher concluded. So the first person to shoot was the person facing north, he reported May 24 in Salt Lake City at a meeting of the Acoustical Society of America.

Maher has analyzed the booming echoes of gunshots in dozens of cases, but he’s also studying the millisecond-long sound of a bullet blasting out of the barrel — and finding differences from one type of gun to the next.

He and colleagues at Montana State University in Bozeman erected a semi-circular aluminum frame studded

with 12 microphones, evenly spaced and raised 3 meters off the ground. When someone standing on a raised platform in the center of the contraption shoots a gun — a 12-gauge shotgun, for example, or a .38 Special handgun — the microphones pick up the sound.

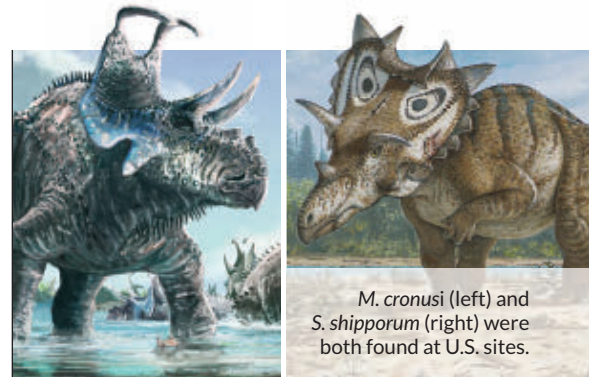
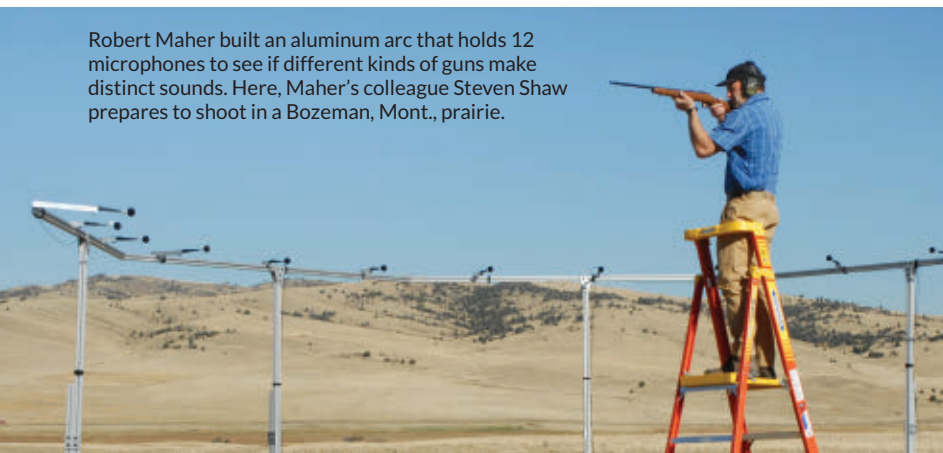
“Each of the different firearms has a distinctive signal,” he says. His team is building a database of sounds made by 20 different guns. To the ear, the gunshots seem alike, but Maher can chart out differences in the sound waves.

One day, investigators might be able to use the information to figure out what kind of guns were fired at a crime scene. Of course, Maher says, most crime scene recordings aren’t high quality — they often come from cell-phones or surveillance systems. But his team will compare those recordings with ones made in his outdoor “lab” and try to figure out which aspects of crime scene audio they can analyze.

Maher, a music lover who plays the cello and sings in a choir, didn’t intend this career. “If I were really talented at music, that’s what I’d be doing full time,” he says. Instead, he has applied his skills in math and science to problems involving sound: studying humans’ contribution to noise in national parks, for example, and now, gunshot acoustics.

For him, it’s “a nice way to bridge the gap between the science and the sound.” — *Meghan Rosen*

Robert Maher built an aluminum arc that holds 12 microphones to see if different kinds of guns make distinct sounds. Here, Maher’s colleague Steven Shaw prepares to shoot in a Bozeman, Mont., prairie.



M. cronusi (left) and *S. shipporum* (right) were both found at U.S. sites.

INTRODUCING

Related dinosaurs donned weird horns

Two newly discovered *Triceratops* relatives sported some peculiar headgear.

Researchers uncovered skull fragments of *Machairoceratops cronusi* in 77-million-year-old mudstone from the Wahweap Formation in southern Utah. Unlike other horned dinosaurs, the roughly 8-meter-long *M. cronusi* had two grooved horns with spatula-like tips bowed forward from the back of its neck shield. The grooves’ function baffles researchers.

A different research team found a younger cousin of *M. cronusi* in Montana’s Judith River Formation. *Spiclypeus shipporum* lived about 76 million years ago and had distinct brow horns that protruded sideways from its skull along with unusual spikes on its neck shield — some pointing outward, others bent forward. *S. shipporum*’s distinct horns and spikes may have allowed individuals of the species to recognize one another, says Jordan Mallon, a paleobiologist involved in the research at the Canadian Museum of Nature in Ottawa.

The new finds add to the diversity among the herbivorous horned dinosaurs that roamed North America during the Late Cretaceous period. “We thought we knew most things [about horned dinosaurs],” says Eric Lund, a paleontologist at Ohio University in Athens who analyzed *M. cronusi*. “But we’ve just scratched the surface.”

Papers detailing the new species were published May 18 in *PLOS ONE*. — *Cassie Martin*

HUMANS & SOCIETY

Hobbit history gets new beginning

Fossils of potential ancestor fuel debate over *Homo floresiensis*

BY BRUCE BOWER

Say hello to hobbits' possible ancestors. Excavations of fossils from roughly 700,000-year-old hominids on the Indonesian island of Flores have reinvigorated scientific debate over the evolutionary origins and identity of *Homo floresiensis*, a half-sized member of the human genus that lived much later on Flores.

Remains of at least three individuals found at a central Flores site, called Mata Menge, probably represent early versions of *H. floresiensis*, says a team led by paleontologist Gerrit van den Bergh of the University of Wollongong in Australia and Japanese biological anthropologist Yousuke Kaifu. A lower-jaw fragment and six teeth excavated in 2014 come from hominids that were about as small as hobbits. These fossils look enough like hobbit jaws and teeth to be assigned provisionally to *H. floresiensis*, the researchers conclude in the June 9 *Nature*.

Researchers are divided over what the new finds imply about hobbit evolution. "Nothing related to humans on Flores has a simple explanation," says paleoanthropologist María Martín-Torres of University College London. She calls the new discoveries "puzzling and exciting."

In a second paper in *Nature*, archaeologist Adam Brumm and colleagues describe chemical analyses of a hominid tooth and two animal teeth, as well as of volcanic ash and sediment layers at Mata Menge, that yielded the age estimate for the finds. Excavations also uncovered 149 stone artifacts, including 47 that lay



Newfound fossils, including these teeth and partial jaw, suggest that tiny members of the human genus inhabited the Indonesian island of Flores about 700,000 years ago.

among hominid fossils, says Brumm, of Griffith University in Nathan, Australia. Nonhuman animal bones unearthed in the new dig indicate that Mata Menge hominids lived in a river valley dominated by grasslands.

Mata Menge hominids were "a dwarfed descendant of early *Homo erectus* that somehow got marooned on Flores," suggests Kaifu, of the National Museum of Nature and Science in Tokyo. The Mata Menge fossils share several similarities with *H. erectus*, his team reports.

H. erectus reached the Flores vicinity deep in the Stone Age, arriving on the nearby island of Java at least 1 million years ago. An unknown hominid species inhabited the Indonesian island of Sulawesi by 194,000 years ago (*SN*: 2/6/16, p. 7).

Hobbit fossils, previously unearthed 74 kilometers west of Mata Menge in Flores' Liang Bua Cave, range in age from 100,000 to 60,000 years old (*SN*: 4/30/16, p. 7). Stone tools probably made by hobbits date to as early as 190,000 years ago.

Stone implements previously found at Mata Menge and another Flores site date to between around 1 million and roughly 800,000 years ago (*SN*: 6/3/06, p. 341). The new hominid fossils provide the first peek at the likely makers of the Mata Menge tools, Brumm says.

Too few fossils have been found to exclude the possibility that Mata Menge and Liang Bua hominids belonged to different, though probably related, populations that arrived on Flores at different times, Martín-Torres says.

Even so, Kaifu says, the new discover-

ies fit a scenario in which presumably large-bodied *H. erectus* settled on Flores around 1 million years ago and shrank in size over the next 300,000 years, a surprisingly short time for such dramatic brain and body changes to evolve. These hominids may have evolved smaller bodies over a relatively short period in response to limited island resources, proposes archaeologist Robin Dennell of the University of Sheffield in England.

But biological anthropologist William Jungers of Stony Brook University School of Medicine in New York says it's unlikely that *H. erectus* shrank to two-thirds of its initial body size and half its original brain size over only several hundred thousand years on Flores. He predicts that ongoing excavations at Mata Menge and nearby sites will uncover 1-million-year-old fossils of small-bodied hobbit ancestors that differed in many respects from *H. erectus*.

Like the Mata Menge team, though, Jungers says the new discoveries challenge an argument that a partial hobbit skeleton represents a *Homo sapiens* with Down syndrome (*SN Online*: 8/5/14).

Proponents of that idea disagree. Different hominids could have reached Flores at different times, as suggested by Martín-Torres, says Penn State developmental geneticist Robert Eckhardt. Not enough fossil evidence exists to show an evolutionary link between Mata Menge and Liang Bua individuals, argue Eckhardt and his colleague Maciej Henneberg, a biological anthropologist at the University of Adelaide in Australia. ■

Microbial signals influence obesity

In rodents, acetate tells brain to up insulin, hunger hormone

BY TINA HESMAN SAEY

Gut microbes cause obesity by sending messages via the vagus nerve to pack on pounds, new research in rodents suggests.

Bacteria in the intestines produce acetate, a short-chain fatty acid that works through the brain and nervous system to make rats and mice fat, researchers report in the June 9 *Nature*.

If the results hold up in humans, scientists would understand one mechanism by which gut microbes induce obesity: First, the microbes convert fats in food to acetate. Acetate in the blood somehow makes its way to the brain. The brain sends a signal through the vagus nerve to the pancreas to increase insulin production. Insulin tells fat cells to store more energy. Fat builds up, leading to obesity.

Acetate also increases levels of a hunger hormone called ghrelin, which could lead animals, including people, to eat even more, says Yale University endocrinologist Gerald Shulman, who led the study.

Biochemist Jonathan Schertzer of McMaster University in Hamilton, Canada, calls the paper a “tour de force.” Most studies that examine the health effects of intestinal microbes just list which bacteria, viruses, fungi and other microorganisms make up

the gut microbiome, he says. But a catalog of differences between lean and obese individuals doesn’t address what those microbes do. “What’s in a name?” he asks. “When you find a factor that actually influences metabolism, that’s important.”

Shulman and colleagues didn’t set out to study the gut microbiome’s role in obesity. In a previous study, the researchers noticed that infusing rats with acetate caused the pancreas’s beta cells to pump out insulin. Feeding rats a high-fat diet also caused acetate levels in the rodents’ blood to increase and stimulate insulin production.

Where the acetate was coming from wasn’t known. Previous studies had shown that gut bacteria can make acetate and other short-chain fatty acids (some of which have been linked to good health). So Shulman and colleagues wondered if gut microbes were responsible for the rodents’ acetate production.

In the new study, rats treated with antibiotics to kill off their gut microbes and germfree mice raised in sterile conditions didn’t produce much acetate. Restoring these rodents’ gut bacteria boosted acetate production, especially when the animals ate high-fat diets. Those results and others confirmed that the acetate comes from gut microbes.

Acetate doesn’t directly stimulate pancreatic beta cells to make insulin, Shulman and colleagues discovered. Instead, acetate somehow influences

the brain to send a “make insulin” signal through the vagus nerve to the pancreas. The vagus nerve is a major nerve system that connects the brain and internal organs, allowing messages to be passed both ways.

Injecting acetate directly into rats’ brains stimulated insulin secretion, the researchers found. Cutting the vagus nerve or blocking its activity with drugs stopped acetate from boosting insulin levels. Those results indicate that the vagus nerve carries the message that prompts fat storage and therefore may

be an important player in obesity.

The nerve has already been implicated in a variety of other ailments; stimulating it may offer some relief for conditions such as rheumatoid arthritis, heart disease and diabetes

Acetate somehow influences the brain to send a “make insulin” signal through the vagus nerve to the pancreas.

(*SN: 11/28/15, p. 18*).

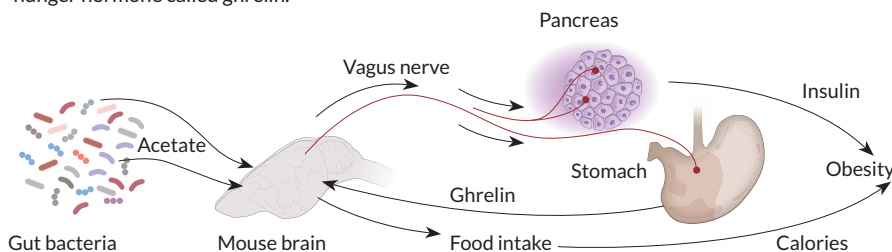
Last year, the U.S. Food and Drug Administration approved a vagus nerve stimulator for treating obesity. That device is supposed to signal the brain that the stomach is full. But Schertzer worries that acetate in the blood could still make it to the brain and override the all-full message. Blocking the signal from the brain to the pancreas may be more effective, he says.

Researchers now need to confirm that the same process happens in people, says Claes Wollheim, a physiologist at the University of Geneva. Wollheim and Geneva colleague Mirko Trajkovski wrote a commentary on the study in the same issue of *Nature*.

