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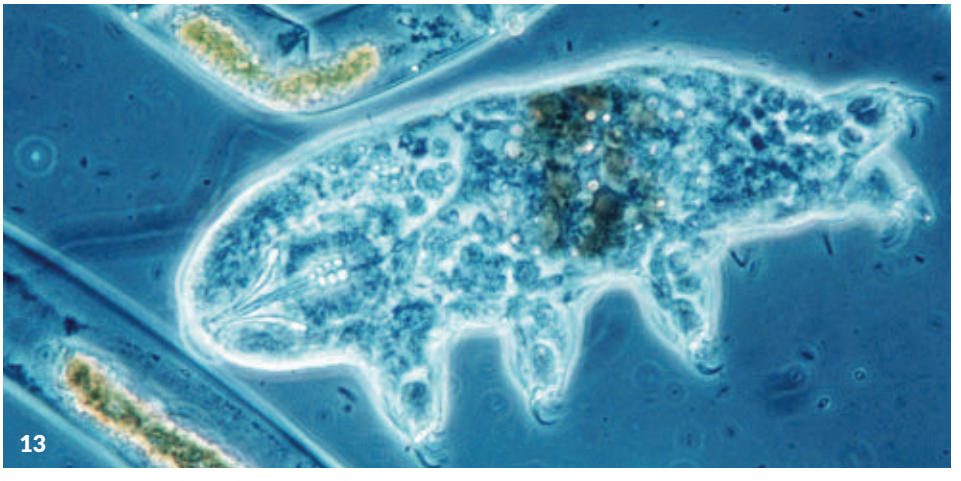
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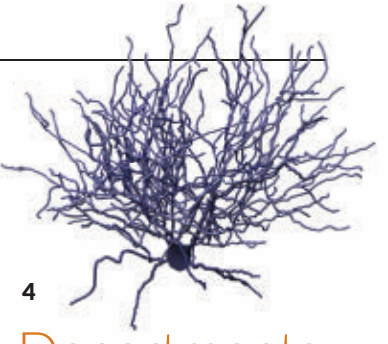
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SOCIETY UPDATE

Alumni share their advice for future scientists

COVER An avalanche thunders down Mount Shkhara in the Greater Caucasus Range. *Lysogor Roman/Shutterstock*

CLOCKWISE FROM TOP: LISE GAGNE/GETTY IMAGES; XIAOLONG JIANG, DANIEL BERGER, ANDREAS TOLIAS; BLICKWINKEL/ALAMY STOCK PHOTO

Climate, new physics and Jupiter on the horizon for 2016

It's fitting that the first issue of the new year features stories about what will, I predict, hold on as scientific newsmakers during 2016. On Page 6, for instance, Thomas Sumner reports on the historic agreement that aims to limit global warming to below 2 degrees Celsius. Exactly how to cut carbon emissions enough to achieve this, and news about climate change's impacts, will surely get major ink this year.

Another story with legs: Results from this year's record-setting proton smashups at the beefed-up Large Hadron Collider has physicists chattering. Operating at substantially higher energies than that of its earlier runs, the LHC has already produced a hint of a possible new character in the drama of particle physics, Andrew Grant writes on Page 7. "All eyes are on a little bump in the data that was presented in December," Grant says. "New collisions in 2016 should either enhance the possibility of a new particle or reveal it as a statistical fluke."

Grant also anticipates news from another frontier of physics. "2016 may be the year we finally detect gravitational waves," he says, which would pave a new avenue for exploring the cosmos. Rumors of such a detection are now circulating.

Other *Science News* staffers are no less bullish about the coming year in science. Among their predictions:

• The gene-editing tool CRISPR will continue to generate breakthroughs and stir controversy.

• Scientists will persist with efforts to figure out what the earliest members of the human genus, *Homo*, looked like and when they first evolved.

• The Juno spacecraft will arrive at Jupiter in July, replacing Plutomania with a Jovian obsession.

In 2016 we'll also look behind the headlines, with in-depth attention to scientific issues, from the potential risks of genetically modified organisms to what science has to say about gun violence and the biology behind the inevitability of aging.

One writer, I should note, thought it might be best to hold her tongue. After all, Susan Milius says, "the best stories of the year are often a surprise." — *Eva Emerson, Editor in Chief*

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Phone: (202) 785-2255
Customer service: member@societyforscience.org
Editorial/letters: editors@sciencenews.org
Sponsor content: ads@societyforscience.org
Science News (ISSN 0036-8423) is published biweekly by Society for Science & the Public, 1719 N Street, NW, Washington, DC 20036.
Online and iPad access: Activate your subscribing member account, including digital access and the ability to opt out of print, at www.sciencenews.org/activate
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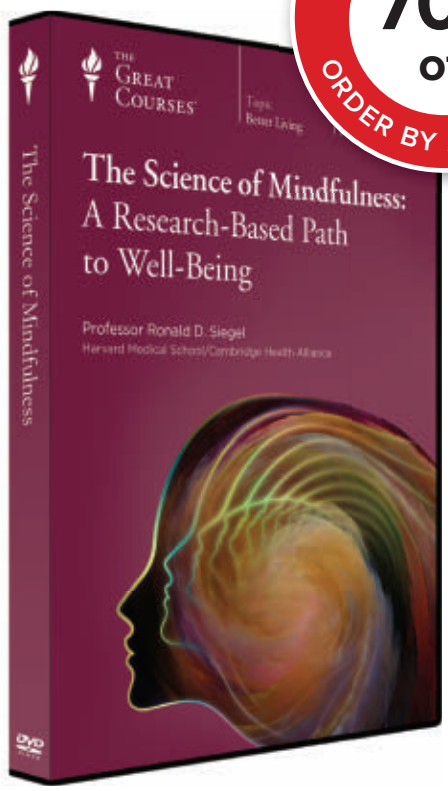

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Excerpt from the January 8, 1966, issue of *Science News Letter*

50 YEARS AGO

DMSO future dimmed

Clinical testing of the experimental drug [DMSO, short for dimethyl sulfoxide] was halted by voluntary agreement of the drug's sponsors ... the action was taken because of undesirable side effects that were observed in the eyes of laboratory animals ... Telegrams have been sent to approximately 1,000 doctors who have been testing this compound on many human patients, mainly for ... arthritis and bursitis pain.

UPDATE: DMSO, a by-product of papermaking, was sold in the early 1960s as a cure for headaches, limb pain, earaches and colds. The compound easily penetrates skin and enters the blood. But testing was halted for a short time when problems occurred in lab animals. Today, the compound is approved by the U.S. Food and Drug Administration to treat severe bladder pain. It is also used as a solvent in other medications. Although some alternative medicine proponents claim DMSO can cure cancer, it actually inactivates several chemotherapy agents, including cisplatin. It is on the FDA list of "fake cancer 'cures' consumers should avoid."

IT'S ALIVE

Tarantula blue is no accident

Unusual among nature's blues, tarantula color doesn't change much when viewed from different angles. Shown is a *Chromatopelma cyaneopubescens*.

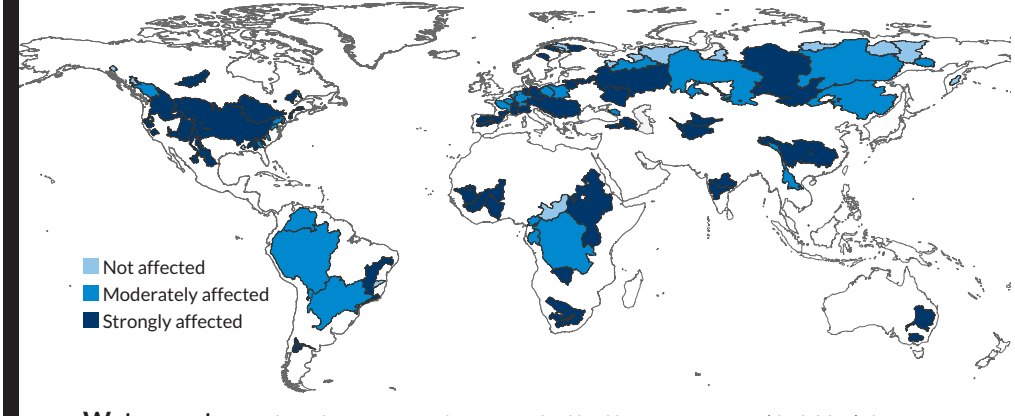
SCIENCE STATS

Humans are worse water hogs than thought

Humans' global water footprint is up to 18 percent greater than 2012 estimates, researchers in Sweden report.

An analysis of water and climate data from 1901 to 2008 from 100 large water basins worldwide revealed more water loss to the atmosphere compared with findings from earlier studies. Human activities — water management techniques such as irrigation and damming rivers to create reservoirs, for example — better explain these findings than climate conditions or geographic location does, the researchers say.

The new results suggest that, globally, people use about 10,700 cubic kilometers of water per year, more than all the water in lakes Michigan, Huron, Ontario and Erie combined. That level of use is increasingly unsustainable, the scientists report in the Dec. 4 *Science*. — *Chris Samoray*



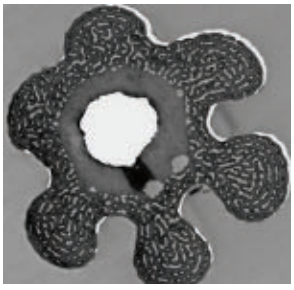
Water, water Half of the 100 water basins studied had heavy water use (dark blue) due to human activities. Only a few locations showed no human impact (light blue).

FROM TOP: MICHAEL KERN, WWW.THEGARDENSOFEDEN.ORG; F. JARAMILLO AND G. DESTOUNI/*SCIENCE* 2015

Roses are red. These tarantulas are blue. They can't see their color, so what does blue do?

Among the various tarantula hues, "the blue color is mysteriously widespread," says Bor-Kai Hsiung of the University of Akron in Ohio. At least one species of tarantula flashes some blue in 40 of the 53 genera he checked. Mapping them onto a tarantula family tree, Hsiung estimates that the color evolved independently at least eight times. At first, he wondered if color among the colorblind spiders was a by-product of some more useful trait. But evidence led elsewhere.

Tarantula blue comes solely from hair. Underneath even the most eye-popping sapphire locks, spider cuticle is a dull dark. Like 90 percent of the blue coloration in nature, Hsiung says, the tarantula hair comes to its blueness from light reflected through embedded nanoscale structures. And, oh the variety. Some species deploy an ordered phalanx of micro pancake stacks, each with cuticle layers alternating with thin air pockets. And for the first time in spiders, Hsiung also found "very, very subtle" arrays (called quasi-ordered spongy structures) like those seen in some blue feathers.

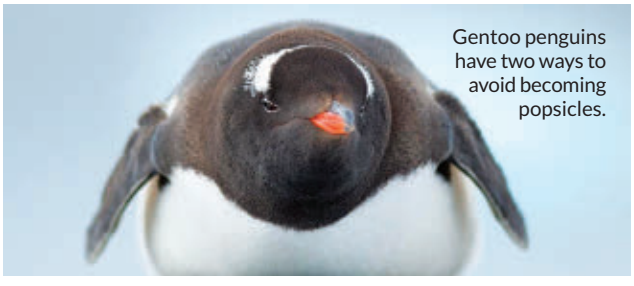


The cross-sectional shapes of blue hairs vary widely among tarantula species, as do the nanostructures within.

The structures and evolutionary histories may differ, but the spiders are "evolving the same blue over and over again," says coauthor Todd Blackledge, also at Akron. Tarantula blue, surely a paint name for the future, lies around the 450-nanometer wavelength, give or take 10 nanometers — a pretty narrow range, Hsiung and his colleagues report in the November 27 *Science Advances*. "Between a navy blue and sky blue," Hsiung says.

With the convergence on a narrow range, the blue seems more than an accident. Maybe in the green-tinted light of forests, a blue tarantula would be hard for predators (or prey) to see, Blackledge speculates. Hsiung wonders if the blue looks enough like the coloring of some fierce wasps to make hungry predators hesitate before attacking. Or maybe the blue resembles flower petals enough to lure some insects within spider-striking distance. All the researchers can say with some confidence is that tarantula blue has little to do with romance. Or roses.

— *Susan Milius*



Gentoo penguins have two ways to avoid becoming popsicles.

MYSTERY SOLVED

Why penguins don't freeze

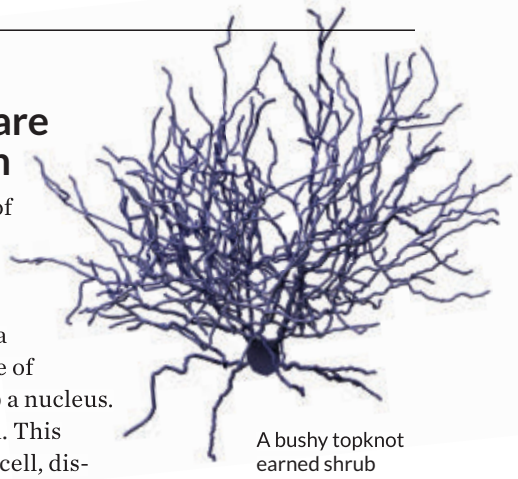
A drenched penguin waddling in bone-chilling air seems like a recipe for frozen feathers. Yet tiny grooves and an oily sheath on the feathers prevent some penguins from becoming popsicles, according to a detailed analysis of penguin plumage reported November 22 at the American Physical Society Division of Fluid Dynamics meeting in Boston.

UCLA mechanical aerospace engineer Pirouz Kavehpour and colleagues observed gentoo penguin feathers under a scanning electron microscope and spotted a jagged surface full of nano-sized pores. The subtle roughness forces water droplets to slide off rather than stay and freeze. Preen oil released from a gland near the base of the tail also works as a water repellent. The Magellanic penguin, which lives in warmer climates than the gentoo, has no pores on its feathers and secretes a less-potent oil, the researchers say.

Kavehpour hopes to exploit the birds' deicing ways to design airplane wings that resist icing. — *Andrew Grant*

INTRODUCING

Shrub cells are true to form



A bushy topknot earned shrub cells, like the one in this illustration, their name.

