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SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
DECEMBER 24, 2016 & JANUARY 7, 2017

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Special Section

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COVER STORY The long-awaited detection of gravitational waves was a shoo-in for top science story of 2016. The devastation from Zika here on Earth and an exoplanet discovery light-years away (illustrated) also made the list, among other stories that will shape how people view themselves and the world.

PLUS: Looming failures in particle physics, the rise of new infections and five big challenges for self-driving cars. *Science News* writers also discuss what they will be watching for in 2017.

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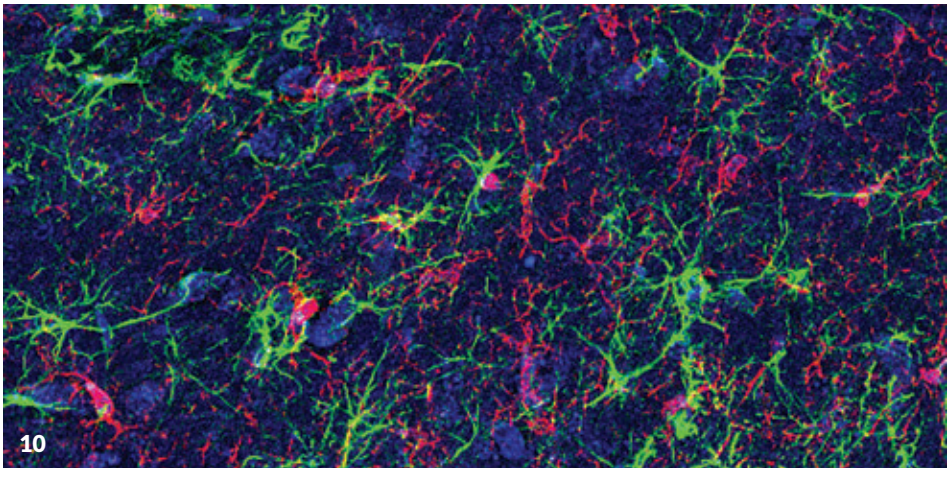

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COVER Scientists reported cosmic ripples from merging black holes for the first time in 2016. *S. Ossokine, A. Buonanno/Max Planck Institute for Gravitational Physics, Simulating eXtreme Spacetime project, W. Benger/Airborne Hydro Mapping GmbH*

The year of gravitational waves, Zika and more

There's no bow or festive wrap, but I hope that you will consider this issue a gift of sorts. That is how the staff of *Science News* thinks of it, our year-end recap of the top science stories (Page 16). In these pages, you'll find the stories that continued to resonate well after we first covered them and many that we expect will resonate for years to come — all collected in one easy-to-read, extremely portable, no-batteries-required package (unless you are reading this on a smartphone or tablet, that is).

Gravitational waves, of course, occupy the top spot on our list this year (Page 17). The "of course" reflects the fundamental importance of the detection of this elusive form of energy, announced in February. The finding confirmed key theories in physics, sure, but even more exciting is what it promises for the future. Gravitational waves are powerful tools for probing the universe. Just as the Hubble Space Telescope revealed cosmic beauty in electromagnetic radiation, gravitational wave detectors may show scientists an unprecedented view of far-off cosmic corners via the spacetime ripples generated by distant phenomena.

Closer to home, the Zika virus (Page 19) became one of our most closely watched stories this year, as the extent of human suffering caused by the mosquito-borne virus became clear. But it's also a tale of progress: Scientists have responded swiftly, creating a robust literature on the virus in a short time. We still don't have all the answers, but we've come a long way in terms of creating the knowledge urgently needed to inform health recommendations.

Other stories made this year's list with a more mixed pedigree. The discovery of a (relatively) nearby exoplanet energized many of our science fiction–fueled fantasies of other worlds, for instance. Research moved ahead on what some call "three-parent babies" — using mitochondrial donors to replace a woman's own disease-prone mitochondria in egg cells — despite a lack of clarity on the procedure's efficacy. Melting Arctic sea ice has led to a historically significant opening of passageways between the Pacific and the Atlantic oceans. New hope for the battle against Alzheimer's disease seemed worthy of mention. All these developments and more were regarded by *Science News* reporters and editors as milestones of discovery or news of importance to society.

We also decided to add some other elements to our year-in-review coverage for 2016. Guided by the deft hand of Beth Quill, our enterprise editor, we augmented our Top 10 list with an essay by managing editor Tom Siegfried about two of physics's noteworthy recent failures and how the two are related. Science journalist and author Sonia Shah offers a roundup of 2016 in public health, reminding us of the thorny problems associated with infectious diseases, from antibiotic resistance to the resurgence of yellow fever. Other pieces illustrate some of the challenges facing the driverless car revolution, as well as what *Science News* reporters see on the horizon for the coming year.

We have tried to pack as much science as possible into this issue, from the biggest stories to the more obscure nuggets of discovery and surprise. I can't think of a gift I'd more like to receive. — *Eva Emerson, Editor in Chief*

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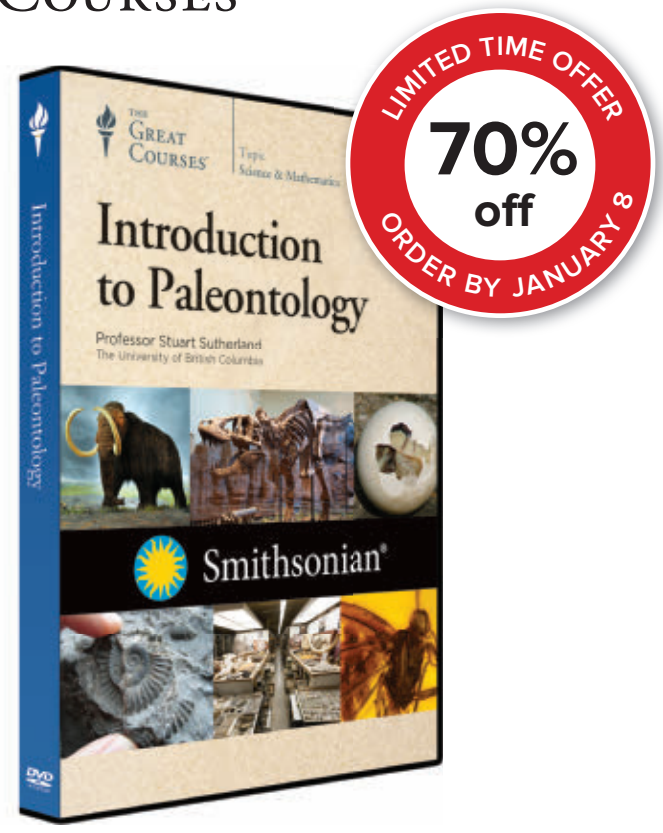

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Excerpt from the December 24, 1966 issue of *Science News*

50 YEARS AGO

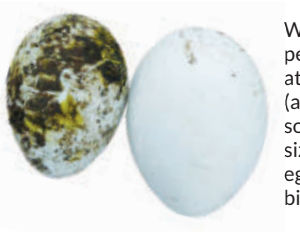
A case for genetic drinking

Whether one drinks at all, how much and how often are partly due to heredity, [according to a Finnish study of 902 male twins].... A genetic element in alcoholism "seems highly plausible," [researchers] said.... Surprisingly, genes also have much to do with creating an abstainer. Lack of control — which should resemble alcoholism — is no single gene, but a group of traits.

UPDATE: As the Finnish researchers predicted, how much or how little someone drinks may be influenced by many genes. A study of rats published August 4 in *PLOS Genetics* linked variants of 930 genes to a preference for drinking alcohol (*SN: 9/3/16, p. 8*). Many of the variants may alter how genes are regulated, rather than changing the genes themselves. Researchers still need to verify whether the same genes are involved in drinking behavior in humans.

THE -EST

When mom has favorite, blame all the swimming



When macaroni penguins convene at a breeding site (above), females lay some of the most size-mismatched eggs known among birds (two, at left).

In crested penguin families, moms heavily favor offspring No. 2 from the start, and a new analysis proposes why. The six or seven species of crested (*Eudyptes*) penguins practice the most extreme egg favoritism known among birds, says Glenn Crossin of Dalhousie University in Halifax, Canada. Females that lay two eggs produce a runty first egg weighing 18 to 57 percent less than the second, with some of the greatest mismatches among erect-crested and macaroni penguins. Some *Eudyptes* species don't even incubate the first egg; royal penguins occasionally push it out of the nest entirely.

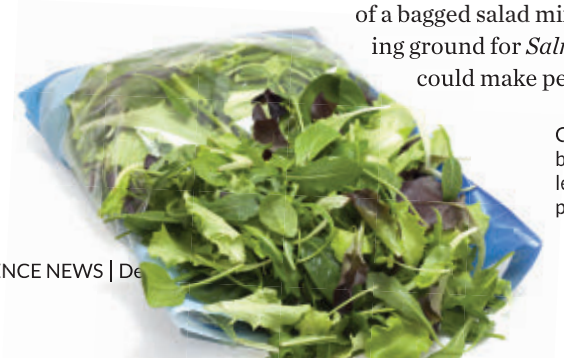
Biologists have proposed benefits for the unusual behavior: A sacrificial first egg might mark a claim to a nesting spot or improve chances of one chick surviving predators. But those ideas haven't held up, Crossin says. He and Tony Williams of Simon Fraser University in Burnaby, Canada, propose in the Oct. 12 *Proceedings of the Royal Society B* that egg favoritism is just a downside of an open-water, migratory lifestyle. Among the 16 penguin species that lay two eggs, only the *Eudyptes* species evolved what's called a pelagic life, spending their nonbreeding season mostly at sea and migrating, in some cases considerable distances, to breeding sites.

Female crested penguins tend to lay their first eggs soon after arriving at a breeding site, meaning that the egg must have started its roughly 16-day development while mom was migrating. The biology of long swims, now encoded genetically, interferes with producing a full-sized egg. A puny first egg might just be a sign that mom is trying to do two things at once, Crossin says. — *Susan Milius*

FOR DAILY USE

Salmonella bacteria love bagged salads

That past-its-prime bag of spinach buried in the back of your fridge should probably hit the compost heap instead of your dinner plate. The watery gunk at the bottom of a bagged salad mix is the perfect breeding ground for *Salmonella* bacteria that could make people sick, researchers report online November 18 in *Applied and Environmental Microbiology*. The culprit? The juice that oozes out of cut or damaged leaves. After five days in the fridge, small amounts of plant juice sped up *Salmonella* growth. The bacteria grew rapidly on the bag and stuck persistently to the salad leaves, so much so that washing didn't remove the microbes. *Salmonella*'s success inside bagged salads means it's important for producers to avoid bacterial contamination from the get-go — and for consumers to eat those greens before they get soggy. Popeye would approve.
— *Laurel Hamers*



Cut or damaged leaves in bagged salad mixes can leak plant juices that promote *Salmonella* growth.

FROM TOP: G. CROSSIN; STACEY ADLARD; STANGA/SHUTTERSTOCK

TEASER

Pap smear enables fetal genome testing

Scanning a fetus's genome just a few weeks after conception may soon be an option for expecting parents. Mom just needs to get a Pap smear first.

By scraping a woman's cervix as early as five weeks into a pregnancy, researchers can collect enough fetal cells to test for abnormalities linked to more than 6,000 genetic disorders, researchers report in the Nov. 2 *Science Translational Medicine*. It's not clear exactly how fetal cells make their way down to the cervix, says study coauthor Sascha Drewlo of Wayne State University School of Medicine in Detroit. The cells may invade mom's mucus-secreting glands and then get washed into the cervical canal.

This ultrasound is of a 9-week-old fetus. Using fetal cells from a Pap smear, researchers can perform genetic tests as early as 5 weeks.

Current prenatal tests include amniocentesis and chorionic villus sampling, but they work later in pregnancy: at least 12 weeks for amnio and at least nine weeks for CVS. Amnio requires a long needle inserted through a pregnant woman's belly and uterus; CVS often does, too. Instead, with a less-risky Pap smear, Drewlo's team gathered fetal trophoblast cells, which give rise to the placenta, and examined the genomes of 20 fetuses.

If found reliable, the new test, which requires just 125 fetal cells, could help physicians care for their tiniest patients. For some genetic conditions, such as congenital adrenal hyperplasia, early detection means mom can take some medicine to "actually treat the fetus in utero," Drewlo says. — *Meghan Rosen*

SOAPBOX

Most penicillin allergies are off base

Rashes are the temporary tattoos of childhood. The prickly, red bumps can blossom across the skin for a host of reasons: an ear infection, a virus or even an allergic reaction to a penicillin antibiotic. What's hard to tell, though, is whether the penicillin or the illness itself triggers the rash. To be safe, doctors label some children as allergic to penicillin, but a skin test to verify the diagnosis rarely happens.

"These kids march into adulthood with a penicillin allergy label that's never really addressed," says Allison Ramsey, an allergist at Rochester Regional Health in New York.

About 10 percent of U.S. adults and children believe they have a penicillin allergy, the most commonly reported drug allergy. But 90 percent of people who think they're allergic to penicillin actually aren't, according to a 2010 report in *Annals of Allergy, Asthma & Immunology*. There is a "massive problem with the overreporting of penicillin allergy," Ramsey says.

When researchers from the University of Texas Southwestern Medical Center in Dallas recently skin tested 228 "penicillin allergic" patients, almost 98 percent of the patients turned out not to be allergic. The team reported the findings November 12 in San Francisco at the annual meeting of the American College of Allergy, Asthma & Immunology. In reality, Ramsey says, people either never had the allergy or they got over it with time.

34 percent
One hospital's drop in vancomycin prescriptions after penicillin allergy testing

To avoid the chance of triggering a severe allergic reaction, doctors often give people who are considered allergic to penicillin a broad-spectrum, second-line antibiotic. Compared with penicillin, these drugs are often more expensive, less effective against certain bacteria and come with more side effects. On a troubling societal level, using the more general antibiotics may encourage the spread of antibiotic resistance (*SN: 10/4/14, p. 22*). Overdiagnosis of penicillin allergy is not benign, Ramsey says.

Red bumps in childhood can be mistakenly identified as a penicillin allergy. In later years, clinicians don't verify the diagnosis, with potential consequences for both the individual and society.

Surveying 276 physicians, physician assistants, nurse practitioners and pharmacists at two Rochester Regional Health hospitals, Ramsey and colleagues found very low levels of allergy testing. More than 85 percent of respondents reported that they never consulted with an allergist or immunologist for antibiotic allergies or skin tests, or they did so only once a year. More than 40 percent didn't know that a penicillin allergy can resolve over time. Ramsey presented the results November 14 at the allergy meeting.

Taking the time to confirm or rule out a penicillin allergy can cut down on the use of second-line antibiotics. In the Dallas study, after penicillin allergy testing, the use of vancomycin, a powerful, last-resort antibiotic, decreased by 34 percent and use of the costly aztreonam dropped by 68 percent.

"Those are big numbers," says Ramsey. It's important that people know that childhood penicillin allergies can be revisited, she adds. "It's not a lifetime label." — *Emily DeMarco*

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LIFE & EVOLUTION

DNA edits boost photosynthesis

Improving response to excess light may increase crop yields

BY SUSAN MILIUS

Enhancing just three genes helps plants harvest more light, raising new hopes for developing crops that can keep up with food demands from a crowded planet.

Genetically engineered tobacco plants, chosen to test the concept, managed the unusual feat of growing 14 to 20 percent more mass — meaning more crop yield — than untweaked plants, says Krishna Niyogi of the University of California, Berkeley and Lawrence Berkeley National Laboratory. The gains came from inserting different versions of three genes that control how quickly plants ramp back up to full energy-harvesting capacity after going into a protective mode to guard themselves from too-bright sunlight, Niyogi and colleagues report in the Nov. 18 *Science*.

Among results in regular air published so far, "to my knowledge, this is the first example where crop growth has been enhanced by improving photosynthesis," says plant physiologist John Evans of Australian National University in Canberra, who wasn't part of the project.

Photosynthesis, the basic green chemistry for converting the sun's energy into food, isn't a perfectly efficient process (*SN: 2/20/16, p. 12*). And the quest to improve efficiency by manipulating the interlocking steps of more than 100 reactions in plants outdoors has been complex. "We can make things worse, but this is the first time we can make something better," Evans says.

The underlying idea for the tobacco experiment came from an appreciation of how light and shade dance over leaves throughout the day in a farm field. Sudden blasts of intense sunlight are dangerous; an overload can lead to chemical scorching in a plant's light-catching chloroplasts. So when the sun's movement or a toss from a breeze suddenly exposes a chloroplast to more sunlight than it can handle, a protection system kicks in.

Enzymes in the leaf create a surge of a molecule called zeaxanthin, which helps off-load the excess energy as heat. This protection turns on within minutes but turns off more slowly when the crisis is over, Niyogi says.

Restoring full photosynthesis takes a lot more than just enhancing the back-to-normal mechanisms, the researchers found. The protein molecule ZEP is an enzyme that dismantles protective zeaxanthin when it's no longer needed. But making the plant simply build more ZEP keeps the protective system from turning on properly in the first place — which could put a plant at risk. So the researchers also enhanced the enzyme VDE, which builds the protective zeaxanthin. With those two enzymes in balance, a chloroplast can still rid itself of excess energy but get back to full operations faster.

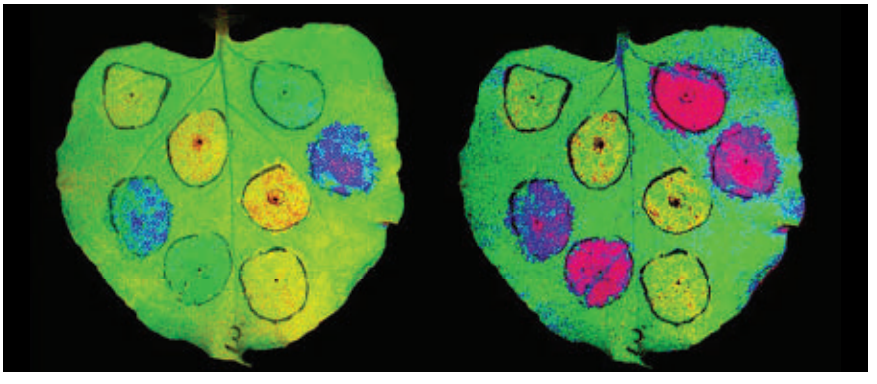
The three tobacco plants on the left, genetically modified to recover more quickly from light overloads, grew bigger than their unmodified counterpart on the right.

Enhancing a third protein, PsbS, also helped, although the researchers don't yet understand the full details of how. Tobacco plants with modified versions of all three proteins grew bigger, as measured by the weight of dried plant material, than others.

The extra growth those genes produced "is a major, economically important gain," says Maureen Hanson of Cornell University, who is working on a different approach to improving photosynthesis. Now, she says, the new paper's idea is ready for attempted transfer to plants that people harvest for grains or fruits. Hanson is hopeful that size will increase there, too.

Coaxing plants to calm down faster after a crisis is just one strategy to make photosynthesis more efficient. Evans and Hanson are among those involved in efforts to improve a notoriously slow and easily sidetracked photosynthetic enzyme called Rubisco. Other researchers are trying to transfer a naturally more efficient photosynthetic system found in some tropical and subtropical plants, called C4 photosynthesis, into rice, one of the world's main grains.

Older strategies for wringing more food from farms are not on track to keep up with soaring human population and food demands, Niyogi says. The United Nation's Food and Agriculture Organization estimates that feeding the world in 2050 could require boosting food production by 70 percent. But the success of all of this, Niyogi notes, may depend on how people around the world feel about genetically engineered food. ■



Colors show where tobacco leaves are wasting energy (blue, purple) by partially shutting down in response to bright light and where they are running closer to full capacity (pink, yellow). Shortening such shutdowns through genetic modifications might make plants more productive.

FROM TOP: HALEY AHLERS; LAURIEBETH LEONELLI, MATTHEW BROOKS/UC BERKELEY

LAUREN BRENT

High-status monkeys receive more grooming and companionship — linked to a healthy immune system — than their low-ranking peers.

BODY & BRAIN

Social status alters immune system

In rhesus monkeys, low rank in group leads to inflammation

BY RACHEL EHRENBERG

Living on the bottom rungs of the social ladder may be enough to make you sick. A new study manipulating the pecking order of monkeys finds that low social status kicks the immune system into high gear, leading to unwanted inflammation akin to that in people with chronic diseases.

The new study, in the Nov. 25 *Science,* gets at an enduring question that's been tough to study experimentally: Does social status alone change biology in a way that can make a person more healthy or more vulnerable to disease?

"We've known for years that human health and longevity are linked to socioeconomic status," says Steve Cole, who studies human social genomics at UCLA. This link often persists regardless of factors such as access to decent health care or clean water, but it's hard to design studies to get at mechanism or causation, he says. "This study is very nice to see and it's very consistent with other lines of research."

To tease out the influence of rank on health, scientists turned to another highly social animal: the rhesus monkey. Evolutionary biologist Jenny Tung of Duke University and colleagues worked with 45 female monkeys at the Yerkes National Primate Research Center field station near Lawrenceville, Ga. The researchers arranged the monkeys into groups of five, adding monkeys one at a time, which reliably resulted in the oldest member dominating and the newest member having the lowest rank. These groups were maintained for a year during which the researchers noted behaviors and took blood samples to assess changes in cellular and gene activity associated with the monkeys' social status.

> Low-ranking monkeys had different proportions of immune system cells circulating in their blood.

Then the researchers rearranged the monkeys into different groups of five and this time grouped monkeys of the same social rank together. Again, the monkeys established pecking orders and the researchers observed behaviors and drew blood.