Identifying the bacteria that make acetate and figuring out how to stop them could lead to new obesity treatments, says microbiome researcher Chad Trent of the New York University Langone Medical Center. The discovery of this possible obesity mechanism will open new research avenues, he predicts.

“I really admire this paper,” Trent says. “It could turn out to be foundational work in the field.” ■

Putting on weight A molecule made by microbes may play a role in obesity, a new study in mice and rats finds. Gut bacteria turn fat in food into acetate. Acetate signals the brain to send messages via the vagus nerve to the pancreas to pump out insulin and to the stomach to make a hunger hormone called ghrelin.



ATOM & COSMOS

More gravitational waves detected

LIGO records signals from another collision of black holes

BY EMILY CONOVER

For the second time, scientists have glimpsed elusive ripples that vibrate the fabric of space. A new observation of gravitational waves, announced June 15 by scientists with the Advanced Laser Interferometer Gravitational-Wave Observatory, LIGO, follows the first detection, reported earlier this year (*SN*: 3/5/16, p. 6). The second detection further opens a new window through which to observe the universe.

“The era of gravitational wave astronomy is upon us,” says astronomer Scott Ransom of the National Radio Astronomy Observatory in Charlottesville, Va., who is not involved with LIGO. “Now that there’s two, you can’t get around that anymore.”

Both sets of cosmic quivers were wrought in cataclysmic collisions of black holes. But the latest observation indicates that such merging pairs of black holes are a varied bunch—the newly detected black holes were much smaller than the first pair. And this time, one in the pair was spinning like a top.

“The most important thing is that it’s a second one,” says LIGO spokesperson Gabriela González of Louisiana State University in Baton Rouge. “But it’s important that it’s different, because it shows that there’s a spectrum of black hole systems out there.”

The two black holes in the most recent detection were about eight and 14 times the mass of the sun and were located roughly 1.4 billion light-years from Earth, the scientists estimate. When the pair fused, they formed one bloated black hole with a mass 21 times that of the sun. One sun’s worth of mass was converted into energy and carried away by the gravitational waves, LIGO scientists reported in San Diego during a meeting of the American Astronomical Society.

“Gravitational astronomy is real,” LIGO laboratory executive director David Reitze said in a news conference. “The future is going to be full of binary black hole mergers for LIGO.”

A paper describing the finding was published in the June 17 *Physical Review Letters*.

As the two black holes spiraled around each other and slammed together, they churned up cosmic undulations that stretched and squeezed space—as predicted by Einstein’s general theory of relativity. These waves careened across the universe, reaching LIGO’s twin detectors in Hanford, Wash., and Livingston, La., on December 26, 2015.

Each L-shaped LIGO detector senses the minuscule stretching and squeezing of space across its two 4-kilometer-long arms. As a gravitational wave passes

through, one arm lengthens while the other shortens. Laser light bouncing back and forth in the arms serves as an ultrasensitive measuring stick that can pick up those subtle length changes (*SN*: 3/5/16, p. 22). As the gravitational waves rumbled past Earth in December, they stretched and squeezed the arms by less than a thousandth the width of a proton. That tiny deviation, appearing in both detectors nearly simultaneously, was enough to pick out the telltale ripples.

Compared with LIGO’s previously detected black hole merger, this one was a more minor dustup. These black holes were less than half the size of those in the first merger (30 and 35 solar masses according to a recently revised estimate). And the signal of their coalescence was more subtle, hiding under the messy wiggles in the data that result from random fluctuations or unwanted signals from the environment.

The first detection, in September, stunned scientists, due to the surprisingly large masses of the black holes and the whopping signals their gravitational waves left in the data. But the new black hole merger is more in line with expectations.

“This is comfort food,” says physicist Emanuele Berti of the University of Mississippi in Oxford, who is not involved with LIGO. “If you had asked me before the first detection, I would have bet that this would have been the first kind of binary black hole to be observed, not the monster we saw.”

In a new twist, the scientists found that one of the two merging black holes was spinning. It was rotating at a speed at least 20 percent of its maximum possible speed. Using gravitational waves to study how pairs of black holes twirl could help scientists understand how they form.

LIGO also saw hints on October 12 of a third black hole collision. The evidence was not strong enough to claim a definitive detection, though.

LIGO is currently offline, undergoing improvements that will allow the detectors to peer even farther out into space. Scientists expect it to be back up and running this fall. ■

Regular ripples LIGO’s newest glimpse of gravitational waves occurred on December 26, 2015. This followed the first observation of the spacetime tremors on September 14. LIGO also saw a hint of gravitational waves on October 12, but the signal wasn’t strong enough to claim detection. The experiment is offline and will resume collecting data this fall.



MEETING NOTES

Molecular handedness discovered in space

A possible clue about why life on Earth chooses only one mirror-image form of certain molecules lies in a gas cloud tens of thousands of light-years away.

For the first time, researchers have detected a chiral molecule, propylene oxide, in interstellar space. Chiral molecules, which come in two mirror-image versions, show up in many of life's building blocks, such as amino acids and sugars. The finding may be a step toward understanding why life prefers one of these versions over the other.

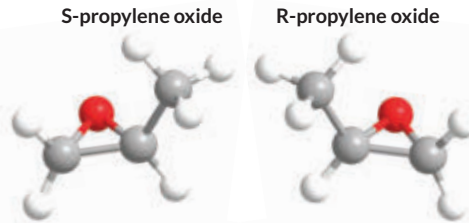
The results were presented June 14 and published in the June 17 *Science*.

The two forms of a chiral molecule are like opposing hands. Left hands and right hands mirror each other, but no amount of turning will get them to match when overlaid. A chiral molecule's two configurations are labeled as either left-handed or right-handed.

Amino acids and sugars come in both styles of handedness. But life on Earth exclusively uses left-handed amino acids and right-handed sugars. "This is one of the longest-standing mysteries in the origin of life," Caltech chemist Brett McGuire said at a news briefing.

Chiral molecules have shown up in meteorites with a slight preference for one configuration. McGuire and colleagues went looking for chiral molecules in space to see whether some interstellar intervention could preferentially seed a solar system with one handedness. The researchers sifted through radio observations from the Green Bank Telescope in West Virginia of a gas cloud dubbed Sagittarius B2. The nebula sits near the center of the Milky Way and has historically been a rich hunting ground for interstellar molecules.

McGuire and colleagues found that the cloud was loaded with the chiral molecule propylene oxide. The stockpile has a mass equal to about 80 percent of Earth's mass, McGuire said. And if compressed into a liquid blob, it would occupy a volume over five times that



Propylene oxide, a molecule that comes in mirror-image configurations, fills a gas cloud near the Milky Way's center. Above, white represents hydrogen; gray, carbon; red, oxygen.

of Earth. The observations don't reveal whether the cloud has a preference for one handedness over another; that will have to wait for future observations. But "we're in the best position we could possibly be," he said, to figure out if life's chiral exclusivity has an interstellar origin. — *Christopher Crockett*

Spinning, bulging stars could cause weird seasons on their planets

On some planets that orbit whirling stars, spring and autumn might be the best time to hit the beach, whereas summer offers a midyear respite from sweltering heat. These worlds' orbits can take them over regions of their suns that radiate wildly different amounts of heat.

"Seasons on a planet like this must be really strange," says Jonathon Ahlers, a graduate student at the University of Idaho in Moscow who presented his findings June 15.

Some stars spin so fast that they bulge in the middle. That bulge pushes the equator away from the blazing core, making it much cooler than the poles. A fraction of these stars also host planets that travel on cockeyed orbits, which take these worlds alternately over the poles and equator of their suns.

Ahlers developed computer simulations to see how the differences in solar energy combined with the tilted orbits might affect a planet's seasons. The outcome depends on how the planet's axis is tipped relative to its orbit. For a world whose north and south poles periodically face the star's equator, "you get a cooler summer than normal and an extremely cold winter, but spring and autumn can be hotter than summer," he says. "You get two distinct hottest times of the year."

How that plays out depends on how the planet is built: An atmosphere or oceans could mitigate climate extremes. Ahlers has yet to work out those details. — *Christopher Crockett*

Limestone world gobbled up by planet-eating white dwarf

A remote planet — the first with hints of a limestone shell — has been shredded by its dead sun, a new study suggests.

A generous heaping of carbon is raining down on a white dwarf, the exposed core of a dead star, astrophysicist Carl Melis of the University of California, San Diego reported June 13. The carbon — along with a dash of other elements such as calcium, silicon and iron — is probably all that remains of a rocky planet, torn apart by its dying sun's gravity. Many other white dwarfs show similar signs of planetary cannibalism (*SN Online: 10/21/15*), but none are as flooded with carbon atoms as this one.

A planet slathered in calcium carbonate, a mineral found in limestone, could explain the shower of carbon as well as the relative amounts of other elements, Melis says. He and astrophysicist Patrick Dufour of the University of Montreal estimate that calcium carbonate could have accounted for up to 9 percent of the doomed world's mass.

While a limestone-encrusted world is a first, it's not shocking, Melis says. The recipe for calcium carbonate is carbon and calcium in the presence of water. "If you have those conditions, it's going to form," he says.

"The real interesting thing is the carbon," Melis adds. Carbon needs to be frozen — most likely as carbon dioxide — to be incorporated into a forming planet. But CO₂ freezes far from a star, beyond where researchers suspect rocky planets are assembled. A limestone planet could have formed in an unexpected place and later wandered in while somehow retaining its carbon stores in the warm environs closer to its sun. Or the carbon might have been delivered to the world after it formed. But, Melis says, it's not clear how either scenario would happen. — *Christopher Crockett*

HUMANS & SOCIETY

Europeans lit fires 800,000 years ago

Cave holds continent's earliest evidence of intentional blazes

BY BRUCE BOWER

Prehumans living around 800,000 years ago in what's now Spain were, literally, trailblazers. They lit small, controlled blazes in a cave, a new study finds.

Discoveries in the cave provide the oldest evidence of fire-making in Europe, say paleontologist Michael Walker of the University of Murcia in Spain and colleagues. The findings also support proposals that members of the human genus, *Homo*, regularly ignited fires starting at least 1 million years ago. Fire-making began in Africa (*SN*: 5/5/12, p. 18), then moved north to the Middle East (*SN*: 5/1/04, p. 276) and Europe, the researchers conclude in the June *Antiquity*.

If the age estimate for the find holds, the report adds to a surprising number of sites from deep in the Stone Age that

retain evidence of small, intentionally lit fires, says archaeologist John Gowlett of the University of Liverpool in England.

Excavations since 2011 at Cueva Negra del Estrecho del Río Quípar have uncovered more than 165 stones and stone artifacts that had been heated, as well as several hundred animal-bone fragments displaying signs of heating and charring. Microscopic and chemical analyses indicate that these finds were heated to between 400° and 600° Celsius, consistent with having been burned in a fire.

Walker's group doubts that sparks from a brush fire near the cave's entrance could have triggered fires five to seven meters



Shallow ripples caused by heating on this rock excavated in a Spanish cave indicate that an undetermined *Homo* species ignited fires there around 800,000 years ago.

inside the cave. Dry brush probably didn't grow near the cave anyway, the researchers add. Geologic evidence suggests that the cave bordered a river and swamp.

Dating of the fire-making depends on the researchers' previous identification of a reversal of Earth's magnetic field, about 780,000 years ago, that left a mark in sediment just above where the burned material was found.

Other researchers suspect Cueva Negra's artifacts aren't that old. A team led by biological anthropologist Juan Manuel Jiménez-Arenas of the University of Granada in Spain says it's hard to say where the finds originally lay relative to several reversals of Earth's magnetic field preserved in the cave's layers. A *Homo* species made tools there no more than about 600,000 years ago, Jiménez-Arenas' group concluded in 2011 in the *Journal of Archaeological Science*.

Walker's team says fossils of extinct animals excavated along with the stone tools support the older age for fire-making. But even at 600,000 years old, the artifacts would still predate other evidence of controlled fire in Europe. ■

BODY & BRAIN

Morphine can prolong rats' pain

Experiment suggests another drawback to using opioids

BY LAURA SANDERS

Painkillers in the opium family may actually make pain last longer. Morphine treatment after a nerve injury doubled the duration of pain in rats, scientists report in the June 14 *Proceedings of the National Academy of Sciences*.

The results raise the troubling prospect that in addition to having unpleasant side effects and addictive potential, opioids such as OxyContin and Vicodin could actually extend some types of pain. If a similar effect is found in people, "it suggests that the treatment is actually contributing to the problem," says study coauthor Peter Grace, a neuroscientist

at the University of Colorado Boulder.

Opioid-based drugs can cause heightened sensitivity to pain for some people while taking the drugs, a condition called opioid-induced hyperalgesia. The new study shows that the effects linger weeks after the drugs are stopped. Male rats underwent surgery in which their sciatic nerves, which run down the hind legs, were squeezed with a stitch—a constriction that causes pain afterward. Ten days after surgery, rats received a five-day course of either morphine or saline.

Rats that received saline took about four weeks to start recovering, showing less sensitivity to a poke. Rats that got morphine took about eight weeks—double the time. "We were definitely surprised by that," Grace says.

Unpublished data indicate that morphine extends pain even longer in female rats, Grace says, which fits with what's known about differences in how males and females experience pain.

Longer-lasting pain in the rats came courtesy of an inflammatory response in the spinal cord. The immune system sees morphine as a threat, the researchers suspect, and responds by revving up inflammation through specialized cells called microglia. Experiments that shut down this process in microglia shortened the duration of the pain.

Many questions remain. Scientists don't yet know if a similar immune reaction happens in people. Nor is it known whether all opioid-based painkillers would behave like morphine.