It didn't take a lot of brainpower to come up with the name for a nerve cell that looks like a bushy, round tangle of fibers perched atop a nucleus. Meet the shrub cell. This botanically named cell, discovered in the brains of adult mice, made its formal debut in the Nov. 27 *Science*.

The newly described cell lives in a particular nervy neighborhood — an area called layer 5 in the part of the brain that handles incoming visual information. Xiaolong Jiang of Baylor College of Medicine in Houston and colleagues defined shrub cells and other newcomers by their distinct shapes, their particular connections to other nerve cells or their similarities to nerve cells found elsewhere. Joining shrub cells are the freshly named horizontally elongated cells, deep-projecting cells, L5 basket cells and L5 neurogliaform cells. Each is an interneuron, a middleman that connects nerve cells to each other. The finding highlights the stunning variety of shapes and wiring patterns of cells in the brain. — *Laura Sanders*

CLOCKWISE FROM TOP: DIMITRI DEHEYN/SCRIPPS INSTIT. OF OCEANOGRAPHY; X. JIANG, DANIEL BERGER, ANDREAS TOLIAS; CHRISTOPHER MICHEL/FLICKR (CC BY 2.0)

EARTH & ENVIRONMENT

Historic climate accord approved

195 countries pledge to limit warming to 2 degrees Celsius

BY THOMAS SUMNER

After years of anticipation, delegates from 195 countries have agreed to curb the worst effects of climate change by limiting warming to "well below" 2 degrees Celsius compared with preindustrial levels. The agreement, approved December 12 at a climate summit outside Paris, aims to be the world's roadmap to kicking the fossil fuel habit, with a possibility of an even more ambitious goal of limiting warming to no more than 1.5 degrees by 2100.

Even with the agreement, political obstacles and technological challenges remain. Countries will have to swap greenhouse gas–emitting energy sources like coal, oil and natural gas for low-emission sources such as wind, solar and nuclear power. Along with yet-to-be-realized technologies that pull greenhouse gases from the air, these changes are meant to reduce net carbon emissions to zero in the second half of the century. By 2020, countries will release their long-term plans to cut emissions. Every five years, countries will reassess their progress and tweak their goals.

For developed countries, the plan is to reverse the rise in emissions as soon as possible. Developing countries such as Bangladesh and Rwanda get more leeway on when they have to start cutting. They will also get help: technological support and a $100-billion-a-year fund provided by developed countries by 2020.

"It took hard work, grit and guts, but countries have finally united around a historic agreement that marks a turning point on the climate crisis," says Jennifer Morgan, a climate policy expert with the World Resources Institute, a research organization in Washington, D.C.

Past international efforts to combat climate change, such as the 1997 Kyoto Protocol and the 2009 Copenhagen climate summit, fell short. But experts viewed this year's talks as more promising. This time around, both China and the United States, the world's biggest carbon emitters, showed newfound interest in striking an agreement to cut emissions.

The agreement comes at a time when many experts warn that humankind is running out of time to avoid severe climate impacts. Human activities such as fossil fuel burning have spiked the concentration of heat-trapping greenhouse gases in the atmosphere. Carbon dioxide concentrations have risen from about 280 parts per million in 1880 to 400 ppm earlier this year. That rise has helped boost the planet's average annual temperature by about 1 degree, with faster warming over land and in the Arctic.

The Paris talks, formally known as the 2015 United Nations Climate Change Conference, were held in response to warnings that a continued rise in greenhouse gases will raise Earth's thermostat further: Business-as-usual climate simulations predict several degrees of additional warming by 2100. That warming would exacerbate droughts in parts of the world (*SN: 3/7/15, p. 10*), boost the intensity of strong storms (*SN Online: 5/29/15*) and raise global sea levels, worsening coastal flooding and drowning low-lying islands (*SN Online: 9/27/13*). In April, scientists also warned that unabated climate change would threaten one in six species with extinction (*SN Online: 4/30/15*).

The 2-degree limit at the heart of the plan is somewhat arbitrary — scientists don't expect an abrupt jump in disasters once that threshold is crossed. Still, as temperatures rise, the effects of climate change will increase rapidly, says Penn State glaciologist Richard Alley.

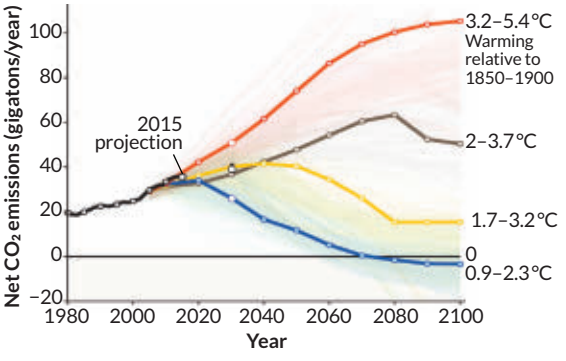
"Each degree of warming costs more than the previous one," Alley says. One degree is within the natural variability of Earth's climate for most places, but once you get to 2 degrees, he says, "you start to move outside of familiar territory."

Many delegates supported an even more ambitious target: a 1.5-degree limit this century. Small island nations such as the Maldives and the Marshall Islands argued that 2 degrees of warming could raise sea levels enough to wipe swaths of their countries off the map. The 1.5-degree goal was also supported by African nations such as Sudan and Angola that are particularly vulnerable to the droughts and extreme heat that climate change intensifies. The deal invites the Intergovernmental Panel on Climate Change to put together a report in 2018 exploring the impact of 1.5 degrees of warming above preindustrial levels.

China opposed that 1.5-degree goal. Before the talks, some experts worried that China would derail any hopes of an aggressive plan. The country is in a unique situation, releasing over a quarter of the world's carbon emissions while trying to support a growing economy.

Coal power plants and other carbon emitters have polluted China's air. On December 8, Beijing ground to a halt after the city's government issued the

Climate change: four scenarios



Paths forward Most future carbon dioxide emission scenarios (four shown) will raise global temperatures by several degrees Celsius. A deal brokered at the Paris climate talks aims to keep warming below 2 degrees compared with preindustrial levels, a goal that requires carbon storage and capture strategies that will offset CO_2 production enough to eventually bring net carbon emissions to less than zero.

GRAPH: GLOBAL CARBON PROJECT, SOURCE: CDIAC, GCP, IPCC, S. FUSS *ET AL/NATURE CLIMATE CHANGE* 2014

country's first red alert for pollution, closing schools and factories. China has started investing heavily in low-emission energy sources, but the country is "doing it for health reasons, not just because they want to be good global citizens," says MIT atmospheric scientist Kerry Emanuel.

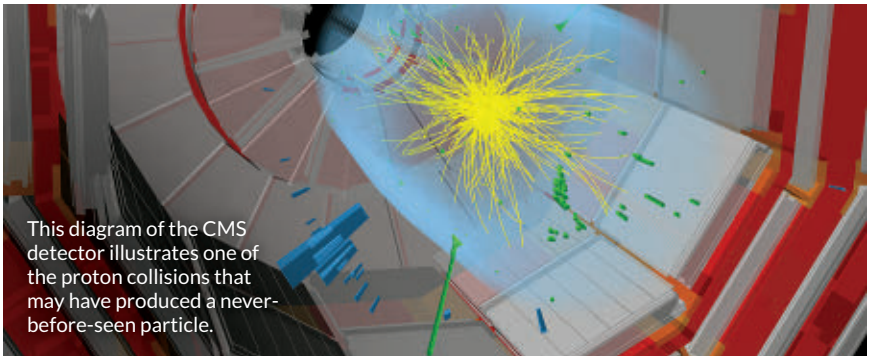
Regardless of the motivations, these investments have made an impact. The Global Carbon Project reported in December that the world's carbon footprint shrank by about 0.6 percent in 2015, largely due to China (*SN Online: 12/8/15*). If confirmed, that would be the first ever reduction in a period of economic growth.

Other countries are also investing in alternative power sources, though many are forgoing nuclear power. That's a mistake, Emanuel and others argued December 3 in an op-ed for *The Guardian* newspaper. While renewable sources such as solar and wind supply energy with a small carbon footprint, they eventually "hit a brick wall," Emanuel says.

When there's not enough sun or wind, backup energy is required. Worldwide, about 80 percent of that always-available energy comes from fossil fuels, Emanuel says; about 20 percent is nuclear power. "If we're going to reach this climate goal, not only do we have to build up renewables, but we also have to build nuclear power plants as fast as we can," he says.

Even with the deal, the world isn't out of hot water yet. Each country will have to figure out how it will reduce carbon emissions, which can pose a challenge in places such as the United States. The country was a signatory to the Kyoto Protocol, but the agreement got mired in politics and was never ratified by Congress. This time around, congressional Republicans have signaled that they'll similarly block the deal's implementation by denying funding.

Despite the hurdles, the world is on a safer path, says Andrew Steer, president and CEO of the World Resources Institute. "The shift from commitment into action will be even harder and take even more determination. But for today at least, we rest a little easier knowing that the world will be stronger and safer for our children and future generations." ■



This diagram of the CMS detector illustrates one of the proton collisions that may have produced a never-before-seen particle.

CMS/CERN

MATTER & ENERGY

LHC sees hints of possible new particle

Researchers pore over data from proton collider's latest run

BY ANDREW GRANT

The recently souped-up Large Hadron Collider isn't revealing the universe's secrets yet.

Two analyses of proton collisions in the retooled LHC, which restarted at record energy in June after a two-year hiatus, have failed to yield any discoveries. The results do contain at least one intriguing hint of a new particle, researchers announced December 15 at a meeting at CERN in Geneva, but scientists will need more collisions to evaluate that possibility. After a successful first wave of collisions from 2010 to 2013 that uncovered the Higgs boson, physicists are hoping the revamped machine exposes new particles that would expand the standard model, the catalog of nature's fundamental components.

LHC physicists collect and analyze the subatomic shrapnel produced when protons slam into each other at nearly the speed of light. This year, the LHC's protons collided with 13 trillion electron volts of energy; the machine was running at 8 trillion electron volts when it exposed overwhelming evidence for the Higgs boson in 2012 (*SN: 7/28/12, p. 5*). The increased energy and other upgrades mean protons collide more often and can produce more massive particles.

Despite the increased potential for discovery, researchers with the LHC's two main detectors, CMS and ATLAS, announced that, for the most part, the fresh data matched the predictions of the standard model. One exception is a small bump, an excess of activity at a particular energy, that could indicate the existence of a particle with a mass of roughly 750 billion electron volts, or 750 GeV. That's about six times as massive as the Higgs. CMS and ATLAS spotted the possible signature of such a particle decaying into pairs of photons.

But the tantalizing detection could be a statistical fluke. While the chances of seeing this bump at 750 GeV are fairly low, says Matt Strassler, a theoretical physicist affiliated with Harvard, finding such a bump within the huge range of masses explored by the LHC is not nearly as unexpected. (He compares it to playing the lottery: There's a very small chance that you win but a very good chance somebody wins.) The bump "is not dramatically better than other hints we've seen in the past," he says. In fact, physicists announced that a similar bump that turned up in the LHC's initial run has all but disappeared in the new data.

The uncertainty won't stop theorists from exploring the implications of the existence of a 750 GeV particle. And plenty of physicists remember that the Higgs boson also began as an inconclusive bump before subsequent data sealed its discovery. Yet once again, physicists have to play the waiting game in the search for unexpected phenomena. The LHC is done smashing protons for now, but is scheduled to resume in the spring. ■

BODY & BRAIN

Not all dieters are created equal

People's glucose levels react differently to the same foods

BY TINA HESMAN SAEY

A cookie can give one person a sugar rush while barely affecting another person, a new study finds, indicating that a food's glycemic index is in the eater.

People's blood sugar rises or falls differently even when they eat the same fruit, bread, desserts, pizza and many other foods, researchers report in the Nov. 19 *Cell*. That suggests that diets should be tailored to individuals.

The discovery came after fitting 800 people with blood glucose monitors for a week. The people ate standard breakfasts supplied by the researchers. Although the volunteers all ate the same food, their blood glucose levels after eating varied dramatically. Factors such as body mass index, sleep, exercise, blood pressure, cholesterol levels and gut microbes are all associated with blood glucose responses to food, the researchers conclude.

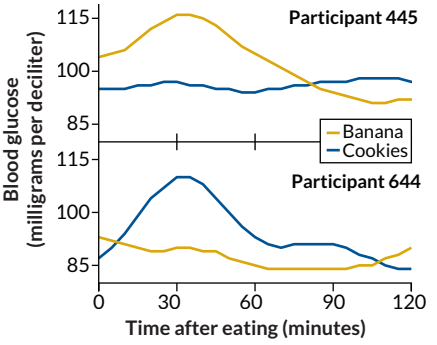
Those findings indicate that blood sugar spikes after eating depend "not only on what you eat, but how your system processes that food," says Clay Marsh, an epigenetics researcher at West Virginia University in Morgantown.

Previous studies had dismissed such differences as flukes, but "we're actually quantifying it," says study coauthor Eran Elinav, an immunologist at the Weizmann Institute of Science in Rehovot, Israel. For instance, eating bread produced a postmeal blood sugar level rise of 44 milligrams per deciliter of hemoglobin on average. But some people's blood sugar rose as little as 15 mg/dl*h, while others' spiked by as much as 79 mg/dl*h.

A team led by Elinav and Weizmann computational biologist Eran Segal created a computer algorithm that used 137 personal measurements and other factors to predict how a person's blood sugar would change after eating a certain food. When tested on a new group of 100 people, the algorithm correctly predicted the response about 70 percent of the time.

A third group of 26 participants were given personalized meals. The algorithm analyzed each person and picked "good" and "bad" diets for 12 of them. A nutritionist did the same for the others. Good and bad diets had the same amount of calories, but good diets were meant to minimize blood sugar spikes while bad ones would send blood sugar skyrocketing.

Carb confusion Study participants had very different responses to eating certain foods. A cookie caused blood sugar levels to spike for one person but didn't affect a second person. SOURCE: D. ZEEVI *ET AL*/*CELL* 2015



For 10 of the 12 people, the algorithm correctly predicted responses to the good and bad diets. Nutritionists were similarly good at predicting how people would fare. But the computerized approach could reach more people, the team says.