It was quite clear which monkeys were dominant and which were subordinate, Tung says. "The alpha female — no one's messing with her," Tung says. Low-ranking monkeys were harassed more and not only did they receive more flak, but they also lacked a shoulder to cry on. Subordinate monkeys participated far less in grooming behaviors, which typically promote feel-good social bonding.

The effects of rank turned out to be more than skin deep. Low-ranking monkeys had different proportions of immune system cells circulating in their blood, the researchers found. And in some of these cells, activity in genes involved in immune response was dialed up. These changes are the cellular and genomic hallmarks of chronic, harmful inflammation. This type of inflammation is like a generic fertilizer that feeds the development of many chronic diseases, such as Alzheimer's and cardiovascular disease, Cole says.

Cells from the monkeys that were exposed to a bit of bacterial toxin to mimic infection also responded differently based on the monkey's rank, the team found.

Overall, the findings add to a body of work detailing how low social standing leads to elevated stress that harms the body, says Robert Sapolsky of Stanford University, who has long studied the physiological effects of stress in primates and wrote a perspective in the same issue of *Science*.

"At the end of the day, being a chronically subordinate nonhuman primate and being a human mired at the bottom of the socioeconomic scale are similar in the most fundamental ways," Sapolsky says. "You have remarkably little control and predictability in your life, your outlets for frustration are limited, and it's relatively hard to access social support. That's the prescription for chronic, stress-related maladies." ■

HUMANS & SOCIETY

Oldest alphabet identified as Hebrew

Israelites turned hieroglyphics into letters, researcher claims

BY BRUCE BOWER

The world's earliest alphabet, inscribed on stone slabs at several Egyptian sites, was an early form of Hebrew, a controversial new analysis concludes.

Israelites living in Egypt transformed that civilization's hieroglyphics into Hebrew 1.0 more than 3,800 years ago, at a time when the Old Testament describes Jews living in Egypt, said archaeologist and epigrapher Douglas Petrovich of Wilfrid Laurier University in Waterloo, Canada. Hebrew speakers seeking a way to communicate in writing with other Egyptian Jews simplified the pharaohs' complex hieroglyphic writing system into 22 alphabetic letters, Petrovich proposed November 17.

"There is a connection between ancient Egyptian texts and preserved alphabets," Petrovich said.

That's a highly controversial contention among scholars of the Bible and ancient civilizations. Many argue, despite what's in the Old Testament, that Israelites did not live in Egypt as long ago as proposed by Petrovich. Biblical dates for the Israelites' stay in Egypt are unreliable, they say. Scholars have also generally assumed for over 150 years that the oldest alphabetic script, which Petrovich studied, could be based on any of a group of ancient Semitic languages. But not enough is known about those tongues to specify one language in particular.

Petrovich's Hebrew identification for the ancient inscriptions is starved for evidence, said biblical scholar and Semitic language specialist Christopher Rollston of George Washington University in Washington, D.C. There is no way to tell which of many Semitic languages are represented by the early alphabetic system, Rollston contended.

The origins of writing in different parts of the world have long stimulated debates (*SN: 3/6/93, p. 152*). In the 1920s, a German scholar identified ancient Egyptian inscriptions as Hebrew. But he failed to identify many letters in the alphabet, leading to implausible translations that researchers rejected.

Petrovich said his big break came in 2012. While conducting research at the Egyptian Museum in Cairo, he came across the word "Hebrews" in a text from as early as 1874 B.C. that includes the earliest known alphabetic letter. According to the Old Testament, Israelites were in Egypt from 1876 B.C. to 1442 B.C.

Petrovich then combined previous identifications of some letters in the ancient alphabet with his own identifications of disputed letters to peg the script as Hebrew. He translated 18 Hebrew inscriptions from three Egyptian sites.

Several biblical figures turn up in the translated inscriptions, including Joseph, who was sold into slavery by his half-brothers and then became a powerful political figure in Egypt. Moses, who led the Israelites out of Egypt, is also mentioned, said Petrovich.

A book by Petrovich detailing his analyses of the ancient inscriptions will be published within the next few months. Petrovich said the book definitively shows that only an early version of Hebrew can make sense of the Egyptian inscriptions. ■

Alphabetic inscriptions on an ancient Egyptian stone slab (left) have been identified by a researcher as Hebrew. A drawing of the slab's inscriptions (right) shows the proposed early Hebrew letters next to corresponding modern Hebrew letters (green).

HUMANS & SOCIETY

Burials give peek at Philistines' lives

Cemetery in Israel offers clues to ancient population's health

BY BRUCE BOWER

A roughly 3,000-year-old cemetery on Israel's coast is providing an unprecedented look at burial practices of the Philistines, a mysterious population known from the Old Testament for having battled the Israelites.

Work at the Ashkelon cemetery from 2013 to 2016 has uncovered remains of at least 227 individuals, ranging from infants to older adults. Only a small section of the cemetery has been explored. Archaeologist and excavation director Adam Aja of the Harvard Semitic Museum estimates that about 1,200 people were interred there over a span of about 100 years.

"For the first time, we have found a formal Philistine cemetery," Aja said November 18. Aja and his colleagues first announced having found the Philistine graveyard on July 10. In November, he was among several researchers to present their latest findings about the cemetery.

Despite the discoveries, the Philistines' geographic origins remain unknown, Aja said. It's also unclear how Philistines reached the Middle East or how much their culture changed by the time they started burying their dead at Ashkelon.

Philistine burial practices have been debated for about a century. Other Philistine sites in Israel, also identified in ancient texts, have yielded individual graves and small-scale burial grounds.

At Ashkelon, the dead were interred in several ways. Most individuals were placed in shallow pits, often with pairs of jugs or storage containers near the bodies. Some pits contained a person's remains that had been buried on top of one or more previously interred bodies. Bronze earrings, bracelets, rings and other jewelry adorn most skeletons of children and women. Several pit graves of male skeletons include ornamental

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beads or engraved stones.

One grave holds a set of iron arrows near a man's hip. A quiver probably once held the arrows at the man's side, Aja said.

Researchers also uncovered ashes and bone fragments from six human cremations in sealed jars placed in pit graves. At least eight burial chambers capped with stone slabs were also found. The largest chamber held 23 skeletons. These burial chambers were aligned in three rows that ran parallel to the coast, Aja said.

Tapered storage jars in pit graves and burial chambers were influenced by pottery of the Canaanites, a nearby population on the Mediterranean coast, said team member Janling Fu of Harvard.

Fu suspects the excavation is located at the cemetery's edge. Considerable space between some burials suggests that denser clusters of grave sites lie nearby, he proposed, raising the prospect of learning much more about how the Philistines treated their dead.

Although the excavation is in its early stages, Philistines buried at Ashkelon show clear signs of physiological stress, reported bioarchaeologist and team member Sherry Fox of Eastern Michigan University in Ypsilanti. Many individuals' teeth have signs of growth interruptions caused by fever, malnutrition or other possible disorders.

Relatively short average heights for people buried at Ashkelon — about 5 feet, 1 inch for men and 4 feet, 10 inches for women — also fit a scenario of biological stress, Fox said. Short stature and minimal height differences between men and women occur with population-wide stresses such as malnutrition, she said.

The Philistines were a famously combative crowd. Archaeologist Eric Meyers of Duke University, who was not a member of the Ashkelon team, wondered if at least some of those buried at Ashkelon had been killed in battles or fights. But no head injuries or other skeletal signs of violent encounters appeared among the dead at Ashkelon, Fox said.

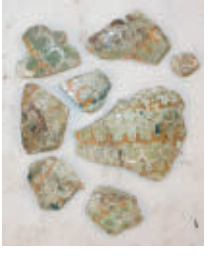
If DNA can be extracted from the Ashkelon skeletons, scientists may get a glimpse of where the Philistines came from. Evolutionary geneticist Johannes Krause of the Max Planck Institute for the Science of Human History in Jena, Germany, is directing efforts to retrieve genetic sequences.

"Our work has only just begun," Aja said. ■

MEETING NOTES

Glassmaking may have begun in Egypt, not Mesopotamia

Ancient Mesopotamians have been credited with inventing glassmaking around 3,600 years ago. But Mesopotamians may have created second-rate knock-offs of glass objects from Egypt, where this craft actually originated, researchers reported November 19.



Early Mesopotamian glass, such as these fragments from a vessel, may represent a crude attempt to copy Egyptian glass.

K. EREMIN, HARVARD SEMITIC MUSEUM

Arguments that glass production began in Mesopotamia largely rest on artifacts recovered nearly a century ago at Nuzi, a site in what's now Iraq.

It's unlikely those discoveries come from the dawn of glassmaking, said conservation scientist Katherine Eremin of Harvard Art Museums. She and a team of colleagues, led by archaeologist Andrew Shortland of Cranfield University in England, determined that glass excavated at Nuzi represents a mix of ancient items and glass from later occupations, some as recent as the 1800s. Genuine Mesopotamian glassware comes from sediment recently dated to around 3,400 years ago, later than initially thought, Eremin added.

Comparably old Egyptian glass items display an array of colors, including red, green, yellow, opaque blue and translucent blue (*SN: 1/24/15, p. 8*). Some Egyptian glass has wavy, colored lines. Nuzi items from Mesopotamian times show a poorer grasp of glassmaking, Eremin said. Those remains consist mainly of translucent blue beads. Wavy, colored lines on some beads are crudely formed and arranged.

"Nuzi glassmakers may have consciously copied Egyptian styles rather than leading the way in the glass industry," Eremin said.

Further study of glass from other sites is needed to pinpoint the region where glassmaking originated, she said. *— Bruce Bower*

For some early monks, hearing loss amplified sounds of silence

Early Christian monks' vows of silence may have attracted a fair number of hearing-impaired men.

A team led by bioarchaeologist Margaret Judd of the University of Pittsburgh found that a substantial minority of Byzantine-era monks buried in a communal crypt at Jordan's Mount Nebo monastery display skeletal signs of hearing impairments. Judd presented these results November 19.

The findings come from a crypt containing skeletons of at least 57 men presumed to have been monks. Oil lamps in the crypt date to the 700s.

About 16 percent of these men had damage to middle ear bones caused by otitis media, an infection that typically occurs in childhood. Monks showing signs of otitis media probably suffered mild to moderate hearing loss.

Damage to one middle ear bone, the stapes, in two other men probably caused severe hearing loss in one ear each. In another case, a fracture above the left eye could have damaged middle ear bones, Judd said. One skull's thickened bone may have resulted from Paget's disease, a viral infection in adults that can impair hearing.

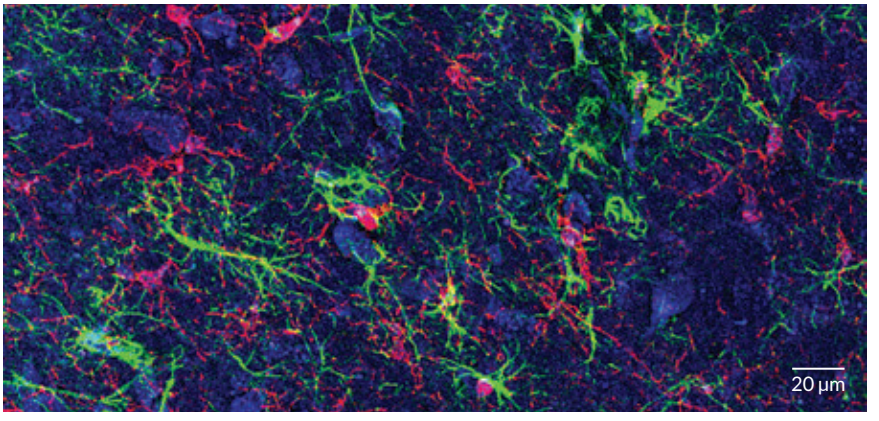
Hearing loss would have had little effect on monks' daily lives, since they communicated with hand signals, nods and other gestures, Judd said. *— Bruce Bower*

BODY & BRAIN

Gut microbes may spark Parkinson's

Bacterial imbalance could be culprit, mouse study suggests

BY LAUREL HAMERS



Signals from gut microbes can activate immune cells called microglia (shown here in green) in the mouse brain, causing inflammation that's characteristic of Parkinson's disease.

For clues to Parkinson's brain symptoms, a gut check is in order.

Intestinal microbes send signals that set off the disease's characteristic brain inflammation and movement problems in mice, researchers report in the Dec. 1 *Cell*. Doctors might someday be able to treat Parkinson's by fixing this bacterial imbalance.

"It's quite an exciting piece of work," says John Cryan, a neuroscientist at University College Cork in Ireland who wasn't involved in the study. "The relationship between the brain and gut for Parkinson's has been bubbling up for many years." The new research, he says, "brings the microbiome really into the forefront for the first time."

Parkinson's affects more than 10 million people worldwide, and roughly 70 percent of those patients also have gastrointestinal issues like constipation. Sometimes the GI symptoms show up years before the muscle weakness and other neurological problems. Several recent studies in humans have suggested a link between gut microbes and Parkinson's. But it hasn't been clear whether intestinal microbes actually cause the disease, says study coauthor Sarkis Mazmanian, a microbiologist at Caltech. "What our study adds is a functional, mechanistic role for the microbiome."

> "The relationship between the brain and gut for Parkinson's has been bubbling up for many years."
>
> JOHN CRYAN

Mazmanian's team studied mice bred to produce too much alpha-synuclein, the protein that's believed to cause Parkinson's when it clumps in the brain. Mice with extra alpha-synuclein acted like they had Parkinson's: They traversed a narrow beam more slowly, they couldn't grip a pole as well and they struggled to pull stickers off their noses. Their brains showed signs of inflammation, too. But when the researchers raised the same type of mice to be germ-free — that is, with no gut microbes — the animals acted less sick.

Those mice were still producing boatloads of alpha-synuclein, but the protein wasn't clumping as much in their brains. Without the clumps, the mice didn't have as much of the unsteady gait and muscle weakness typical of Parkinson's — and in fact, some of the mice acted completely healthy.

In another experiment, the researchers transferred gut microbes from Parkinson's patients into germ-free mice making too much alpha-synuclein. Those mice developed motor problems when tested six or seven weeks after the transfer, but mice who got microbes from healthy humans were fine.

"Even though the mice that received the healthy microbiota received hundreds of bacteria, they didn't get the disease," Mazmanian says. That suggests it's not the presence or absence of bacteria that triggers Parkinson's but the specific composition of the microbial cocktail.

Alpha-synuclein clumps can move from the gut to the brain (*SN: 12/10/16, p. 12*), a recent study showed. It seems that gut bacteria themselves are also sending important signals.

Researchers are now trying to figure out which signals — and which microbes — throw off the balance.

Fecal samples from the mice implanted with bacteria from Parkinson's patients had higher than normal levels of certain gut bacteria. That imbalance could be sparking symptoms, says study coauthor Tim Sampson, a Caltech microbiologist. "I'm interested in trying to understand if there are potential pathogenic microbes that might be individually driving the disease," he says. "Once we've figured that out, we'll be able to understand whether we can remove that group of organisms or block them."

Abnormally low levels of helpful bacteria could also factor in. The new analyses aren't large enough to firmly conclude which microbes are particularly important players. But if scientists can figure out what those missing beneficial bacteria are, Mazmanian says, targeted probiotic therapy might be a treatment option in the future.

Aging-associated diseases such as Parkinson's are tricky to study in a mouse model, cautions Stanford University microbiologist Justin Sonnenburg. "They're typically the result of decades of accumulations of problems," whereas the mice in the current study were just a couple months old. So the findings will need to be validated in human studies before influencing treatments. Still, he says, "it's a really important contribution to the growing list of ways that gut microbes can alter our health." ■

T. SAMPSON/CALTECH

Enzyme links up carbon and silicon

Selective breeding enables biological bonding of the atoms

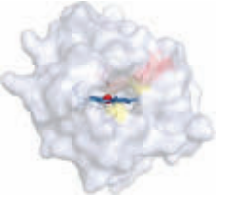
BY LAUREL HAMERS

Carbon and silicon don't play nice in nature — they link up only in human-made products like paint and pharmaceuticals. But just three generations of selective breeding of a microbe yielded an enzyme that brings the two atoms together, scientists report in the Nov. 25 *Science*. It's the first time biological tools have bonded carbon to silicon, perhaps opening a way to let organisms build proteins and other molecules with silicon.

"What excites me is the demonstration of how rapidly biological systems can innovate," says Frances Arnold, a chemical engineer at Caltech. "They can create new chemistry, new catalytic capabilities out of what's already there."

Enzymes are biological catalysts — they kick-start chemical reactions inside living organisms. For instance, cytochrome c shuffles electrons around to help cells make energy. In the new study, Arnold, chemical engineer Jennifer Kan and their Caltech colleagues discovered that cytochrome c from hot spring–dwelling *Rhodothermus marinus* bacteria had an untapped potential for forging carbon-silicon bonds.

To improve on that limited capability, the team introduced mutations into *R. marinus*' DNA and picked out the bacteria making the most catalytically active cytochrome c. After three rounds of mutations, the team was left with a finalist that could jump-start the formation of carbon-silicon bonds more than 15 times better than the top synthetic catalysts used for the reaction.



With an alteration to the part of the enzyme shown in pink, this cytochrome c's ability to bond carbon and silicon improved.

Carbon-silicon bonds are found in hundreds of products. So the enzyme-based catalyst might someday offer a more sustainable alternative to the expensive metal catalysts that are now used to create these compounds.

But first the enzyme might need additional tweaking. "The caveat is the particular carbon-silicon bond being made," says John Hartwig, an organic chemist at the University of California, Berkeley. The specific silicon-containing compounds made by the enzyme aren't widely produced by chemical companies — although the compounds could be intermediate steps in other reactions.

The study also opens up a way to let simple organisms like bacteria use silicon as a building block, which could change their behavior in ways scientists have never been able to study. "We can think about the effects of having silicon there," Arnold says. "In the past, that's been hard to do." ■

F. ARNOLD LAB/CALTECH

GENES & CELLS

Toxicologists look to epigenetics

Chemical tags on DNA could one day help assess exposure risks

BY TINA HESMAN SAEY

Nearly everything people do, eat or come into contact with can change them in little ways — sometimes with big consequences. Exposure to some chemicals can damage DNA, leading to cancer and other problems. Other molecular changes — chemical tags added to DNA or to proteins called histones — may affect health without injuring DNA.

There are more than 100 varieties of these chemical tags, collectively known as epigenetic marks. While they may help humans and other organisms respond to their environments, the tags can also alter development and body functions in unhelpful, even harmful, ways. Yet people who make decisions about safe levels of exposure to chemicals, heavy metals and other environmental factors generally aren't including epigenetic alterations in their deliberations.

Risk assessors take a wide variety of scientific data into account when making recommendations for preventing overexposure to chemicals. When it comes to epigenetic information, though, "honestly, we don't know what to do with it," says Marie Fortin, a toxicologist and risk assessor for Colgate-Palmolive Co. "We don't have a framework to interpret it," she said at the Society of Toxicology's ToxicoEpigenetics meeting in Tysons Corner, Va., in November.

Even researchers studying how environmental factors write, erase and tweak epigenetic marks admit that the field is in its infancy and still has a long way to go before it can be used to make public health decisions. Epigenetics is "a science that offers enormous opportunities for research, and maybe in a long time it will be useful for risk assessment, but right now we don't know enough," says neurotoxicologist Deborah Cory-Slechta of Rochester University Medical Center in New York.

> When it comes to epigenetic information, "honestly, we don't know what to do with it."
>
> **MARIE FORTIN**

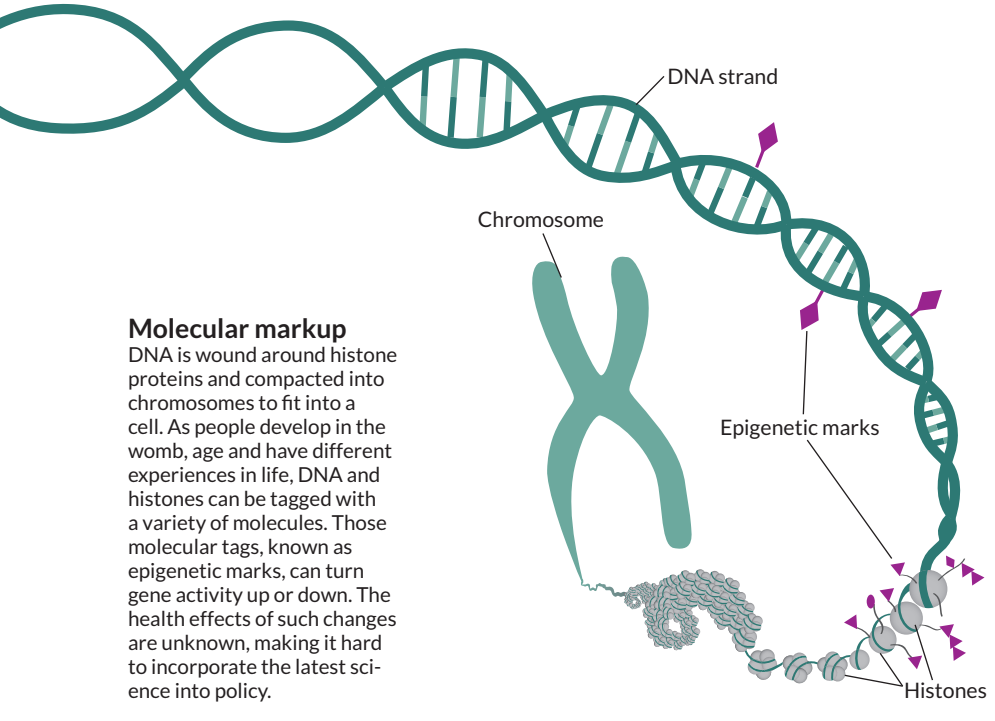
Cory-Slechta coauthored a paper describing the epigenetic effects of lead and stress on developing mouse brains. Studying those changes may help scientists learn how lead impairs human brain function and may suggest ways to counteract the heavy metal's effects, she says.