Understanding the details of how the process works has implications for doctors, many of whom may be unaware of opioids' complex relationship with pain, says Jonathan Chen, an internal medicine physician at Stanford University School of Medicine. Clarity on how opioids influence pain could change doctors' prescribing habits and encourage the search for better pain treatments, he says. ■

Zika may be less risky in last trimester

Study of moms infected late in pregnancy finds no birth defects

BY MEGHAN ROSEN

Early results from cases tracked in Colombia suggest that Zika infection late in pregnancy is not linked to microcephaly, a birth defect that leaves infants with abnormally small heads and brains.

In a group of 1,850 pregnant women reported to be infected with the virus during the third trimester, more than 90 percent have given birth. None of their babies have any “apparent abnormalities,” researchers report online June 15 in the *New England Journal of Medicine*.

The finding offers a slight glimmer of hope in the ongoing Zika crisis. Since 2015, the mosquito-borne virus has spread to 46 countries and left more than 1,500 babies with severe birth defects.

But any optimism should come with caution, says Anna Durbin, an infectious diseases physician at Johns Hopkins

Bloomberg School of Public Health. The absence of microcephaly warrants “a huge sigh of relief,” she says. But releasing the results now “is a little bit premature.” Thousands of pregnant women in Colombia reported to have been infected have yet to give birth (*SN: 4/2/16, p. 26*). “What we really want to know is what’s going to happen to women who were infected in their first trimester,” Durbin says.

In May, a study estimated that the risk of delivering a baby with microcephaly after a first trimester Zika infection could be up to 13 percent.

Zika reached Colombia in October 2015, a year and a half after the virus broke out in Brazil. As of April 2, Colombia reported 11,944 suspected cases of Zika virus in pregnant women. Of 2,037 of these women checked for Zika virus RNA so far, 1,484 have tested positive.

These numbers, however, underestimate the total effect of the Zika outbreak, because they include only people with symptoms, Margaret Honein of the U.S. Centers for Disease Control and Prevention in Atlanta and coauthors note in the new paper. Scientists estimate that some three out of four people infected with Zika have no symptoms.

Among the women studied, none gave birth to babies with microcephaly. Four others in Colombia, though, have delivered babies with birth defects linked to Zika. Because these mothers had no symptoms, it is unclear when in pregnancy they contracted the disease.

The new findings are no guarantee that infection late in pregnancy is OK—or that the Colombian infants are out of the woods just yet. “The fact that these babies do not have an anatomical problem... does not mean that they do not have any problem,” says University of Pittsburgh public health researcher Ernesto Marques. “We need to follow the development of these kids.” ■



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LIFE & EVOLUTION

Squid stays hidden by leaking light

Inefficiency in bioluminescent cells may aid in camouflage

BY SUSAN MILIUS

A sloppy light system may be just what a squid needs to hide from predators. Bioluminescent cells in some glass squid work in a surprisingly inefficient way — leaking a lot of light rather than fully channeling it, a new study suggests.

Glass squid have largely transparent bodies, helpful for inconspicuous swimming in deep open water. Marine predators often scan the waters above them for the telltale silhouettes of prey blocking sunlight, but there's little to betray a glass squid — except for a few notable

In glass squid, five types of photophore cells (cross sections shown) plus a mixed cluster (far right) can produce different effects as they leak bioluminescent light.

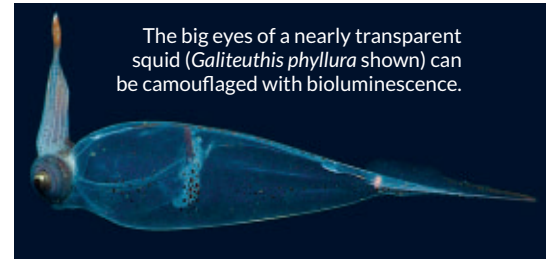


features such as the shadow-making eyes on its head.

Underneath those eyes, squid in the genus *Galiteuthis* grow silvery patches of cells that act as undersurface bioluminescence, a camouflage technique that has evolved in various marine creatures, making their shadows less conspicuous to hunters below.

Biophysicist Alison Sweeney of the University of Pennsylvania had hypothesized that the cells, called photophores, act like microscopic cables that channel the bioluminescent glow of the squid down or out in a specific direction. The skinny cells are surrounded by thin, protein-dense layers that create a silver tube. But in the first detailed look at these structures, Sweeney and Pennsylvania colleague Amanda Holt found that the channels perform poorly, letting most of the light leak away sideways. That inefficiency could be useful, Sweeney and Holt report June 8 in the *Journal of the Royal Society Interface*.

“We always expect that the most ‘perfect’ or efficient mechanism will be the pinnacle of evolution, but this study shows that there are many ways to solve challenges imposed by the environment,”



The big eyes of a nearly transparent squid (*Galiteuthis phyllura* shown) can be camouflaged with bioluminescence.

says marine biologist Steven Haddock of the Monterey Bay Aquarium Research Institute in California.

Other researchers had discussed the idea that certain sea creatures show a great deal of subtlety in disguising their silhouettes, but Sweeney knew of no other study trying to figure out how the supposed cables work.

It turns out that the squid structures were “really bad at being fiber-optic cables,” Sweeney says. The cells are longish for a cell but short for a cable. And the cells couldn’t guide light even over that short distance without losing much of it. Looking at the cross sections of the photophores under a microscope showed big, uneven gaps in the layers. When Sweeney first recognized this, she expected to write “a boring paper that’s, ‘Gee, squid cells kind of sort of guide

LIFE & EVOLUTION

Plankton held hostage by viral pirates

Infections inhibit marine microbes’ capture of carbon dioxide

BY SUSAN MILIUS

When plankton on the high seas catch a cold, the whole ocean may sneeze. Viruses hijacking these microbes could be an important overlooked factor in tracing how living things trap — or in this case, fail to trap — the climate-warming gas carbon dioxide.

Plants and other organisms that photosynthesize use energy from the sun to capture CO₂ for food. The most abundant of these photosynthesizers are two genera of marine cyanobacteria: *Synechococcus* and *Prochlorococcus*.

Now, for the first time, a study has looked in detail at what happens when some ocean viruses infect these microbes.

Two viruses tested in the lab hijacked cell metabolism, allowing photosynthesis to continue but shunting the captured energy to virus reproduction. The normal use of that energy, capturing CO₂, largely shuts down, David Scanlan of the University of Warwick in England and colleagues report in the June 20 *Current Biology*. So, scientists may overestimate by as much as 10 percent the amount of CO₂ that photosynthesis in the oceans captures.

On any given day, 1 to 60 percent of these plankton may have a viral infection, researchers have estimated. That means viruses may prevent marine organisms from capturing up to 5.39 petagrams of carbon — 5.39 billion metric tons — a year.

That is equivalent to 2.8 times the CO₂ captured annually by all the planet’s salt marshes, coral reefs, estuaries, sea grass meadows and seaweeds put together.

Synechococcus and *Prochlorococcus* “are organisms that you’ve never heard of, but you really should have,” says Adam Martiny of the University of California, Irvine, who studies these plankton. What he appreciates about the new work is the intriguing biology of viral manipulation it has uncovered.

Researchers have had clues that viruses attacking these marine organisms might manipulate photosynthesis, perhaps keeping the process running in an infected cell. These viruses have genes for proteins used in photosynthesis, even though a virus doesn’t even have its own cell much less a way to photosynthesize.

What the viruses are doing, Scanlan and colleagues now show, is subverting

light, but not really.’”

Then came the “of course” moment. “These things are meaningless until you consider the habitat,” Sweeney says. After considering the light environment where squid swim, the researchers realized that the overall effect of the leaking tubes creates a plausible approximation for the twilightlike haze in which the squid live. A glowing blur might actually make the eyes less conspicuous to predators approaching from a variety of angles.

Irregularities in the sheathing and shapes of the leaky cables might even make the living cables more remarkable, Sweeney speculates. Dividing them into five rough types, the researchers investigated the kinds of light effects each produced and matched those effects with measurements of ocean conditions. If squid can pick which cable doodads to use and when, the animals could improve the match between their under-eye shine and conditions in the ocean.

Other squid with opaque skin flicker, darken and quick-change their tiny color-making structures, she points out. So, the suggestion that eye-glow structures might change, too, “is not crazy,” Sweeney says. ■

their victims’ photosynthesis. Energy capture, the part of photosynthesis directly involved with light, goes on as usual; the cells carry out the routine electron transport for catching energy. But instead of using those electrons to then capture CO₂, the viruses shut down this process. The light reactions are the ones that researchers normally measure to estimate how much carbon photosynthesis captures, but the viral shunting means that estimate could be too high.

Scanlan cautions that this is just the beginning of working out the effects of these viral diseases. Whatever the effects turn out to be outside the lab, they may intensify as the climate changes. Plankton are “projected to be winners in the new, warmer oceans” and may become even more numerous, Martiny says. And what’s good for them may also be good for the viral pirates that hijack them. ■

BODY & BRAIN

Autism tied to aberrant sense of touch

In mice, mutations in skin nerve cells cause behavioral problems

BY LAURA SANDERS

Most people think that autism is a disorder of the brain. But the skin may play a role, too, a new study suggests.

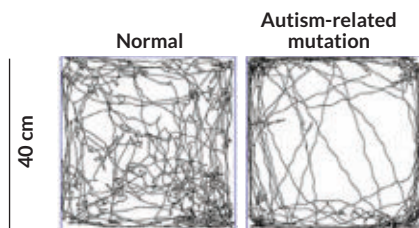
Nerve cells in the skin are abnormal in mice with mutations in autism-related genes, leading to altered touch perception, scientists report online June 9 in *Cell*. This trouble sensing touch may influence the developing brain in a way that leads to social deficits and anxiety later in life.

The results raise the provocative idea that fixing abnormal senses may alleviate some of the behavioral symptoms of autism, says David Ginty, a neuroscientist at Harvard Medical School.

To explore the role of touch, Ginty and colleagues used mice that carried mutations in genes linked to autism. The genes are active in many places, including the brain. But the researchers used genetic tricks to place the mutated genes only in the peripheral nervous system — the collections of nerves outside the brain and spinal cord.

These mutations interfered with the mice’s sense of touch. The mice had trouble telling a smooth object from a rough one, and they had outsized reactions to harmless puffs of air. “They’re really touchy when you pick them up,” Ginty says. The sensory breakdown was caused by touch-sensing nerve cells that seemed to have trouble sending messages to the spinal cord, the researchers found.

Some mice also had behavioral deficits.



Nervous mice Compared with normal mice, mice that carried an autism-related mutation in their peripheral nerve cells avoided the center of an enclosure (mice’s tracks shown in black), a sign of anxiety.

Those with mutations in one of two genes — *Mecp2* or *Gabrb3* — in the peripheral nervous system showed more signs of anxiety and interacted with other mice less than mice that didn’t have those mutations.

The skin’s influence seems to be important early in life. Social behaviors and anxiety didn’t suffer when the genes were first mutated in touch-sensing nerve cells during adulthood. The effect on behavior showed up only when the genes were abnormal during development.

That finding is “the most impressive part of the work,” says neuroscientist Kevin Pelphrey of George Washington University in Washington, D.C. The results emphasize how autism is a developmental disorder, he says.

Pelphrey and colleagues previously found that the brains of children with autism react differently to light touch, which fits with the idea that problems of touch may be involved in the disorder.

Ginty and colleagues plan to figure out exactly when these genes do their important work in the peripheral nervous system. “We are now really interested in the window of time,” he says. “Presumably that window closes at some point, and we’re trying to figure out when that is.” The researchers will also explore ways to restore normal touch sensation, including drugs or genetic manipulations, that would work before the window closes.

It’s possible that other nerve cells outside the brain are affected in autism, too, says neuroscientist Aaron McGee of the University of Southern California in Los Angeles. If there are similar problems with the nerves that innervate the gut, he says, that could help explain why people with autism often experience gut trouble.

McGee cautions that it’s difficult to compare behaviors of mice with symptoms of autism in people. But he says that the genetic experiments described in the paper are “awesome, thorough and significant.” ■

ATOM & COSMOS

Jupiter's turbulent weather runs deep

Radio telescopes peer into giant planet's stormy atmosphere

BY CHRISTOPHER CROCKETT

Jupiter's turbulence is not just skin deep. The giant planet's visible storms and blemishes have roots far below the clouds, researchers report in the June 3 *Science*. The new observations offer a preview of what NASA's Juno spacecraft, set to arrive at Jupiter July 4, will see.

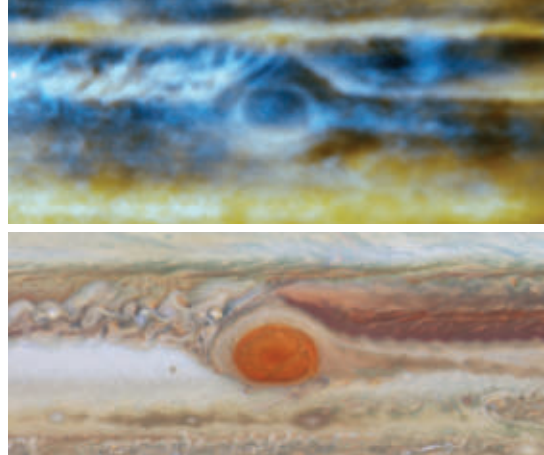
A chain of rising plumes, each coming from nearly 100 kilometers into Jupiter's atmosphere, dredge up ammonia to form ice clouds. Between the plumes, dry air sinks back into the Jovian depths. The famous Great Red Spot, a storm wider than Earth that has churned for several hundred years, extends at least dozens of kilometers below the clouds as well.