Foods on the good diet for one person were sometimes on another's bad list. "What our data suggest is that relying on population averages is not only inaccurate, but may even be dangerous in some cases," Elinav says. ■

BODY & BRAIN

Potent-pot users show brain damage

More THC associated with weakness in key white matter tract

BY LAURA SANDERS

People who use especially potent marijuana show signs of damage in a key part of the brain. The results, reported online November 27 in *Psychological Medicine*, are limited, though: The small study doesn't show that pot caused the abnormality — only that the two go hand-in-hand. But the findings suggest that potency matters, says psychiatrist Tiago Reis Marques of King's College London.

Just as vodka packs more of a punch than beer, a high-potency toke delivers much more of the psychoactive substance tetrahydrocannabinol, or THC. A bigger dose of THC may have stronger effects on the brain, Reis Marques says.

That's important because as marijuana plant breeders have perfected their products, THC levels in the plants have soared (*SN Online: 3/24/15*).

Reis Marques and colleagues scanned the brains of 43 healthy people, about half of whom use cannabis. The team used a method called diffusion tensor imaging to study the structure of the brain's white matter, neural highways that carry messages between areas. Participants gave a detailed history of their past drug use, including how potent their pot was.

People who self-reported using high-potency pot showed signs of damage in the corpus callosum, the major white matter tract connecting the brain's left and right sides. Water diffused more easily along that tract, a sign of weaker tissue.

While the results show a link between high-potency cannabis use and white matter damage, they can't prove that cannabis caused the trouble. "These people could have had deviant brain structures prior to use," says psychologist Mitch Earleywine of the University at Albany in New York. The results could be explained by other drug use, too. Cocaine, for instance, has been tied to corpus callosum abnormalities, says Earleywine, who serves on the advisory board of NORML, a marijuana advocacy group.

Because the study focused only on anatomy, it's unclear whether these changes would affect behavior. ■

MATTER & ENERGY

Multiparticle entanglement quantified

Physicists measure quantum connection between several atoms

BY ANDREW GRANT

A first-of-its-kind measurement has quantified a mysterious quantum bond when it is shared by several particles rather than just two. The work, reported in the Dec. 3 *Nature*, brings physicists closer to understanding the scope of this link, known as quantum entanglement.

Entanglement interweaves particles' fates so that some of each particle's properties, which are inherently uncertain according to quantum mechanics, are tied to those of its partners. Each particle sacrifices its individuality to become part of an umbrella entangled state. While physicists have developed reliable methods for detecting entanglement between pairs of particles, the measurements get tricky when more particles are involved.

Harvard physicists measured a property called entanglement entropy, which quantifies the apparent randomness that comes with observing a portion of an entangled whole. Markus Greiner and colleagues used lasers to create an optical cage with four compartments, each holding a rubidium atom chilled to nearly absolute zero. The researchers could tweak the laser to adjust the height of the walls between compartments. If the walls were low enough, atoms could exploit their quantum ability to occupy multiple compartments at once. As the atoms jumped around, they interacted and established a state of entanglement.

Greiner's team created a pair of four-compartment systems and confirmed that they were identical. Then the researchers compared portions of the two cages — say, two of the four compartments where atoms could reside. The partial system of one cage differed from the corresponding partial system of the other cage. A difference between parts when the wholes are indistinguishable "only happens if there is entanglement within each system," Greiner says.

Peter Zoller, a theoretical quantum physicist at the University of Innsbruck in Austria, says that analyzing particles in collections similar to those in the new experiment could help physicists understand the complex entanglement-rich interactions between electrons in superconductors, which conduct electrical current with no resistance. ■

MATTER & ENERGY

New solid form of carbon identified

Material could offer a simple way to manufacture diamonds

BY MEGHAN ROSEN

A glow-in-the-dark, magnetic, stronger-than-diamond material might be a bizarre new form of carbon.

Scientists call it Q-carbon. After diamond and graphite, it's the third known solid phase, or form, of the element, materials scientists Jagdish Narayan and Anagh Bhaumik report in the Dec. 7 *Journal of Applied Physics*.

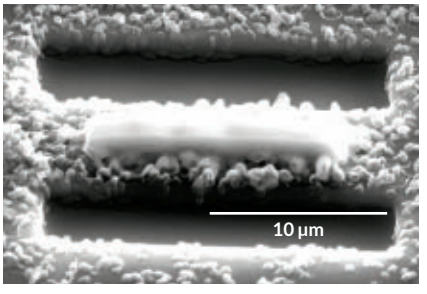
Q-carbon's unusual properties make it ideal for many applications, Narayan says, from electronic displays to abrasive coatings on tools to biomedical sensors. The new material could also offer a quick, easy way to manufacture diamonds.

"If these claims stand up, the formation of a new phase of carbon would be extraordinary," says Penn State chemist John Badding. But, he notes, "extraordinary claims require extraordinary evidence."

Carbon takes several structural forms. At room temperature and pressure, atoms link up in 2-D honeycomb sheets called graphene that stack together to form graphite. Crushed under high pressure, carbon's atomic bonds buckle, popping atoms into the 3-D tetrahedral arrangement of diamonds. Other structures include nanotubes (rolled up graphene) and soccer ball–shaped buckyballs.

"When carbon goes into a new structural arrangement, really exciting properties can arise," Badding says. Diamonds and nanotubes, for example, are superstrong, and graphene conducts electricity.

Q-carbon is exciting, Narayan says, since no other solid carbon is magnetic.



A new way to make diamond uses a laser to convert carbon into "Q-carbon," from which diamond crystals can grow, as shown in this electron micrograph.

J. NARAYAN AND A. BHAUMIK/JOURNAL OF APPLIED PHYSICS 2015

Narayan and Bhaumik, of North Carolina State University, created the material by zapping a carbon pellet with a high-power laser beam, which blasted a thin carbon coating onto a flat sheet of sapphire about the size of a postage stamp. Then they turned the power down and hit the coat with just enough heat to melt it.

After the quick toasting, the carbon was rapidly cooled, or quenched (hence Q-carbon's name), transforming it into the new material. Instead of interlocking in the neat lattices of diamonds, carbon tetrahedrals jumbled together in an amorphous heap. It's as if someone smashed a diamond's structure, but left most of its building blocks intact, says Narayan. From these building blocks, the team grew tiny dots, films and needles of diamonds.

The team probed Q-carbon's structure by measuring the atoms' locations and bonds and by using Raman spectroscopy, a molecular fingerprinting technique. The fingerprints of diamond and nanotubes are clear-cut, but those of amorphous carbon are complex, says Badding. So it might be tricky to decipher exactly what material was created. ■

GENES & CELLS

Liberia's Ebola outbreak tracked

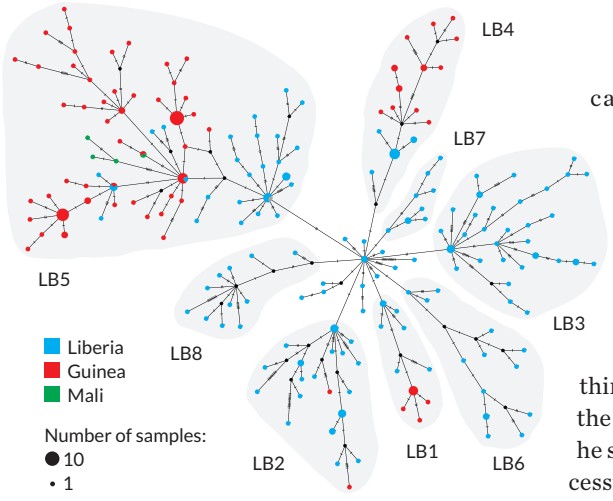
Genetic analysis traces most cases to one virus lineage

BY TINA HESMAN SAEY

A single introduction of the Ebola virus led to most cases of the deadly disease in Liberia, a new genetic study suggests.

Researchers examined 165 Ebola genomes, most collected during the second wave of infection that started in the West African country in late May 2014. The analysis, reported in the Dec. 9 *Cell Host & Microbe*, adds missing information about how the virus spread in Liberia. Ebola had previously been genetically tracked in Sierra Leone (*SN: 3/7/15, p. 12*; *SN: 9/20/14, p. 7*) and Guinea.

Tracing the genetic lineages of Ebola and other viruses may help researchers better understand and control such outbreaks, says evolutionary geneticist Jason Ladner of the U.S. Army Medical Research Institute of Infectious Diseases in Frederick, Md.



Branching out In Liberia, an Ebola virus lineage called SL2 (center dot) split into subgroups as it passed from person to person and mutated. Each dot is a slightly different version of the virus within the subgroups. Dot size indicates how many samples carried that version.

Ebola first entered Liberia in March 2014 from neighboring Guinea. That outbreak ended in early April 2014.

A second wave soon started with at least three sources, say Ladner and colleagues. But by July 2014, all of the collected virus samples were from a single lineage, SL2. The virus probably came to Liberia when a woman traveled from Sierra Leone to Liberia's capital, Monrovia. The SL2 lineage is very similar to other versions of the virus in Sierra Leone, Ladner says.

"We have no reason to think there's any difference in the function of these viruses," he says. SL2 was probably successful at spreading because of circumstances: Once the virus was established in the crowded city, people spread it widely around the country, Ladner and colleagues say. As the virus moved, it separated into eight sublineages, each characterized by a separate mutation. This internal spread of the virus is much like what happened in Sierra Leone.

Ebola later crossed from Liberia into Guinea at least five times, Ladner and colleagues determined. One of the sublineages was then passed from Guinea to Mali on at least two separate occasions.

One comforting finding is that "the

EARTH & ENVIRONMENT

Warming culprit CO_2 has a cool side

Peculiar conditions in central Antarctica have chilling effect

BY THOMAS SUMNER

In a cold corner of the world, carbon dioxide is doing something surprising. Instead of causing warming, rising CO_2 levels over central Antarctica produce a net cooling effect, new research suggests.

That discovery does not contradict the fact that accumulating greenhouse gases raise temperatures elsewhere around the world (*SN: 4/4/15, p. 14*). "We're not saying the greenhouse effect is rubbish," says study coauthor Justus Notholt, an atmospheric physicist at the University of Bremen in Germany. "But in Antarctica, the situation is different."

In central Antarctica, surface temperatures are regularly colder than those in the overlying stratosphere, a layer of the atmosphere some 10 to 50 kilometers high. So instead of primarily trapping heat radiating from the ground, CO_2 boosts the amount of heat escaping into space from the atmosphere, the researchers report online December 14 in *Geophysical Research Letters*.

Unlike the rest of the planet, the Antarctic interior has not warmed over the last few decades and has even shown signs of slight cooling (*SN: 7/27/13, p. 18*). A chilling effect from CO_2 could explain some of that lack of warming, though further research is needed, Notholt says.

CO_2 absorbs and emits heat in the form of infrared radiation. When infrared radiation from Earth's relatively warm surface hits a CO_2 molecule in the atmosphere, the molecule can absorb the energy and later reemit it as infrared radiation. Like a pinball machine, the CO_2 molecule fires the infrared energy in a random direction. Sometimes, the emitted energy continues out into space; other times, it returns to the surface, creating warming called the greenhouse effect.

Satellites monitor the amount of radiation escaping into space. Where CO_2 blocks radiation from the surface, scientists see a dip in the amount of radiation escaping. Over the Antarctic Plateau in the continent's center, satellites instead see an increase in the infrared radiation escaping into space within the range of frequencies associated with CO_2.

This negative greenhouse effect, Notholt and colleagues propose, results from the region's frigid temperatures, the lowest on Earth (*SN: 1/25/14, p. 15*).

The ground is so cold that the surface emits little heat. But in the stratosphere above, CO_2 molecules still soak up

J.T. LADNER *ET AL/CELL HOST & MICROBE* 2015

virus is not rapidly mutating or changing into something more virulent," says virologist Matthew Cotten of the Wellcome Trust Sanger Institute in Hinxton, England. The new data from Liberia should allow scientists to assemble a more detailed picture of how the Ebola virus spread throughout West Africa. "It's a valuable resource," Cotten says.

Over 28,000 people in Guinea, Sierra Leone and Liberia were infected with Ebola, resulting in 11,300 deaths. Sierra Leone was declared free of Ebola on November 7. Guinea has not recorded a new case since October 29. The World Health Organization has twice declared Liberia Ebola-free only to have cases crop up again. The latest was a 15-year-old boy diagnosed on November 19 who died November 23. His father and 8-year-old brother also contracted the virus.

Isolated cases may continue to appear as survivors who unwittingly carry active virus pass it to others, Cotten and Ladner say. One such case was an Ebola survivor who earlier this year infected a woman through sexual intercourse (*SN Online: 10/14/15*). ■

atmospheric heat and send some infrared radiation out into space. Normally, this loss would be offset by heat trapped from the ground. Instead, the process results in an overall cooling effect.

It's not clear exactly where in the atmosphere that cooling occurs. Finding that out will be important, Notholt says, because the cooling could alter wind patterns or cause other climate shifts.

In addition, just because part of the atmosphere cools doesn't mean the mechanism cools the ground below as well, says environmental scientist Scott Rutherford of Roger Williams University in Bristol, R.I. The new work predicts that other places with frigid surface temperatures, such as Greenland, should see a reduced, but still positive, greenhouse effect. Temperatures in Greenland, however, are rising much faster than the global average, Rutherford says, suggesting that the effect doesn't significantly affect surface temperatures there. ■

M.L. RUDOLPH, V. LEKIĆ AND C. LITHGOW-BERTELLONI

EARTH & ENVIRONMENT

Gooey mantle boundary discovered

Region resists movement of magma plumes, sinking plates

BY THOMAS SUMNER

A sixth of the way to the center of the Earth, things get goopy. Using variations in the planet's gravitational tug, geophysicists have discovered that the viscosity of Earth's mantle rapidly increases about 1,000 kilometers below ground.

The increasingly viscous rock acts like geologic molasses, slowing down anything trying to push through it. That includes sinking tectonic plates and the rising plumes of hot rock that fuel volcanoes, geophysicist Maxwell Rudolph of Portland State University in Oregon and colleagues report in the Dec. 11 *Science*.