Stressed mouse moms that drank water laced with lead during pregnancy had offspring in which two important epigenetic marks differed in parts of their brains, Cory-Slechta and colleagues reported in the May *NeuroToxicology*. At various times during development, male and female pups had different changes in the hippocampus, a brain structure involved in learning and memory. Those findings could indicate that males are at higher risk of developing learning problems when their mothers are exposed to lead and are under stress.

Other epigenetic studies have indicated that high-fat diets, smoking, exposure to pesticides or to estrogen-mimicking chemicals could have health effects — including increased risk of breast and other cancers — that last for generations (*SN: 4/6/13, p. 18*). A study published in *Scientific Reports* in 2015 indicated that grandchildren could inherit epigenetic marks if their grandmothers were exposed to lead (*SN: 3/19/16, p. 8*). And researchers regularly publish new studies showing that epigenetic marks can be altered by exposure to air pollution, arsenic in drinking water or chemicals such as bisphenol A that are found in products including plastics, canned food and cash register receipts.

Yet there are limits to applying the conclusions to human risk assessment. For one thing, most of what scientists know about environmental effects on epigenetic marks comes from animal studies. Such studies will always be imperfect mimics of what goes on in humans.

One obstacle to using lab animals as stand-ins for humans is that the animals aren't living in the real world. Researchers give lead to mice for only a short time, for example; humans typically face long-term exposures, Cory-Slechta



Molecular markup
DNA is wound around histone proteins and compacted into chromosomes to fit into a cell. As people develop in the womb, age and have different experiences in life, DNA and histones can be tagged with a variety of molecules. Those molecular tags, known as epigenetic marks, can turn gene activity up or down. The health effects of such changes are unknown, making it hard to incorporate the latest science into policy.

J. GRÄFF AND L.-H. TSAI/*NATURE REVIEWS* 2013, ADAPTED BY E. OTWELL

says. Her mouse studies indicate that stress can make lead's effects worse, but lab mice don't deal with the same sort of social and economic stress that people do. Those types of chronic stress may have different epigenetic consequences than those produced by the short-lived physical challenges mice are usually subjected to.

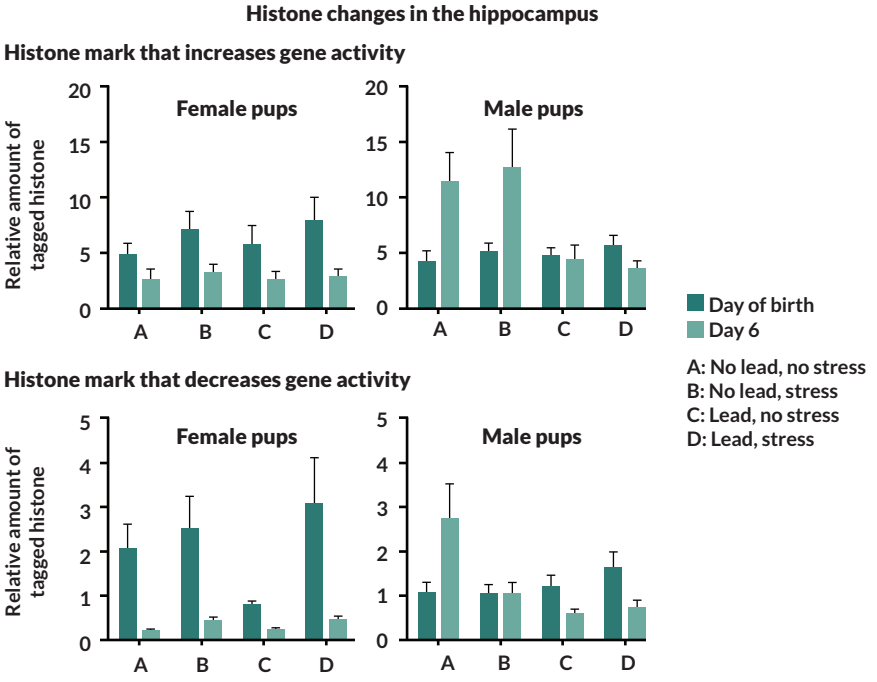
Another major roadblock to determining whether mice and people respond similarly to lead exposure is that Cory-Slechta and her colleagues can't get samples of people's brains. The closest the researchers might get is examining epigenetic marks in people's white blood cells, but lead is likely to affect those cells differently than it does brain cells.

Researchers also don't agree on which epigenetic marks they should track. Some scientists favor DNA methylation, an alteration in which molecules called methyl groups are attached to the DNA building block cytosine. That mark usually signals that gene activity has been turned down.

Other researchers concentrate on chemical modifications of histones. Histones are proteins that form spools around which DNA is wound to fit into a cell. A dizzying array of chemical changes at various spots on the histones are associated with more or less gene activity. For instance, tacking an acetyl group onto the histone H3 protein at a specific spot is associated with increased gene activity, but switching the acetyl group for a couple of methyl groups can reduce gene activity. Researchers may not be able to get away with choosing just one of these epigenetic marks to predict how a chemical exposure, diet, exercise and stress might combine with a person's age, sex and genetic makeup to affect them, says molecular toxicologist Shaun McCullough.

Each epigenetic mark is like a letter in a language, says McCullough, of the U.S. Environmental Protection Agency's National Health and Environmental Effects Research Laboratory in Chapel Hill, N.C. If researchers look at only one type of modification, "it's like trying to get something out of reading a book in which you can only see one of the letters. You're not going to get the full story."

Lead marks the brain Lead may have different effects on the brains of males and females, a recent study suggests. Scientists laced the drinking water of some pregnant mice with lead. Some of the pregnant mice were put under stress. When the moms' pups were born, the researchers measured two types of epigenetic marks — one that dialed up gene activity (top graphs) and one that tamped it down (bottom graphs) — in a learning and memory center of the brain called the hippocampus. Some of these marks naturally change during the first few days after birth as pups explore their environment, but lead and stress seem to alter that natural process. The health consequences of these changes is not yet clear. SOURCE: J.S. SCHNEIDER *ET AL/NEUROTOXICOLOGY* 2016



Filling in all of the letters may not be necessary. Like contestants on *Wheel of Fortune*, researchers may be able to guess at the meaning of a particular epigenetic change with a few key letters. To play the guessing game, researchers may have to construct a database compiling all the epigenetic changes in response to particular chemicals and how these changes influence the activity of many genes. Such a project is still a dream; most researchers are still concentrating on only one mark at a time and its effect on a few genes.

Even if researchers learn to read the epigenetic language, they still need to establish whether changes cause disease, are merely indicators that something has gone wrong, or are neutral, says environmental epigeneticist Dana Dolinoy.

Dolinoy, of the University of Michigan School of Public Health in Ann Arbor, and McCullough co-organized the Toxico-Epigenetics meeting. Their goal was to bring policy makers and research scientists together to learn how epigenetics might be incorporated in risk assessment. Even though participants walked away from the conference with no definite answer, they have begun talking about the steps needed to determine whether epigenetic marks are reliable predictors of chemical exposure safety.

Regulators shouldn't wait for epigenetics to mature as a field before making a ruling on safety, says Ivan Rusyn, a toxicologist at Texas A&M University in College Station. But they should keep the door open for revising decisions as more data become available.

Rusyn is one of 46 authors of a report in the November issue of *Environmental Health Perspectives* on the promise and challenges of incorporating new technology into risk assessment. He's optimistic that epigenetics can one day contribute valuable data about health risks, but that day won't come soon. "Right now this is not an airplane we can fly," he says. "It's an airplane that's still in the drawing stage." ■

J. HIRSHFELD

MATTER & ENERGY

At low temps, bismuth superconducts

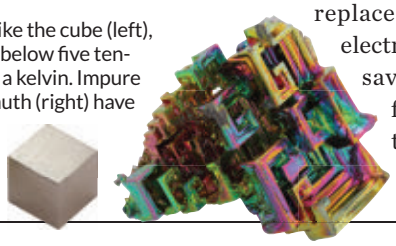
Despite few free electrons, element loses electrical resistance

BY EMILY CONOVER

An oddball superconductor is the first of its kind — and if scientists are lucky, its discovery may lead to others.

At a frigid five ten-thousandths of a degree above absolute zero, bismuth becomes a superconductor — a material that conducts electricity without resistance. Physicists at the Tata Institute of Fundamental Research in Mumbai, India, report the feat online December 1 in *Science*.

Bismuth, a semimetallic element, conducts electricity less efficiently than an ordinary metal. It is unlike most other known superconductors in that it has very few mobile electrons.



Pure bismuth, like the cube (left), superconducts below five ten-thousandths of a kelvin. Impure crystals of bismuth (right) have iridescent patterns due to oxidation.

Consequently, the prevailing theory of superconductivity doesn't apply.

New ideas — either a different theory or a tweak to the standard one — are needed to explain bismuth's superconductivity, says theoretical physicist Marvin Cohen of the University of California, Berkeley. "It might lead us to a better theory of superconductivity with more details."

An improved theoretical understanding might then point to other new superconductors, potentially ones that work at more practical temperatures, says study coauthor Srinivasan Ramakrishnan.

Physicists' ultimate goal is to find a superconductor that operates at room temperature. Such a material could replace standard metals in wires and electronics, providing massive energy savings and technological leaps, from advanced supercomputers to magnetically levitated trains.

Ramakrishnan and collaborators chilled ultrapure crystals of bismuth while shielding the crystals from magnetic fields. Below 0.00053 kelvins (about −273° Celsius), the researchers observed a hallmark of superconductivity known as the Meissner effect, in which the superconductor expunges magnetic fields.

In the standard theory of superconductivity, electrons partner up in a fashion that removes resistance to their flow, thanks to the electrons' interactions with ions in the material. But the theory works only for materials with many free-floating electrons. A typical superconductor has about one mobile electron for each atom in the material, while in bismuth each electron is shared by 100,000 atoms.

Bismuth has previously been made to superconduct when subjected to high pressure, when formed into nanoparticles or when its atoms are disordered, rather than neatly arranged in a crystal. But under those conditions, bismuth behaves differently, so the prevailing superconductivity theory still applies. The new result is the first sign of superconducting bismuth in its normal form. ■

BODY & BRAIN

Report offers food allergy guidance

Little evidence supports some common prevention strategies

BY RACHEL EHRENBERG

Science's grasp of food allergies is as jumbled as a can of mixed nuts. While there are tantalizing clues on how food allergies emerge and might be prevented, misconceptions are plentiful and broad conclusions are lacking, finds a new report by the National Academies of Sciences, Engineering and Medicine.

As a result, both the general public and medical community are confused and ill-informed. Most prevention strategies and many diagnostic tests aren't supported by evidence and should be abandoned, the 562-page report concludes.

"We are much more in the dark than we thought," says Virginia Stallings, a coeditor of the report, released November 30.

While solid data are hard to come by, an estimated 12 million to 15 million Americans suffer from food allergies. Common culprits include peanuts, milk, eggs, shellfish, wheat and soy.

Food allergies should be distinguished from food intolerances, says Stallings, research director of the nutrition center at the Children's Hospital of Philadelphia. Food allergies arise from a specific immune response to even a small amount of the allergen; they can produce hives, swelling, vomiting, diarrhea and anaphylaxis, a potentially deadly reaction. These effects occur within two hours after every time a person ingests that food. The mechanisms behind reactions that fall outside this definition are probably very different, as are the outcomes, Stallings says.

Anyone suspecting a food allergy should see a specialist. Only the gold standard diagnostic test, the oral food challenge, can confirm an allergy. This test exposes a person to small amounts of the potentially offending food while under a physician's supervision. Doctors should abandon unproven tests, such as analyzing gastric juices or skin's electrical resistance, the report concludes.

Regarding prevention, the authors recommend that parents give infants foods that contain potential allergens. This advice is largely based on peanut allergy research suggesting early exposure is better than late (*SN: 3/21/15, p. 15*). Virtually all other prevention strategies, such as vitamin D supplements or women avoiding allergens while pregnant or breastfeeding, lack evidence.

Epidemiologist Anita Kozyrskyj of the University of Alberta in Canada calls the report "very impressive." Its real value, she says, is in the recommendations for parents, schools, caregivers and health care providers who deal with food allergies in the here and now. ■

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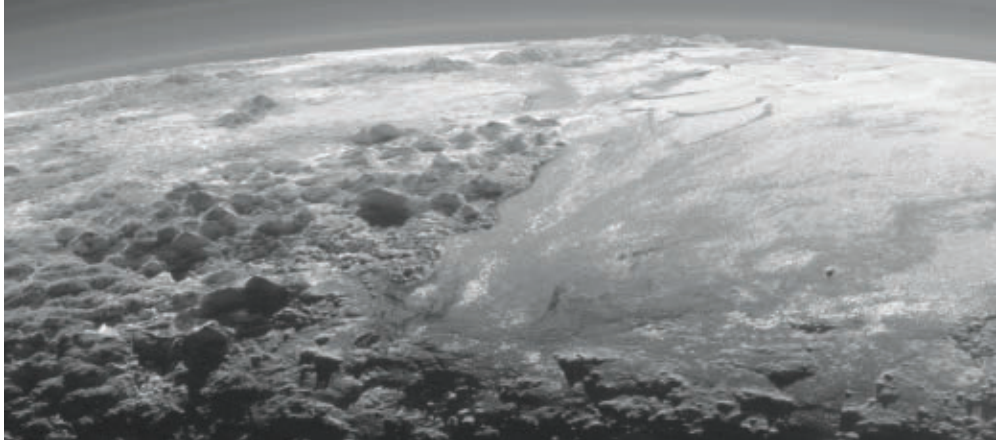

A basin on Pluto named Sputnik Planitia (shown in this image from the New Horizons spacecraft) might be a depression formed by the weight of a massive ice cap, researchers report.

NASA, JHUAPL, SWRI

ATOM & COSMOS

Ice gave Pluto a heavy heart

Pluto's heart may carry a hefty burden.

Weight from massive deposits of frozen nitrogen, methane and carbon monoxide, built up billions of years ago, could have pushed down the left half of Pluto's heart-shaped landscape, researchers report in the Dec. 1 *Nature*.

Previous studies had proposed that the roughly 1,000-kilometer-wide frozen basin dubbed Sputnik Planitia could be a scar left by an impact with interplanetary debris (*SN: 12/12/15, p. 10*).

Sputnik Planitia sits in a cold zone, a prime location for ice to build up, planetary scientist Douglas Hamilton of the University of Maryland in College Park and colleagues calculate. Excess ice deposited early in the dwarf planet's history would have led to a surplus of mass. Gravitational interactions between Pluto and its largest moon, Charon, slowed Pluto's rotation until that mass faced in the opposite direction from Charon. Once Charon became synced to Pluto's rotation — it's always over the same spot on Pluto — gravity would have held Sputnik Planitia in Pluto's cold zone, attracting even more ice. As the ice cap grew, the weight could have depressed Pluto's surface, creating the basin that exists today. — *Christopher Crockett*

LIFE & EVOLUTION

Bird fossil holds new color clue

A 130-million-year-old bird holds a clue to ancient color that has never before been shown in a fossil.

Feathers from an *Eoconfuciusornis* fossil contain not only microscopic pigment pods called melanosomes, but also signs of beta-keratin, a protein in the stringy matrix surrounding melanosomes. Mary Schweitzer and colleagues report the find online November 21 in the *Proceedings of the National Academy of Sciences*.

Together, these clues could strengthen the case for inferring color from dinosaur fossils (*SN: 11/26/16, p. 24*). Schweitzer, a paleontologist at North Carolina State University in Raleigh, has long pointed out that the microscopic orbs that some scientists claim are melanosomes may actually be microbes. The two look similar, but they have some key differences. Microbes aren't enmeshed in keratin, for one.

In *Eoconfuciusornis*' feathers, the researchers found round, 3-D structures visible with the aid of an electron microscope. And a molecular analysis revealed bundles of skinny fibers, like the filaments of beta-keratin in modern feathers.

"Identifying keratin is key to ruling out a microbial source for microbodies identified in fossils," the researchers write. — *Meghan Rosen*

BODY & BRAIN

Old blood carries risks for brain

Harmful factors circulating in old blood may be partly responsible for the mental decline that can come with age, a small study in mice suggests.

Stem cell researcher Irina Conboy of the University of California, Berkeley and colleagues devised a new way to mingle blood in two mice that doesn't involve stitching their bodies together, as in previous experiments (*SN: 5/31/14, p. 8*). A microfluidic device that shuttles blood controlled the timing and amount of blood transferred between the mice. The method, reported November 22 in *Nature Communications*, allows more precise tests of blood's influence on aging, the researchers believe.

Old mice benefited from infusions of young blood in some ways, experiments with four young-old pairs of mice revealed. With young blood, old muscles recovered better after an injury. And young blood seemed to improve old livers.

Young blood did not seem to help one measure of brain health. After transfusions of young blood, old mice still had fewer newborn nerve cells in the hippocampus, a brain structure important for learning and memory. In young mice, old blood reduced the number of newborn nerve cells. This damage happened after just one blood exchange. The results suggest that old blood contains components that harm brain cells, an insight that leaves scientists eager to identify those factors. — *Laura Sanders*

LIFE & EVOLUTION

Skimpy sea ice linked to reindeer starvation in Siberia

Unseasonable shrinking of sea ice could trigger another peril of climate change: increasing ice-overs on land that starve reindeer and threaten Siberian herders' way of life.

The worst of these events in the memory of Nenets herders on Russia's Yamal Peninsula killed 61,000 of 275,000 reindeer in 2013, a blow to the herders' livelihood that will take years to recoup. Such events have grown more frequent and more severe in the northwest Russian Arctic, says ecologist Bruce Forbes of the University of Lapland in Finland.

Weather data and interviews with herders suggest how such disasters occur, Forbes and colleagues propose November 16 in *Biology Letters*. When variations in the currents of the North Atlantic bring unusual warmth to the Barents Sea, ice forming there and in the Kara Sea in fall and winter can retreat instead of grow. This retreat leaves open water that can provide more moisture to storms blowing inland. Rain drenches snow, which freezes into a thick layer of ice that starves the reindeer because they can't graze on forage under the snow. — *Susan Milius*

2016 Year in Review

At first glance, the stories taking the top two spots in *Science News*' review of 2016 have little in common. Scientists began searching decades ago for gravitational waves. Discussions of these subtle signals from dramatic and distant phenomena appear dozens of times in the *SN* archive starting as early as the 1950s. Their long-awaited discovery, our No. 1 story of the year, touched off celebration of a new era in astronomy. Less expected, and far from subtle, was the sudden rise in Brazil of microcephaly cases, linked this year to Zika virus infections — our No. 2 story. Little was known about Zika before the outbreak, which delivered devastation and fear across the Americas. In fact, only a single previous mention of Zika exists in the *SN* archive, in a book review from the 1990s.

But the stories have at least one thing in common: Both highlight the power of scientific discoveries to trigger our deepest human emotions. Pure elation as well as overwhelming dread can accompany research advances. 2016 brought many more sentiments, too. There was enthusiasm for the discovery of the exoplanet Proxima b, concern for the prospects of three-parent babies and feelings of potential but also impending peril in the openings of Arctic passageways.

The editors and writers at *Science News* also recognize that some of the best and most moving stories are those that are still unfolding. So, in addition to the discoveries of 2016, we review milestones, setbacks and other tales of unsteady progress. Sonia Shah writes about a new wave of infectious diseases; Tom Siegfried explores convergent failures in the field of particle physics; and Laurel Hamers covers key challenges for self-driving cars. Then, *Science News* writers share what science news they're most excited about in the year to come. — *Elizabeth Quill*

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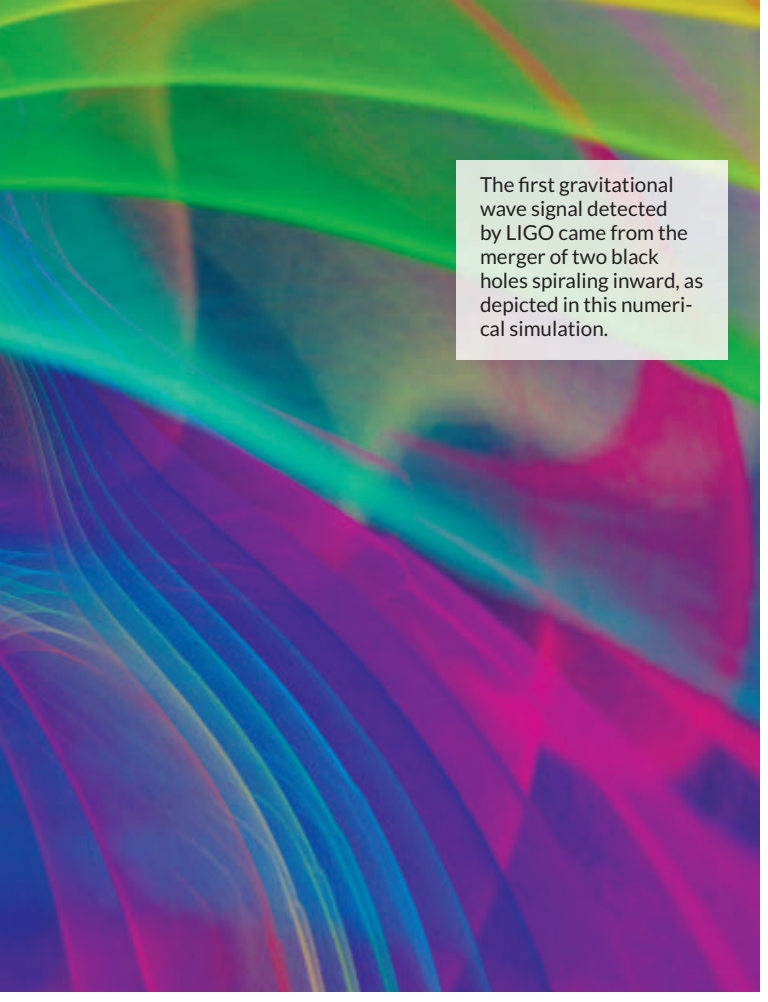


The first gravitational wave signal detected by LIGO came from the merger of two black holes spiraling inward, as depicted in this numerical simulation.