Jupiter's dynamic atmosphere provides a possible window into how the planet works inside. "One of the big questions is what is driving that change," says planetary scientist Leigh Fletcher of the University of Leicester in England. "Why does it change so rapidly, and what are the environmental and climate-related

factors that result from those changes?"

Planetary scientist Imke de Pater of the University of California, Berkeley and colleagues observed Jupiter with the Very Large Array radio observatory in New Mexico. Jupiter emits radio waves generated by heat left over from its formation. Ammonia gas within the atmosphere intercepts certain radio frequencies. By mapping how and where those frequencies are absorbed, the researchers created a 3-D map of the ammonia that lurks beneath the clouds. Those plumes and downdrafts appear to be powered by a narrow wave of gas that wraps around much of the planet.

The depth of Jupiter's atmospheric choppiness isn't too surprising, says Scott Bolton, a planetary scientist at the Southwest Research Institute in San Antonio. "Almost everyone I know would have guessed that," he says. But the observations do provide a teaser for what to expect from the Juno mission (*SN*: 6/25/16, p. 16), led by Bolton.



A radio map (top) shows ammonia churning around Jupiter's Great Red Spot dozens of kilometers below the cloud cover. The bottom image shows the same region in visible light.

By getting close to the planet — just 5,000 kilometers from the cloud tops — Juno will break through the fog of radio waves from Jupiter's radiation belts that obscures observations made from Earth and limits what telescopes like the Very Large Array can see. But the spacecraft will see only a narrow swath of Jupiter's bulk at a time. "That's where ground-based work like the research de Pater has been doing is really essential," Fletcher says. Observations such as these will let Juno scientists know what's going on across the atmosphere so they can better understand what Jupiter is telling them. ■

EARTH & ENVIRONMENT

Volcanic rock can quickly store CO₂

Basalt injections offer benefits over other disposal schemes

BY THOMAS SUMNER

A new technique turns climate-warming carbon emissions to stone. In a test program in Iceland, more than 95 percent of the carbon dioxide injected into basaltic lava rocks mineralized into solid rock within two years. This surprisingly fast transformation quarantined CO₂ from the atmosphere and could ultimately help offset society's greenhouse gas emissions, scientists report in the June 10 *Science*.

"It's working, it's feasible and it's fast enough to be a permanent solution

for storing CO₂ emissions," says study coauthor Juerg Matter, a geochemist at the University of Southampton in England.

Many existing carbon storage schemes pump CO₂ underground, though the approach has been prone to leaks. Targeting basalt, the cooled remains of volcanic outpourings, may offer an advantage over using other rock types. As much as 25 percent of basalt is made up of elements that react with CO₂ to form solid carbonate minerals such as limestone, a process that occurs naturally during rock weathering. Since it was thought that this mineralization process takes hundreds to thousands of years in most rock, it seemed far too slow to be useful in combating near-term climate change.

In Iceland, Matter and colleagues blended groundwater with 230 metric tons of CO₂ emissions from a geothermal

power plant to create a kind of seltzer water. The team then injected the mixture 400 to 800 meters belowground into basaltic rock. After about two years, the team collected samples of the deep rock. Almost all of the CO₂ had mineralized.

At \$17 per ton, mineralizing carbon emissions is roughly twice as expensive as existing storage methods, though it doesn't require long-term monitoring to prevent leaks, Matter says. And "we have enough basalt globally to take care of all anthropogenic CO₂ emissions, theoretically."

Another group's work backs up the findings. Peter McGrail, a geochemist at the Pacific Northwest National Laboratory in Richland, Wash., and colleagues conducted similar tests using pure CO₂ without water. The yet-to-be-published findings revealed rapid mineralization similar to that reported, McGrail says. ■

FROM TOP: M.H. WONG, I. DE PATER, R.J. SAULT, NASA, ESA, A.A. SIMON, M.H. WONG, G.S. ORTON

DNA tells of dual origins for dogs

Domestication might have happened in Asia and Europe

BY TINA HESMAN SAEY

Dogs were domesticated at least twice, a new study suggests.

Genetic analyses of a 4,800-year-old Irish dog and 59 other ancient dogs suggest that canines and humans became pals in both Europe and East Asia long before the advent of farming, researchers report in the June 3 *Science*. Later, dogs from East Asia accompanied their human companions to Europe, where their genetic legacy trumped that of dogs already living there.

That muddled genetic legacy may help explain why previous studies have indicated that dogs were domesticated from wolves only once. Dogs may have originated in East Asia, Central Asia or Europe. The idea that dogs came from East Asia or Central Asia is mostly based on DNA from modern dogs; claims for European origins have been staked on prehistoric pups' genetics. "This paper combines both types of data" to give a more complete picture, says paleontologist Mietje Germonpré of the Royal Belgian Institute of Natural Sciences in Brussels, who was not part of the study.

Understanding this domestication process may illuminate humans' lifestyles in the distant past — dogs were probably the first domesticated animal and may have paved the way for taming other animals and plants.

Evolutionary geneticist Laurent Frantz of the University of Oxford and colleagues compiled the complete set of genetic instructions, the genome, of an ancient dog found in a tomb near Newgrange, Ireland. The dog probably looked like a mutt with fur similar to a wolf's, Frantz says.

The ancient mutt had a stretch of enigmatic DNA, says Germonpré. "This Irish dog has a component that can't be found in recent dogs or recent wolves."

That distinct DNA could represent the genetic ancestry of indigenous prehistoric dogs in Europe, she says. Or it could be a trace of an extinct ancient wolf that may have given rise to dogs (*SN: 7/13/13, p. 14*).

Comparisons of the ancient Irish dog's DNA with that of modern dogs reveal that East Asian dogs are genetically different from European and Middle Eastern dogs, the researchers found. Other researchers may have missed the distinction between the two groups because they were working with only subsets of the data that Frantz and colleagues amassed. Frantz's team generated DNA data from the Newgrange dog and other ancient dogs, and used genetic data from previous studies of 685 modern dogs.

The distinct genetic profiles of today's Eastern and Western dogs suggests that two separate branches of the canine family tree once existed. The Newgrange dog's DNA is more like that of the Western dogs. Since the Irish dog lived 4,800 years ago, the Eastern and Western dogs must have formed distinct groups before then, probably between about 6,400 to 14,000 years ago. The finding suggests that dogs may have been domesticated from local wolves in two separate locations during the Stone Age.

Although there may have been two

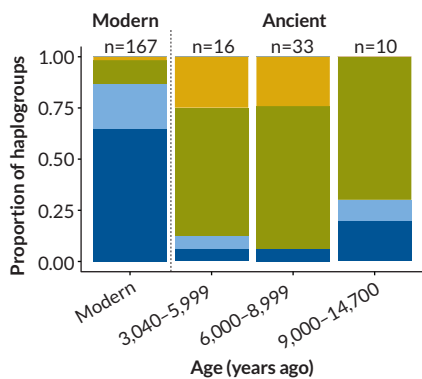
origin points for dogs, humans' canine companions have since mixed and mingled. By comparing mitochondrial DNA, the genetic material inside energy-generating organelles, from 59 ancient European dogs and 167 modern dogs, the researchers determined that East Asian dogs at least partially genetically replaced European dogs at some point in the distant past. Ancient European dogs' mitochondrial DNA varieties, or haplogroups, differed from those of modern dogs, the researchers found. Of the ancient dogs, 63 percent carried haplogroup C and 20 percent carried haplogroup D. Two different haplogroups are most prevalent in present-day dogs: 64 percent carry haplogroup A and 22 percent carry haplogroup B. That shift and other evidence indicate that dogs from the East moved west with humans, and Eastern dogs passed more of their genetic heritage to descendants than Western dogs did.

Archaeological evidence supports the dual origin story. Dog fossils as old as 12,500 years have been found in East Asia. In Europe, dogs date back 15,000 years. But there is a dearth of dog remains older than 8,000 years in Central Eurasia. That lack of fossils may rule out this in-between region as a domestication site, despite some genetic evidence from village dogs that says otherwise (*SN: 11/28/15, p. 8*). "The argument in this paper, pointing out a pattern in the archaeological data of an absence of early dog remains in the period [before] 10,000 years ago, should be taken very seriously," says Pontus Skoglund, an evolutionary geneticist at Harvard Medical School.

But he's not yet won over by the double-domestication hypothesis. The researchers admit they can't yet rule out that dogs were domesticated once, then transported to different places where isolation, random chance and other factors caused them to drift apart genetically.

More ancient DNA may help clarify the still-hazy picture of dog domestication. "It's going to be an exciting time going forward," Skoglund says. ■

Shift in dogs' genetic makeup



Mitochondrial haplogroups A ■ B ■ C ■ D ■

Doggy DNA The proportion of mitochondria types (haplogroups) that European dogs carry has changed over time, as seen in the graph above. That shift probably happened as dogs from East Asia came to Europe and took over genetically, new research suggests.

ATOM & COSMOS

Space-based probe passes tests for gravitational wave detection

Gravitational waves, ripples in the fabric of spacetime, can be detected with a space-based observatory, researchers say.

LISA Pathfinder, a European Space Agency satellite launched on December 3, 2015, has been testing technologies needed to put a gravitational wave detector in space. By avoiding the rumblings that detectors on the ground have to deal with, a space-based observatory can peer much deeper into space. At a news conference on June 7, mission scientists announced that the orbiting facility has surpassed the precision needed for future missions to detect spacetime disturbances.

That precision equates to measuring changes in the distance between two free-floating cubes, 38 centimeters apart, of roughly a millionth of a millionth of a meter. LISA Pathfinder can't detect gravitational waves; it only shows that a space-based facility can measure such subtle changes. A full-blown gravitational wave detector, planned to launch around 2030, will track the distance between three satellites millions of kilometers apart. — *Christopher Crockett*

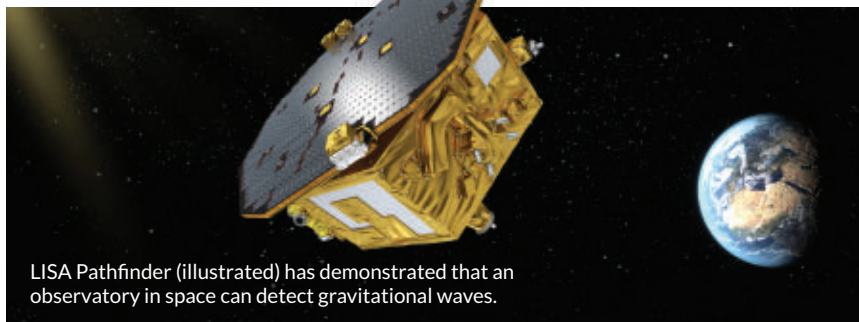
GENES & CELLS

City life shortens birds' telomeres

Urban living could pose risks to great tits, at least in terms of their DNA.

City life comes with a host of factors that can, for better or worse, affect a bird over its life span. To see how urbanization might influence early development in great tits (*Parus major*), biologists at Lund University in Sweden took newly hatched great tits from the city and the country and mixed them up. After just two weeks, great tits raised in urban environments had shorter telomeres regardless of where they were born, the team reports June 14 in *Biology Letters*.

Telomeres are bits of DNA that protect the ends of chromosomes from unraveling or degrading. If telomeres get too short, cells are more likely to die. Telomere length is associated with longevity in other birds as well as in humans. So if growing up in an urban setting shortens



LISA Pathfinder (illustrated) has demonstrated that an observatory in space can detect gravitational waves.

birds' telomeres, it could lead to a host of other problems down the line, the team argues. — *Helen Thompson*

MATTER & ENERGY

Newest elements on periodic table receive names, symbols

Four new elements now have names.

In December, the International Union of Pure and Applied Chemistry officially recognized the discovery of elements 113, 115, 117 and 118, filling out the seventh row of the periodic table (*SN: 2/6/16, p. 7*). As is traditional in chemistry, the naming rights went to the discoverers: Scientists at RIKEN in Wako, Japan, named element 113, and a Russian-U.S. collaboration named the others.

Element 113 is dubbed "nihonium" with the chemical symbol Nh. Its name comes from the Japanese word *Nihon*, or "Land of the Rising Sun," a name for Japan.

Element 115 will receive the moniker "moscovium," shortened to Mc, after the Moscow region, home to the Joint Institute for Nuclear Research in Dubna, where the element was discovered in collaboration with researchers at Lawrence Livermore National Laboratory in California and Oak Ridge National Laboratory in Tennessee.

Tennessee also gets a periodic table shout-out. The name for element 117 is "tennessine," after the home state of Oak Ridge and Vanderbilt University, which was also involved in the discovery. It will bear the symbol Ts.

Element 118 will be named oganesson, or Og, after Yuri Oganessian, a Russian physicist who contributed to the discovery of several superheavy elements.

After a five-month public review period and approval by the IUPAC, the names will become official. — *Emily Conover*

EARTH & ENVIRONMENT

Bikini Atoll radiation levels remain high

Radiation from the 23 nuclear tests conducted near Bikini Atoll in the 1940s and '50s has lingered far longer than predicted.

After measuring radioactive material across Bikini Atoll, researchers determined the island produces an average of 184 millirems of radiation per year. And some parts of the island emit as much as 639 millirems per year, researchers report online June 6 in the *Proceedings of the National Academy of Sciences*. Those measurements, made last year, surpass the 100 millirems per year safety standard set by the United States and the Republic of the Marshall Islands, which controls the island.

Scientists had predicted that, by now, radiation rates would have dropped to 16 to 24 millirems per year. But those estimates came from extrapolating from measurements made in the 1970s. The mismatch probably stems from incorrect assumptions about how rapidly radioactive material washes off the island, says study coauthor Emlyn Hughes, a physicist at Columbia University.