While the origins of the viscosity increase remain unknown, its discovery should help geologists better understand the flow of heat and rock through the planet's interior.

The depth of the viscosity jump may be a more suitable dividing line between the upper and lower mantle than the 660-kilometer-deep region currently used, suggests MIT geophysicist Robert van der Hilst. "In terms of structure and dynamics, 1,000 kilometers could be more important."

The mantle extends from roughly 7 to 35 kilometers beneath the ground to 2,900 kilometers down. It's hard to study this region because even the deepest drill sites do not descend far enough to scratch the top of the mantle.

Geophysicists indirectly peek at the mantle by measuring how fast the ground rebounds after being compressed by gargantuan glaciers and by listening for the ricochets of earthquakes that rattle through the planet. Those techniques, however, offer an incomplete view.

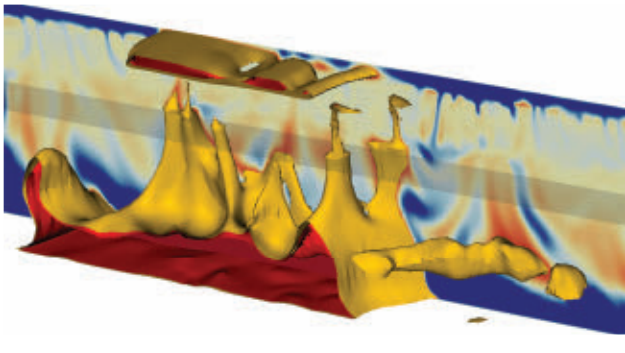
Rudolph's team used a relatively new technique that relies on variations in Earth's gravitational tug. Rising and falling mantle material can cause surface dips and rises. Near Hawaii, for instance, mantle upwelling causes the ground to bulge roughly 1.3 kilometers in places. The downward force felt over a rise will be stronger than over a dip.

How strongly the mantle alters the local gravitational pull depends on both the viscosity and density of the mantle material. Seismic waves traveling through Earth's interior partially reflect off boundaries where the mantle becomes denser. That information allowed the researchers to separate the two effects.

Using knowledge of Earth's composition and gravity measurements collected by NASA's GRACE satellites, the researchers created a profile of Earth's interior. A computer program systematically simulated hundreds of thousands of different configurations of Earth's innards, hunting for setups consistent with the GRACE gravity data. Most of the simulations suggested that the viscosity of the mantle increases 10- to 150-fold around 1,000 kilometers down.

The 1,000-kilometer depth corresponds to a region where many sinking tectonic plates stall, a separate research team reports in the December *Science Advances*. The team used reflecting seismic waves to track the motions of several sinking tectonic plates around the world.

While some previous studies proposed such a rapid viscosity increase at that depth, the two new papers provide a clear confirmation that the viscosity increase exists, says geodynamicist Lijun Liu of the University of Illinois at Urbana-Champaign, who was not involved with either study. ■



Earth's mantle becomes more viscous about 1,000 kilometers below ground (gray bar). That goopiness could narrow and deflect the rising plumes of hot rock (yellow) that fuel volcanoes.

Cells in the body migrate in groups that follow rules similar to those of flocking birds, biologists are discovering.

GENES & CELLS

Body's cells move like flocks of birds

Collective behavior of animals can help explain movement

BY TINA HESMAN SAEY

Cell biologists are finding clues from marching ants, flocking birds and other animals to learn how groups of cells move through the body.

Such studies are yielding insights about cell movement during development and during the spread of cancer. Learning about cells' social interactions may give researchers new ways to peer-pressure cells into good behavior.

Cell biologists have traditionally studied individual cells or how groups of physically connected cells move. It's only in the last few years that researchers have begun to regard cells as individuals with collective behavior. Taking cues from the linked movements of animals helps researchers "understand how cells, which everybody assumed had minds of their own, could possibly move as a group," says Brian Stramer, a cell biologist at King's College London.

Developmental biologist Roberto Mayor and colleagues have collected evidence that the migration of some important developmental cells is akin to the movement of swarming locusts. Mayor, of University College London, described the mass migration of neural crest cells December 13.

Neural crest cells are developmentally flexible cells in embryos that help form the bones and cartilage of the face, some nerves and brain cells, smooth muscle and other tissues. Some scientists have proposed that changes in early movements of these cells may lead to the juvenile-looking physical features of domesticated animals (*SN: 8/23/14, p. 7*).

Like locusts that cringe away from nipping neighbors, neural crest cells repel each other, thanks to a process known as "contact inhibition of locomotion," Mayor and colleagues found. Avoidance can increase the ability of cells to move in groups; cells that move astray and bump into a neighbor change course and move in the right direction again. A large crowd governed only by avoidance tactics, though, tends to break into smaller cliques, the researchers discovered in computer simulations. Cells are not just repelled by each other, they are also often attracted to other cells. That attraction causes cells to play follow-the-leader. On its own, attraction produces a group of cells that don't get very far, computer simulations showed. A balance between avoidance and attraction produces the most efficient mass migrations, the simulations suggest.

Neural crest cells and other embryonic cells called placode cells display just the sort of run-and-chase behavior that enables effective migration, Mayor said. Placode cells give rise to sense organs or groups of nerves called ganglia. When neural crest cells make contact with placode cells, contact inhibition causes the placode cells to run away. The neural crest cells are attracted to the placodes and give chase, said Mayor, whose group is learning some of the molecular details of this attraction and repulsion.

Cancer cells may also follow group behavior rules seen in swimming, swarming and flocking animals. Brain tumors organize themselves into streams and swirls reminiscent of patterns made by schools of fish, researchers reported December 14. Neurobiologist Pedro Lowenstein of the University of Michigan in Ann Arbor teamed up with mathematician Sebastien Motsch of Arizona State University in Tempe to study movement of glioma cells.

Gliomas are tumors that run finger-like projections through the brain. Each finger is a stream of cells about 10 to 20 cells wide. Motsch and colleagues constructed computer simulations of the cells' movement, considering each as an independent entity and taking into account connections and repulsion among tumor cells. A picture emerged showing brain tumors as self-organizing structures that form streams, swirls and spheres. The simulations also showed that cells leading the pack would become elongated.

Lowenstein and colleagues tested the computer predictions in the lab and found that round cells don't move but stretched-out ones do. Adding mobile cells into a group of stationary ones got the sedentary cells to move. That could be bad news for patients, the researchers discovered. Mice in which brain tumors don't form streams live about 200 days, while those whose brain tumor cells do stream died after about 50 days. If this finding holds up in people, discerning mobile cancer cells from stationary ones might help determine the aggressiveness of a tumor. ■

TODDARBINI/ISTOCKPHOTO

MEETING NOTES

For water bears, the glass is all full

Water bears turn into glass when they dry out.

That glazing enables the hardy microscopic creatures, also known as tardigrades, to withstand extreme desiccation, biologist Thomas Boothby of the University of North Carolina at Chapel Hill reported December 15.

Boothby and his colleagues discovered that water bears make a lot of certain proteins under dry conditions. Those proteins are floppy and unformed when tardigrades are hydrated. As the animals dry, the proteins fold into a glasslike solid that encases and protects other proteins and molecules that would normally fall apart when dried. Adding water melts the glass and the tardigrade recovers. Yeast engineered to produce the tardigrade's glass proteins survive desiccation better than yeast normally do, Boothby's collaborators discovered.

Reducing levels of the glass proteins hampers the water bears' desiccation resistance, but doesn't harm their remarkable ability to withstand extreme cold. That suggests that other proteins offer cold protection, Boothby said.

Tardigrade glass may have practical applications, such as preserving useful molecules in a dry state, experiments with an enzyme called lactate dehydrogenase suggest. The enzyme loses its activity when dried out. But when the researchers mixed the enzyme with the glass proteins before drying, the enzyme bounced back to normal activity when rehydrated. Mixing in water bear proteins after drying didn't help, indicating that the glass proteins need to form around other molecules to protect them.

Glass proteins may one day help preserve vaccines in parts of the world where keeping them cold is impractical, Boothby suggested. — *Tina Hesman Saey*

Upending body's daily rhythm triggers growth of fat cells

New research may help explain why chronic stress, sleep deprivation and other disruptions in the body's daily rhythms are linked to obesity.

Chronic exposure to stress hormones stimulates the growth of fat cells, Mary Teruel of Stanford University reported December 16. Normally, stress hormones, such as cortisol, are released during waking hours in regular bursts that follow daily, or circadian, rhythms. Those regular pulses don't cause fat growth, Teruel and colleagues discovered. But extended periods of exposure to the hormones, caused by such things as too little sleep, break up that rhythm and lead to more fat cells.

Even though only about 10 percent of fat cells are replaced each year, the body maintains a pool of prefat cells that are poised to turn into fat. "If they all differentiated at once, you'd be drowning in fat," Teruel said.

Previous studies have shown that a protein called PPAR-gamma controls the development of fat cells and that stress hormones turn on the production of PPAR-gamma. Teruel's team discovered that prefat cells with levels of PPAR-gamma below a certain threshold don't transform into fat in laboratory tests. Steady hormone exposure eventually allowed the precursor cells to build up enough PPAR-gamma to cross the threshold into fat making. But in cells given the same total amount of stress hormone in short pulses, PPAR-gamma levels rose and fell.

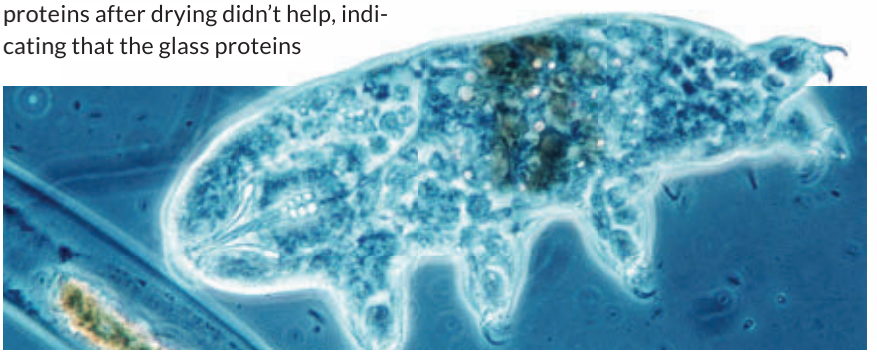
The stress hormone works like pushing on a car's accelerator. Steadily increasing pressure eventually puts the car over the speed limit, while pulses effectively take the foot off the gas pedal, causing periodic slowdowns, making it harder to reach the limit. Pulses shorter than 12 hours didn't make extra fat, while longer pulses, such as those that may be caused by sleep deprivation or other disruptions in circadian rhythms, increased the number of precursor cells that became fat cells.
— *Tina Hesman Saey*

Cancer cells get help migrating throughout the body

Some helper cells may smooth the way for cancer cells to move, a new study suggests. Cells called cancer-associated fibroblasts arrange a normal meshwork of fibers into straight tracks, cell biologist Begum Erdogan of Vanderbilt University in Nashville and colleagues reported December 13. Fibroblasts are cells that help construct connective tissue. Erdogan and colleagues examined one type of fiber built of a protein called fibronectin.

Normal fibroblasts form a meshwork of fibronectin that helps support cells. But Erdogan and colleagues found that fibroblasts associated with prostate cancer could either lay straight new fibronectin tracks or grab and pull snarled networks into straightaways that cancer cells could then move along. Such tracks may help cancer spread throughout the body.

Compared with normal fibroblasts, cancer-associated fibroblasts pull harder on connective fibers, thanks partly to increased activity of a motor protein called myosin II. Extra doses of a protein called alpha5beta1 integrin may also give the cancer-associated fibroblasts extra handholds on fibers.
— *Tina Hesman Saey*



BLICKWINKEL/ALAMY STOCK PHOTO

Water bears, or tardigrades (one shown), make proteins that turn into glass when the microscopic animals dry out. The glass preserves other proteins, new research suggests.

X-ray scans of the skulls of lizards and snakes, including the oriental rat snake (*Ptyas mucosa*), reveal clues that today's snakes descended from burrowers.

LIFE & EVOLUTION

Snakes evolved from burrowing ancestor

The mother of all snakes got its start underground.

X-ray images of snake and lizard skulls suggest that modern snakes' ancestors burrowed rather than swam, scientists report in the November *Science Advances*.

The study is the latest to suggest that snakes evolved from land lizards that lost their limbs while adapting to a slithery, subterranean lifestyle (*SN: 8/22/15, p. 10*). Another theory posits that today's snakes descended from marine reptiles — with a svelte body and lack of legs serving as adaptations to move through a watery home.

Paleontologists Hongyu Yi of the University of Edinburgh and Mark Norell of the American Museum of Natural History in New York City used X-ray scans to build 3-D virtual models of the inner ears of 44 fossil and modern reptile species.

Snakes use the inner ear, a tiny structure within the skull, for balance and hearing. The inner ears of snakes living in different environments have telltale shapes, the researchers found. Burrowers' inner ears appear more inflated than those of other reptiles — like a balloon wrapped with a piece of cord. Such a structure has been linked with low-frequency hearing, and would have helped underground snakes detect the rumbling vibrations of predators or prey.

Dinilysia patagonica, a Late Cretaceous relative of modern snakes that lived roughly 90 million years ago, also had the balloon-shaped inner ear of a burrower, Yi and Norell report. And an analysis of the snake family tree suggests that modern snakes' direct ancestors did too. — *Meghan Rosen*

ATOM & COSMOS

Japanese spacecraft finally reaches Venus

After missing a turn off the interplanetary expressway, a spacecraft has now finished taking the scenic route to Venus. The Japan Aerospace Exploration Agency Akatsuki probe successfully went into orbit around Earth's sister planet on December 7 at 8:51 a.m. Japan Standard Time — five years after its first attempt.

Akatsuki has been looping around the sun since 2010, after an engine misfire prevented the spacecraft from slowing down enough to be captured by Venus' gravity. A nudge from its remaining thrusters put the probe on an orbit that would bring it back to Venus in five years. With its main engine offline and the planet in sight, Akatsuki relied on its thrusters to slow it enough during this year's encounter to stay for an extended visit.