Gravitational waves offer new view of dynamic cosmos

By Emily Conover

The secrets gleaned from the universe's most mysterious giants are incongruously subtle when witnessed at Earth: Detectors budge by a tiny fraction of a proton's breadth, outputting a feeble, birdlike chirp.

For centuries, astronomers have peered out into the universe almost exclusively by observing its light. But 2016's announcement of the first detection of gravitational waves, produced 1.3 billion years ago in the collision of two monstrous black holes, has given scientists a whole new way of observing the heavens.

The waves tore through the cosmos at the speed of light and arrived at Earth just in time for the start-up of the Advanced Laser Interferometer Gravitational-Wave Observatory, LIGO, which measured the minute stretching and squeezing of space. With a second detection already recorded and more expected in 2017, scientists hope to uncover new details about elusive black holes and their pairings. Soon, as more detectors come online, scientists will even be able to pinpoint where gravitational waves originate and inspect the sky for the aftermath of the cataclysms that caused them.

"This is a great success story of science," says astrophysicist Avi Loeb of Harvard University, who was not involved in the detection. It's the kind of major discovery that comes along only once in a few decades, he says.

On February 11, LIGO scientists announced the discovery at a news conference in Washington, D.C., and in a paper published in *Physical Review Letters*. Since publication, the paper has garnered around 100 citations a month, evidence of a newly intensified focus on the waves. Some physicists had dedicated entire careers to finding the spacetime tremors, which will be a boon for researchers for decades if not centuries to come.

The patterns of ripples appeared nearly simultaneously in LIGO's two enormous L-shaped detectors — in Hanford, Wash., and Livingston, La., — on September 14, 2015. The signal closely matched that expected from a pair of black holes that spiral around one another, getting closer and closer before merging into one. At the early stages of their do-si-do, the two black holes were about 35 and 30 times the mass of the sun. The behemoths melded together into a black hole 62 times the sun's mass, releasing three suns' masses worth of energy (*SN: 3/5/16, p. 6*; *SN: 7/9/16, p. 8*). When scientists converted the gravitational waves into sound waves, the waves produced something like the everyday chirp of a bird, quickly rising in pitch and volume before cutting off. The sound felt like a plaintive question, as if the universe was asking, "Hello? Is anyone there?" This time, the answer was yes.

Taken on its own, the discovery was a blockbuster — confirming Einstein's prediction that spacetime can ripple, providing an intimate new glimpse of black holes and verifying astrophysicists' calculations for how two black holes can fuse into one. But the detection's landmark status is largely because of its future promise. LIGO is expected to usher in a new era of astronomy, in which gravitational wave detections could become commonplace. Black holes, previously dark to humankind, will regularly communicate their coalescences to Earth.

In pursuit of this new type of astronomy, scientists have been chasing gravitational waves for decades. After such a long search, it was "incredibly gratifying," says David Shoemaker, leader of LIGO's efforts at MIT, "to wake up in the morning and know in my bones" that gravitational waves had finally been detected.

Almost as soon as LIGO's updated detectors were turned on, the gravitational waves rippled by, slightly altering the length of LIGO's ultrasensitive detectors. "We flipped the switch and said, 'OK, we're going to start running,' and boom," says LIGO laboratory executive director David Reitze of Caltech. That quick detection raised hopes among astrophysicists who daydream of datasets with tens or hundreds of such events.

With each new coalescence, scientists will learn more about how common black hole pairs are, as well as the properties of black holes and the dying stars that collapsed into oblivion to create them. "What we're really learning about when we study these black holes is the stars that were their progenitors," says LIGO member Daniel Holz of the University of Chicago. "From the stars, we then are learning about the early universe."

Scientists hope to reconstruct how pairs of black holes find one another in the lonely universe. There are two main

competing theories: Two stars could be born together like twins, with each later collapsing into a black hole, or the black holes could meet up later in life, in dense systems where many black holes and stars interact (*SN Online: 6/19/16*).

Proving that the detection was no fluke, LIGO scientists reported June 15 that they had spotted the quivers of a smaller pair of merging black holes (*SN: 7/9/16, p. 8*). LIGO shut down for upgrades following the two detections, but restarted again in November. Further improvements to the LIGO detectors will boost their sensitivity, allowing them to catch even fainter ripples. When those upgrades are complete — perhaps by 2019 — scientists could glimpse black hole mergers as frequently as once a day.

With the first detections, physicists used LIGO's data to confirm Einstein's general theory of relativity in a more extreme environment than ever before. "That's a triumph," says Loeb. But future detections will add even more precision to tests of general relativity. Any deviation from expectations could signal some way in which Einstein's theory breaks down. The equations of general relativity also suggest that black holes have no "hair," or distinguishing characteristics aside from mass, electric charge and angular momentum. But this leads to a conundrum about what happens to information swallowed up by the black hole (*SN: 10/3/15, p. 10*). In the future, scientists could use gravitational waves to test whether the no-hair theorem is true.

The discovery "injected a lot of momentum in the field," says Emanuele Berti, an astrophysicist at the University of Mississippi in Oxford.

Another gravitational wave detector, Virgo, in Italy, is undergoing upgrades and should be switched on in 2017 (*SN: 3/5/16, p. 24*). The trio of detectors — Virgo, plus LIGO's two — will give scientists the ability to locate the sources of gravitational waves on the sky. The government of India is also taking steps toward creating a gravitational wave observatory. And related projects are garnering more attention: Results announced in June from the European Space Agency's LISA Pathfinder satellite demonstrated the technological capabilities needed to search for gravitational waves not from the ground but from space (*SN Online: 6/7/16*).

If researchers can triangulate the source of the waves, they can point telescopes in that direction to spot any luminous aftermath. Such a signal would be unexpected for shadowy black holes, but they aren't the only source. Scientists expect to find undulations from smashups of neutron stars, which might produce detectable light. If luck is on LIGO's side and a star explodes within the Milky Way, LIGO may be able to spot its gravitational fallout, too.

Combining gravitational waves with other messengers from space, including various wavelengths of light and particles such as neutrinos, will create a diverse toolkit for observing the cosmos. Scientists may even find unforeseen sources of gravitational waves, says Loeb. "There is a chance that our imagination is limited." ■

Public health checkup

Drug use continued to threaten the health and safety of the American public in 2016, while a hidden menace in drinking water remained a major worry for the people of Flint, Mich.

Teen vaping

Vaping has surpassed cigarette smoking among U.S. high school students, according to a report released in 2016 from the National Youth Tobacco Survey. Estimates suggest that some 2.39 million U.S. high school kids vaped in 2015, compared with an estimated 1.37 million who smoked cigarettes (*SN: 5/28/16, p. 4*). The popularity of e-cigarettes has increased recently despite a lack of evidence showing that they are safer than conventional tobacco products, according to the U.S. Food and Drug Administration, which in May extended its regulatory authority to e-cigarettes. Studies reported in 2016 show a host of potential health risks, including effects on the brain, immune system and fertility (*SN: 3/5/16, p. 16*).

Opioid epidemic

Against a backdrop of rising prescription opioid addiction, deaths related to opioid use have become an issue of national importance. A surge in fentanyl-spiked drugs emerged as a primary concern in 2016 (*SN: 9/3/16, p. 14*). U.S. deaths from synthetic opioids rose from 3,105 in 2013 to 5,544 in 2014, a change that could not be explained by fentanyl prescription rates, according to a report released in August by the Centers for Disease Control and Prevention. Drug enforcement seizures involving fentanyl more than doubled from 2014 to 2015.

Fallout in Flint

After lead in the drinking water in Flint, Mich., launched a public health crisis (*SN: 3/19/16, p. 8*), a federal state of emergency remained in effect into August. The most recent tests conducted by the U.S. Environmental Protection Agency show that levels of lead, which is toxic to the brain, are below those considered dangerous and that filtered tap water is safe to drink. Many residents are still relying on bottled water, however. There's also growing concern that lead contamination and testing is not being taken seriously elsewhere in the United States. — *Cassie Martin*

LINDA PARTON/SHUTTERSTOCK

Zika virus devastates Brazil, spreads fear across Americas

By Meghan Rosen

A Brazilian mother cradles her baby girl under a bruised purple sky. The baby's face is scrunched up, mouth open wide — like any other crying child. But her head is smaller than normal, as if her skull has collapsed above her eyebrows.

A week earlier, not far away, a doctor wrapped a measuring tape around the forehead of a 1-month-old boy, held in the arms of his grandmother. This baby too has a shrunken head, a birth defect whose name — microcephaly — has now become seared into the public consciousness.

These images and many more told a harrowing story that case reports alone couldn't convey: A little-known mosquito-borne virus called Zika appeared to be taking a terrible toll on women and babies, and their families. The world got a gut-wrenching view of microcephaly in 2016, along with a mountain of evidence convincing scientists that Zika bears much of the blame for the dramatic increase in cases.

"Once you've seen those pictures from Brazil, you realize what a huge impact this kind of outbreak can have," says Sonja Rasmussen, a pediatrician at the U.S. Centers for Disease Control and Prevention in Atlanta. Brazil logged its first cases of Zika in 2015, but infections there peaked this spring with perhaps up to 8,000 new infections per week. The virus crept northward and infiltrated many more countries including Panama, Haiti and Mexico. Now, the threat has come to the United States: Cases have been reported in every state except Alaska. They stem mostly from travelers infected abroad, but the virus has staked out new territory in Puerto Rico, the U.S. Virgin Islands, American Samoa and Florida.

As of December 1, Puerto Rico had reported more than 34,000 people with Zika infections. More than 2,700 are pregnant women. And elsewhere in the United States, the CDC has reported well over 4,000 laboratory-confirmed cases of Zika. In these places and others, the images from Brazil have filled expectant mothers (and anyone considering having kids) with uncertainty and fear. "It's really scary to be pregnant right now," Rasmussen says. "We don't know what to tell women."

The threat to unborn babies wasn't clear when Zika first hit Brazil, or in earlier, smaller outbreaks on Yap Island in the western Pacific and in French Polynesia. In fact, before 2016, not much was known about the virus at all. The majority of people infected don't show any symptoms. But in the last year, scientists have thrown themselves at Zika, publishing more than 1,500 papers on different facets of the virus, from what species of mosquito it hides in to what cells it invades.

"We're learning something new every day," says obstetrician/gynecologist Catherine Spong, deputy director of the National Institute of Child Health and Human Development in Bethesda, Md.

FELIPE DANA/AP PHOTO

A young woman holds her daughter, born with microcephaly, outside their home in Recife, Brazil. Researchers this year linked the upsurge in microcephaly cases in Brazil to the mosquito-borne Zika virus.

The studies have scrubbed away some of Zika's mystery — in particular, what the virus does in the womb. Scientists have found traces of Zika in the brains of human fetuses and confirmed that the virus can infect and kill brain cells in the lab. "This is the year that people became convinced that this mosquito-borne virus could cause birth defects," Rasmussen says.

Though there was no smoking gun — no single piece of evidence that clinched Zika as the culprit — little clues began adding up, beginning with the conspicuous timing of Brazil's microcephaly upsurge (*SN: 4/2/16, p. 26*). In January the CDC first issued a warning to pregnant women to postpone travel to Zika-affected regions. On April 13, a day that may be forever etched into Rasmussen's memory, she and colleagues reported "a causal relationship" between Zika and microcephaly, along with other birth defects, in a study published online in the *New England Journal of Medicine*. Since then, Rasmussen says, "The data have become absolutely overwhelming."

In May, a mouse study offered the first direct proof in animals that in utero Zika infection can lead to microcephaly (*SN Online: 5/11/16*). In September, researchers reported that a pregnant pigtailed macaque infected with Zika in the third trimester then gave birth to a baby whose brain had stopped growing. In human babies, the range of disorders linked to Zika has ballooned to include problems with the eyes, ears and joints, as well as seizures and extreme irritability (*SN: 10/29/16, p. 14*). At a workshop in North Bethesda, Md., this

fall, a room crowded with doctors and scientists watched videos of inconsolable infants jerking erratically, arms and legs unnaturally stiff. "Heartbreaking," Rasmussen says.

Zika isn't the first virus to harm babies in the womb. Cytomegalovirus can also cause microcephaly, for example, and rubella, known as "German measles," can leave babies with hearing, vision and heart problems. Even among these viruses, though, Zika stands out. "It's such a precedent-setting thing," Rasmussen says. "Never before has there been a mosquito-borne virus known to cause birth defects."

1–13
percent
Estimated risk of bearing a baby with microcephaly for a pregnant woman infected with Zika in the first trimester

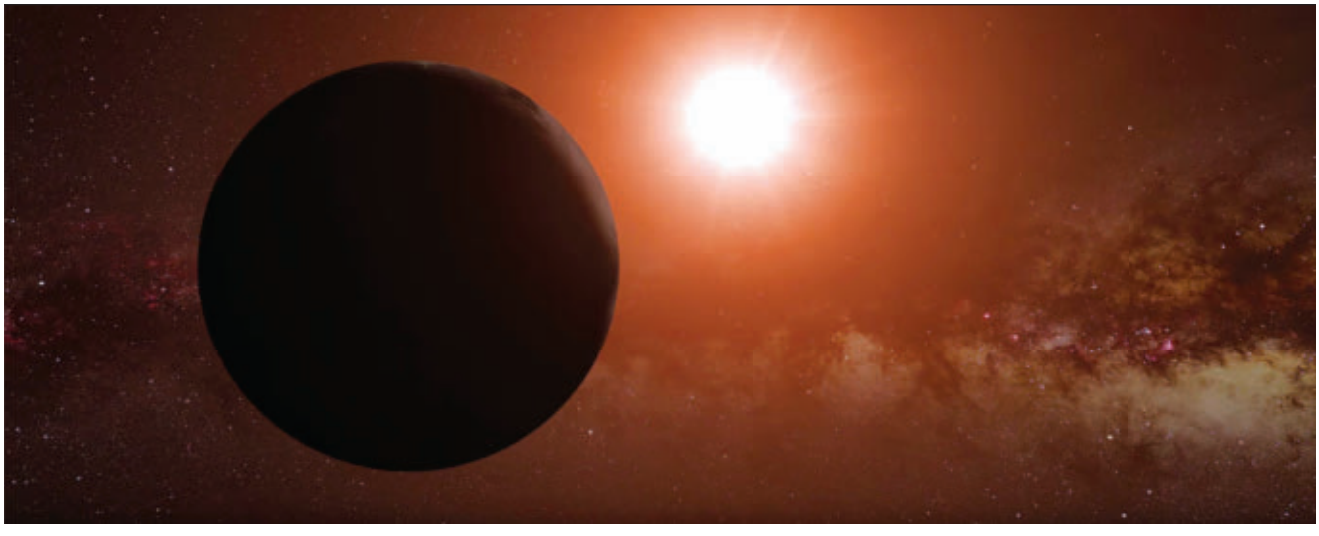
Despite what scientists have learned in 2016, there's little consolation for families already affected by microcephaly. And huge questions remain for expectant mothers. In particular, says Spong, it's not clear just how risky Zika infection during pregnancy really is. One study published in the *New England Journal of Medicine* in July estimated that the risk of bearing a child with microcephaly increases to somewhere between 1 and 13 percent for women infected in their first trimester.

Spong hopes that a new study will clarify things. It's called the Zika in Infants and Pregnancy Cohort Study, or ZIP, and the plan is to enroll 10,000 women in their first trimester. They'll come from Puerto Rico, as well as Brazil and other countries, Spong says, and include both infected and uninfected women.

Tracking these women through pregnancy, birth and their baby's first year of life could fill in some answers, like whether an infected pregnant woman who doesn't have symptoms is better off than one who does. It's also possible that some type of cofactor, like environmental toxins or other infections, is working with Zika to cause birth defects. Such a cofactor might explain why there have been fewer babies born with microcephaly in Colombia than expected. It's also possible that greater awareness has led to more terminated pregnancies.

"You're supposed to avoid stress when you're pregnant," Rasmussen says. "How do you avoid stress when you're thinking that your baby could have these problems related to Zika?"

In the best-case scenario, a Zika vaccine could still be a few years away. And though infection rates may be winding down in some places, in areas with seasonally high temperatures and rainfall, such as Puerto Rico, Zika could become a local fixture. Still, any scrap of new information might help. Results from ZIP and other studies won't erase the damage, but they could offer a pinprick of light following a year darkened by disease. ■



L. CALÇADA, NICK RISINGER, SKYSURVEY.ORG/ESO

Proxima b, depicted with its star in this illustration, is at least 1.3 times as massive as Earth — but that is just a minimum estimate.

Closest known exoplanet 'just' 4.24 light-years away

By Christopher Crockett

Worlds in the Alpha Centauri system — the trio of stars closest to our sun — have been a staple of science fiction for decades. From *Star Trek* to *Avatar*, writers have dreamed up exotic landscapes (and inhabitants) for interstellar explorers to encounter. Now a planet around one of those stars is no longer fiction.

In August, breathless headlines heralded the discovery of a small, potentially habitable planet orbiting Proxima Centauri, a dim red dwarf star just 4.24 light-years away (*SN: 9/17/16, p. 6*). The planet, Proxima b, isn't the first roughly Earth-mass planet discovered. It's not the first seen in a star's habitable zone, the region where temperatures are just right for liquid water. Nor is it the first found around a red dwarf, the most common type of star in the galaxy.

Proxima b got special attention for one reason: It's the closest known exoplanet to us. "This is a game changer in exoplanetary science," says Rory Barnes, an astronomer at the University of Washington in Seattle. "The fact that it's so close means we have

the opportunity to follow up on it better than any other planet discovered so far."

When it comes to interstellar distances, "so close" is still incomprehensibly far. Proxima Centauri is a roughly 40 trillion kilometer jaunt (*SN Online: 8/25/16*). The fastest spacecraft to leave Earth — the New Horizons probe that zipped past Pluto in 2015 (the mission took the top spot in *Science News*' 2015 Year in Review) — would need nearly 80,000 years to get there, traveling at its launch speed of roughly 58,000 kilometers per hour. But if Earthlings ever do venture beyond the solar system, Proxima Centauri is likely to be the first stop.

Astronomers found Proxima b by looking for a tiny wobble in the speed of its parent star, the sign of a gravitational tug from an orbiting planet. Observations from telescopes in Chile confirmed its existence. But not much is known about the planet. Researchers have determined, based on that tiny wobble, that the planet is at least 1.3 times as massive as Earth and it travels along an 11.2-day orbit. Its habitability is speculative. The planet basks in enough light to sustain liquid water, but other factors might foil the possibility of life. The planet's climate depends strongly on the characteristics of its atmosphere — if it even has one. No one knows if Proxima b has a solid surface where water could pool and critters could crawl. No one knows the planet's size. Even its mass is just a minimum estimate.

With a near-term voyage to Proxima b unlikely, the best chance to learn more about the planet might come from a transit, when a planet periodically slips between us and its sun. If the planet transits, it would block a smidgen of starlight from reaching Earth, subtly dimming Proxima Centauri. Astronomers could then estimate the size of Proxima b by measuring how much light the planet intercepts. A transit could also pin down the true mass by removing some ambiguity in the details of the planet's orbit. By considering the size of the planet and its mass, researchers could calculate the planet's density, revealing whether Proxima b is really a rocky world like Earth (as a lot of the initial news coverage jumped to proclaim) or a gassy one.

During a transit, a sliver of light would also have to pass through Proxima b's atmosphere. Molecules in the atmosphere would block specific wavelengths of starlight, allowing astronomers to deduce the chemical makeup of the atmosphere and hunt for any by-products of living organisms.

The odds of a transit are slim — there's just a 1.5 percent chance the orbit's orientation is right — and one early investigation is not promising. The Canadian Microvariability and Oscillations of Stars satellite, MOST for short, monitored Proxima Centauri for hints of a transiting planet in May 2014 and May 2015 for about 44 days and turned up nothing, astronomer David Kipping of Columbia University and colleagues reported online at arXiv.org in September.

But researchers aren't giving up yet. Several groups are keeping an eye on Proxima Centauri in the hopes of catching the telltale dip from a transit. "We should know whether there is a transit or not before the end of the year," says Guillem Anglada-Escudé, the astronomer at Queen Mary University of London who led the Proxima b discovery team. Seeing the planet directly could also reveal new details, though that is probably beyond the capability of any current or planned telescopes.

HUBBLE SPACE TELESCOPE/NASA, ESA

Astronomers are monitoring Proxima Centauri (shown in a Hubble Space Telescope image) hoping to catch a transit of Proxima b. The chance that the planet's orbit is oriented for a transit is just 1.5 percent.

Even if astronomers can't learn anything more about Proxima b, there will be plenty of other nearby worlds to study. Late in 2017, NASA plans to launch the Transiting Exoplanet Survey Satellite, or TESS, a telescope on a two-year mission to monitor about 200,000 stars for transiting exoplanets. Many of these stars are among the sun's closest neighbors.