Whether the higher radiation levels pose a serious health risk to caretakers who live on the island for part of the year depends on how long they stay on the island and whether the local fruit they eat is safe, Hughes says. — *Thomas Sumner*

TECHNOLOGY SIMPLIFIED – BIGGER AND BETTER

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DEADLY Devotion

New studies explore why ordinary people turn terrorist **By Bruce Bower**

Fierce combat erupted in February 2016 at the northern Iraqi village of Kudilah. A Western-backed coalition of Arab Sunni tribesmen, Kurds in the Iraqi army and Kurdish government forces advanced on Islamic State fighters who had taken over the dusty outpost.

Islamic State combatants, led by young men wearing explosive vests, fought back. The well-trained warriors scurried through battle lines until they reached their enemy. Then they blew themselves up along with a few coalition soldiers, setting the stage for an Islamic State victory. These suicide bombers are called *inghamasi*, meaning “those who dive in deep.”

The *inghamasi*'s determination and self-sacrifice inspires their comrades to fight to the death, says anthropologist Scott Atran of the University of Michigan in Ann Arbor. Outnumbered about 6-to-1, Islamic State fighters still retained control of Kudilah after two days of heavy fighting. Coalition forces retreated, unwilling to lose more soldiers.

Atran and colleagues arrived in northern Iraq a couple of weeks later. Their plan: study “the will to fight” among soldiers on both sides of the Kudilah clash, even as fighting in the area continued. Their goals: try to understand what motivates people to join brutal organizations such as the Islamic State, and describe the personal transformations that push people leading comfortable, peaceable lives to commit acts of incredible violence and self-destruction.

Atran wondered whether there were common individual traits that explain the fierce devotion held by fighters for the Islamic State (also known as ISIS, ISIL or Daesh) as well as troops trying to take down ISIS. Scientists typically treat extreme sacrifice for others as premised on a careful weighing of pros and cons by “rational actors” who behave in a way that best satisfies their own interests even if others benefit as well. But it's hard to see how a “what's in it for me” formula applies to *inghamasi*, Atran says, much less someone who operates in a more conventionally altruistic way, such as a Navy SEAL. It's a mistake to write off ISIS fighters as lonely losers, each seeking death as a gateway to a heavenly rendezvous with a private stock of virgins, he contends.

To break out of the rational-actor rut, Atran shifted his experimental focus nearly a decade ago to examine cherished values that mobilize people to take collective action, regardless



of risks or rewards. In the last several years, he has moved his studies to the field, to focus on combatants in current conflicts and their sympathizers. And he's finding that extreme personal sacrifices made for outfits such as the Islamic State can be understood, but only by accounting for values he describes as “sacred” and by tracking the way in which individuals identify with like-minded comrades.

Collective identity

Academics who study warfare and terrorism typically don't conduct research just kilometers from the front lines of battle. But taking the laboratory to the fight is crucial for figuring out what impels people to make the ultimate sacrifice to, for example, impose Islamic law on others, says Atran, who is affiliated with the National Center for Scientific Research in Paris.

Atran's war zone research over the last few years, and interviews during the last decade with members of various groups engaged in militant jihad (or holy war in the name of Islamic law), give him a gritty perspective on this issue. He rejects popular assumptions that people frequently join up, fight and die for terrorist groups due to mental problems, poverty, brainwashing or savvy recruitment efforts by jihadist organizations.

Instead, he argues, young people adrift in a globalized world find their own way to ISIS, looking to don a social identity that gives their lives significance. Groups of dissatisfied young adult friends around the world — often with little knowledge of Islam but yearning for lives of profound meaning and glory — typically choose to become volunteers in the Islamic State army in Syria and Iraq, Atran contends. Many of these individuals connect via the internet and social media to form a global community of alienated youth seeking heroic sacrifice, he proposes.

Preliminary experimental evidence suggests that not only global terrorism, but also festering state and ethnic conflicts, revolutions and even human rights movements — think of the U.S. civil rights movement in the 1960s — depend on what Atran refers to as devoted actors. These individuals, he argues, will sacrifice themselves, their families and anyone or anything

A collective sense of identity plus deeply held values may inspire Islamic State supporters, such as those shown here, to sacrifice everything for their cause.

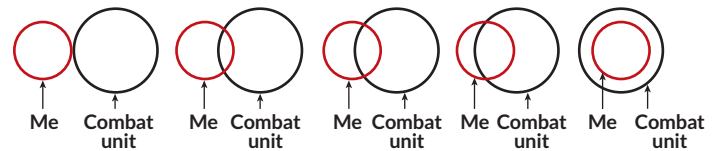
else when a volatile mix of conditions are in play. First, devoted actors adopt values they regard as sacred and nonnegotiable, to be defended at all costs. Then, when they join a like-minded group of nonkin that feels like a family—a band of brothers—a collective sense of invincibility and special destiny overwhelms feelings of individuality. As members of a tightly bound group that perceives its sacred values under attack, devoted actors will kill and die for each other.

His team's studies of devoted actors may help to explain why a growing number of people from around the world are leaving their families and home nations to join ISIS. Congressional and United Nations reports suggest that by October 2015, nearly 30,000 recruits from more than 100 countries had become fighters in Syria and Iraq, primarily for the Islamic State.

"The rise of the Islamic State is a revolutionary movement of historic proportions," Atran says. "Many of its members are devoted actors with an apocalyptic belief that they must destroy the world to save it." That uncompromising vision feeds off the promise of a global caliphate—a joint political and Islamic entity that kills or controls nonbelievers—that will bring on the end of the world and replace it with God's true kingdom. Volunteers to that cause have participated in more than 50 terror attacks in 20 countries since June 2014. Muslim militants carried out 450 suicide bombing attacks in 2015, with 174 attributed to the Islamic State.

Atran's research may provide a rare tool to study soldiers' will to fight, whether or not they're Islamic State adherents, says psychologist and terrorism researcher John Horgan of Georgia State University in Atlanta. Too many investigators have dismissed those deemed to be terrorists "as either incomprehensible or not even worthy of understanding," Horgan says.

At the time of the Kudilah battle, the Islamic State controlled hundreds of thousands of square kilometers in the Middle East. It had successfully defended a 3,000-kilometer-long military front stretching from Iraq to Syria against multinational forces. It's certainly possible to destroy the Islamic State with



In a test of identity fusion, captured ISIS fighters and others depict the extent to which they identify with others by moving a "me" circle so that it partly or completely overlaps with a larger circle representing fellow combatants or other groups. SOURCE: H. WHITEHOUSE ET AL/PNAS 2014

overwhelming military might, Atran says, but that approach would come at a price. It would leave a fragmented Sunni Muslim world, from which the Islamic State arose, as well as a global pool of passionate young men and women seeking liberation through sacrifice and martyrdom. A military take-down alone might trigger "a volcanic resurgence of rebels with a cause, even readier for doomsday," he predicts.

Sacred apocalyptic values are best opposed by the spread of deeply held, life- and freedom-affirming values that supporters are willing to defend unconditionally, Atran argues. The Kurds have had success with this approach.

Sacred kin

In the Middle East, only Kurdish people living in northern Iraq have consistently held off Islamic State attacks. The Kurds, Atran finds, display a will to fight equal to that of captured Islamic State fighters. As important as guns and other material support are to a military operation, an indomitable will to fight may be even more crucial, he says. Both the Islamic State and the Kurdish army have achieved considerable military success without all the hardware of Western armies.

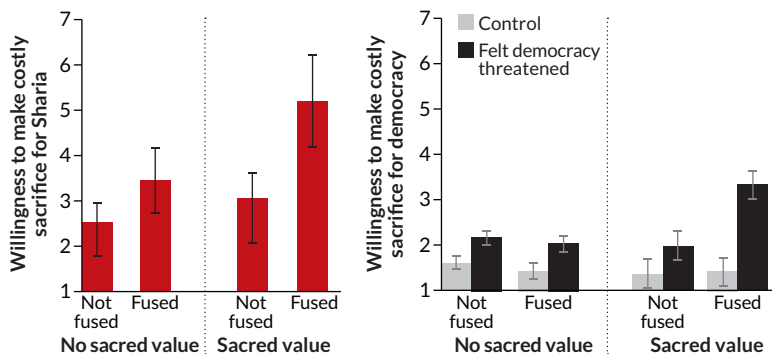
At Kudilah, Kurdish soldiers showed their mettle in a fierce clash. Several of these men later described the event to Atran. As Iraqi army units withdrew, Islamic State forces rapidly pushed forward. A small company of Kurds stood their ground. After the fight raged for several hours, Iraqi army reinforcements arrived, enabling the Kurds to live to fight another day.

Atran's team interviewed 28 Kurdish soldiers plus 10 Kurds who provided supplies, medical care and other frontline assistance. Seven Islamic State fighters, six of them prisoners, also agreed to be interviewed. One had been freed and changed sides, working with groups opposed to the Islamic State.

Among the 38 Kurdish volunteers, 22 reported devotion to a homeland of "Kurdistan" as a sacred value that they would fight and die for, even overriding family ties and their Islamic religion, Atran reports in the June *Current Anthropology*. All but one of the 22 reported feeling a collective bond, or what Atran calls identity fusion, with the Kurdish people.

Captured ISIS members reported visceral, family-like bonds with their fellow fighters. All Islamic State prisoners cited an absolute

Sacrificial divide In ISIS-supporting Moroccan neighborhoods, people who viewed the imposition of Islamic law, or Sharia, as a sacred value and who identified closely with a kinlike group ("fused") were most willing to kill and die for Islamic law (left graph). A sample of Spaniards reported a weaker willingness to kill and die for democracy (right graph). Those most likely to make costly sacrifices saw democracy as a sacred value and identified closely with a kinlike group of friends. SOURCE: H. SHEIKH, A. GÓMEZ, AND S. ATRAN/*CURRENT ANTHROPOLOGY* 2016



commitment to an imposition of Islamic law, or Sharia, on nonbelievers.

Investigators measured identity fusion by presenting participants with touch-screen computer tablets showing a small circle labeled “me” and a large circle with a group label, such as “Kurds” or “family.” To represent their relationship to a particular group, individuals could move the circles together so that they partly or completely overlapped. Those who moved the small circle inside the large circle were regarded as fully fused with that group.

Atran adopted this test from ongoing research initiated nearly a decade ago by psychologist William Swann of the University of Texas at Austin. An international team led by social anthropologist Harvey Whitehouse of the University of Oxford, including Swann, studied Libyan men who tried to overthrow their government in 2011. The researchers found that nearly all the men reported intense, family-like bonds with fellow combatants. Revolutionary leaders granted the researchers access to 42 Libyan soldiers and 137 support personnel, including mechanics and ambulance drivers, as hostilities wound down in late 2011.

On the overlapping circles test, 45 percent of fighters reported being more strongly bonded to their battalions of three to five comrades than to their families, the researchers reported in 2014 in the *Proceedings of the National Academy of Sciences*. A smaller portion of support personnel, 28 percent, identified more with revolutionary battalions than with their families. That’s consistent with the idea that frontline fighters most often bond tightly to their units, upping their readiness to give their lives for comrades.

Libyan soldiers who felt intense connections to their battalions probably qualified as devoted actors, says psychologist Hammad Sheikh of the New School for Social Research in New York City, who was not involved in Whitehouse’s study. The soldiers’ commitment to the revolution’s goals probably transcended even family loyalties, Sheikh suspects. He bases that opinion on Atran’s findings. Whitehouse’s team did not try to identify devoted actors among Libyan fighters.

People willing to sacrifice everything in defense of the Islamic State’s sacred values also exist outside of the war zone. Among 260 Moroccans who lived in either of two city neighborhoods known as pro-ISIS hotbeds, testing indicated that about 30 percent were devoted actors. They described the imposition of Sharia as a nonnegotiable necessity, Sheikh and his colleagues, including Atran, report in a second paper in the June *Current Anthropology*.

On the overlapping circles test, devoted actors in Morocco depicted especially close bonds with family-like groups of friends, ranging from Islamic State supporters to soccer buddies.

Western weakness

Such dedication to collective values may be tougher to come by in Western nations. Online testing of 644 people in Spain identified only 12 percent as devoted actors willing to sacrifice all for democracy, even after being reminded of threats by ISIS and Al Qaeda. Frequent corruption scandals have left many Spaniards disillusioned with democracy, Sheikh says. Whether a similarly weak devotion to democratic values applies to citizens of other European countries or the United States remains to be tested.

Field research suggests that collective commitments to democratic values may be weaker in the West. When devoted actors among Islamic State fighters, Kurds and members of a Kurdish-speaking religious community known as Yazidis were given a hypothetical choice between abandoning their sacred values if others in

their group do, or leaving the group to fight on for their sacred values, they nearly always opted to fight on for their values, Atran says.

Devoted actors in Spain, however, typically say they’d follow their group if it rejected democratic values. People in France and Spain tested by Atran’s team also rate their own society’s “spiritual force,” or the strength of collective beliefs and commitments, as much weaker than that of ISIS.