The original plan was to spend two years at Venus, studying the planet's meteorology and mapping the surface. Now, mission engineers may have to rethink what the probe can do. Akatsuki is stuck on a highly elliptical orbit and the spacecraft got a little cooked during a journey that brought it closer to the sun than intended. — *Christopher Crockett*

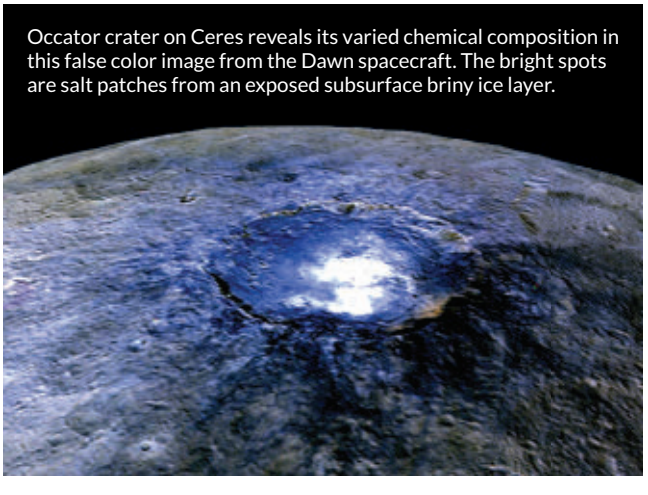
ATOM & COSMOS

Source of Ceres' bright spots found

Bright patches of salt on the dwarf planet Ceres hint at a subsurface layer of briny water ice. Ammonia-laden minerals also suggest that Ceres was at least partially assembled from material hauled in from the outskirts of the solar system, researchers report in two papers in the Dec. 10 *Nature*.

Reflective spots on Ceres have been one of the enduring mysteries of the Dawn mission (*SN Online: 9/10/15*), which arrived at the dwarf planet March 6 (*SN: 4/4/15, p. 9*). During its visit, the spacecraft has cataloged more than 130 bright blemishes on Ceres' surface. Image analysis now indicates that hydrated magnesium sulfates, a type of salt, blanket the brightest patches. Haze also appears over those same patches every morning (local time), probably from sublimation of dusty, briny water ice exposed by impacts with space rocks, Dawn scientists suggest.

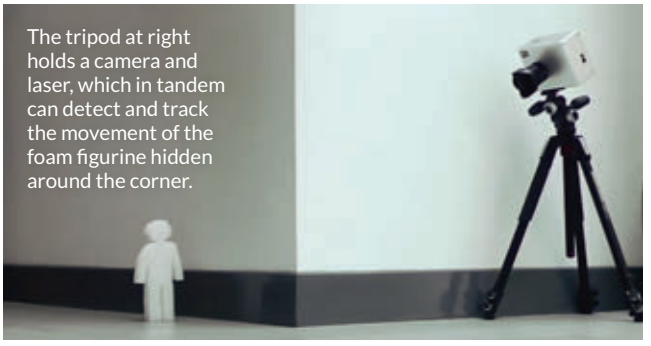
While there is no evidence of water ice on the surface, spectra from Dawn show that the landscape is coated in ammoniated phyllosilicates. These minerals form in the presence of ammonia ice. In its current home in the asteroid belt, Ceres is too close to the sun to freeze ammonia. But early in its life, Ceres might have grabbed ice-rich material drifting in from the outer solar system (*SN: 5/16/15, p. 18*), the researchers suggest. Or Ceres might even have formed near the orbit of Neptune and subsequently wandered in after some nudging by the giant planets. — *Christopher Crockett*



Occator crater on Ceres reveals its varied chemical composition in this false color image from the Dawn spacecraft. The bright spots are salt patches from an exposed subsurface briny ice layer.

FROM TOP: H. YI; JPL-CALTECH/NASA, UCLA, MPS, DLR, IDA

See the bulbous inner ear of an extinct snake at **bit.ly/SN_snakeear**



The tripod at right holds a camera and laser, which in tandem can detect and track the movement of the foam figurine hidden around the corner.

MATH & TECHNOLOGY

There's no hiding from new camera

Being "it" in a game of hide-and-seek could mean never losing, thanks to a new camera that can see around corners. The device, reported December 7 in *Nature Photonics*, tracks obscured objects in real time by detecting light echoes, similar to the way bats use sound to find prey.

Daniele Faccio, a physicist at Heriot-Watt University in Edinburgh, and colleagues evaluated their camera's ability to spot Terry, a 30-centimeter-tall foam figurine hidden from view by a wall. The researchers fired a small laser at the floor just beyond the edge of the wall and pointed the camera at a neighboring spot. Laser light bounced off the floor and scattered in all directions. The camera spotted light rebounding off the foam person. While the images didn't have enough resolution to make out the object's shape, the researchers could precisely determine its changing position as it moved along a track.

For now, the camera can detect only small objects located about a meter away. But Faccio's team is working to track human-sized figures hiding meters from the camera. In the future, cars fitted with a similar device could automatically slam on the brakes when a vehicle or pedestrian is about to emerge from around a corner. — *Andrew Grant*

LIFE & EVOLUTION

Gut bacteria's compounds bring cockroaches together

Talk about micromanagement: Gut microbes may control a cockroach's social life.

Gut bacteria in young German cockroaches (*Blattella germanica*) produce fragrant compounds that, when excreted, attract other roaches, researchers report online December 7 in the *Proceedings of the National Academy of Sciences*. The microbes' chemical creations may play a large role in encouraging roaches to cluster — and may even provide each cockroach colony with its own distinct aroma, the scientists say.

German cockroaches may rely on gut bacteria to help attract fellow roaches.

FROM TOP: D. FACCIO AND HEEHAW FOR HERIOT-WATT UNIV.; SMUAY/SHUTTERSTOCK

Of 40 compounds the team identified in roach dung that might produce an enticing scent, 31 were reduced by at least half in the dung of roaches raised in a bacteria-free environment. And these cockroaches' feces were much less attractive to other roaches, the scientists found. In addition to drawing roaches together, these compounds could provide *B. germanica* with information about the health or size of a colony, the researchers suggest. — *Sarah Schwartz*

BODY & BRAIN

Taking antiviral drug 'on demand' can guard against HIV

For preventing HIV infection, a daily pill may not be needed. Instead, an antiretroviral drug taken before and after sex could get the job done, researchers report in the Dec. 3 *New England Journal of Medicine*. The treatment plan might be easier for patients, too.

Scientists have previously suggested that a daily dose of antiretroviral drugs guards against HIV infection, but results have been mixed (*SN: 11/14/15, p. 14*). That's probably because study participants have a hard time sticking to the regimen, say Jean-Michel Molina of Hôpital Saint-Louis in Paris and colleagues.

So they instructed 199 men at high risk of contracting HIV to take a drug called Truvada two to 24 hours before sex, and then again 24 and 48 hours afterwards. The men were 86 percent less likely to acquire HIV compared with 201 men who took a placebo, the researchers found. — *Meghan Rosen*

BODY & BRAIN

Eyes hard at work can make ears go temporarily deaf

There's only so much brainpower to go around, and when the eyes hog it all, the ears suffer.

When challenged with a tough visual task, people are less likely to perceive a tone, scientists report in the Dec. 9 *Journal of Neuroscience*. The results help explain what parents of screen-obsessed teenagers already know.

For the study, people heard a tone while searching for a letter on a computer screen. When the letter was easy to find, participants were pretty good at identifying a tone. But when the search got harder, people were less likely to report hearing the sound, a phenomenon called inattentional deafness.

Neural responses to the tone were blunted when people worked on a hard visual task, but not when the visual task was easy, researchers found. The results suggest that perceptual overload can jump between senses. — *Laura Sanders*

See how a camera finds hidden objects at **bit.ly/SN_camera**

An earthquake in April 2015 shook a glacier near the Mount Everest base camp, dislodging a massive avalanche that killed 21 people. Here, rescuers evacuate injured climbers.

WHITE OUT

To save lives, researchers explore the physics of avalanches

By Alexandra Witze

Olivia Buchanan loved to ski. She grew up in the high country of Colorado and, at age 23, was studying snow science at Montana State University in Bozeman, hoping to make a career in the mountains she adored. On January 6, 2015, however, the snow turned against her. In the backcountry terrain of Colorado's San Juan Mountains, Buchanan's skis cut through the powder, freeing a slab of hard older snow beneath. An avalanche tumbled 700 feet down the mountain, carrying Buchanan to her death. It was Colorado's second avalanche fatality in a week.

In the United States each year, between two dozen and three dozen people die in avalanche disasters, most of them recreational accidents like Buchanan's. In other parts of the world — such as those picturesque villages nestled at the base of Europe's towering Alps — people's homes and businesses are also at risk.

Scientists are studying the fundamental physics of avalanches in hopes of avoiding tragedies like Buchanan's. A small but dedicated cadre of snow researchers are asking what causes snow particles to clump together and how they interact as they tumble downhill — with the force of up to 100 onrushing cars.

In a steep Swiss valley, scientists have built the world's most advanced avalanche research center. There, they automatically trigger snowdrifts to race downhill, while scrutinizing the avalanche with cameras, radar systems, pressure meters and other high-tech instruments. Among the surprising recent discoveries is how just a slight temperature shift can radically reshape an avalanche, turning it from a slower-moving "wet" avalanche to a faster and more deadly "dry" one.

Other researchers are turning data into models that predict avalanche danger. Recent computer simulations have found that incorporating new types of particle motion — in which snow particles interact much like gas molecules flying through air — improves predictions of how far and how fast a particular avalanche will go. The work helps explain why an avalanche in April 2015 on Mount Everest, triggered by an earthquake in Nepal (*SN: 5/16/15, p. 12*), was so lethal.

"Avalanches can have different flow forms, which is why they can do lots of different things," says Perry Bartelt, an avalanche engineer at the WSL Institute for Snow and Avalanche Research SLF in Davos Dorf, Switzerland. "That makes a big difference when you're talking about how to protect yourself."

Watch and wait

Every avalanche is a battle of snow versus gravity, and gravity always wins. It begins when snow piles up in ridges or drifts and its weight exceeds the load that the underlying snowpack can bear. A block or slab detaches — often along a preexisting weak layer, perhaps an old surface that melted a bit and then froze again — and begins to slide downhill.

The nature of that slipping snow depends on the path that it follows and the properties of the sliding mass. Wet avalanches occur mostly in the springtime, when liquid water percolating among the snow crystals weakens the snowpack. They move at speeds of 15 to 65 kilometers an hour, slumping like liquid concrete down the hillside. Because of their sheer weight, wet avalanches can cause a lot of damage to infrastructure, such as chairlifts and power lines.

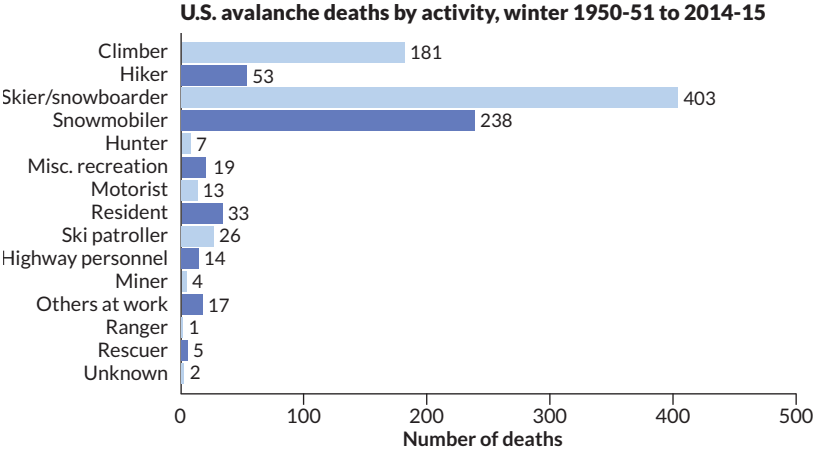
Dry avalanches, in contrast, can race along at 130 kilometers an hour or more. They are usually caused when winds pile up more and more fresh snow, then a passing skier accidentally triggers the slope to release. The avalanche barrels downhill at high speeds, with powdery snow billowing out and obscuring the deadly rush. Because of their fast pace, dry avalanches kill far more people than wet ones do.

27
Average annual U.S. avalanche deaths since 2005

67
Avalanche deaths in Colorado, the state with the most accidents, since 2005

SOURCE: COLORADO AVALANCHE INFORMATION CENTER

Snow risk In the United States, most avalanche accidents involve recreational users — skiers, snowboarders, snowmobilers, climbers and hikers — on fresh powder.
SOURCE: COLORADO AVALANCHE INFORMATION CENTER



OPPOSITE: ROBERTO SCHMIDT/AFP PHOTO

Two types of flow Avalanches can be categorized in many ways, but one important distinction is between dry flows — where the snow particles move quickly and billow outward — and wet flows, which move in a slower, more dense slide. Air temperature is a key factor in determining the type of flow. SOURCE: NATIONAL AVALANCHE CENTER

	Dry avalanche	Wet avalanche
Cause	Too much stress on the snowpack	Decreasing strength of the snowpack
Are people involved?	In 90 percent of cases, triggered by the victims or someone in the victims' party	Difficult for people to trigger; most occur naturally
Contributing weather factors	Loading of wind-drifted snow or loading of new snow	Rain, prolonged melting by sun or very warm temperatures
Speed and type of flow	Fast (130 km/h or so), usually with an ice dust cloud	Slower (15–65 km/h); moves like wet concrete, usually without an ice dust cloud

To tease out the science between the two, and to understand avalanches more generally, many of the world's leading avalanche researchers flock to the scenic Swiss valley of Sionne. There, the SLF institute oversees an experimental avalanche site, a sophisticated laboratory for understanding snow dynamics. Scientists can scrutinize every detail of natural and artificially triggered avalanches.