Astronomers estimate that TESS will turn up about 1,700 worlds in addition to the more than 3,500 already discovered. That haul could include more than 500 planets less than twice the size of Earth, roughly 50 of which might lie within the habitable zone of their stars, Peter Sullivan, now an engineer at NASA's Jet Propulsion Laboratory in Pasadena, Calif., and colleagues reported in 2015 in the *Astrophysical Journal*. And because TESS will add only transiting planets, many will be ripe for follow-up investigations by future observatories such as the James Webb Space Telescope, which will view the cosmos in the infrared and is scheduled to launch in 2018 (*SN: 4/30/16, p. 32*).

More planets means more chances of finding life beyond the solar system. But finding aliens isn't the only goal. Astronomers want "to understand how our solar system — and how Earth — fits into the universe," Barnes says. "What's special and what's not special about our solar system?"

And interstellar travel will continue to capture imaginations. In the 1935 short story *Proxima Centauri*, published just 18 years after astronomers measured the distance to the star, Murray Leinster wrote of Earth's first interstellar spaceship closing in on an imagined planet orbiting our stellar neighbor. In Leinster's story, an alien race of mobile carnivorous plants ends up devouring most of the crew. Hopefully our first ambassadors to an exoplanet, whether Proxima b or elsewhere, will fare better. ■

Birth of 'three-parent baby' prompts hope and concern

By Tina Hesman Saey

A "three-parent baby" was born in April, the world's first reported birth from a controversial technique designed to prevent mitochondrial diseases from passing from mother to child.

"As far as we can tell, the baby is normal and free of disease," says Andrew R. La Barbera, chief scientific officer of the American Society for Reproductive Medicine. "This demonstrates that, in point of fact, the procedure works."

The baby boy carries DNA not only from his mother and father but also from an egg donor, raising both safety and ethical concerns. In particular, people worry that alterations of the genetic makeup of future generations won't stop with preventing diseases but could lead to genetically enhanced "designer babies."

Opponents, such as Marcy Darnovsky, executive director of the Center for Genetics and Society in Berkeley, Calif., are also worried that the technique hasn't been fully tested. "We wish the baby and family well, and hope the baby stays healthy," Darnovsky says. "But I have a lot of concerns about this child and about future efforts to use these techniques before they've been shown to be safe."

About one in 4,000 children are born with dysfunctional mitochondria. These energy-generating organelles are inherited from the mother and have their own DNA. Mutations in some of the 37 mitochondrial genes can lead to fatal diseases, often affecting energy-hungry organs such as the brain and muscles. Because there is no cure or effective treatment for many mitochondrial diseases, the recent birth has been heralded as a sign of new hope for affected families.

Even if women don't have mitochondrial diseases themselves, they can pass the diseases to their children if their egg cells contain large numbers of defective mitochondria. The mother of the recent three-parent baby had previously had two children who died of Leigh syndrome, a mitochondrial disease that affects the nervous system and eventually prevents a person from breathing.

Fertility doctor John Zhang of the New Hope Fertility Center in New York City and colleagues performed what's called a spindle transfer to put all the chromosomes from the mother's egg into a donor egg that contained healthy mitochondria but had been emptied of its chromosomes (*SN Online: 10/18/16*). The egg was then fertilized with sperm and implanted in the mother.

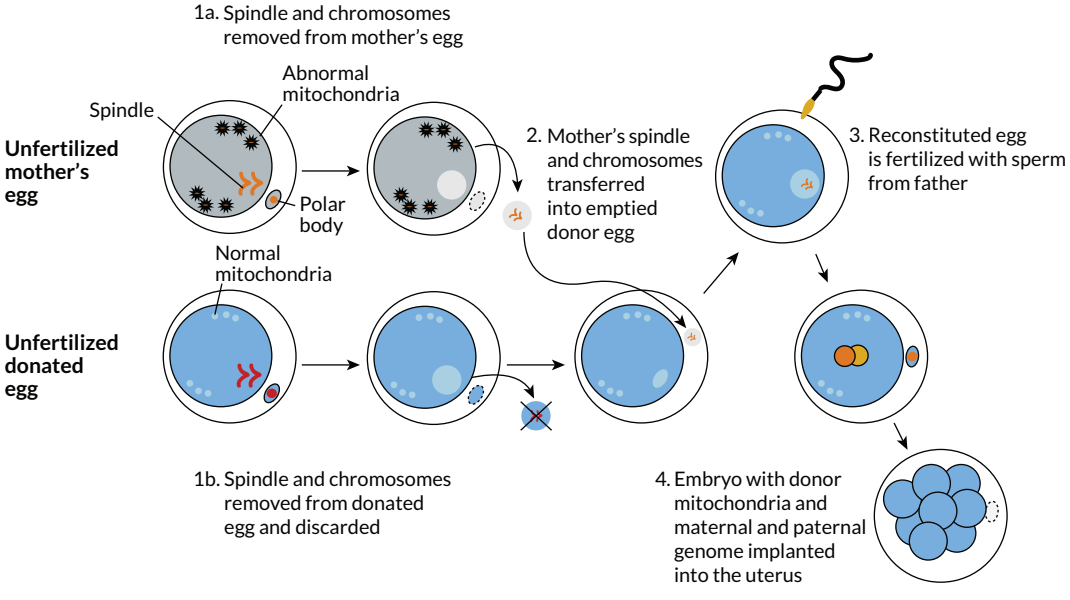
"It's very important that they follow up," to monitor the child's long-term health, says Shoukhrat Mitalipov, a mitochondrial biologist at Oregon Health & Science University in Portland. Mitalipov pioneered the spindle transfer technique in monkeys (*SN: 9/26/09, p. 8*). Even a small number of defective mitochondria carried over from the mother's egg may replicate and cause problems later on, he and other scientists have found (*SN: 6/25/16, p. 8; SN Online: 11/30/16*).

Zhang reported that just 1.6 percent of the baby boy's mitochondrial DNA came from his mother (*SN Online: 10/19/16*). Mitalipov notes, however, that doctors can't know from sampling a few types of tissue whether other tissues have different levels of mitochondrial carryover. What's more, levels of mutant mitochondria may change as the child grows.

Mitalipov supports research on the technique but says it should be done in carefully controlled clinical trials. Results

Cell swap

A baby boy born in April has DNA from three people. To produce the embryo, researchers transferred the chromosomes from the mother's egg into a donor egg with healthy mitochondria. The technique is called "spindle transfer" for the cellular structure that segregates the chromosomes.



T. TIBBITTS

SOURCE: THIRD SCIENTIFIC REVIEW OF THE SAFETY AND EFFICACY OF METHODS TO AVOID MITOCHONDRIAL DISEASE THROUGH ASSISTED CONCEPTION, HUMAN FERTILISATION AND EMBRYOLOGY AUTHORITY, JUNE 2014

of a mouse study published in July suggest that mismatches between the parents' nuclear DNA and the donor mitochondrial DNA could affect metabolism and aging (*SN: 8/6/16, p. 8*). Those effects could show up years or decades after birth.

The baby boy born in April is technically not the first three-parent baby. At least two children born in the late 1990s carry mitochondrial DNA from a donor. Those two and 15 other children were born to mothers who had a small amount of cytoplasm — the gelatinous fluid that fills cells and holds mitochondria — from a donor egg injected into their own eggs in an effort to improve results of in vitro fertilization. No major health problems have been reported, but the studies were abandoned because of ethical concerns, lack of funding and the difficulties in obtaining newly required permits.

La Barbera disputes the term "three-parent baby" entirely. "A person's essence as a human being comes from their nuclear genetic material, not their mitochondrial genetic material," La Barbera says. Children who are born after mitochondrial transfer procedures have only two parents, he contends.

Zhang drew fire for going to Mexico to perform the procedure. Congress currently bars the U.S. Food and Drug Administration from reviewing applications to make heritable changes in human embryos, which includes the spindle transfer technique. A panel of experts said in February that it is ethical to make three-parent baby boys (*SN Online: 2/3/16*), a provision that would prevent future generations from inheriting the donor mitochondria. Because mothers pass mitochondria on to their babies but fathers usually do not, technically baby boys born through this technique don't carry an inheritable modification in their DNA.

Clinics in the United Kingdom can legally perform the procedures, but none have been reported yet. A panel of experts there recommended November 30 that clinical studies could move ahead, so more babies may be born in 2017. ■

Opening Arctic passageways will shake up ecosystems

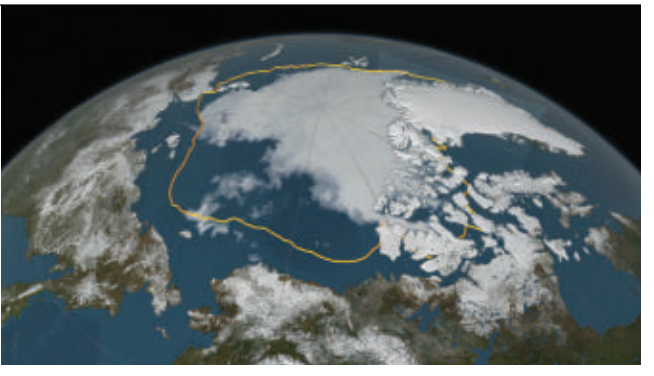
By Susan Milius

5 In a better world, it would be the big news of the year just to report that Arctic sea ice shrank to 4.14 million square kilometers this summer, well below the 1981–2010 average of 6.22 million square kilometers (*SN Online: 9/19/16*). But in this world of changing climate, extreme summer ice loss has become almost expected. More novel in 2016 were glimpses of the complex biological consequences of melting at the poles and the opening of Arctic passageways, talked about for at least a decade and now well under way.

With top-of-the-world trade and tourist shortcuts opening, less ice means more travel. Europe-to-Asia shipping routes will typically shorten by about 10 days by midcentury, a report in *Geophysical Research Letters* predicted. Hopes for Northwest Passage routes obsessed (and killed) explorers in previous centuries, but in 2016, the thousand-passenger cruise ship *Crystal Serenity* offered the first megascale tourist trip from Alaska to New York with fine dining, casino gambling and an escort icebreaker vessel.

Biologists are delving into consequences for organisms other than human tourists — or the much-discussed polar bear. "There's been a marked shift in the research community," says climate change ecologist Eric Post of the University of California, Davis. There's new interest in considering more than just species that dwell on sea ice, with researchers looking for the less direct effects of declining ice (see Page 15).

In the February *Global Change Biology*, eight scientists issued a call for observations of what could be early signs of faunal exchange: the mingling of Atlantic and Pacific species. One possible indicator is the sighting of gray whales off the coast of Namibia and also off Israel, even though that species went extinct in the Atlantic two centuries ago. These whales feed by snouting around in soft ocean bottoms, adding another predator to the system but also creating new habitat opportunities for some creatures (*SN: 1/23/16, p. 14*).



Polar melting Arctic sea ice hit its annual low on September 10, extending just 4.14 million square kilometers (shown). Though it didn't break a record, this minimum is more than 2 million square kilometers less than the average minimum from 1981 to 2010 (outlined in yellow).

C. STARR/NASA GODDARD'S SCIENTIFIC VISUALIZATION STUDIO

Since the call was published, biodiversity scientist Seabird McKeon of Colby College in Waterville, Maine, has heard new reports, such as a sighting of an ancient murrelet off the coast of Maine. It's not the first wrong-coast report for the bird, which typically resides in the northern Pacific, but repeat sightings could be important, too. "What I think we're seeing is not just new species coming across, but also perhaps an increased chance of survival and reproduction if more come over," McKeon says. He is hoping to get new data from the online Encyclopedia of Life's upcoming Fresh Data system, which connects scientists to people reporting nature observations.

For terrestrial northerners, melting ice often means loss of mobility. Peary caribou on the 36,000 or more islands of Canada's northern archipelago occasionally use ice bridges to travel to new territories and mix genes with other populations.

Yet ice losses since 1979 have made it some 15 percent harder to find traveling paths, researchers reported in September in *Biology Letters* (*SN: 10/29/16, p. 8*).

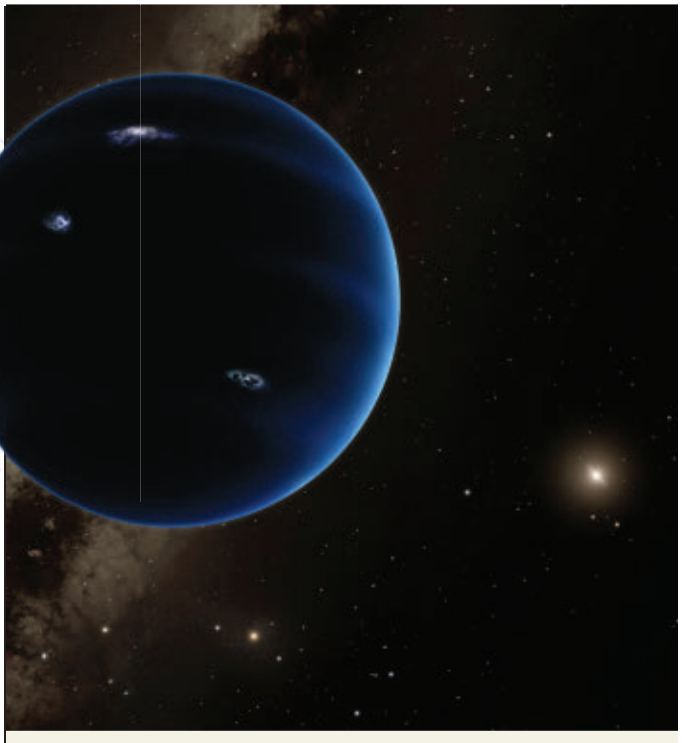
Even some plants such as dwarf birch probably travel by ice, scientists also reported in September in *Biology Letters*. Reconstructing long-ago sea ice extent and plant colonization dates suggests that seeds hitchhiked on slowly creeping frozen conveyors around northern Europe to colonize new territory at the end of the Ice Age. Losing ice roads could lead to tattered, disconnected populations as recolonization becomes less likely. Yet, there are pluses and minuses, says Post, who is helping to develop a package of scientific articles for *Biology Letters* on the biological effects of sea ice loss. Reseeding populations after a wipeout could be more difficult with tattered ice, but for the highly specialized and vulnerable plants very far north, the loss of sea ice could slow the arrival of invasive species that threaten the natives.

The minimum summer sea ice extent since 1979 has declined by about 87,000 square kilometers per year, equivalent to an area more than three times the size of New Jersey disappearing annually, as Post has put it. The September 2016 sea ice minimum didn't break a record, as some had expected it might. It tied for second worst, behind the 2012 minimum, and roughly equaled the 2007 minimum. 2016 did set a new record low for winter Arctic ice extent (*SN Online: 3/28/16*).

Sea ice changes reverberate through the ecosystem. Ice melting cues the springtime phytoplankton blooms that feed copepods and other tiny marine grazers. The grazers feed their predators and, in turn, the predators of those predators. In years when spring warming brings an early ice retreat, the phytoplankton bloom is not a huge, rich burst. It favors smaller grazing zooplankton that don't fuel as much of a boom in their predators, marine ecologist Martin Renner of Homer, Alaska, and colleagues reported in a paper for the *Biology Letters* special collection.

Tracing the effects of shrinking ice through these grazers to fish to seabirds revealed a tangled web of ups and downs and shifting foraging grounds. In the end, Renner and colleagues predict "a very different eastern Bering Sea ecosystem and fishery than we know today." And that may be far from the only sea change in the far north. ■

The melting of Arctic ice could affect seed dispersal among plants, such as the dwarf birch (shown here in Greenland).



Big if true

These findings would have rocked the scientific world, if only the evidence had been more convincing.

New Planet 9 clues

A giant planet lurking at the outskirts of the solar system could explain the odd orbits of far-flung hunks of icy debris (*SN: 2/20/16, p. 6*). If the planet (illustrated above) exists, its average distance from the sun would be between 500 and 600 times Earth's distance (*SN: 7/23/16, p. 7*).

Signs of ancient life

Mounds of minerals discovered in Greenland appear to have been deposited by clusters of microbes 3.7 billion years ago. If so, these stromatolites represent the oldest fossilized evidence of life on Earth (*SN: 10/1/16, p. 7*).

Lucy's big fall

A controversial study claims that Lucy, the most famous fossil in the study of human evolution, died after falling from high up in a tree (*SN: 9/17/16, p. 16*). The autopsy supports the hypothesis that *Australopithecus afarensis* split its time between the ground and the trees.

Nucleus with no charge

Researchers have spotted signs of a "tetraneutron," an atomic nucleus with four neutrons but no protons (*SN: 3/5/16, p. 10*). If confirmed, this first-of-its-kind nucleus might be explained by a new, interneutron force. — *Cassie Martin*

FROM TOP: R. HURT/IPAC, CALTECH; KIM HANSEN/WIKIMEDIA COMMONS (CC BY SA-2.5)

Genetics alone won't explain how humans left Africa

By Bruce Bower

No paper or digital trails document ancient humans' journey out of Africa to points around the globe. Fortunately, those intrepid travelers left a DNA trail. Genetic studies released in 2016 put a new molecular spin on humans' long-ago migrations. These investigations also underscore the long trek ahead for scientists trying to reconstruct Stone Age road trips.

"I'm beginning to suspect that the ancient out-of-Africa process was complex, involving several migrations and subsequent extinctions," says evolutionary geneticist Carles Lalueza-Fox of the Institute of Evolutionary Biology in Barcelona.

Untangling those comings, goings and dead ends increasingly looks like a collaborative job for related lines of evolutionary research — comparisons of DNA differences across populations of present-day people, DNA samples retrieved from the bones of ancient hominids, archaeological evidence, fossil finds and studies of ancient climates. It's still hard to say when the clouds will part and a clear picture of humankind's journey out of Africa will appear. Consider four papers published in October that featured intriguing and sometimes contradictory results.

Three new studies expanded the list of present-day populations whose DNA has been analyzed. The results suggest that most non-Africans have inherited genes from people who left Africa in a single pulse between about 75,000 and 50,000 years ago (*SN: 10/15/16, p. 6*). One team, studying DNA from 142 distinct human populations, proposed that African migrants interbred with Neandertals in the Middle East before splitting into groups that headed into Europe or Asia. Other scientists whose dataset included 148 populations concluded that a big move out of Africa during that time period erased most genetic traces of a smaller exodus around 120,000 years ago. A third paper found that aboriginal Australians and New Guinea's native Papuans descend from a distinctive mix of Eurasian populations that, like ancestors of other living non-Africans, trace back to Africans who left their homeland around 72,000 years ago.

MICHAL KNITL/SHUTTERSTOCK

Recent genetic analyses suggest that natives of Papua New Guinea, shown here during a traditional Enga cultural show in 2015, descend from people who left their African homeland some 72,000 years ago.

The timing of those migrations may be off, however. A fourth study, based on climate and sea level data, identified the period from 72,000 to 60,000 years ago as a time when deserts largely blocked travel out of Africa. Computer models suggested several favorable periods for intercontinental travel, including one starting around 59,000 years ago. But archaeological finds suggest that humans had already spread across Asia by that time.

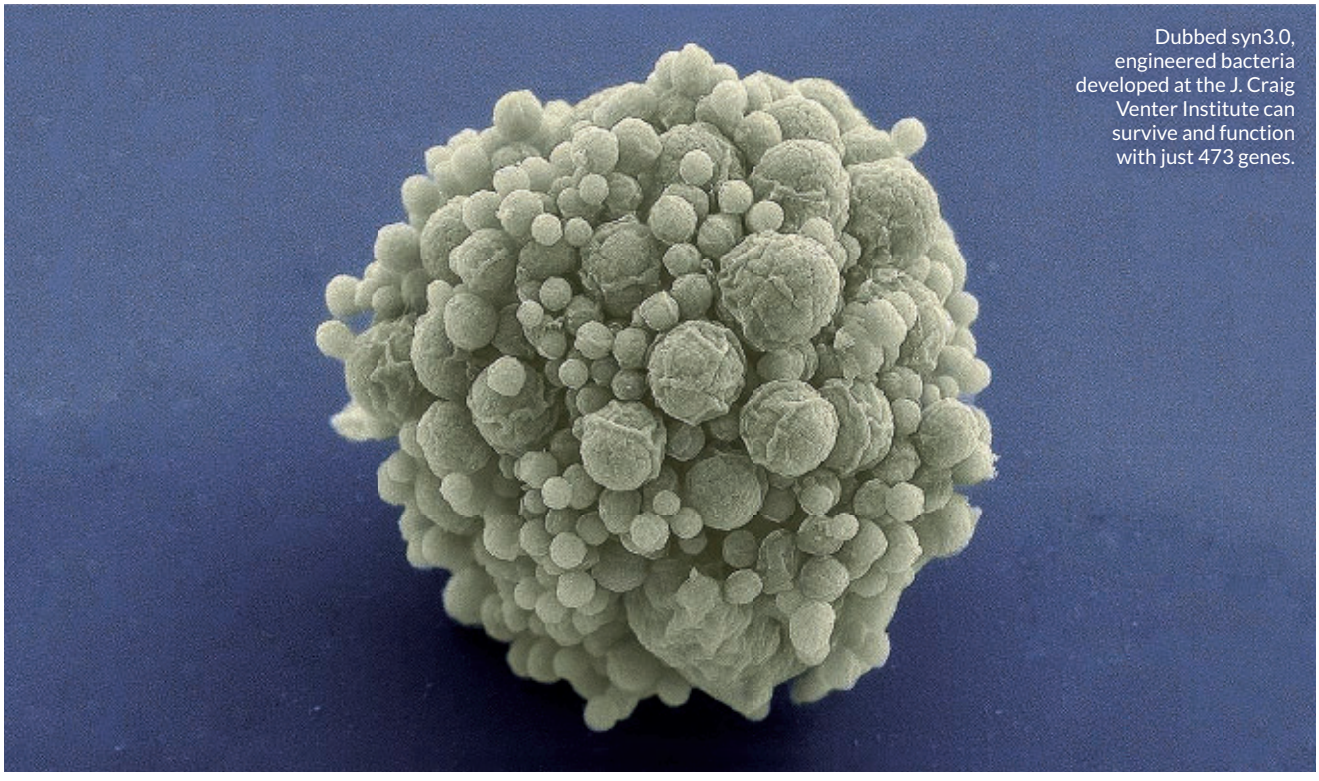
Clashing estimates of when ancient people left Africa should come as no surprise. To gauge the timing of these migrations, scientists have to choose a rate at which changes in DNA accumulate over time. Evolutionary geneticist Swapan Mallick of Harvard Medical School and the other authors of one of the new genetics papers say that the actual mutation rate could be 30 percent higher or lower than the mutation rate they used. Undetermined levels of interbreeding with now-extinct hominid species other than Neandertals may also complicate efforts to retrace humankind's genetic history (*SN: 10/15/16, p. 22*), as would mating between Africans and populations that made return trips.