Among U.S., British and former Soviet soldiers, there have long been indications from interviews, field reports and personal letters of a stronger willingness to die for close comrades in

Direct recruiting by militant organizations appears to be up since 2013. But social networks are still an important source of volunteers for groups such as ISIS. The top three ways jihad volunteers are recruited:

- **1/2** Via direct personal contact with militant group members
- **1/5** Through social networks of friends and family
- **1/5** Via internet contact only

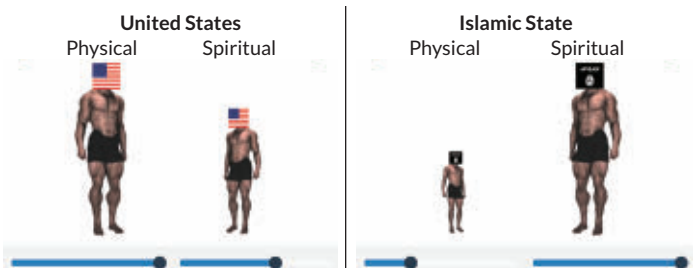
Existing relationships are important:

- **3/4** of those who become foreign fighters travel in a group, often with people they know, such as friends and family

SOURCES: S. ATRAN, COMBATING TERRORISM CENTER



Body types In testing in Iraq, a captured ISIS fighter, left, chose how to mask himself to ensure anonymity to conform with human subjects safety protection. ISIS and Kurdish fighters depict U.S. military physical force as strong and its spiritual force as middling. The same men portray Islamic State physical force as weak and spiritual force as strong.



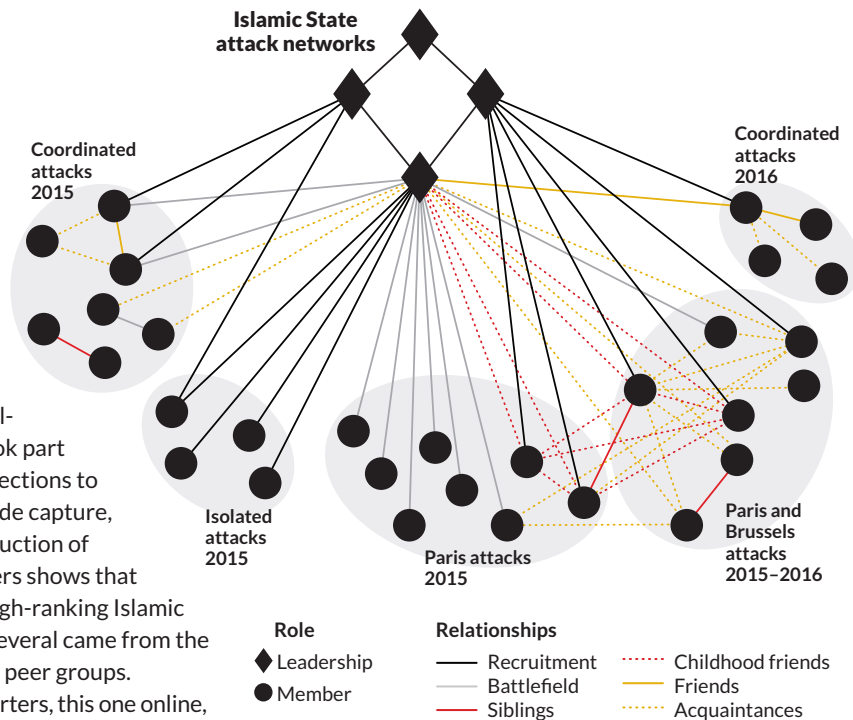
BOTH: S. ATRAN

Radical ties

A tight-knit network of friends within the Islamic State, connected to arms dealers, human traffickers, document forgers and others, carried out the November 2015 Paris attacks and the March 2016 Brussels attacks, say social psychologist Nafees Hamid of the Jean Nicod Institute in Paris and anthropologist Scott Atran. Individuals who took part in both attacks used their many connections to carry out the two operations and evade capture, Atran says. This preliminary reconstruction of social ties among some of the attackers shows that many were sponsored by the same high-ranking Islamic State mentor (center diamond) and several came from the same families, locales and hometown peer groups.

In a different network of ISIS supporters, this one online, women serve as key messengers, reports computer scientist Stefan Wuchty of the University of Miami in Coral Gables, Fla., and colleagues June 10 in *Science Advances*. Men outnumbered women, but women maintained many more direct contacts with more people, giving them a big advantage in transmitting information.

Jihadi networks depend on women's contributions,



Atran adds. Mothers in some radicalized neighborhoods actively recruit others to join the Islamic State, travel to expand recruiting and encourage their kids to fight in Syria, he says. About one in three French citizens who travel to Syria to join ISIS are women, Atran estimates.

— Bruce Bower

war than in defense of broader values, Atran says. Historical evidence, however, suggests that certain relentless fighters, including Nazi troops during World War II and Viet Cong soldiers in the Vietnam War, were devoted actors inspired by beliefs in a higher cause, he says, adding that the same may have been true for soldiers on both sides of the U.S. Civil War.

Sacrificial appeal

Atran and his colleagues now have their own cause: describing more fully how some people go from holding extreme beliefs on the sidelines to becoming devoted actors at the front lines of extreme movements.

It would help, says political psychologist Clark McCauley of Bryn Mawr College in Pennsylvania, if researchers could clarify what counts as a sacred value and why some sacred values outweigh others. Identity fusion is also a tricky concept to pin down, McCauley says. Further research needs to determine whether a person who moves a “me” circle inside a circle representing a fighting unit still feels a sense of individuality or totally buys into a collective identity, he suggests.

Only by venturing into war zones can researchers begin to understand the will to fight on all sides, from the perspectives of the fighters themselves, Atran argues. It's daunting work. He has seen ISIS fighters advancing on an Iraqi army outpost, then detonating their explosive vests in the ultimate show of

commitment to their cause. He has spoken to Kurdish veterans missing arms or legs and men who had joined the Kurdish army back in the 1950s, all of them now fighting at the front to defend their homeland.

A young Yazidi fighter told Atran that he used vacation time from college to train for a week with Kurdish Marxists in Syria to defend his Kurdish religious community against the Islamic State. Fighting with a few comrades in August 2014, the student-soldier fended off ISIS attackers long enough for reinforcements to arrive. He helped save thousands of Yazidis from slaughter. The young man then returned to his studies. He wanted to be an archaeologist.

“You learn more in five minutes in the field than in five years of analysis from afar,” Atran says.

Despite careful planning, Atran's team sometimes gets distressingly close to warring parties while conducting research in Iraq. It's an unavoidable risk but not a deal breaker for the researchers. “There's something so compelling,” he says, “about trying to figure out humans in extreme circumstances such as war.” ■

Explore more

■ Scott Atran. “The devoted actor: unconditional commitment and intractable conflict across cultures.” *Current Anthropology*. June 2016.



The power of opioid dependence sends growing numbers of people to street drugs and deadly chemical mixes.

ADDICTION PROTECTION

Vaccinating against opioid drugs may offer relief from a dangerous habit **By Susan Gaidos**

By age 25, Patrick Schnur had cycled through a series of treatment programs, trying different medications to kick his heroin habit. But the drugs posed problems too: Vivitrol injections were painful and created intense heroin cravings as the drug wore off. Suboxone left him drowsy, depressed and unable to study or go running like he wanted to. Determined to resume the life he had before his addiction, Schnur decided to hunker down and get clean on his own.

In December 2015, he had been sober for two years and had just finished his first semester of college, with a 4.0 grade point average. Yet, just before the holidays, he gave in to the cravings. Settling into his dorm room he stuck a needle in his vein. It was his last shot.

Scientists are searching for a different kind of shot to prevent such tragedies: a vaccine to counter addiction to heroin and other opioids, such as the prescription painkiller fentanyl and similar knockoff drugs. In some ways, the vaccines work like traditional vaccines for infectious diseases such as measles, priming the immune system to attack foreign molecules. But instead of targeting viruses, the vaccines zero in on addictive chemicals, training the immune system to usher the drugs out of the body before they can reach the brain.

Such a vaccine may have helped Schnur, a onetime computer whiz who grew up in the Midwest, far removed from the hard edges of the drug world. His overdose death reflects a growing heroin epidemic and alarming trend. In the 1960s, heroin was

seen as a hard-core street drug abused mostly in inner cities. Now heroin is a problem in many suburban and rural towns across America, where it is used primarily by young, white adults — male and female, according to research published by psychiatrist Theodore Cicero of Washington University in St. Louis and colleagues in 2014 in *JAMA Psychiatry*.

His team's surveys of nearly 2,800 patients in substance abuse treatment programs suggest a shift in the demographics of heroin users in recent years. In the 1960s, more than 80 percent of users took heroin as their first opioid. From 2000 to 2010, 75 percent of heroin users came to the drug because it was easier to get and less expensive than the prescription opioids they had been taking.

In recent decades, overdoses of both illicit and prescription drugs have surged. In 2014, overdose deaths surpassed deaths from motor vehicle accidents, the U.S. Centers for Disease Control and Prevention reported in January. In that year, 28,647 people died of opioid-related overdoses, primarily from prescription pain relievers and heroin.

"The opioid epidemic is devastating and the number of people dying demands an urgent intervention," says Nora Volkow, director of the U.S. National Institute on Drug Abuse.

A family of drugs

The term opioid refers to a host of painkillers derived from the opium poppy as well as synthetic versions of its active

compounds. Heroin is processed from morphine, which is extracted from the plant. Prescription medications such as Vicodin, Percocet, OxyContin and fentanyl are made from synthetic morphine, altered to produce different effects.

Currently, three medications, sold under various brand names, are available to help people with heroin or opioid addiction get clean and stay drug-free: methadone, buprenorphine and naltrexone. The treatments work, Volkow says, but not perfectly. Some addicted patients, such as Schnur, experience unwanted side effects from the daily or monthly treatments and stop using them. Others lack access to treatments due to high costs and strict federal limits on dispensing the drugs.

“Unfortunately, only a small percentage — about 25 percent — of people who could benefit from treatment actually get these medications,” Volkow says.

Round two for vaccines

Vaccines could offer an alternative to patients who have kicked their habit and want to stay clean, scientists say. The vaccines aim to make an addict immune to a drug’s effects, decreasing the motivation to seek more of the drug. That’s important, Volkow says, because over time the treatment may allow recovery of the overactive circuitry in the brain that pushes drug users to keep using.

The idea of antidrug vaccines isn’t new. Scientists began working on formulations in the 1970s, but those efforts were eclipsed by the availability of methadone. Methadone, a synthetic opioid, relieves withdrawal symptoms and cravings for heroin or prescription painkillers by acting on the same brain targets as the drugs, but in a slow, controlled manner, so patients can function normally without feeling high. But the treatment is a method for harm reduction, not a cure for addiction, and must be taken daily to be effective.

In the late 1990s, scientists resumed antidrug vaccine efforts, focusing on vaccines for everything from cocaine to nicotine to heroin (*SN*: 2/10/07, p. 90). Vaccines for nicotine and cocaine were tested in people, but worked for only a small percentage.

Now, to help combat the growing opioid addiction crisis, two vaccines for heroin users are advancing toward human trials and other antiopioid vaccines are in the pipeline, including one for fentanyl, now a popular street drug.

Among the antiheroin vaccines being tested, one — developed at the Scripps Research Institute in La Jolla, Calif. — spurs the immune system to attack heroin and helps eliminate it from the body so effectively that it can neutralize even lethal levels of the drug in animals. A second antiheroin vaccine, developed at the Walter Reed Army Institute of Research in Silver Spring, Md., goes after two closely linked problems: It keeps heroin from reaching the brain while preventing HIV infection.

Addiction’s grip

Once a person is addicted, the fight to stay clean never ends, Volkow says. That’s because heroin and other addictive substances alter the brain’s pleasure circuits, producing changes that persist long after users stop taking the drug. Volkow, who has studied these effects for more than two decades, says addiction is a brain disease because of the structural and functional changes that occur.

Drugs of abuse produce their high by interacting with cells located in brain areas that govern reward, including the nucleus accumbens, a key region in the pleasure circuit. Though each type of drug works in a slightly different way, all addictive drugs increase the amount of the chemical dopamine in this area. Dopamine is a neurotransmitter, carrying signals between nerve cells, or neurons.

Opioids boost dopamine levels by stimulating molecules called *mu* receptors that sit on the surface of certain neurons. Normally, these receptors are activated by hormones and brain chemicals made in the body, such as endorphins, to reinforce pleasurable behavior such as eating, having sex or listening to music. A single dose of heroin, however, releases many times the amount of dopamine produced by a favorite food or song.

Dopamine fuels the high that people feel from taking an addictive drug, but other molecules help to get people hooked. Glutamate, a neurotransmitter that increases the chatter among cells in areas that govern learning and boost motivation, helps engrave the experience of a drug’s high into the brain. Memories of the high become so enduring that years later they can be reawakened. This long-lasting pull is why more than 60 percent of people with addiction experience relapse within the first year after they

2.5

million

Number of Americans abusing or dependent on opioids in 2014

45

percent

Fraction of heroin users in the United States also addicted to prescription opioid painkillers

SOURCES: NIDA; CDC



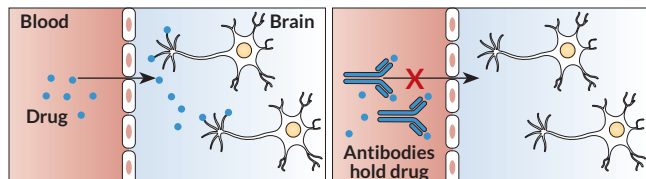
Potent painkiller

Fentanyl is a powerful synthetic opioid, up to 50 to 100 times more potent than morphine. Doctors prescribe it to control acute and chronic pain, but because it’s so powerful, fentanyl can increase the risk of an overdose. Music icon Prince died April 21 of an overdose of prescription fentanyl.

Fentanyl is sometimes mixed with heroin to produce a higher high, or sold by illicit laboratories under the names “Apache,” “China White” and “TNT.” Users often don’t know what they’re getting. In 2015, fentanyl-laced heroin was involved in a rise in overdose deaths in the United States, including dozens of deaths in states such as Connecticut, Ohio and West Virginia. — Susan Gaidos

Block the passage Drug molecules easily pass through the blood-brain barrier. Vaccines prompt the body to make antibodies that bind to the drug molecules, creating complexes that are too large to cross into the brain. If the drugs can't reach the brain, there's no high.