The first research instruments arrived in the valley in 1996, although catastrophic snows wiped many of them out three winters later, forcing SLF scientists to rebuild. Today, a 20-meter-high steel pylon rises from the steep hillside, built to withstand avalanches that hurtle at it. It holds instruments that measure air pressure, impact pressure, flow speed, density, temperature and other factors.

Each winter, researchers watch and wait. Every couple of years, they get lucky. When at least 80 centimeters of snow falls in less than three days, and the white stuff builds up in drifts and the skies are clear, Betty Sovilla starts making phone calls. Sovilla, an engineer and avalanche researcher at SLF, is the scientific coordinator for the Sionne site. She mobilizes a team of researchers who travel to the valley and prep the instruments, video and other systems before technicians set off an avalanche to study.

At Sionne, SLF scientists have discovered several fundamental but previously unknown differences between wet and dry avalanches. Small nuances in temperature can have a big impact. For example, avalanches that flow warm and wet smash with an impact pressure that increases with depth, hitting the hardest at the avalanche base. In contrast, avalanches that start at colder temperatures move in a giant shearing sideways collapse, with the densest and fastest-moving parts of the powder cloud smashing the hardest. Whether a person survives a dry powder avalanche could thus depend on whether he or she gets hit with a fast-moving or slow-moving part of the slide.

A shift in temperature is also crucial for the clumpiness of snow. Sovilla and her colleagues recently put fresh snow into a rotating tumbler, the sort used to mix concrete. When the snow was relatively cold, between about −5° and −10° Celsius, it stayed powdery and fine. But just a little bit warmer, about −2°, the snow began to clump together in larger granules.

"This is a fundamental change in the structure of the snow, and it changes completely the movement," Sovilla says. Other properties of the snow, however, such as its density and hardness, did not change nearly as dramatically at −2°.

The experiment may sound like a high-tech version of kids making snowballs, but it is the first time researchers have explored the physical differences underlying the transition between wet and dry snow avalanches, the team reported in June in the *Journal of Geophysical Research: Earth Surface*.

To peer even more closely into avalanches, the SLF team uses a high-resolution radar probe that penetrates the obscuring clouds of a powder avalanche at Sionne. Like a police officer's radar gun, the instrument can map the speed of structures such as the densest concentrations of snow. "If you don't understand the small-scale turbulence, you can't reproduce physically the whole movement of the flow," Sovilla says.

Particle interactions

Making practical use of such real-world data is the job of computer modelers. At SLF, Bartelt and his colleagues develop software that can be used anywhere in the world to reduce avalanche dangers.

Early Swiss models, in the 1950s, treated the physics of avalanches very simply: A block of snow detaches from a slope and slides downhill, slowed only by friction. But avalanches are made not of a single block but of billions of snow crystals, each blown about by various forces acting on it and each interacting with others. Today's models are

much more sophisticated and incorporate interactions among particles, such as cohesive effects that help hold back the otherwise expanding cloud of particles. By introducing some of the same equations that govern the expansion of gases, for example, avalanche modelers now better understand how heavy, dense avalanches can transform into fast-moving flows.

Bartelt's main software is called RAMMS, for "rapid mass movements," and it can simulate a wide array of avalanche types. "We simulate the worst case that we can imagine," Bartelt says. Such a simulation might describe how a particular amount of snow falls in a specific area, with winds blowing from a particular direction to build it up unstably and create a hazard.

More than 300 organizations around the world use RAMMS to help evaluate avalanche risk at their particular location. In Juneau, Alaska, city officials have worked with SLF to develop the worst-case scenarios for an avalanche in their city, which rests in a strip of low-lying land between the coast and steeply rising, snow-covered mountains. Having the ocean nearby introduces lots of humidity, and warm moist winds blowing from the south typically collide with dry winds from the north, causing huge amounts of snow to fall in the nearby mountains. In 1962, an avalanche barreled into a city neighborhood, blowing off roofs and chimneys; luckily no one was killed. In 2011, RAMMS modelers ran simulations on where wet and dry avalanches might flow in Juneau, and found dozens of homes in the danger area.

Modeling can also reveal the secrets of other powerful avalanches, like the one that killed 21 people at the Mount Everest base camp last April when a magnitude-7.8 earthquake struck near Kathmandu, Nepal.

The shaking dislodged huge chunks of ice from a mountain glacier, sending air blasting outward and killing people in the camp. Scientists simulated this type of hybrid avalanche, which has a fast-moving core of dense ice and snow particles surrounded by a billowy cloud of lighter dust. By adding equations into the calculations to represent the mean potential energy of particles in the avalanche — that is, the precise location of all the bits of snow and ice dust — the software could accurately describe how the avalanche sucked more air into the core, allowing it to accelerate dramatically, Bartelt and his colleagues write in a paper published online October 21 in *Annals of Glaciology*. "I want the users to begin to appreciate the complexity of avalanches," he says.

All these improved models are helping engineers identify new places that might face danger from avalanches. For instance, Bartelt and his colleagues studied how the icy core and powdery cloud of avalanches can move independently from one another, although how fast and in which direction the core is moving does influence the direction that the powder might travel. Studying a simulation of Switzerland's 1999 All'Acqua avalanche, which damaged a mountain hut as well as an electric power line, the scientists realized that this interaction between the core and the cloud of an avalanche meant the snow can run farther down a hill than previously expected. That suggests more places in steep mountain valleys are at risk than thought.

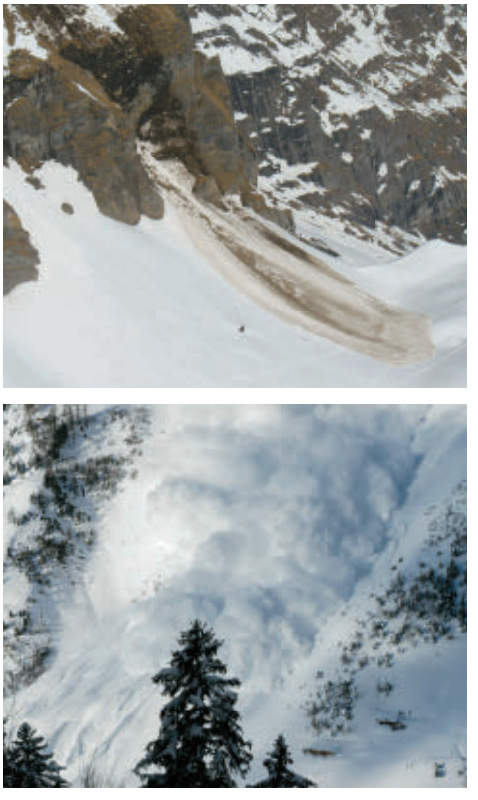
> "We simulate the worst case that we can imagine."
>
> **PERRY BARTELT**

Saving lives

In the end, all the avalanche science in the world won't help if the people on the front lines of danger can't put it into practice. Ski patrollers and highway engineers often set off intentional avalanches, perhaps early in the morning or along a closed road, to defuse danger for future visitors. Officials can also build dams or other structures to deflect avalanches as they come down, construct snow fences to keep drifts from accumulating in dangerous places or ban buildings altogether in areas of danger.

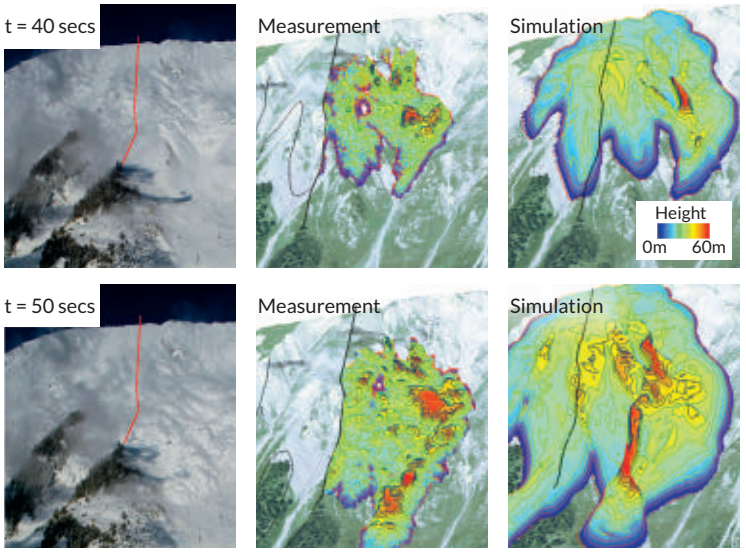
In Colorado, where more people die in avalanches than in any other state, Jeffrey Deems, a snow scientist at the National Snow and Ice Data Center in Boulder, is trying to bridge the gap between science and public safety.

In Arapahoe Basin, a popular ski area west of Denver, Deems has pioneered the use of high-tech lasers to help ski patrollers save lives. He travels to the slopes in the summer, when they are snow-free, and uses a laser system to scan the landscape in extraordinary detail. It generates a three-dimensional cloud of points, each representing a spot on the slope. The point cloud appears as a ghostly mimic of the hillside, but one that Deems can click and drag around on his computer into any



Wet flows (top) often threaten infrastructure, whereas dry avalanches (bottom) are more dangerous to people.

BOTH: ARCHIVE SLF



Simulating slides The RAMMS avalanche software simulates (right) how a powder avalanche in Switzerland (left) flows. At center are measurements of the avalanche movement (where red represents deeper snow) taken from photographs.

orientation, getting fresh views of where exactly the snow might build up into deep drifts, ridges and pillows.

During snow season, Deems goes back to Arapahoe Basin and scans the hillsides again, before and after snowstorms. By comparing the two sets of data, he can show the local resort's ski patrollers precisely where snow has piled up. Even patrollers who know the mountain intimately are often surprised by the insights from the laser mapping, he says. "It's fascinating to look at a high-resolution map of terrain you're really familiar with," he says. "You can see [ski patrollers] start to see things that don't fit with their mental map."

Patrollers typically trigger avalanches by skiing carefully back and forth above an unstable drift, or by setting off small explosive blasts in deliberately chosen locations. The laser data showing where snowdrifts have built up allow them to better pinpoint those trigger points. With laser mapping, Deems can also go back after the fact and check why an explosive might not have set off an avalanche as it was supposed to — perhaps it was set in a particularly deep pillow of snow. Such surveys may allow resort managers to make research-based decisions about what areas to close off, he and his colleagues write in the December *Cold Regions Science and Technology*.

Avalanches are not just a problem at resorts. This winter, Deems plans to work with the Colorado Department of Transportation to laser-scan areas where highway engineers use remote-controlled exploders to detonate blasts along mountain passes. The idea is to keep slopes free enough of snow so that heavy avalanches won't close the highways — or harm drivers. This is the first year the department will use remotely detonated explosives; in 2014, an explosive went off prematurely in the gun of an avalanche control system, injuring two people. But the engineers are ready to try again with the remote control. Deems will use the laser scans to assess snow before and after the blasts, to see how well the remote exploders work.

Deems isn't just working to make avalanche country safer today; he is trying to prepare for a future when there may be more avalanches. With fieldwork and satellite imagery, he has documented how snow has been growing dirtier, thanks to soot from power plants and dust blown in from deserts. In southwestern Colorado, where the snowpack is a major source of water for many states and cities downstream, the snowpack is getting darker every year. Dust changes surface roughness and reflectivity, warming the surface and causing additional melt in the spring — which in turn weakens the snow layers and makes them more prone to launching wet avalanches.

"There's a lot of concern now about climate change, especially the possibility of wet snow avalanches," says Bartelt. Researchers aren't entirely sure how avalanches might change as global temperatures rise, but in general, they expect more rain and snowfall in some mountain areas.

"Even if global temperatures change slowly, if we start seeing more extreme weather patterns, that can lead to more extreme avalanche conditions," says Karl Birkeland, director of the U.S. Forest Service's National Avalanche Center in Bozeman. Some of the worst conditions for avalanche danger are an early-season snowfall, followed by a warm period when the top of the snow begins to melt, then refreezes and gets covered with cold heavy snows. That results in a lot of fresh snow sitting atop an older weak layer — prime conditions for the snow to detach and begin sliding.

Avalanche science may also become more important this winter, when a strong El Niño is expected to bring more snows to the Rockies, Alaska and other avalanche-prone areas.

As in other winters, avalanche researchers will be waiting. ■

Explore more

- National Avalanche Center: www.fsavalanche.org
- National Snow and Ice Data Center: www.nsidc.org
- W. Steinkogler *et al.* "Granulation of snow: From tumbler experiments to discrete element simulations." *Journal of Geophysical Research: Earth Surface.* June 2015.

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Over the EDGE

What leads a person to move from thinking about suicide to taking action? **By Bruce Bower**

Craig Bryan treats military personnel who struggle with thoughts of ending their own lives, as well as those who've survived an actual suicide attempt. But these days he's fighting an uphill battle.

Suicide rates in the United States have been rising, especially among veterans and members of the armed forces. Traditional assumptions about why people kill themselves have not led to effective strategies for suicide prevention, Bryan says. So in recent years psychologists and others have been reconsidering basic beliefs about why people carry out the ultimate act of self-destruction.

"There has been an explosion of new thinking about suicide in the past decade," says Bryan, a clinical psychologist at the University of Utah in Salt Lake City.

This shift in focus was inspired by psychologist Thomas Joiner's introduction in 2005 of the interpersonal theory of suicide. Unlike previous theorists, Joiner, of Florida State University in Tallahassee, treated thinking about suicide and attempting suicide as separate experiences, each with its own explanations and risk factors.

Joiner's approach has inspired much new suicide research by Bryan and others. One line of work suggests that three factors render individuals especially prone to moving from suicidal thoughts to actions: a partly inborn ability to withstand pain, self-hate triggered by extremely distressing experiences and, finally, access to guns or other lethal means.

The same factors appear to hold true among military personnel. Combat soldiers are fearless and relatively impervious to pain, even before enlisting, according to recent studies. Personal

LISE GAGNE/GETTY IMAGES

traits that may predispose people to volunteer for combat may also up their chances of attempting suicide if war experiences trigger intense guilt and shame.