"This can be clarified, to some extent, with genetic data from ancient people involved in out-of-Africa migrations," says Lalueza-Fox. So far, though, no such data exist.

The uncertainty highlights the need for more archaeological evidence. Though sites exist in Africa and Europe dating from more than 100,000 years ago to 10,000 years ago, little is known about human excursions into the Arabian Peninsula and the rest of Asia. Uncovering more bones, tools and cultural objects will help fill in the picture of how humans traveled, and what key evolutionary transitions occurred along the way.

Mallick's team has suggested, for example, that symbolic and ritual behavior mushroomed around 50,000 years ago, in the later part of the Stone Age, due to cultural changes rather than genetic changes. Some archaeologists have proposed that genetic changes must have enabled the flourishing of personal ornaments and artifacts that might have been used in rituals. But comparisons of present-day human DNA to that of Neandertals and extinct Asian hominids called Denisovans don't support that idea. Instead, another camp argues, humans may have been capable of these behaviors some 200,000 years ago.

Nicholas Conard, an archaeologist at the University of Tübingen in Germany, approaches the findings cautiously. "I do not assume that interpretations of the genetic data are right," he says. Such reconstructions have been revised and corrected many times over the last couple of decades, which is how "a healthy scientific field moves forward," Conard adds. Collaborations connecting DNA findings to archaeological discoveries are most likely to produce unexpected insights into where we come from and who we are. ■



Dubbed syn3.0, engineered bacteria developed at the J. Craig Venter Institute can survive and function with just 473 genes.

Synthetic cell may reveal what is necessary for life

By Rachel Ehrenberg

One of biology's biggest achievements of 2016 was intentionally as small as possible: building a bacterium with only 473 genes. That pint-size genetic blueprint, the smallest for any known free-living cell, is a milestone in a decades-long effort to create an organism containing just the bare essentials necessary to exist and reproduce. Such "minimal genome" cells might eventually serve as templates for lab-made organisms that pump out medicines, make innovative chemicals for industry and agriculture, or churn out other molecules not yet imagined. The project also identified genes crucial for the microbe's survival yet largely unfamiliar to science, highlighting major gaps in researchers' grasp of life's playbook.

The newly engineered bacterium was praised as a technical triumph. In 2010, researchers at the J. Craig Venter Institute in La Jolla, Calif., had stitched together a copy of the entire genome of the bacterium *Mycoplasma mycoides* and popped it into the cell of another bacterium whose genome had been removed. But that "synthetic cell," dubbed JCVI-syn1.0, contained a full copy of an existing genome. With more than 1 million chemical building blocks of DNA, including 901 genes, it was far from minimal.

The latest version, JCVI-syn3.0, reported in March in *Science* (*SN: 4/16/16, p. 6*), has roughly half that much DNA. It's also the first cell built using human design principles: One segment of the genome has genes for various processes, such as DNA repair, grouped together rather than scattered willy-nilly. Abandoning the untidiness of evolution for a logic-driven blueprint enables a "plug and play" approach, says Daniel Gibson, a member of the JCVI team. To tinker with a metabolic process such as glycolysis, for example, "Rather than changing one gene, then another, then another, you could pop out a whole module and then pop in a new one."

Making such fundamental changes to the genome while still getting a functioning cell is noteworthy, says genome scientist George Church of Harvard University. "They could have found that, no matter what they did putting it together, it broke," Church says.

The potential of synthetic cells is enormous, says Claudia Vickers, a biotechnologist at the Australian Institute for Bioengineering and Nanotechnology in Brisbane. Scientists have succeeded in engineering existing organisms such as yeast to help make, for example, malaria drugs. Now little cellular factories designed to be highly efficient and tailored to specific tasks are within sight, Vickers says.

The techniques used to build JCVI-syn3.0, especially when considered alongside other engineering tools such as the recently developed CRISPR/Cas9 system (*SN: 9/3/16, p. 22*), are a meaningful step toward the once-distant goal of self-replicating minimachines. "It's important for the future it allows us to imagine," Vickers says.

Since announcing JCVI-syn3.0, the team has used the same engineering techniques to turn the fast-growing bacterium

MARK ELLISMAN/NATIONAL CENTER FOR IMAGING AND MICROSCOPY RESEARCH

Vibrio natriegens into a laboratory workhorse. The engineered *Vibrio* — dubbed Vmax — cuts the time it takes to do particular lab experiments in half compared with the original, Gibson says.

The minimal genome effort also aims at a larger philosophical question: What is life? In a lecture in 1984, origin-of-life expert Harold Morowitz discussed how studying the small and simple *Mycoplasma* genome might invigorate basic biology in much the way that studying the hydrogen atom sharpened questions for physics and chemistry. (Morowitz died in March, two days before the JCVI-syn3.0 work was published online.)

Many scientists, for example, were stunned to learn that JCVI-syn3.0 had 65 genes with no known function that were nevertheless required for survival. "This is one of our best studied organisms, and we haven't the foggiest idea what those genes are doing," says evolutionary genomics expert Laurence Hurst of the University of Bath in England. "It's a brilliant result." ■

Promising Alzheimer's drug will test amyloid hypothesis

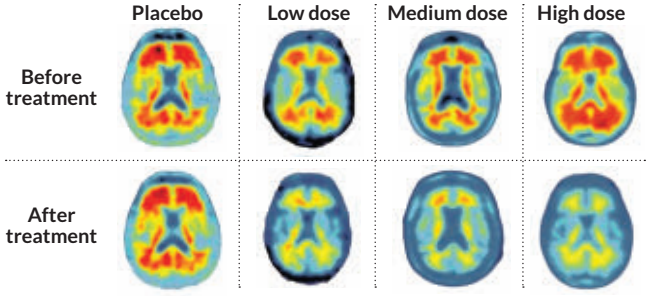
By Laura Sanders

A quarter century after scientists proposed an idea that profoundly influenced the arc of Alzheimer's research, they might finally find out whether they are correct. A new antibody drug called aducanumab appears to sweep the brain clean of sticky amyloid-beta protein. The drug may or may not become a breakthrough Alzheimer's treatment — it's too soon to say — but either way it will probably answer a key question: Have researchers been aiming at the right target?

According to the proposal, called the amyloid hypothesis, Alzheimer's disease, estimated to affect more than 5 million people in the United States alone, is caused by abnormal buildup of A-beta protein in the brain. The buildup chokes vital brain areas and destroys nerve cells. Despite amassing much support in recent decades, the proposal hasn't managed to shake off its detractors. Aducanumab offers a seemingly reliable and safe way to lower A-beta levels and thus test the amyloid hypothesis.

Over the course of a year, aducanumab entered the brains of people with early Alzheimer's disease and cleared out the A-beta, scientists reported in September in *Nature* (*SN: 10/1/16, p. 6*). The trial was small — only 165 people. Yet in these people's brains, amyloid-beta clearly declined. The higher the dose, the more A-beta cleanup.

There were hints that people on higher doses of the drug had cognitive improvements, too. If confirmed in larger studies, those cognitive benefits "would be a game changer for the field," says Alzheimer's researcher Eric Reiman of the Banner Alzheimer's Institute in Phoenix. But those results "need to be treated agnostically for now," at least until the larger studies currently under way are completed, he cautions.



J. SEVIGNY ET AL/NATURE 2016

Plaques begone In a small trial of the experimental Alzheimer's drug aducanumab, brain scans of people receiving the drug showed reductions in amyloid-beta plaques (red). Larger trials are now testing the drug in over 2,000 participants to look for signs of mental improvement.

There is already strong evidence that A-beta is a disease culprit: Rare genetic mutations in genes related to A-beta almost always come with Alzheimer's, an observation that has been confirmed in mice. A-beta is toxic to nerve cells in dishes, damaging their communication abilities before eventually killing the cells outright. "All the basic science work and natural history work supports it," says neuroscientist John Hardy of University College London, who is among those who proposed the amyloid hypothesis.

Yet contradictions exist. Cognitively healthy people have been found with A-beta accumulation in their brain (*SN: 12/10/16, p. 13*). And so far, scientists have found only a weak correlation between A-beta plaques and cognition, results that have led some scientists to look elsewhere — to inflammation, overzealous pruning of brain cell connections called synapses and changes to the protein tau, which is known to accumulate inside nerve cells in people with Alzheimer's. Each of these cellular processes has also been implicated as a driver of the disease.

Identifying the true cause of Alzheimer's is difficult because all of these processes are closely related and occur simultaneously, making it nearly impossible to study their effects in isolation. What's more, many of the key changes might happen years, or even decades, before symptoms begin to appear. Hardy concedes that in the years since he and others introduced the amyloid hypothesis, scientists have struggled to put together a full picture of Alzheimer's. "It is tougher than we all thought it would be," he says.

There won't be clear answers for several years yet. In August of 2015, larger clinical trials of aducanumab began enrolling patients around the world with the goal of finishing by 2022. As more people with Alzheimer's are tested, researchers hope to see obvious signs of mental improvement that track reductions in brain A-beta. It's possible that aducanumab will lower A-beta in the brain yet fail to bring meaningful improvements in symptoms. Such a result might appear to be a strike against the amyloid hypothesis, a contradiction that could prod some researchers to explore other ideas more deeply. Either way, people with Alzheimer's and their loved ones are waiting anxiously. ■

9 Antarctic ozone hole officially on the mend

By Alexandra Witze

In a rare bright spot for global environmental news, atmospheric scientists reported in 2016 that the ozone hole that forms annually over Antarctica is beginning to heal. Their data nail the case that the Montreal Protocol, the international treaty drawn up in 1987 to limit the use of ozone-destroying chemicals, is working.

The Antarctic ozone hole forms every Southern Hemisphere spring, when chemical reactions involving chlorine and bromine break apart the oxygen atoms that make up ozone molecules. Less protective ozone means that more ultraviolet radiation reaches Earth, where it can damage DNA and lead to higher rates of skin cancer, among other threats.

The Montreal Protocol cut back drastically on the manufacture of ozone-destroying compounds such as chlorofluorocarbons, or CFCs, which had been used in air conditioners, refrigerators and other products. It went into force in 1989 and phased out CFCs by 2010.

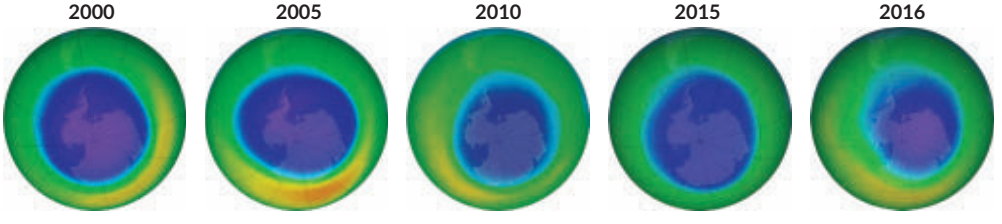
Earlier studies had hinted that the ozone hole was on the mend. The new work, reported in *Science* in June, is the most definitive yet (*SN: 7/23/16, p. 6*). A team led by Susan Solomon, an atmospheric chemist at MIT, looked not only at the month of October, when Antarctic ozone loss typically peaks, but also at September, when the hole is growing. The healing trend was most obvious in September. Satellite measurements showed that from 2000 to 2015, the average extent of the September ozone hole shrank by about 4.5 million square kilometers, to approximately 18 million square kilometers. Soundings taken by weather balloons over Antarctica confirmed the findings.

CFC concentrations peaked above Antarctica in the late 1990s and early 2000s and have been dropping ever since, says Birgit Hassler, an atmospheric chemist at Bodeker Scientific in Alexandra, New Zealand. Each passing year allows scientists to gather more convincing data. The new study, Hassler says, "makes the whole development of the Antarctic ozone hole healing very transparent and understandable."

It is a fitting capstone to Solomon's career. In the 1980s she led a team that proposed that chlorine compounds were to blame for Antarctic ozone loss. She then traveled to the frozen continent to conduct pioneering experiments that measured the accumulating chemicals there. "It's very humbling now to be 30 years later and be able to say we have a clear fingerprint that the ozone hole is starting to get better," she says.

Solomon says that public engagement was key to solving the ozone problem, with people coming together to identify an issue that threatened society and develop new technologies to fix it. In that respect, the most successful environmental treaty in history holds lessons for dealing with a much bigger threat, she says — climate change.

To fix the ozone layer, industry stopped using CFCs and similar compounds and replaced them with hydrofluorocarbons. Those chemicals, however, turned out to be powerful greenhouse gases that accelerated global warming. In October, the nations that ratified the Montreal Protocol agreed to expand it to cover hydrofluorocarbons as well (*SN: 11/26/16, p. 13*). ■



Ozone restored A study of satellite measurements over Antarctica from 2000 to 2015 found the ozone healing trend was most obvious in September. Average total ozone for Septembers, including 2016, are shown. Blue and purple indicate areas with the least ozone.

NASA OZONE WATCH

10 Computer defeats master at ancient Chinese game

By Thomas Sumner

In a hotel ballroom in Seoul, South Korea, early in 2016, a centuries-old strategy game offered a glimpse into the fantastic future of computing.

The computer program AlphaGo bested a world champion player at the Chinese board game Go, four games to one (*SN Online: 3/15/16*). The victory shocked Go players and computer gurus alike. "It happened much faster than people expected," says Stuart Russell, a computer scientist at the University of California, Berkeley. "A year before the match, people were saying that it would take another 10 years for us to reach this point."

The match was a powerful demonstration of the potential of computers that can learn from experience. Elements of artificial intelligence are already a reality, from medical diagnostics to self-driving cars (see Page 34), and computer programs can even find the fastest routes through the London Underground (*SN Online: 10/14/16*). "We don't know what the limits are," Russell says. "I'd say there's at least a decade of work just finding out the things we can do with this technology."

AlphaGo's design mimics the way human brains tackle problems and allows the program to fine-tune itself based on new experiences. The system was trained using 30 million positions

from 160,000 games of Go played by human experts. AlphaGo's creators at Google DeepMind honed the software even further by having it play games against slightly altered versions of itself, a sort of digital "survival of the fittest."

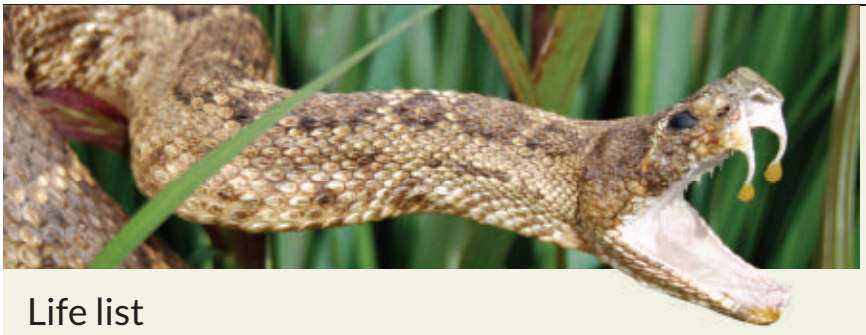
These learning experiences allowed AlphaGo to more efficiently sweat over its next move. Programs aimed at simpler games play out every single hypothetical game that could result from each available choice in a branching pattern — a brute-force approach to computing. But this technique becomes impractical for more complex games such as chess, so many chess-playing programs sample only a smaller subset of possible outcomes. That was true of Deep Blue, the computer that beat chess master Garry Kasparov in 1997.

But Go offers players many more choices than chess does. A full-sized Go board includes 361 playing spaces (compared with chess' 64), often has various "battles" taking place across the board simultaneously and can last for more moves.

AlphaGo overcomes Go's sheer complexity by drawing on its own developing knowledge to choose which moves to evaluate. This intelligent selection led to the program's surprising triumph, says computer scientist Jonathan Schaeffer of the University of Alberta in Canada. "A lot of people have put enormous effort into making small, incremental progress," says Schaeffer, who led the development of the first computer program to achieve perfect play of checkers. "Then the AlphaGo team came along and, incremental progress be damned, made this giant leap forward."

AlphaGo won four games to Lee Sedol's one in their Go matchup. Sedol, a South Korean professional player, studies the board after his third loss.

Real-world problems have complexities far exceeding those of chess or Go, but the winning strategies demonstrated in 2016 could be game changers. ■



Life list

Scientists filled in the details of some famous evolutionary tales in 2016 — and discovered a few surprises about creatures large and small.

Venom repertoire
By studying a gene family important for toxin production, researchers found that modern rattlesnakes (one above) have pared down their venom arsenal over time (*SN: 10/15/16, p. 9*). Rattlers now have a smaller repertoire of toxins, perhaps more specialized to their prey.

Stepping forward
Small tweaks to a gene that makes a protein important for skeletal development may have led to the big toe and helped shape the human foot for bipedalism (*SN: 2/6/16, p. 15*).

Surprise absence
A gut microbe collected from chinchilla droppings appears to have no mitochondria, making it the first known complex life without the supposedly universal organelle (*SN: 6/11/16, p. 14*).

Turtle power
Studies of prototurtle fossils suggest that, instead of serving as natural armor, turtle shells might have got their start by aiding in burrowing (*SN: 8/6/16, p. 15*). The idea could help explain how turtle ancestors survived a mass extinction 252 million years ago.

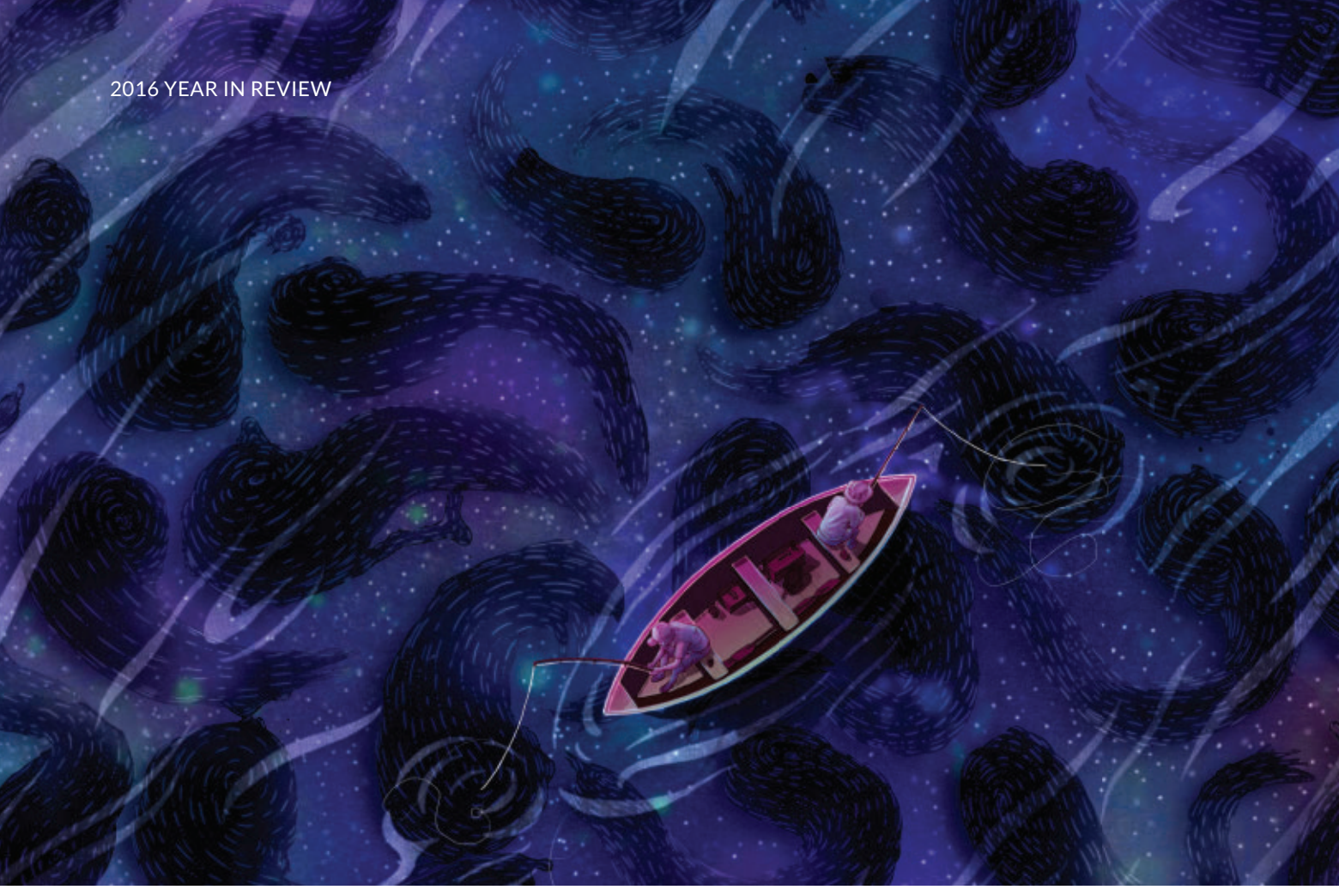
Color change
Scientists pinned down the genetic changes that, in a famous example of natural selection, made peppered moths soot-colored (*SN: 6/25/16, p. 6*).