SOURCE: K.D. JANDA AND J.B. TREWEEK/NAT. REV. IMMUNOLOGY 2012



are discharged from treatment.

Taken over time, drugs of abuse can change signaling in a number of the brain's circuits. Last year in *Cell*, Volkow and NIDA biochemist Marisela Morales outlined two common features of the addicted brain: a decreased sensitivity in the brain's reward centers and disruption of circuits involved in self-control.

With repeated drug use, the number of dopamine receptors declines as the brain attempts to calm down, Volkow says. With fewer receptors available to take up dopamine molecules, it takes more stimulation to produce feelings of pleasure. Addicts soon find that they are no longer motivated by everyday activities that had been enjoyable or exciting, and they need higher doses of the drug to get the euphoric feelings once provided by smaller doses.

"The brain rapidly learns that the only thing that's going to stimulate these pleasure circuits is the drug," Volkow says. "That's one of the components that drives drug-seeking behavior." Eventually, the drug no longer produces a high. Instead, it becomes a necessity to stave off feelings of anxiety and despair.

Addiction also impairs dopamine functioning in the prefrontal cortex, an area of the brain that includes regions involved in analysis, decision making and self-control. "Taking drugs interferes with one's capacity to make good decisions" and follow through, Volkow says. "An addict might say 'I don't want to take that drug.' But they don't have the capacity to easily change their behavior."

Protect the brain

Vaccines, potentially, offer a "transformative" way to treat addiction, Volkow says, because the treatments can train the immune system to attack drug molecules before they reach the brain. Vaccines typically contain an agent that resembles a disease-causing virus, teaching the immune system to respond quickly when it encounters the invader. In designing vaccines, scientists try to provoke at least one of the human body's primary immune responders: T cells, which attack infected cells, or B cells, which release antibodies that recognize hostile molecules and attach to them, targeting them for destruction.

Easier said than done. For starters, drug molecules are tiny, much smaller than a bacterium or virus, and are not easily detected by the immune system. In addition, the body's

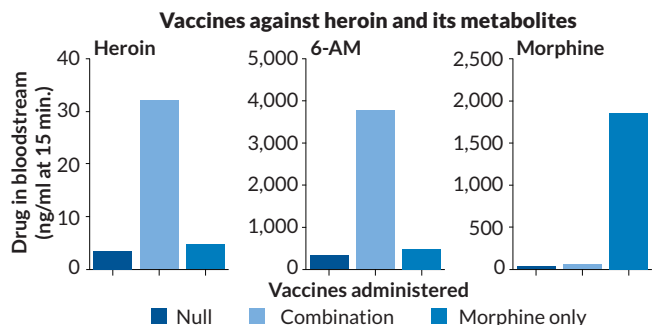
immune system is set up to fight invaders that arrive in small groups. When an influenza virus makes its way into a body, the initial levels of virus in the blood are very low, Volkow says. But when people inject heroin, for example, many millions of drug molecules and their breakdown products quickly rush into the bloodstream. In recent years, researchers have found new ways to help call the immune system's attention to such surges of "invading" drugs.

While developing one heroin vaccine, chemist Kim Janda of Scripps and colleagues noticed that antibodies to heroin molecules alone didn't stop animals from getting high. That's because once heroin gets into the body — whether it's injected, snorted or smoked — it is broken down into its active components, 6-acetylmorphine, or 6-AM, and morphine. "Those two metabolites are the real drugs in heroin," Janda says.

Typically, vaccines lead to production of antibodies that target a single invader. To get the immune system to notice both heroin and its metabolites, Janda joined forces with neurobiologist George Koob, director of the National Institute on Alcohol Abuse and Alcoholism, to design a multitarget vaccine. The vaccine "cocktail," as Janda calls it, has three components: a large protein that carries the druglike molecules into the body; a molecule called a hapten, chemically designed to induce an immune response to heroin and its metabolites 6-AM and morphine; and finally, alum, an agent commonly added to vaccines to stimulate release of cytokines, proteins that help rally the immune cells to fight invaders.

Over the last six years, Janda's group has tinkered with the hapten to help the antibodies get a tight grip on heroin, 6-AM and morphine. The hapten, along with the protein carrier, draws attention from the immune system's T cells, which learn to recognize the drug molecules as invaders. Later, if heroin or its metabolites are detected in the blood, the T cells will "remember" the invaders and remove them.

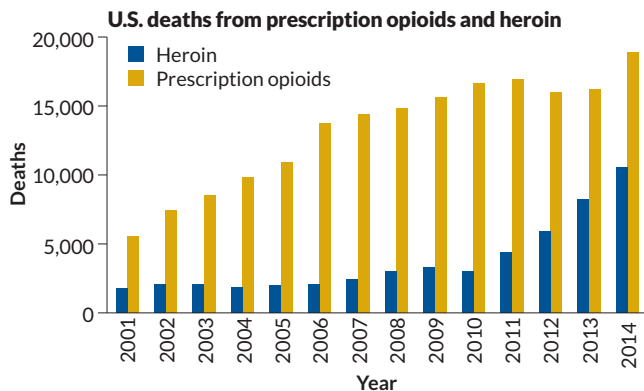
In rats, the three-pronged vaccine generated high numbers of antibodies against the drug and its metabolites, blocking heroin's action on the brain. Once vaccinated, the



Break it down Heroin and its breakdown products 6-acetylmorphine (6-AM) and morphine enter the brain and cause trouble. In rats, an intravenous vaccine that grabs all three (combination) worked better than a vaccine that targets only morphine and a null vaccine. The morphine-only vaccine was best at keeping morphine in the blood, but the combo vaccine did a better job of stopping drug-seeking behavior.

SOURCE: J.E. SCHLOSBERG ET AL/PNAS 2013

BOTH: J. HIRSHFIELD



A growing toll From 2001 to 2014, 52,830 people died of heroin overdoses in the United States and more than 185,500 died of prescription opioid overdoses. SOURCE: NATIONAL CENTER FOR HEALTH STATISTICS, CDC

formerly addicted rats were unable to get high, even when injected with extremely high doses of the drug, Janda's group reported in 2013 in the *Proceedings of the National Academy of Sciences*. The result was decreased drug-seeking behavior in the vaccinated rats. By contrast, control rats, and those vaccinated only against morphine, continued to seek higher doses of the drug.

The vaccine showed similar effectiveness in nonhuman primates, Janda reported in May at the American Psychiatric Association's annual meeting in Atlanta. In addition, the vaccine is specific to heroin metabolites, not other opiates. A vaccine that's too broad could potentially make patients immune to the effects of all prescription opioids, leaving them vulnerable if they become injured and need pain relief.

Janda's team recently tested another antiopioid vaccine in animals, one that arms the body against fentanyl. When given to mice, the vaccine trained the animals' immune systems to generate antibodies that bind to fentanyl and prevent it from traveling to the brain from the bloodstream. The results, published March 7 in *Angewandte Chemie*, showed that in mice, the antibodies neutralized high levels of the drug — more than 30 times a normal dose — for months after a series of three shots. By blocking the effects of the drug and its high, the vaccine could potentially curb drug-seeking behavior.

Another group is going after heroin and its strong tie to high HIV infection rates worldwide. Scientists at the Walter Reed Army Institute of Research are developing a dual-purpose vaccine, called H2, to treat heroin addiction while preventing HIV infection.

Biochemist Gary Matyas and his group at Walter Reed first designed a vaccine to stimulate antibodies against heroin. Similar to Janda's antiheroin vaccine, haptens are bound to a protein carrier, spurring the immune system to create high levels of antibody to bind heroin and its metabolites in the blood and prevent it from crossing the blood-brain barrier. Users will then experience no euphoria or addictive reactions.

The researchers plan to combine the heroin vaccine with an HIV vaccine, a combination that's much trickier to develop.

Scientists have long been frustrated by the ability of the AIDS virus to mutate and evade the immune system. The virus constantly changes the makeup of the proteins on its surface so that antibodies have difficulty recognizing and attacking it. But researchers have found that targeting a region called V2 on the surface of the virus decreased the risk of HIV infection.

The vaccine, tested in volunteers in Thailand by the country's Ministry of Public Health and Walter Reed scientists, protected about a third of participants against HIV infection, according to a 2009 report.

There's no timeline for moving the H2 vaccine into human trials, Matyas says. His hope is that the vaccine will concurrently address the entwined epidemics. "If you can reduce heroin use, you can reduce the spread of HIV," he says. "That's why we're focusing on both heroin and HIV in one vaccine."

Extra help

While vaccines can't be the only treatment for the opioid epidemic, they could offer users who want to abstain an additional and much needed option to deal with addiction. It's not unusual for people to relapse, or to require more than one type of treatment, before finding a course of recovery that suits them, Volkow says.

Treating addiction like a disease that needs to be managed, such as diabetes or high blood pressure, with a multiplicity of treatment options would help addicts find a treatment that works well for them over the long haul, she says.

"Addiction is an extremely serious disease, with a high mortality rate and devastating consequences," Volkow says. "We need to treat it very aggressively, and we need to have a variety of interventions so if one doesn't work we have something else to offer the patient."

Because relapse is common in addiction, Janda says he thinks that the antidrug vaccines' value will come in helping people who want to abstain, but might falter in a weak moment. "Even if they try to do the drug, they're not going to get the reward effects of the drug," he says. "That means that they won't spiral out of control and have to start all over again."

Kathy Schnur, Patrick's mother, remembers how, years into her son's treatment, when the conversation turned to heroin — its euphoric high and mysterious spell — her son would confess to a desire to taste the drug "one more time." A heroin vaccine would have taken a relapse off the table, she says. He would no longer have needed to make a daily decision to stay clean.

"If he knew he couldn't get what he expected from the drug, it would remain a nonevent," Schnur says. "Or, if he slipped up and tried it just one more time, the vaccine would prevent an overdose." ■

Explore more

■ Berma Kinsey. "Vaccines against drugs of abuse: Where are we now?" *Therapeutic Advances in Vaccines*. July 2014.



Lab Girl
Hope Jahren
KNOPF, \$26.95

BOOKSHELF

Engrossing memoir invites readers into the hidden world of plants

The first, tiny root that emerges from a baby plant can make it or break it.

Anchor to a good patch of ground, and the plant can thrive for decades. Set up someplace else, without enough water or sunshine, and all may be lost.

The odds of a single rootlet mooring itself to just the right spot of soil are more than a million to one, writes geobiologist Hope Jahren. “The gamble is

everything, and losing means death.”

Jahren touches only briefly on the plight of the newborn root, just a page or so near the beginning of her new book, *Lab Girl*, but it’s enough to bring drama to a topic not usually considered all that thrilling. Jahren’s great skill, here and throughout the book, is making readers care — to root for the root, in this case.

In *Lab Girl* — which is part memoir, part plant love story — each cactus, tree and leaf gets the same empathetic treatment. Jahren doesn’t so much spice up plant life as she does reveal it — histories, triumphs, tragedies and all — to those who might not have been paying close enough attention.

But this isn’t just a book for botanists. Or science geeks. Or lovers of nonfiction. This is a book for anyone who has stayed up late with a flashlight beneath the covers, vowing to finish just one last chapter.

Interspersed between snippets about plants, Jahren puts her own life under the microscope, baring gritty details about her struggles with bipolar disorder (she had to go off her medications during pregnancy) and as a woman desperately scrambling to eke out a career in science. She’s made it now, and is currently at the University of Hawaii at Manoa in Honolulu, studying, among other things, how carbon in fossilized plants can reveal information about ancient climates.

But the book’s lifeblood, or xylem and phloem, if you will, are Jahren’s stories from her early days as a scientist. For Jahren, and her long-term scientific partner in crime, an otherworldly character named Bill Hagopian (he once lived in a hole he dug in his parents’ yard), life is a series of adventures. The duo crisscross the country for scientific meetings, take students on madcap road trips and regularly pull all-nighters in the lab.

Though Jahren and Hagopian often end up in exotic places (an island in the Arctic Ocean or Miami’s Monkey Jungle, among other places), Jahren somehow makes the everyday tasks of lab work thrilling, too. And through it all, she pauses to tell the untold stories of plants — to consider life’s wonders from a plant’s point of view.

Vines, for instance, “do not play by the rules of the forest,” she writes. They steal light and water, and will climb over anything in their paths to do so. And trees, scientists have discovered, can actually “remember” their childhood.

In the epilog, Jahren eases the reader back to the reality we know. “Plants are not like us,” she writes. “They are beings we can never truly understand.”

But anyone who reads *Lab Girl* will know that can’t be true. Because for nearly 300 pages, Jahren has made us feel like we can.

— Meghan Rosen

BOOKSHELF



Jellyfish
Lisa-ann Gershwin

This beautifully illustrated guide introduces readers to the diversity of jellyfish and provides a primer on the seemingly alien animals’ physiology, ecology and evolution. *Univ. of Chicago*, \$40



The Unknown Universe
Stuart Clark

An astrophysicist and science writer explores how the most detailed map of the universe’s first light, based on data from the Planck spacecraft from 2009 to 2013, will affect scientists’ understanding of the cosmos. *Pegasus*, \$27.95



The Mind-Gut Connection
Emeran Mayer

Combining his decades of experience practicing medicine with the latest scientific research, a gastroenterologist explains how interactions between the brain and microbes living in the gut influence health and mental well-being (SN: 4/2/16, p. 23). *Harper Wave*, \$27.99



Coyote America
Dan Flores

The coyote’s evolutionary history and close — often antagonistic — relationships with people across North America are detailed in this biography of the resourceful canine. *Basic Books*, \$27.50



Serendipity
James A. Estes

An ecologist looks back at his long career and shares what he has learned from studying sea otters, kelp and other species on the Aleutian Islands. *Univ. of California*, \$29.95

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SOCIETY UPDATE

Society workshop attracts new Advocates, research ideas

More than a dozen recipients of the Society for Science & the Public's Advocate Grant Program, which assists mentors of underserved students, convened in Washington, D.C., the weekend of June 3 to discuss the best methods for helping students enter science research competitions.