A new view

Between 1986 and 2000, U.S. suicide rates dropped from 12.5 to 10.4 deaths for every 100,000 people. But since then, the suicide rate has climbed steadily, reaching 12.6 deaths per 100,000 people, or more than 41,000 deaths, in 2013. That continuous rise — and the lack of effective countermeasures — has prompted researchers to revisit the suicide theories found in textbooks.

More than a century ago, sociologist Emile Durkheim proposed that severed bonds between an individual and his or her community are crucial factors in suicide. Others have held that people kill themselves to escape intolerable pain, feelings of hopelessness or depression and other mental disorders.

But evidence suggests there's more to it: Most people who contemplate suicide never actually try to kill themselves. A 2008 study estimated that for every person who attempts suicide, about three others have considered suicide but never acted on those thoughts.

In Joiner's theory, being convinced that one is a burden to others and, at the same time, feeling isolated or unimportant bring on suicidal thoughts. But taking one's own life is a scary prospect, even for those who regard themselves as disposable liabilities, Joiner reasoned. Overcoming an ingrained survival instinct to make a suicide bid requires a person to have a reduced fear of death and considerable tolerance for physical pain, probably acquired via harsh life experiences, he proposed.

Joiner's ideas have caught on as the limits of depression and other mental ailments as predictors of suicide have become obvious.

As early as 1999, a national survey of psychiatric disorders led by psychiatric epidemiologist Ronald Kessler of Harvard Medical School found an excess of self-reported suicidal thoughts — but not of documented suicide attempts — among people with depression or several other mental conditions.

Studies since then have found that psychiatric disorders as well as two other characteristics traditionally viewed as suicide risk factors — feelings of hopelessness and a tendency to act impulsively — only weakly predict whether individuals have attempted suicide or will try to end their own lives in the coming weeks or months, says psychologist E. David Klonsky of the University of British Columbia in Vancouver. Klonsky directed several of those investigations.

Inspired by Joiner's approach, Klonsky and British Columbia colleague Alexis May proposed what they call the three-step theory of suicide in the June *International Journal of Cognitive Therapy*.

In step one, a combination of physical or emotional pain and hopelessness spurs thoughts of killing oneself. "Depression and other traditional risk factors matter to the extent that they increase hopelessness and pain," Klonsky says.

Second, he and May suggest that suicidal thoughts further intensify for people who lack connections to loved ones, to valued roles or to any sense of purpose in life.

Finally, echoing Joiner, the researchers hold that suicide attempts occur only among people with a low sensitivity to pain — a partly genetic trait, according to studies of animals, human genetic variants and human twins — and an ability to overcome fears of death.

Klonsky and May conducted an online survey of 910 U.S. adults, ages 18 to 70, that supports the three-step theory. Participants who reported having contemplated or planned a suicide — 27 percent of the sample — described especially high levels of preexisting pain or hopelessness, the researchers report in their June paper. Those who said they had never considered suicide, even if they had experienced pain and hopelessness, reported having close friends and relatives and usually were involved in activities they found meaningful. The 14 percent of participants who reported that they had tried to kill themselves — a higher figure than in the general population — cited relatively few fears of dangerous situations and physical pain. They were also more likely to know about and have access to guns or other lethal methods.

Primed for danger

Joiner originally proposed that a buildup of painful and provocative experiences cultivates the fearlessness and pain tolerance needed to attempt suicide. Building on that theme, many researchers suspect that increasing numbers of soldiers have killed themselves because military training followed by combat desensitized them to death's pain and finality.

But new findings from a team led by Bryan challenge that scenario. Many soldiers who encounter war violence grow up with an elevated "set point" of fearlessness and pain tolerance that prompts

U.S. suicide facts

Men take their own lives at nearly

4x

the rate of women

Men represent

78

percent of all suicides

From 1999–2010, the suicide rate among middle-aged adults increased by nearly

30

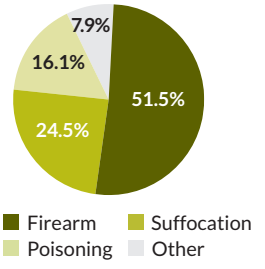
percent

In 2013, suicide accounted for

41,149

deaths

Suicide method:

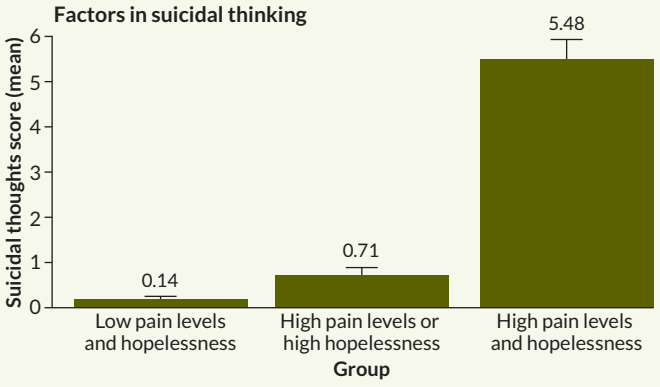


SOURCE: CDC

Volatile mix

In a survey of U.S. adults, suicidal thoughts spiked only among people who had both high emotional pain levels and feelings of hopelessness.

SOURCE: E.D. KLONSKY AND A. MAY/*INT. J. COGNITIVE THERAPY* 2015



Taking action is another story. Those who had made an actual suicide attempt — 14 percent of participants — scored higher, as a group, on a suicide capability scale. The scale assesses whether someone is likely to move from thinking about self-harm to making an attempt. The scale asks about three variables:

- **Dispositional:** long-standing traits, such as low pain sensitivity and general fearlessness, that are assumed to be largely genetic
- **Acquired:** experiences associated with pain, injury, fear and death that boost suicide risk over time
- **Practical:** concrete factors that make it easier to kill oneself, such as access to guns and other lethal methods

them to seek out harsh and provocative experiences, such as combat, Bryan suggests. As a result, these soldiers run a heightened risk of encountering wartime horrors that spark suicide-promoting reactions such as guilt, shame and self-hate.

This is an urgent issue. In 2009, the military suicide rate surpassed that of the general population for the first time since at least 1977. From 2009 to 2012, suicides increased from 18.5 to 22.7 out of 100,000 active-duty service members. Those numbers declined in 2013, the latest year in which data are available, although it's too early to say whether that's the beginning of a downward trend.

Determining how soldiers move from suicidal thoughts to actions is essential for developing better therapies, Bryan says.

To check the popular assumption that combat experiences groom soldiers for suicide, Bryan and his colleagues studied 168 U.S. Air Force members, mostly men, working as ground convoy operators. At the beginning and end of three months of training before deployment overseas, the soldiers completed a questionnaire on suicide capability, a measure of the likelihood of turning one's suicidal thoughts into actions developed by Joiner's team. Once they returned from a nine-month mission to Iraq in 2009, participants completed the same questionnaire at four points during the next year.

Participants rated their fearlessness in general, their fear of death, their ability to withstand pain and their preference for contact sports and other aggressive pastimes.

Combat didn't change their self-reported fearlessness, pain tolerance and susceptibility to attempting suicide. Suicide capability scores were just as high before deployment as afterward, even among convoy operators whose overseas stints exposed them to plenty of disturbing, combat-related events, Bryan's group reported August 11 in *Clinical Psychological Science*. Those incidents included being attacked or ambushed, being shot at and seeing dead bodies or severed body parts.

8 out of 76 soldiers

made at least one suicide attempt within two years of cognitive-behavioral therapy aimed at reducing guilt and shame

18 out of 76 soldiers

made at least one suicide attempt within two years of receiving standard talk therapy

SOURCE: M.D. RUDD *ET AL/ AM. J. PSYCHIATRY* 2015

Comparably elevated suicide capability scores have been reported in combat veterans as well as in new military personnel, Bryan says.

Having a preexisting capacity for suicide is not enough, however, to push someone over the edge. Evidence increasingly suggests that the way current and former soldiers judge themselves and their wartime actions helps to explain why some burdened by symptoms of depression and post-traumatic stress try to kill themselves and others don't. In the last several years, Bryan's team has found particularly intense thoughts of suicide among soldiers with depression and PTSD who also report guilt, shame and self-hatred stemming from having committed or witnessed wartime acts that violated their moral beliefs.

Those soldiers are perilously close to attempting suicide, the researchers suspect. Some clinicians are working to tamp down the self-hatred with specific forms of therapy.

A 12-session course of cognitive-behavioral therapy aimed at altering guilt- and shame-related beliefs showed promise with Army personnel who were briefly hospitalized following suicide attempts or who reported having serious suicidal thoughts, say University of Memphis psychologist M. David Rudd and colleagues, including Bryan. Most of the soldiers had been deployed one or more times.

In the two years after they had received the cognitive-behavioral therapy treatment, eight of 76 soldiers made at least one suicide attempt, the researchers reported last May in the *American Journal of Psychiatry*. During the same period, 18 of 76 soldiers who received traditional forms of talk therapy and medication tried to kill themselves at least once. One soldier in each group died by suicide.

Combat protection

Rudd and Bryan see a future for treatments that target emotions such as guilt in soldiers who are apt to act on their suicidal thoughts. Those suicide-prevention efforts will probably need to be tailored to different branches of the military, says Robert Ursano of the Uniformed Services University of the Health Sciences in Bethesda, Md. Ursano is the coleader of Army STARRS, the largest study of military mental health ever conducted. Army STARRS investigators have access to medical and hospital records of more than 1.6 million active-duty Army soldiers from 2004 through 2009.

Ursano sees this massive investigation as an opportunity to explore why some soldiers ponder but reject suicide, others plan ways to kill themselves but stop short of doing so and a third group follows through on suicidal plans.

Bryan's finding that an elevated tendency to attempt suicide stems from preexisting traits, rather than from combat experiences, among Air Force convoy operators may not apply to other military branches, Ursano holds. Army soldiers and Marines, for instance, may get deployed to more intense war zones than Air Force personnel do, Ursano says. In those cases, brutal combat incidents may represent larger contributors to soldiers' risk of suicide, he suspects.

But Bryan has a point, Ursano concedes. There are suggestions that Army personnel who choose combat duty — in the U.S. military, such duty isn't mandatory — display elevated suicide rates before deployment, in line with Bryan's findings for Air Force convoy operators. Army STARRS data published in the November *Psychological Medicine* show that, between 2004 and 2009, Army infantrymen and combat engineers killed themselves at substantially higher rates before and after deployment than while stationed overseas. A sensation-seeking personality or other background characteristics may serve these soldiers well in war zones, but boost the odds that they'll become suicidal before and after their tours of duty, suggests Harvard psychologist and study coauthor Matthew Nock.

Intense camaraderie during deployment may also discourage suicides while soldiers are actively in combat, Nock adds.

Enlisted soldiers in noncombat jobs and those who performed construction and demolition tasks under combat conditions killed themselves more often during and after deployment, not before. That's consistent with the possibility that soldiers in those jobs were already fearful and pain-sensitive enough to have a relatively low suicide risk. However, the stress, loneliness and uncertainty of spending months on the front lines may nudge them into self-harm's way.

These findings come from an Army STARRS team led by Harvard's Kessler that analyzed suicide patterns among combat and noncombat personnel. The researchers examined administrative data on the 729,337 men enlisted in the Army from 2004 to 2009, including 496 who took their own lives.

Other suicide trends are emerging from Army STARRS. One investigation found elevated suicide rates among personnel during their first four years after enlisting, whether deployed in

18.7
per 100,000
2013 suicide rate among active military

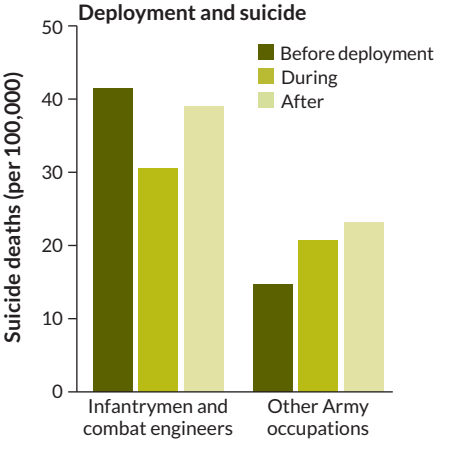
12.6
per 100,000
U.S. suicide rate

SOURCES: DOD; CDC

War's ups and downs

Suicide rates per 100,000 soldiers each year among U.S. Army infantrymen and combat engineers were relatively high but dropped during deployment (left). For other personnel, rates rose during and after deployment (right).

SOURCE: R. KESSLER *ET AL*/ *PSYCHOL. MED.* 2015



combat or noncombat positions. Army women also kill themselves considerably more often while deployed.

Traditional notions of combat as the primary culprit in prompting military suicides appear destined for extinction. "The association between deployment and suicide is not as simple as we expected," Nock says.

Fluctuating risks

In the general population as well as in the military, it's hard to know when someone who is unafraid of death, wracked by self-hatred and plagued by other suicide risks will tumble over the edge. For insight into precisely when suicidal thoughts turn into actions, some scientists are tracking risk factors that come and go, some from one moment to the next.

Memphis' Rudd theorizes that certain personal characteristics linked to a heightened risk of suicide are stable, such as being a man or having survived personal traumas early in life. Other risks fluctuate, such as bouts of depression, arguments with friends and money troubles. As stable risk factors add up, Rudd predicts, fluctuating risk factors become increasingly able to instigate suicide attempts.

The pull of accumulating risks can be offset by protective factors, such as a supportive family or landing a new job.

The pull of accumulating risks can be offset by protective factors, such as a supportive family or landing a new job. Rudd calls his approach fluid vulnerability theory.

Psychologist Courtney Bagge of the University of Mississippi Medical Center in Jackson recently led a rare effort to identify behaviors and events that intensified suicidal thinking among people shortly before they tried to kill themselves.

Bagge and her colleagues recruited 166 men and women who received hospital care within a day after making a suicide bid. In interviews, participants carefully rehashed what had happened in the 24 hours leading up to those attempts.

Alcohol drinking and upsetting personal experiences typically triggered spikes in thinking about suicide shortly before patients tried to end their lives, the researchers reported in 2014 in the *Journal of Affective Disorders*. Distressing events reported by volunteers included fights with a loved one and receiving bad health or financial news.