Tall beginnings
Giraffes should thank genes that regulate embryonic development for their long necks and strong hearts (*SN: 6/11/16, p. 9*).

Evolution at speed
A study of Darwin's finches found that medium ground finches with smaller beaks survived better than big-beaked counterparts during a drought. The advantage was linked to a key gene, offering insight into the birds' speedy evolution (*SN: 5/28/16, p. 7*).

Age record
Scientists have crowned a Greenland shark as the vertebrate with the longest known life span. Their analysis suggests the predator lived to an age of 392 years (*SN: 9/17/16, p. 13*). — *Cassie Martin*

FROM TOP: LEE JIN-MAN/AP PHOTO; LIVESLOW/ISTOCKPHOTO



Double Darkness

Shadows of two failed searches loom over physics

By Tom Siegfried

Scientists, like athletes, are obsessed with experiencing the thrill of victory. Just as they fear the agony of defeat. And in the wide world of science, thrills make news much more often than the agony. Winners get the publicity, losers can't get published.

But sometimes the defeats deserve to make news too, especially when highly publicized experiments fail in their quest. Data reported in 2016 have forced physicists to face the prospect of just such a failure — not once, but twice. Dark matter, supposedly the most abundant form of mass in the cosmos, declines to show up in devices designed to detect it. And it refuses to appear in experiments constructed to make it.

For decades, physicists specializing in subatomic particles have expected to find an entirely new species of matter, a type never seen on Earth, swarming throughout the vastness of space. Galaxies rotate too rapidly and clump too closely if the only source of gravitational force is the matter that glows in visible light. Something else must be out there — an invisible, unidentified source of gravity that does not glow like stars or gas. In fact, most (roughly 85 percent) of the matter in the cosmos, astronomers have long known, must be dark.

Billions of these dark matter particles ought to be passing through your body every second. Your body wouldn't notice, but large, sophisticated detectors should record a vibration or flash of light when a dark matter particle collides with an atomic nucleus in the detecting material.

And yet such experiments repeatedly come up empty. In August and September, for instance, three search teams reported no luck detecting dark matter particles (*SN: 11/12/16, p. 14*). These

DAVID CURTIS

were just the latest disappointing reports from similar searches over the last two decades. (One search, from a detector in Italy called DAMA/Libra, does claim dark matter detection, but nobody can confirm it and hardly anybody believes it.)

Still, physicists continue the search, largely because they have a second motivation for believing that dark matter is made of a new kind of particle — a theoretical concept known as supersymmetry.

Supersymmetry appeals to physicists because it hints at ways to solve unsolved problems, such as incorporating gravity into the theory explaining other forces. It originated in physicists' efforts to understand symmetries connecting force and matter, just as Einstein had exploited symmetries of space and time to develop his theory of relativity. Supersymmetry's equations imply the existence of "superpartner" particles heavier than particles now known: a force particle partner for every known matter particle, and a matter particle partner for every known force particle. A massive superpartner should have precisely the properties needed to account for the dark matter in space; it would interact only weakly with ordinary matter, inspiring the nickname of WIMP (weakly interacting massive particle).

To many physicists, this confluence of motivations seemed sufficient justification to invoke Gibbs' Rule No. 39 (for those who watch *NCIS* on TV): There is no such thing as a coincidence. It was called the "WIMP miracle." Independently of any theoretical forecasts, astronomers had observed clear signs of a mysterious source of gravity, most likely particles unknown on Earth. Independently of gravitational anomalies in space, theorists had forecast exotic new massive particles permeating the cosmos. One reinforced the other, just as centuries ago Isaac Newton's law of gravity gained credibility because it explained both the orbits of the planets in space and falling apples on Earth.

Many physicists fully expected the world's most powerful particle collider — the Large Hadron Collider outside Geneva — to produce WIMPs. But just as direct dark matter detection experiments have failed to spot them, the LHC has reported no sign of creating them (*SN: 10/1/16, p. 12*).

There's still hope. LHC experiments might yet create superpartners; dark matter detectors might yet snatch a WIMP from the sky. It's like a football game late in the fourth quarter, says cosmologist Rocky Kolb of the University of Chicago. "The game is not over yet," he says. "The clock is ticking, but they have a couple of more years of exploration ahead."

Nevertheless this convergence of failures hints at a dual crisis in the quest to understand the cosmos. If WIMPs don't exist, two huge gaps in that understanding persist. Something else must be messing with the motion of galaxies. And something other than supersymmetry will be needed to help physicists incorporate gravity into, and solve other problems with, their standard model of particles and forces.

At a deeper level, the double failure calls into question the very strategies for success that 20th century physics established. Perhaps the power of symmetry principles to reveal nature's secrets has been drained, and a novel insight into how to pry secrets from nature awaits discovery. And the confidence provided by converging motivations may turn out to be more like wishful thinking than rigorous reasoning. Advocates of a multiplicity of universes, for instance, cite two independent arguments: One, that the best theory for explaining the observed universe implies the existence of others; two, that mathematical formulations (embodied in superstring theory) describe a vast number of different potential vacuum states. Those many states can be interpreted as descriptions of multiple universes. But the dual dark matter failures would suggest that convergent motivations are no guarantee of correctness. Reasoning based on Rule 39 might not be so solid.

So maybe something extraordinarily revolutionary is lurking behind today's failures. Or maybe not. The dark source of gravity distorting the motion of galaxies might simply be particles other than WIMPs — perhaps a very light, wispy hypothetical particle called the axion. Or it might consist of black holes littered in and around galaxies.

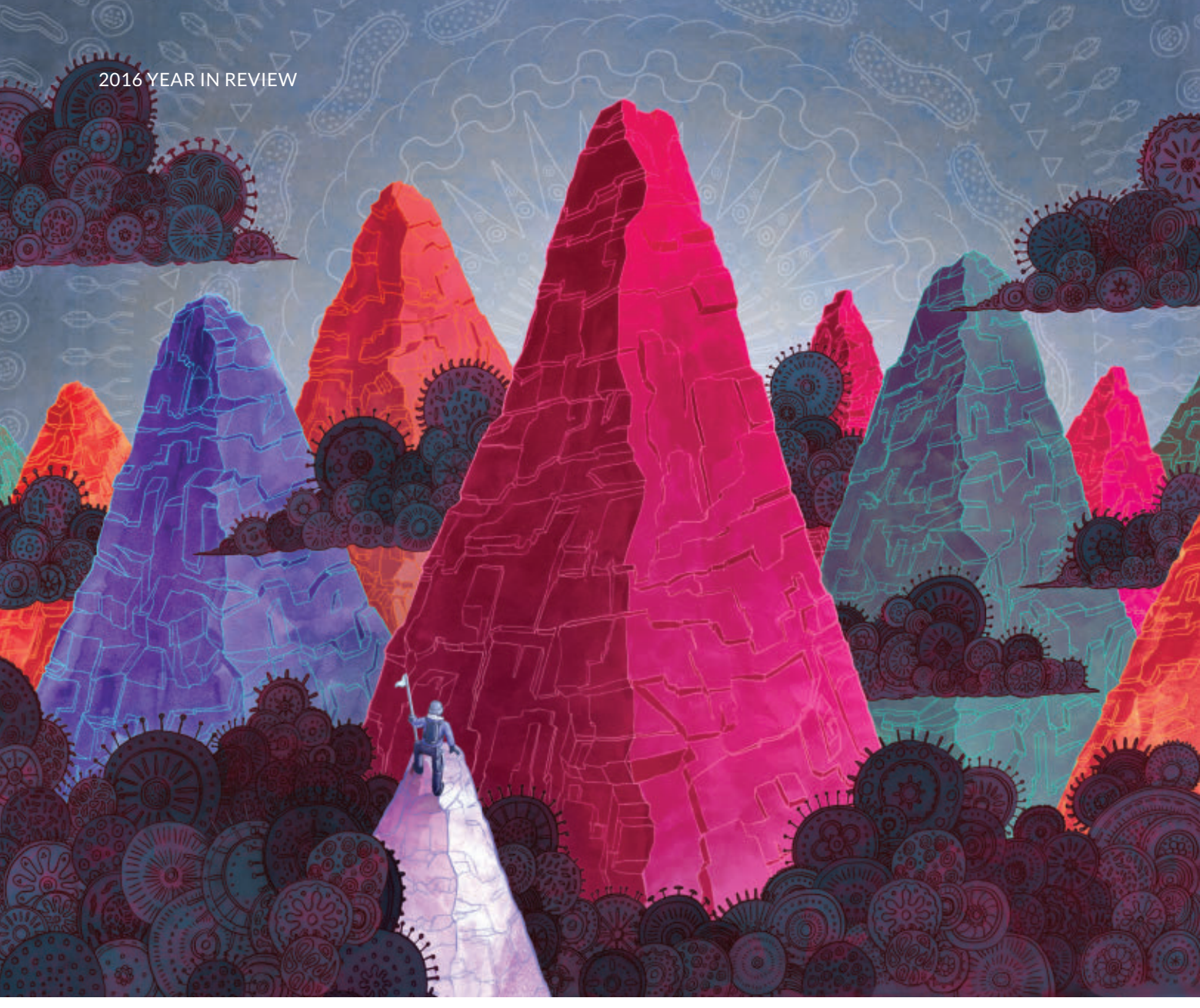
In any event, failure to find or make dark matter particles does avoid one snafu that Kolb had worried about.

"Five years ago, I was concerned that we would have indications of new physics from LHC and different signals from direct detection experiments, and we would be in a period of confusion trying to reconcile the signals," he says. "Well, we don't have that problem." ■

> "The game is not over yet. The clock is ticking, but they have a couple of more years of exploration ahead."
>
> **ROCKY KOLB**

Explore more

- Gianfranco Bertone and Dan Hooper. "A history of dark matter." May 24, 2016. arXiv.org.



DAVID CURTIS

Contagions Make a Comeback

The fight against infectious diseases has entered a new era

By Sonia Shah

It was barely more than half a century ago that the Nobel Prize–winning virologist Sir Frank Macfarlane Burnet mused about the demise of contagions. "To write about infectious disease," he wrote in 1962, "is almost to write of something that has passed into history."

If only. In the past several decades, over 300 infectious pathogens have either newly emerged or emerged in new places, causing a steady drumbeat of outbreaks and global pandemic scares.

Over the course of 2016, their exploits reached a crescendo. Just as the unprecedented outbreak of Ebola in West Africa was collapsing in early 2016, the World Health Organization declared Zika virus, newly erupted in the Americas, an international public health emergency (see Page 19). What would balloon into the largest outbreak of yellow fever in Angola in 30 years had just begun. A few months later, scientists reported the just-discovered "superbug" *mcr-1* gene in microbes collected from humans and pigs in the United States (*SN Online: 5/27/16*). The gene allows bacteria to resist the last-ditch

antibiotic colistin, bringing us one step closer to a looming era of untreatable infections that would transform the practice of medicine. Its arrival presaged yet another unprecedented event: the convening of the United Nations General Assembly to consider the global problem of antibiotic-resistant bugs. It was only the fourth time over its 70-plus-year history that the assembly had been compelled to consider a health challenge. It's "huge," says University of Toronto epidemiologist David Fisman.

But even as UN delegates arrived for their meeting in New York City in September, another dreaded infection was making headlines again. The international community's decades-long effort to end the transmission of polio had unraveled. In 2015, the WHO had declared Nigeria, one of the three last countries in the world that suffered the infection, free of wild polio. By August 2016, it was back. Millions would have to be vaccinated to keep the infection from establishing a foothold.

Three fundamental, interrelated factors fuel the microbial comeback, experts say. Across the globe, people are abandoning the countryside for life in the city, leading to rapid, unplanned urban expansions. In crowded conditions with limited access to health care and poor sanitation, pathogens like Ebola, Zika and influenza enjoy lush opportunities to spread. With more infections mingling, there are also more opportunities for pathogens to share their virulence genes.

At the same time, global demand for meat has quadrupled over the last five decades by some estimates, driving the spread of industrial livestock farming techniques that can allow benign microbes to become more virulent. The use of colistin in livestock agriculture in China, for example, has been associated with the emergence of *mcr-1*, which was first discovered during routine surveillance of food animals there. Genetic analyses suggest that siting factory farms full of chickens and pigs in proximity to wild waterfowl has played a role in the emergence of highly virulent strains of avian influenza. Crosses of Asian and North American strains of avian influenza caused the biggest outbreak of animal disease in U.S. history in 2014–2015. Containing that virus required the slaughter of nearly 50 million domesticated birds and cost over $950 million. Worryingly, some strains of avian influenza, such as H5N1, can infect humans.

The thickening blanket of carbon dioxide in the atmosphere resulting from booming populations of people and livestock provides yet another opportunity for pathogens to exploit. Scientists around the world have documented the movement of disease-carrying creatures including mosquitoes and ticks into new regions in association with newly amenable climatic conditions. Climate scientists predict range changes for bats and other animals as well. As the organisms spread into new ranges, they carry pathogens such as Ebola, Zika and *Borrelia burgdorferi* (a bacterium responsible for Lyme disease) along with them.

Since we can rarely develop drugs and vaccines fast enough to stanch the most dangerous waves of disease, early detection will be key moving forward. Researchers have developed a welter of models and pilot programs showing how environmental cues such as temperature and precipitation fluctuations and the insights of wildlife and livestock experts can help pinpoint pathogens with pandemic potential before they cause outbreaks in people. Chlorophyll signatures, a proxy for the plankton concentrations that are associated with cholera bacteria, can be detected from satellite data, potentially providing advance notice of cholera outbreaks. Even social media chatter can be helpful. Innovative financing methods, such as the World Bank's recently launched Pandemic Emergency Financing Facility — a kind of global pandemic insurance policy funded by donor countries, the reinsurance market and the World Bank — could help ensure that resources to isolate and contain new pathogens are readily available, wherever they take hold. Right now, emerging disease expert Peter Daszak points out, "we wait for epidemics to emerge and then spend billions on developing vaccines and drugs." The nonprofit organization that Daszak directs, EcoHealth Alliance, is one of a handful that instead aim to detect new pathogens at their source and proactively minimize the risk of their spread.

Burnet died in 1985, two years after the discovery of HIV, one of the first of the latest wave of new pathogens. His vision of a contagion-free society was that of a climber atop a foothill surrounded by peaks, mistakenly thinking he'd reached the summit. The challenge of surviving in a world of pathogens is far from over. In many ways, it's only just begun. ■

With more infections mingling, there are also more opportunities for one pathogen to share its virulence genes with another.

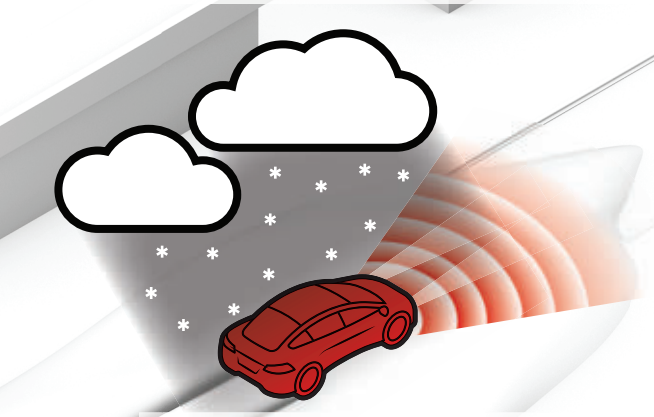
Sonia Shah is a science journalist and author. Her most recent book is Pandemic: Tracking Contagions, from Cholera to Ebola and Beyond.

The Future of Cars

Five big challenges for autonomous vehicles

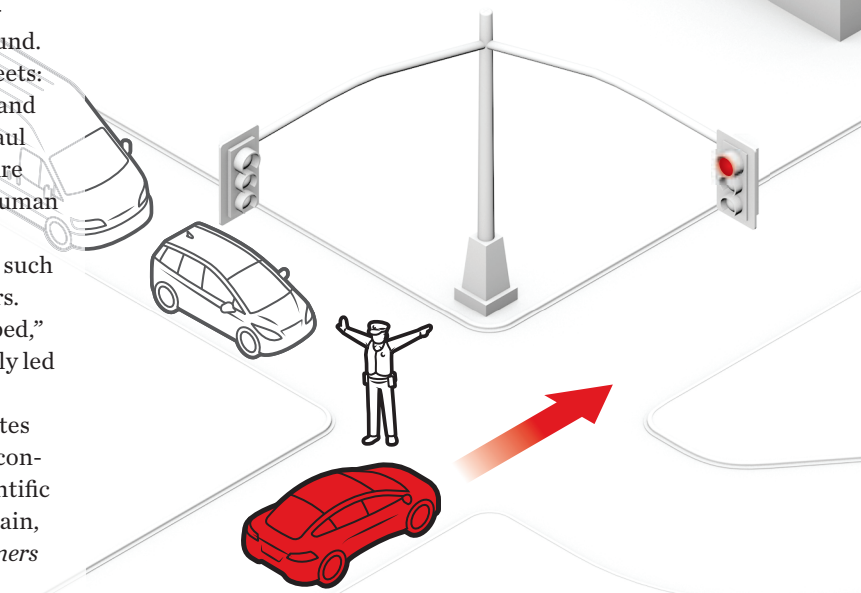
Self-driving cars promise to transform roadways. There'd be fewer traffic accidents and jams, say proponents, and greater mobility for people who can't operate a vehicle. The cars could fundamentally change the way we think about getting around. The technology is already rolling onto American streets: Uber has introduced self-driving cabs in Pittsburgh and is experimenting with self-driving trucks for long-haul commercial deliveries. Google's prototype vehicles are also roaming the roads. (In all these cases, though, human supervisors are along for the ride.) Automakers like Subaru, Toyota and Tesla are also including features such as automatic braking and guided steering on new cars. "I don't think the 'self-driving car train' can be stopped," says Sebastian Thrun, who established and previously led Google's self-driving car project.

But don't sell your minivan just yet. Thrun estimates 15 years at least before self-driving cars outnumber conventional cars; others say longer. Technical and scientific experts have weighed in on what big roadblocks remain, and how research can overcome them. — *Laurel Hamers*



SENSING THE SURROUNDINGS

To a computer, a highway on a clear day looks completely different than it does in fog or at dusk. Self-driving cars have to detect road features in all conditions, regardless of weather or lighting. "I've seen promising results for rain, but snow is a hard one," says John Leonard, a roboticist at MIT. Sensors need to be reliable, compact and reasonably priced — and paired with detailed maps so a vehicle can make sense of what it sees. Leonard is working with Toyota to help cars respond safely in variable environments, while others are using data from cars' onboard cameras to create up-to-date maps. "Modern algorithms run on data," he says. "It's their fuel."

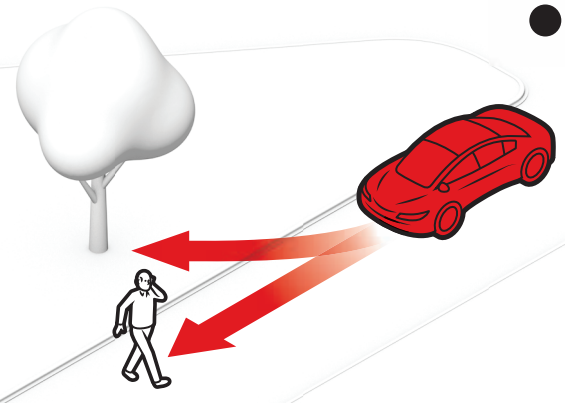


UNEXPECTED ENCOUNTERS

Self-driving cars struggle to interpret unusual situations, like a traffic officer waving vehicles through a red light. Simple rule-based programming won't always work because it's impossible to code for every scenario in advance, says Missy Cummings, who directs a Duke University robotics lab. Body language and other contextual clues help people navigate these situations, but it's challenging for a computer to tell if, for example, a kid is about to dart into the road. The car "has to be able to abstract; that's what artificial intelligence is all about," Cummings says. In a new approach, her team is investigating whether displays on the car can instead alert pedestrians to what the car is going to do. But results suggest walkers ignore the newfangled displays in favor of more old-fashioned cues — say, eyeballing the speed of the car.

HUMAN-ROBOT INTERACTION

Even with fully autonomous vehicles on the horizon, most self-driving cars will be semiautonomous for at least the foreseeable future. But figuring out who has what responsibilities at what time can be tricky. How does the car notify a passenger who has been reading or taking a nap that it's time to take over a task, and how does the car confirm that the passenger is ready to act? "In a sense, you are still concentrating on some of the driving, but you are not really driving," says Chris Janssen, a cognitive scientist at Utrecht University in the Netherlands. His lab is studying how people direct their attention in these scenarios. One effort uses EEG machines to look at how people's brains respond to an alert sound when the people are driving versus riding as a passive passenger (as they would in a self-driving car). Janssen is also interested in the best time to deliver instructions and how explicit the instructions should be.



ETHICAL DILEMMAS

In exploring the ethical questions of self-driving cars, Iyad Rahwan, an MIT cognitive scientist, has confirmed that people are selfish: "People buying these cars, they want cars that prioritize the passenger," says Rahwan — but they want other people's cars to protect pedestrians instead (*SN Online: 6/23/16*). In an online exercise called the Moral Machine, players choose whom to save in different scenarios. Does it matter if the pedestrian is an elderly woman? What if she is jaywalking? Society will need to decide what rules and regulations should govern self-driving cars. For the technology to catch on, decisions will have to incorporate moral judgments while still enticing consumers to embrace automation.