The workshop taught Advocates about the different competitions available to students, the timing of each aspect of the competitions and requirements for participation. More important, it provided a forum for Advocates to meet other people from across the country who are working toward the same goal of reaching underserved students.

"Just bringing these Advocates into a room together, in person, is incredibly valuable," says Caitlin Sullivan, the Society's director of science education programs and Regeneron Science Talent Search program manager. "We at the Society may be experts in competitions, but they are experts in working with these students on a daily basis." Sullivan and Victor Hall, the Society's senior specialist for outreach, led the workshop.

Out of 240 applications from 45 states, Washington, D.C., and Puerto Rico, 31 mentors — including high school and middle school teachers, scientists and community leaders — were selected as Advocate Grant Program recipients for 2016. Each Advocate receives a stipend of \$3,000 to guide three to five students in entering their scientific or engineering research projects into competitions. Research competitions include, but are not limited to, the Regeneron Science Talent Search, Intel International Science and Engineering Fair and Broadcom MASTERS.

The grant is sponsored by the Alcoa Foundation, the Jack Kent Cooke Foundation and the Society for Science & the Public.

Learn more about the Advocate Grant Program at societyforscience.org/society-advocate-grant



Top: Advocates Deanna Cusick and Lauren Allgood test their sense of smell in a hands-on lab. Middle, left: Program leaders Victor Hall and Caitlin Sullivan discuss science research competitions with the group. Middle, right: Advocate Sheila Marquez explains how a simple experiment can be expanded into many. Bottom: Advocate Dolores Caffey-Fleming participates in a discussion on the challenges of mentoring students in science research.

The 2016 - 2017 Advocates:

Lauren Allgood
Nashville, Tenn.

Oluwatoyin Asojo
Houston, Texas

Scott Bolen
Conyers, Ga.

Dolores Caffey-Fleming
Los Angeles, Calif.

Carrie Cao
San Francisco, Calif.

Charlene Chan
Queens, N.Y.

Sarah Connelly
St. Paul, Minn.

Deanna Cusick
Aurora, Colo.

Alexa Dantzler
Atlanta, Ga.

Sakinah Ellickson
Iowa City, Iowa

Antonio Gamboa
Pomona, Calif.

Shari Harrison
Indianapolis, Ind.

Bonnie Lasorsa
Wareham, Mass.

Priscilla Lumbreras
La Joya, Texas

Sheila Marquez
Tucson, Ariz.

Douglas Masterson
Hattiesburg, Miss.

Patricia Monteith
Boston, Mass.

Lynne Muhammad
Chicago, Ill.

Kelly Norton Pipes
Wilkesboro, N.C.

Jennifer O'Connor
Ethete, Wyo.

Deanna Pick
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Monticello, Ga.

Anne Rammelsberg
Decatur, Ill.

Lisa Ranney
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MAY 14, 2016

SOCIAL MEDIA

Somber shout-out

On June 12, 2016, a gunman killed 49 people and injured 53 others at a nightclub in Orlando, Fla. In response to the mass shooting, television personality and science educator **Bill Nye** tweeted his support for the victims and a photo of himself holding **Meghan Rosen's** article "Misfires in the gun control debate" (*SN*: 5/14/16, p. 16).



"Heartbreak in Orlando. As citizens of the U.S., we will unite and vanquish hatred."
@BillNye

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Gun debate cross fire

In "Misfires in the gun control debate" (*SN*: 5/14/16, p. 16), **Meghan Rosen** reported on the roadblocks researchers face in collecting informative data on gun violence in the United States. Readers responded passionately, expressing many different viewpoints about the story and the controversial topic of gun control. "I thought Ms. **Rosen's** article was well-written, fairly balanced, well-researched and highly informative," **Benjamin Griffel** wrote. "She cited relevant statistics, her conclusions were well-founded on facts and research and she uncovered many truths about the issue that were new to me, such as the way statistical information about gun violence is kept from researchers."

Other readers thought the article was biased in favor of gun control as a solution to gun violence. "I actually expected more of you — an unbiased approach which recognizes that when all the study results looking at gun control as the answer come back with ambiguous results, just maybe you are asking the wrong question," wrote **Mike Hargrove**. "The right question is why do people resort to violence, not why do they choose a firearm to do so." **Jerry Stuckle** echoed that sentiment. "A good science magazine would dig deeper — for instance, gun control is not the only factor involved," he wrote. "There are numerous other sociological factors involved, including educational levels, financial status, law enforcement activity, race and others. Yet *Science News* chose to investigate none of those."

And still more readers thought the article should have framed any discussion of gun violence around the Second Amendment, which protects the right to bear arms. "A gun is merely a tool," wrote online reader **Lifeonerth**. "The Second Amendment is no less relevant today than it was when it was written, and maybe more so."

Gun control remains a politically fraught subject, as evidenced by readers' responses. Some people, like online

reader **James DiGriz**, think *Science News's* coverage is becoming too political — citing **Rosen's** article and a recent piece by **Thomas Sumner** on climate change (*SN*: 4/16/16, p. 22) as examples. But reader **Jose Barbosa**, who referred to the editor's note by **Eva Emerson** titled "Scientific evidence should inform politicized debates" (*SN*: 5/14/16, p. 2), disagreed. "I'd prefer more articles on such an important subject in *Science News*," he wrote. "When many of our politicians utter outrageous statements in relation to well-documented scientific topics such as evolution or climate change, this nation badly needs scientists who rebuke those politicians loud and clearly."

Cholesterol cleanup

Cyclodextrin, a sugar found in the air freshener Febreze, cleared mouse arteries of cholesterol plaques, **Tina Hesman Saey** reported in "A sugar can melt away cholesterol," (*SN*: 5/14/16, p. 10). "Will using the (nonscented) spray in cleaning possibly deliver doses via the aerosol action, nasally to the lungs, the blood?" reader **Terry McDermott** asked on Facebook.

Researchers have not tested the sugar's plaque-clearing effects in humans, so it is unclear if it would be safe or effective. And no one knows whether inhaling or eating cyclodextrin would produce the results seen in mice, **Saey** says. In the lab, researchers injected mice with measured doses of the compound. More studies are needed.

"Most important, it may not be safe to inhale the compound, especially in concentrated doses," she says. Researchers suspect that the sugar has some potentially adverse side effects, including liver damage. Other studies in mice have shown that the sugar is associated with hearing loss. And directly breathing in a spray of air freshener, which contains fine particles of the sugar and other potentially harmful ingredients, may irritate or damage lungs and mucous membranes lining the airways. "In short, do not inhale air fresheners," **Saey** says.

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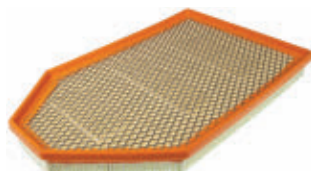
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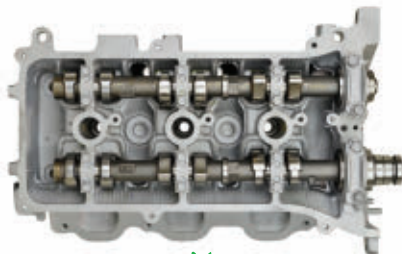


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Atlas reveals where light pollution masks Milky Way

At night, a river of stars cuts through the dense darkness of space. The soft glow of these celestial bodies earned our galaxy the moniker “Milky Way.” But for more than a third of Earth’s population, the glare of artificial lights conceals this cosmic wonder from view, researchers report June 10 in *Science Advances*. Nearly 80 percent of North Americans and 60 percent of Europeans can no longer see the galactic core, the researchers estimate.

Populations with best and worst views of Milky Way:

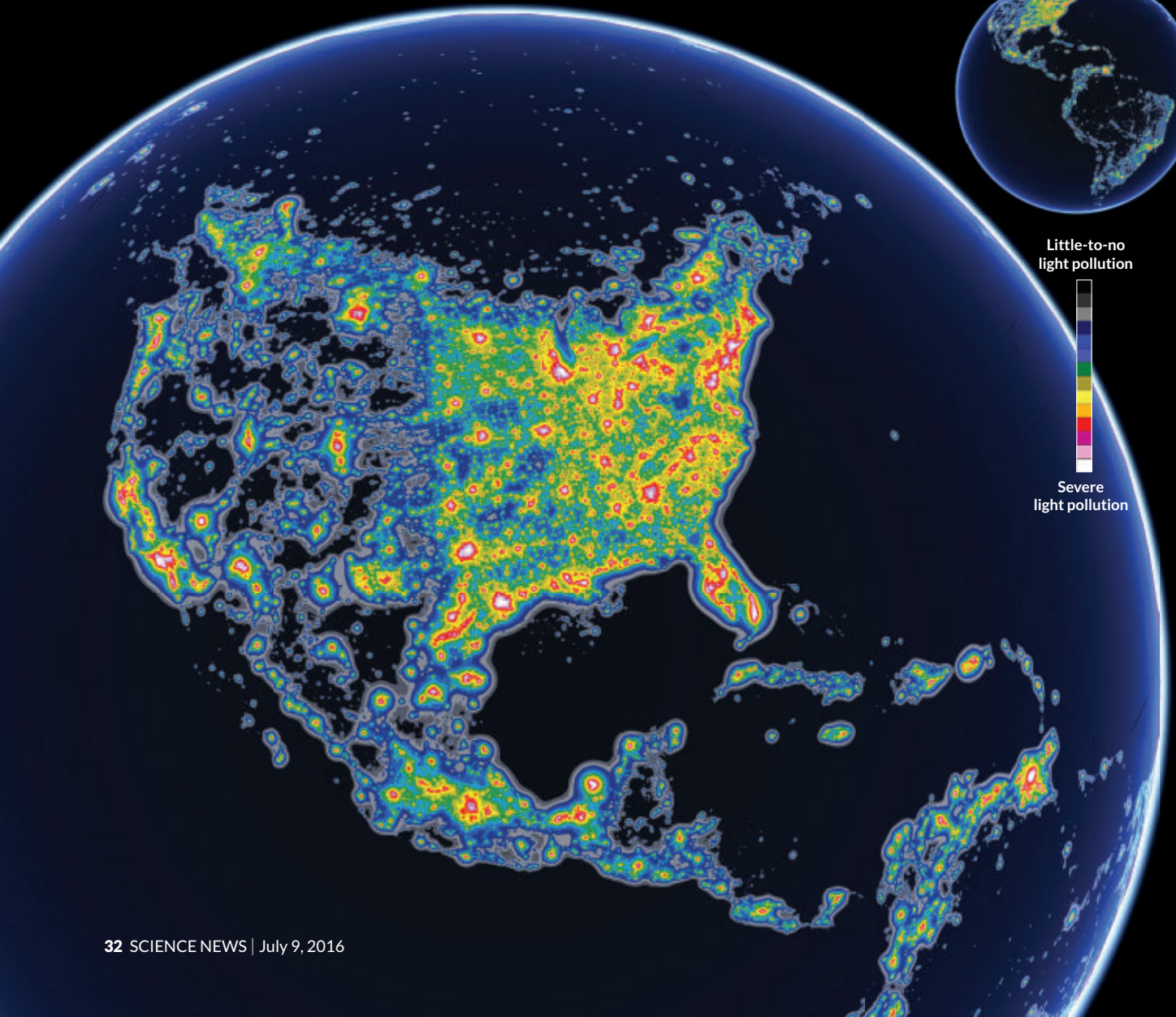
Most pristine skies

1. Chad
2. Central African Republic
3. Madagascar
4. Guinea
5. Somalia

Worst light pollution

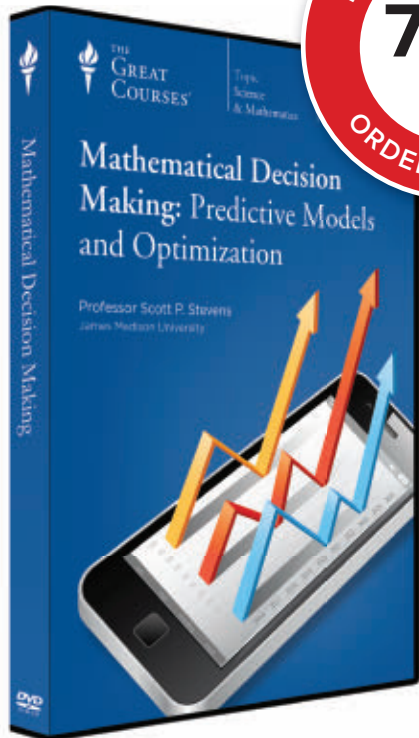
1. Singapore
2. Kuwait
3. Qatar
4. United Arab Emirates
5. Saudi Arabia

Using a combination of satellite measurements and on-the-ground observations, the researchers assembled the first global atlas of artificial sky luminance, recording light pollution from everything from streetlamps to spotlights. Nearly four in five people worldwide live under light-polluted skies, the atlas reveals. Singapore boasts the brightest nights, the team found, with skies so luminous that people’s eyes never have to fully adapt to night vision. Nights are darkest in Chad, the Central African Republic and Madagascar, where more than three-quarters of inhabitants can gaze up at the stars under pristine viewing conditions. — *Thomas Sumner*





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