If these findings hold up, suicide-prevention treatment will need to help clients develop strategies to squelch booze-drinking urges and to cope with sudden setbacks, the researchers say. Fast responses are crucial. In other studies, Bagge has found that the majority of suicide attempters report devising or recalling a plan to kill themselves and deciding to act on that plan within three hours of actually attempting suicide.

People in distress may also hurt themselves without suicidal intent. Examples include cutting, burning or hitting oneself. But such behavior may serve as an early warning. Nock and other researchers have found a strong risk for suicide attempts among people who harm themselves in these ways.

A team led by psychologist Teena Willoughby of Brock University in St. Catharines, Canada, measured college students' suicide capabilities in their freshman year and again one year later. Those who reported frequently cutting or otherwise injuring themselves during that year cited substantial drops in pain sensitivity and death fears — Joiner's cardinal signs of suicide capability — from their freshman to sophomore years.

Joiner has also argued that, based on his interpersonal theory, nonsuicidal forms of hurting oneself — say, repeatedly slicing one's skin with a razor blade or hitting oneself to the point of bruising — are painful and provocative enough to promote suicide attempts. The new findings lend support to that idea, Willoughby's team concludes in the November *Journal of Abnormal Psychology*.

Still, most college students don't try to end their own lives, whether or not they intentionally harm themselves. Neither do most combat veterans. Neither do people in any other segment of society. So why does a growing minority of the population view self-destruction as an option?

The way forward in suicide prevention lies in determining how stable and fluctuating risks for suicide interact to push people over the edge, Bryan says. The trick will be to equip individuals with the equivalent of an emotional GPS system that steers clear of the abyss, a place where dire thoughts can lead to death at one's own hand. ■

Explore more

- E. David Klonsky and Alexis May. "The three-step theory (3ST): A new theory of suicide rooted in the 'ideation-to-action' framework." *Intl. J. of Cognitive Therapy*. June 2015.

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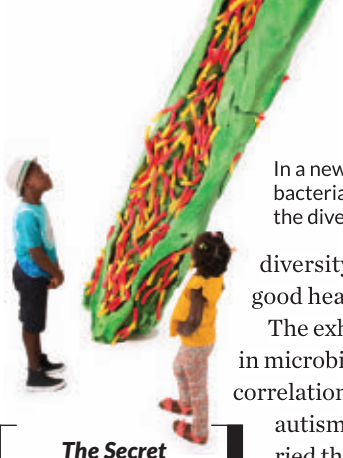
EXHIBIT

Get to know your microbes at 'The Secret World Inside You'



In a new museum exhibit, larger-than-life models of bacteria, like these cellulose-eating *Bacteroidetes*, show the diversity of microbes that live in and on people.

The Secret World Inside You
THROUGH AUGUST 14, 2016
AMERICAN MUSEUM OF NATURAL HISTORY
New York City

Bacteria are not necessarily bad. That in a nutshell is the message of the newest exhibit at the American Museum of Natural History in New York City. Featuring oversized models of glowing green bacteria, and in some places reeking of cheese and socks, the exhibit is on a mission to rehabilitate the reputation of microbes.

"There has been a paradigm shift recently," says Rob DeSalle, cocurator of "The Secret World Inside You." "Scientists had been focused on how individual microbes make us sick for almost a century, but now we want people to realize that the grand majority of them won't hurt you."

Visitors meander through dark corridors on a tour that celebrates the community of often benign and even helpful microorganisms living in and on us. Drawing on the explosion of research into that community, the microbiome, the exhibit introduces guests to their particular microbial makeup.

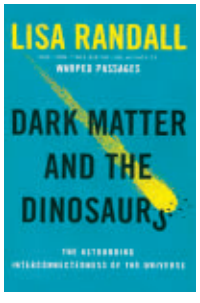
Do you own a dog? Your skin bacteria tend to be more diverse than those of the dogless. Did you have a C-section? Your infant didn't get the typical dose of birth canal bacteria that babies born the old-fashioned way do. The consequences of such differences are often not addressed explicitly. But diversity — which some studies have linked to good health — is celebrated again and again.

The exhibit also leaves out some emerging fronts in microbiomics. For instance, it doesn't explore correlations between gut bacterial diversity and autism (*SN: 1/11/14, p. 8*). DeSalle says he worried that people might confuse that association with the idea that gut bacteria cause autism, which has not been shown in human studies.

Activities for kids include a game and a quiz room. On the whole, though, the exhibit seems geared toward adults. Its displays, projected on walls dressed up to look like the gut, tend to be text heavy.

The museum tried to avoid advocating, DeSalle says. "We don't want to say, 'Don't use hand sanitizer.' " Nevertheless, much of the information comes across as prescriptive. Experts in a video warn about "excessive washing" and caution that "we need to back off on antibiotics" to prevent resistant bacteria. Eating vegetables leads to a more diverse gut microbiome, we learn; eating fast food has the opposite effect.

My tour companion, a microbiome researcher, heeded that reminder at lunch. He ordered a salad that nourished his fiber-digesting gut bacteria. I stuck with the burger, apologizing all the while to my poor microbiome. — *Devin Powell*



Dark Matter and the Dinosaurs
Lisa Randall
ECCO, $29.99

BOOKSHELF

Cosmos and life meet in unusual proposal

Dark matter. Dinosaurs. Few topics are as effective at grabbing the attention of science enthusiasts. But Lisa Randall doesn't just muse about these topics for their popular appeal. The accomplished particle physicist's latest book, *Dark Matter and the Dinosaurs*, draws on her 2014 study positing that mysterious invisible matter permeating the cosmos can dislodge comets from their orbits and trigger the kind of impact that wiped out *T. rex* and friends.

If that seems like a wild proposition, Randall admits that it is: "I'll tell you right up front that I don't yet know if this idea is correct," she writes. Yet she also knows that it is a compelling hook to reel readers in as she focuses the book on communicating the broader science behind her idea. If you really want to know how something as intangible as dark matter, which has never been directly detected, could possibly upend the hierarchy of Earth's life, then you need to learn a little cosmology, astronomy, geology and paleontology.

In describing fossils alongside the Big Bang, Randall explains how arcane-sounding concepts like inflation and orbital dynamics are integral to the emergence and history of life on Earth. Though dark matter might be to blame for mass extinctions, its gravitational influence also helped create the galactic conditions in which life could arise. Randall's simple explanations, interspersed with anecdotes from her career, appeal even to the reader more in it for the extinctions than the physics.

The provocative proposal that led to the book, however, has holes. Randall suggests that every 35 million years or so, the solar system weaves through a thin but concentrated disk of dark matter in the Milky Way. The dark matter's gravitational pull, while not strong enough to disturb planets or asteroids, jostles distant comets from their orbits and sends them toward the inner solar system. Unfortunately, scientists aren't sure how the Milky Way's dark matter is distributed, if the rate of impacts does in fact peak every 35 million years or whether the dinosaur-killing body was a comet or an asteroid.

Still, there's plenty to get out of *Dark Matter and the Dinosaurs* even if the premise doesn't hold up. It remains to be seen whether another scientist can one-up Randall with a theory connecting black holes and pandas. — *Andrew Grant*

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SOCIETY UPDATE

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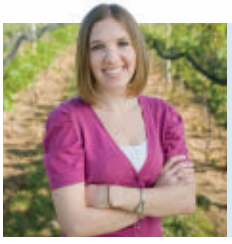

"Find someone — a teacher, a parent, a mentor — and have them guide you through your scientific curiosity."

— DENISE GARDNER, INTEL ISEF 2003 FINALIST

"Take risks and be bold. Often the most risky projects turn out to be the greatest."

— ANNIKA URBAN, BROADCOM MASTERS 2014 FINALIST

"The classroom should not be the end of your learning. Whether you go home and read, debate with peers, do research, work online, whatever – you can not allow yourself to stop learning once school is over."

— VINCENT O'LEARY, MULTIYEAR INTEL ISEF FINALIST AND INTEL STS 2013 FINALIST

"Don't stop dreaming. If you have an idea, even if it sounds crazy, don't limit yourself to the textbook. Get hands-on!"

— ASHWIN DATTA, INTEL ISEF 2015 FINALIST

"The best way to understand science and math is to go out and do it on your own. I've learned more through research than in a class or a lecture or a textbook."

— MEGHAN SHEA, INTEL ISEF 2011 AND INTEL STS 2013 FINALIST

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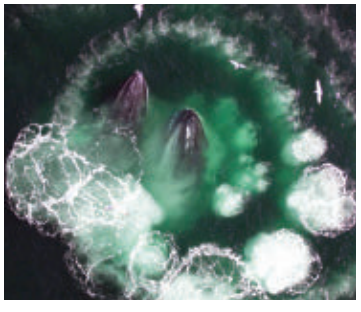
OCTOBER 31, 2015

Whale watcher

A reader offered some new names for instruments used to measure whale respiration in **Susan Milius'** story, "'Whalecopter' drone swoops in for a shot and a shower" (*SN: 10/31/15, p. 32*).



I heard about this. I believe they call this drone the "snot bot"; the raft that launches the drone is called the "snot shot" and the boat [housing] the control center is called the "snot yacht."

Nick Piesco, online

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How hominids heard

Ancient South African hominids that lived between 2.5 million and 1.5 million years ago could have heard high-frequency consonants better than either chimps or modern humans. An ability to hear, and presumably make, these sounds might have made these species more competitive, ***Bruce Bower*** *wrote in "Ancient hominid ears were tuned to high frequencies"* (SN: 10/31/15, p. 17).

Such communications would not have required a language like that of modern humans, **Bower** wrote, but simply vowel and consonant sounds with shared meanings. Reader **Mike Kobrick** wanted to know what distinguishes a language. "If vowel and consonant sounds with shared meanings isn't language, then what is?" he asked in an e-mail.

There's a big difference between sound combinations with shared meanings, such as warning or mating calls, and a grammatical language with words that can be combined in a multitude of ways to express all sorts of ideas, **Bower** says. Scientists consider the use of a complex grammatical structure a trait that separates humans from other animals. For decades, scientists have been debating how early hominids communicated. Unfortunately language, like social behavior, doesn't fossilize, **Bower** notes.

A way to stop aging?

Scientists discovered that the GATA4 protein acts like a biochemical switch and forces cells to stop growing and dividing, ***Sarah Schwartz*** *reported in "Protein buildup triggers cellular aging"* (SN: 10/31/15, p. 7).

The researchers also found that GATA4 accumulates with age. This caused online commenter **Mike G** to wonder, "If they find a way to get rid of GATA4 proteins, will that end aging?"

Getting rid of GATA4 altogether would definitely be problematic. The protein has a lot of other functions in the body, including helping organs develop, says geriatrician **James Kirkland** of the Mayo Clinic in Rochester, Minn.

For example, says geneticist **Stephen Elledge** of Harvard Medical School, "you can't make your heart without it, and testes are inactive if you don't have GATA4." He says that turning off the genes that make GATA4 isn't necessarily the answer to combatting cell senescence or aging. However, it might be possible to find a way to reverse the "switch" that GATA4 flips that causes cells to halt growth. Or it could be useful to target the protein only in adults, after new tissues finish developing. For now, the researchers say there's a lot more to learn about exactly how the protein functions and how the genes that control it work.

Bird breath

Birds aren't the only creatures to breathe with one-way airflow, ***Susan Milius*** *revealed in "Chasing breath"* (SN: 10/31/15, p. 22). *Alligators and some lizards do, too, which offers tantalizing clues about the evolution of lungs in these groups.*

Reader **Patrick McMonagle** speculated about whether the mechanisms of one-way airflow allow birds to breathe more efficiently with less oxygen. Millions of years ago, when Earth's atmospheric oxygen levels would have been much lower than today's, "such a function could add enough evolutionary advantage" that creatures using one-way airflow had a competitive edge, he posited in an e-mail.

"It does seem like the big advantage of one-way flow in the bird lung exists when they are breathing lowered oxygen," agrees University of Utah researcher **Colleen Farmer**, who's studying one-way air flow in reptile lungs. She points out that during the Mesozoic era, which started about 251 million years ago, ancestors of birds and crocodilians diversified into a great variety of forms. Oxygen was less concentrated in the atmosphere, she says. Unidirectional air flow may have been one of the features that gave these ancient reptiles an advantage over mammals during that time.

A halo at the end of the world

In the sky above eastern Antarctica, airborne ice crystals sculpt the sun's rays into a ring.

This phenomenon, called a 22-degree halo, is the result of sunlight passing through tiny, six-sided ice cylinders in high-altitude clouds. The crystals act like prisms, bending incoming light 22 degrees off course. Millions of crystals at various orientations can cast a full circle of light around the sun. While dramatic over polar regions, these halos can occur worldwide, even at the equator. Some halos are decorated with bright spots known as sun dogs or mock suns.

Italian photographer Enrico Sacchetti captured this halo in 2013 over Concordia Station, a joint Italian-French research base on the Antarctic Plateau, one of the coldest places on Earth. While ice in the air puts on a light show, the ice surrounding the station provides researchers an opportunity to study the planet's history: Accumulating layers of snow trap bubbles of atmospheric gases and, over time, build up an archive of past climates. Ice cores from near Concordia provide the oldest records of atmospheric carbon dioxide, dating back at least 800,000 years. — *Sarah Schwartz*

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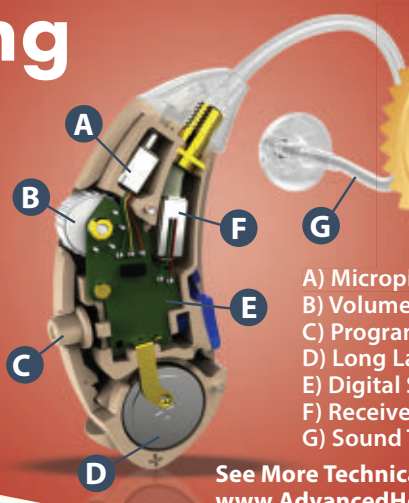

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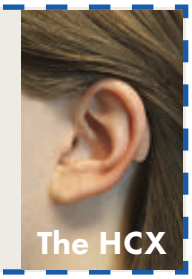
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