CYBERSECURITY

In 2015, hackers brought a Jeep to a halt on a St. Louis highway by wirelessly accessing its braking and steering via the onboard entertainment system. The demonstration proved that even conventional vehicles have vulnerabilities that, if exploited, could lead to accidents. Self-driving cars, which would get updates and maps through the cloud, would be at even greater risk. "The more computing permeates into everyday objects, the harder it is going to be to keep track of the vulnerabilities," says Sean Smith, a computer scientist at Dartmouth College. And while terrorists might want to crash cars, Smith can imagine other nefarious acts: For instance, hackers could disable someone's car and hold it for ransom until receiving a digital payment.

JAMES PROVOST

What's Ahead in 2017

As science journalists look back on the top stories of the year, scientists push on, asking the next questions and chasing fresh data. What big discoveries might they deliver in 2017? *Science News* writers reveal what they are watching for — and hoping for — in the year ahead. — *Elizabeth Quill*

Bruce Bower

BEHAVIORAL SCIENCES

"I look forward to seeing where the reproducibility debate goes," says Bruce Bower, referring to recent reports that many findings in psychology (and other sciences) don't hold up in repeat experiments (*SN: 4/2/16, p. 8*). Some psychology journals now publish multilab replication efforts that often challenge influential findings, such as the claim that willpower decreases the more you use it. Bower wonders whether the current hubbub over failed replications will prompt psychologists, as well as researchers in other disciplines, to experiment with new ways of doing science. "I would be lying if I said I was optimistic, but I'm ready to be proven wrong," says Bower. He believes social and cognitive psychology rely far too heavily on significance testing and too many researchers don't generate and test alternative explanations for statistically significant results. "It's a general problem of not developing and integrating theories."

As for the types of stories he looks for, Bower says he chases anything that sheds light on what makes us human — what distinguishes us from other species and what unites us, both biologically and culturally. ■

Emily Conover

PHYSICS

Emily Conover isn't yet over the discovery of gravitational waves (see Page 17), which is "still the darling of the physics world," she says. But in 2017 she'll be focused on experiments seeking "weird stuff in physics." Neutrino experiments will be searching for differences between matter and antimatter — "a big deal for how everything in the universe came to be," she says. Researchers with the dark matter experiment ADMX plan to unveil results in their latest search for the light, electrically neutral and still hypothetical axions. "People are focusing on axions because WIMPs aren't showing up" (see Page 30). And Fermilab's Muon g-2 experiment will measure the magnetic properties of the muon, a particle like an electron but much more massive. "We could get something new anytime," Conover says.

While particle physicists wait for a big find to shake up the field, researchers studying quantum materials are making steady progress. In 2017, scientists will take that quantum prowess to space. When it arrives at the International Space Station, the Cold Atom Laboratory will offer a stable and isolated environment to study quantum systems known as Bose-Einstein condensates at temperatures as low as a tenth of a billionth of a degree above absolute zero. ■

ALL PHOTOS: SSP

Christopher Crockett

ASTRONOMY

Space missions across our solar system will fill the news in 2017, says Christopher Crockett, with NASA's Juno probe building a 3-D picture of the inside of Jupiter (*SN: 6/26/16, p. 16*) and the European Space Agency's ExoMars orbiter looking for trace gases in the Red Planet's atmosphere. Cassini's mission at Saturn will be "the most fun," says Crockett. "It is the end of the mission, so the engineers are getting braver with the spacecraft." Planetary scientist Glen Stewart of the University of Colorado Boulder calls it "kamikaze" stuff. "They are taking the spacecraft to places it was never designed to go," Crockett says. "They are going to start flying close to the rings. And early in 2017, they are going to use the gravity of Titan to slip between the rings and Saturn, and will eventually dive toward the planet." The findings could fill in details of how the solar system formed and evolved.

August's solar eclipse (*SN: 8/20/16, p. 14*) will be big news, Crockett says, and the Event Horizon Telescope (*SN: 5/31/14, p. 16*) could make headlines, too. The project has linked together telescopes around the world to build a virtual radio dish as wide as Earth that could take a picture of the supermassive black hole at the center of the galaxy. "What they are trying to do is phenomenally difficult," Crockett says. "We'll see if that actually works." ■

Tina Hesman Saey

MOLECULAR BIOLOGY

"Everybody is CRISPRing everything," says Tina Hesman Saey, referring to the breakout gene editor that made headlines in 2015. There are efforts to modify chickens to produce hypoallergenic eggs and to create mushrooms that don't brown. Pigs are being developed to grow organs for transplant into people. Researchers are using CRISPR/Cas9 (*SN: 9/3/16, p. 22*) as a tool to investigate which genetic variants may cause heart disease and cancer and to learn more about how genes turn on and off.

Still more exciting developments are on the way. Clinical trials in people using CRISPR have begun and more will start in 2017 (*SN Online: 11/16/16*). "If researchers can actually make headway on curing sickle cell disease or muscular dystrophy, which has shown promise in animals, that would be amazing," Saey says. She is also anxious to see progress in making functioning gene drives, engineered DNA designed to propel itself through generations of organisms (*SN: 12/12/15, p. 16*). "What form will it take and would we dare use it? So much of my beat seems to be, 'We *can* do these things, but *should* we do them?' "

Saey also believes that there will continue to be more avian flu outbreaks and other emerging diseases. "Bats will get blamed for a lot, even though it is probably not their fault," she says. ■

Susan Milius

LIFE SCIENCES

After an exciting year in mosquito science, Susan Milius says she is "suffering through the reruns until we get to Season 2 of great mosquito research." The basic biology of these diverse insects received quite a bit of attention in 2016 because it mattered for predicting how Zika virus (see Page 19) would spread. In particular, Milius wonders how the conflicting results will sort out between U.S. labs that report that a common *Culex* mosquito can't transmit Zika and labs in China, Brazil and Canada (work still ongoing) that suggest the species can (*SN: 10/29/16, p. 13*). "Is it differences in the mosquitoes? In the viruses? What's going on?" In 2017, a long-debated pest-control test in Florida could release the first genetically modified mosquitoes to fly free-range in the United States. "We are at an interesting time in the application of biology," Milius says.

But the best stories in organismal biology are the ones you don't predict: "Given several billion years, all that mindless happenstance evolution has veered way into the improbable." She points to 2016's finding that melatonin makes midshipman fish sing (*SN: 10/29/16, p. 4*). And what's been supposedly known for years — that spiders can't hear airborne sounds from across the room (*SN: 11/12/16, p. 9*) — "can turn out to be just wonderfully wrong." ■

Meghan Rosen

GENERAL ASSIGNMENT

"The world will be keeping a close eye on Puerto Rico," says Meghan Rosen, where some 2,700 pregnant women have been infected with Zika (see Page 19). As those women give birth, researchers will learn even more about the virus and related birth defects. In the meantime, "there are a handful of vaccines beginning to be tested in humans," Rosen says (*SN: 9/3/16, p. 17*). Results of safety testing on a DNA vaccine developed by the National Institutes of Health are expected in 2017. If those data are encouraging, the vaccine could move to Phase II clinical testing. A different vaccine, which uses a purified inactivated form of Zika, also began testing late in 2016. Even with success, Rosen notes, it's unlikely a vaccine will be widely available before 2018 or 2019. "It sounds like forever," she says, "but researchers are really hustling along."

Zika is a topic "I'll want to follow for years to come," Rosen says. But she also expects to cover lighter material in 2017 — her typical territory includes dinosaurs and robots. The new journal *Science Robotics* has launched, and Rosen looks forward to developments in one area in particular: soft robots. "These squishy machines eschew the clunky mechanical bits of old-school robots, instead relying on soft materials such as silicone rubber," she says. Such robots could offer one way to safely integrate machines into people's live. ■

Laura Sanders

NEUROSCIENCE

"Our ability to figure out what the brain is doing, and to really influence it, is going to be a promising area in the coming year," says Laura Sanders. The Brain Initiative, which launched to both skepticism and excitement in 2013 (*SN: 2/22/14, p. 16*), "is rolling on and picking up steam."

Sanders will be tracking developments in new technologies, including neural dust, those miniature ultrasonic devices that recently demonstrated their ability to detect nerve activity in rats (*SN: 9/3/16, p. 10*). She's also interested in ultrasound's potential to influence neural activity, along with other approaches that work from outside the skull and so don't require brain surgery. In a dramatic example, researchers reported in 2016 that they had helped a patient recover from a minimally conscious state through low-intensity ultrasound stimulation of the thalamus. "It'll be interesting to see where that goes," Sanders says. Still, there's a long way to go between basic brain science and treatments.

Sanders — who was born in the analog age but has children who will be digital natives — is curious to find out how iPads and other digital devices are affecting kids' brains. "Deep down I'm worried about it because I think there are so many valuable aspects of face-to-face communication," she says. "The art of conversation is so different from texting." ■

Thomas Sumner

EARTH SCIENCES

"In climate news," says Thomas Sumner, "2017 is almost certainly going to be cooler than 2016." El Niño boosted global temperatures, but it has now ended — making it unlikely that 2017 will be another record breaker (*SN Online: 6/9/16*). "The last time we had a big dropdown, people started saying 'Global warming doesn't exist anymore.'" Sumner wants to be clear about the science up front: "There is natural variability. We will continue seeing temperature increases in the long run."

In a special issue in *Science News* planned for early 2017, Sumner will take readers on a geologic journey back to the dinosaurs' last days. A recent drilling expedition into the Chicxulub crater (*SN Online: 11/17/16*) is taking a shot at the long-standing, sometimes heated debate over what killed the vast majority of plant and animal species on the planet 66 million years ago. Did massive volcanic eruptions bring down the dinosaurs? Or did their end come from the fallout of an asteroid that struck Earth's surface near the Yucatán Peninsula, leaving a crater as wide as New Jersey is long. "It's a dino mass-murder whodunit," Sumner says. The drilling team will probably pin down the energy released by the collision and will study the resulting environmental consequences. New clues may offer an answer or spark a whole new round of questions. ■

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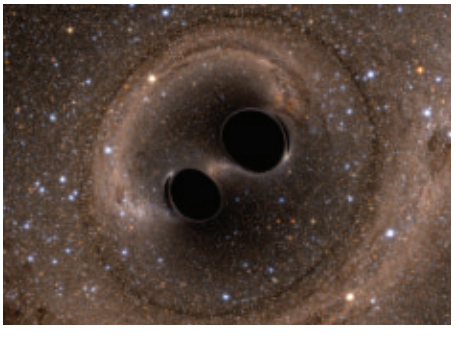
2016 Society for Science & the Public accomplishments

The Science Talent Search celebrated its 75th anniversary in 2016 by announcing its third title sponsor, Regeneron. Founded by STS alumni George Yancopoulos and Leonard Schleifer, Regeneron has committed to support STS through 2027.

In 2016, 1,700 students from more than 75 countries, regions and territories competed for more than $4 million in awards in Phoenix at the Society's annual Intel International Science and Engineering Fair.

Broadcom MASTERS welcomed 30 of the nation's top middle school students to Washington, D.C., to present their independent STEM research projects and compete for a grand prize of $25,000 to continue their research.



Science News' coverage of gravitational waves — the No. 1 news story of 2016 — and reporting on gene drives won awards from *Folio*, a publishing industry magazine. Two more features and the special issue "In Search of Aliens" received honorable mentions.

With support from Regeneron, Arconic Foundation and other sponsors, the 2016–2017 *Science News* in High Schools program is now in more than 4,000 high schools, reaching students in all 50 states, Washington D.C., the United Kingdom and Australia.

The Society launched an improved digital platform for *Science News for Students*, allowing this award-winning publication for middle schoolers to make an even larger impact by placing it on its own website and improving its design and navigation.

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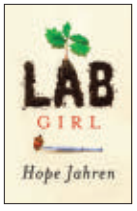
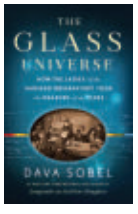
BOOKSHELF

Science News' favorite books of 2016

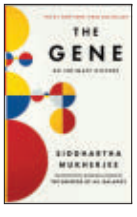
Once again, *Science News* writers and editors have reviewed the stacks of science books published this year to pick their favorites. Most of the books listed here have been reviewed previously in the magazine. Find those longer reviews at bit.ly/SN_books2016.



Lab Girl
Hope Jahren
In this engrossing memoir, a geomicrobiologist hopscotches through the exploits of her life as a scientist while revealing the hidden world of her favorite research subject: plants (*SN: 7/9/16, p. 26*). *Knopf, $26.95*

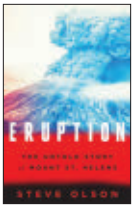


The Glass Universe
Dava Sobel
More than just "human computers," the women working at the Harvard Observatory in the late 19th and early 20th centuries contributed fundamental knowledge to astronomy, a science writer shows (*SN: 12/10/16, p. 28*). *Viking, $30*



The Gene
Siddhartha Mukherjee
Drawing on centuries of scientific research and thinking, plus his own personal family history, a physician and Pulitzer Prize–winning author traces how scientists came to understand the basic unit of heredity. *Simon & Schuster, $32*

Are We Smart Enough to Know How Smart Animals Are?
Frans de Waal
A primatologist reviews research on a range of diverse creatures, from wasps to whales, to make the case that animals possess greater intelligence than most people give them credit for. *W.W. Norton & Co., $27.95*



Eruption
Steve Olson
The 1980 eruption of Mount St. Helens was a natural disaster exacerbated by social and economic forces. A science writer explores the dynamics and offers survivors' accounts (*SN: 3/5/16, p. 28*). *W.W. Norton & Co., $27.95*

Seven Skeletons
Lydia Pyne
Filled with fascinating anecdotes, this historical look at how some of the most illustrious hominid fossils achieved worldwide fame also traces the development of the field of paleoanthropology (*SN: 9/3/16, p. 27*). *Viking, $28*

What the F
Benjamin K. Bergen
Profanity should not be a taboo subject among cognitive scientists, this book argues. Research on swearing offers insights into language and how the human mind works (*SN: 9/17/16, p. 28*). *Basic Books, $27.99*

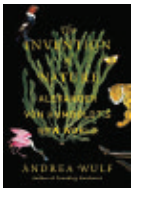
Silent Sparks
Sara Lewis
In a book that's sure to rekindle a reader's childhood fascination with fireflies, a biologist shares the secrets of these beetles' glow and explains the utility of lightning bugs to industry (*SN: 6/25/16, p. 27*). As a bonus, the book includes a firefly field guide. *Princeton Univ., $29.95*

Book awards in 2016

Science book awards this year honored best sellers as well as overlooked gems. One thing these works have in common — they're all must-reads:

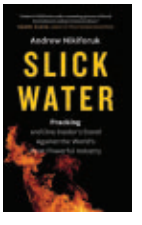
NATIONAL ACADEMIES COMMUNICATION AWARD

The Narrow Edge
Deborah Cramer
Described by the judges as a "beautifully written natural history," this book follows the epic migration of the tiny sandpiper known as the red knot and examines the big environmental threats facing this small bird. *Yale Univ., $28, 2015*



ROYAL SOCIETY INSIGHT INVESTMENT SCIENCE BOOK PRIZE

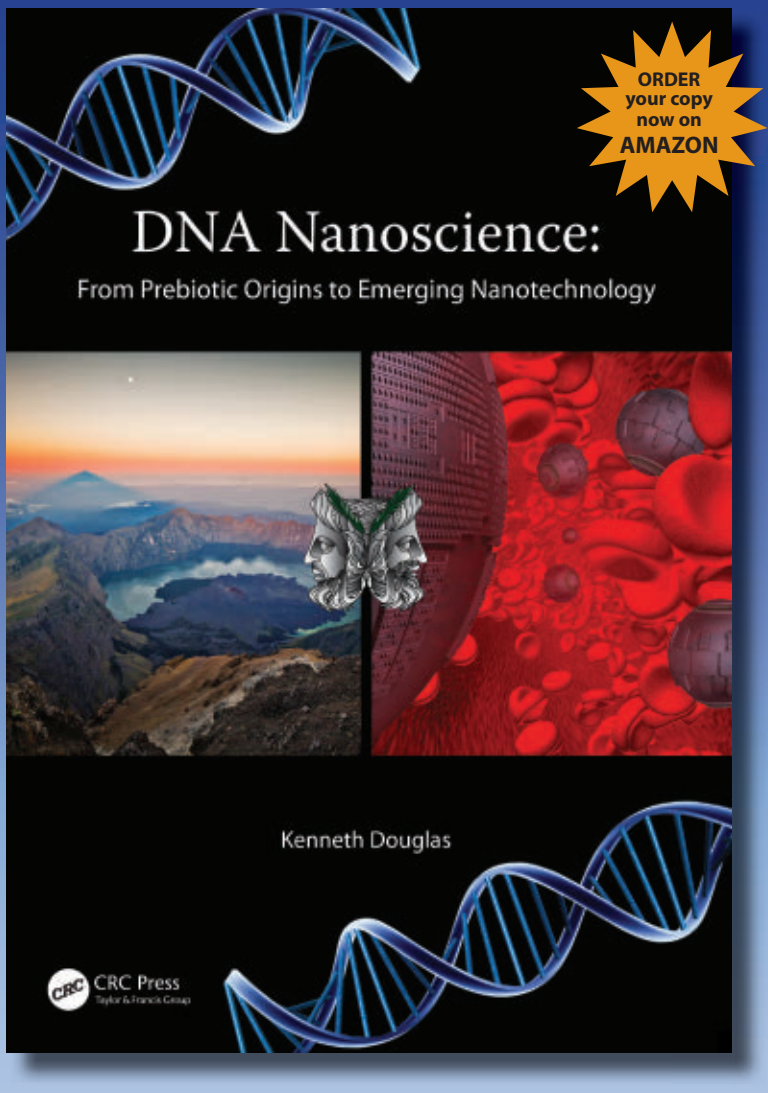
The Invention of Nature
Andrea Wulf
"A thrilling adventure story," as one prize judge called it, this biography of Alexander von Humboldt chronicles the German scientist and polymath's achievements and considers his lasting influence on scientists' understanding of the natural world. *Knopf, $30, 2015*



NATIONAL ASSOCIATION OF SCIENCE WRITERS' SCIENCE IN SOCIETY JOURNALISM AWARD

Slick Water
Andrew Nikiforuk
In this "page-turner," as the judges called it, a Canadian woman's battle against a corporation that secretly fracked gas wells near her home is the central story in a broader look at fracking and its potential environmental effects. *Greystone Books, $26.95, 2015*

Buy Books Reviews on the *Science News* website include Amazon.com links that generate funds for Society for Science & the Public programs.



Discover DNA

from ancient nanoDNA to the future of DNA nanodevices

DNA Nanoscience: From Prebiotic Origins to Emerging Nanotechnology explores two tales of DNA joined by a common motif: base complementarity. Learn about this remarkable convergence in Douglas' new book.

FEATURES

- **More than 200 full color illustrations**
- **Over 200 sidebars containing definitions and key concepts from the main text**

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DNA Nanoscience takes us on a journey into the future, where sub-microscopic gadgets built from DNA may be used to detect specific molecules one-at-a-time or to deliver therapeutic drugs specifically to cancer cells. Looking in the other direction, the journey takes us back 4 billion years to a time when the self-organization of DNA into liquid crystals may have facilitated the reproduction of what would become our genetic material, arguably the key step in the origin of life.

DNA Nanoscience is scholarly and full of technical figures. But the science is accompanied by clear explanations that make it accessible to college students and science-savvy citizens. It is a pleasure to find a book that is so true to the science while being so enjoyable to read.

—Thomas R. Cech
Distinguished Professor,
University of Colorado-Boulder;
Director, BioFrontiers Institute; Nobel Laureate
(Chemistry, 1989)

Douglas's *DNA Nanoscience* is something of a miracle.

—Stuart Kauffman
Emeritus Professor Biochemistry and Biophysics,
University of Pennsylvania; Affiliate Professor,
The Institute for Systems Biology, Seattle;
Author of *At Home in the Universe*

This book changed my life. Every seven years, as my sabbatical approaches, I search about for a new direction to focus my research and Ken Douglas' book, *DNA Nanoscience*, appeared just in time.

—Seth Fraden
Professor of Physics; Director, The Bioinspired
Soft Materials Center, Brandeis University

Author: Dr. Kenneth Douglas is a member of the research faculty in the Department of Physics at the University of Colorado–Boulder. His primary research interest is in biomimetic nanofabrication. He is co-inventor of the first-ever U.S. patents for the parallel fabrication of nanoscale multi-device structures.

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OCTOBER 29, 2016

Best of the rest

Science News published more than 100 blog posts, and overall, blogs received nearly 5 million views in 2016. Here are the most popular posts for each of our five blogs:

1. *Context*: "A new 'Einstein' equation suggests wormholes hold key to quantum gravity," by Tom Siegfried (*SN Online: 8/17/16*).
2. *Growth Curve*: "Should C-section babies get wiped down with vagina microbes?" by Laura Sanders (*SN Online: 3/30/16*).
3. *Wild Things*: "Capybaras may be poised to be Florida's next invasive rodent," by Sarah Zielinski (*SN Online: 8/12/16*).
4. *Scicurious*: "High-intensity interval training has great gains — and pain," by Bethany Brookshire (*SN Online: 1/5/16*).
5. *Culture Beaker*: "'GMO' isn't a four-letter word, but it is hard to define," by Rachel Ehrenberg (*SN Online: 2/5/16*).

Join the conversation

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Corals in crisis

*Algae that provide nutrients to corals turn toxic and lead the corals to "bleach" and sometimes die when ocean temperatures spike. Researchers are seeding damaged reefs with baby corals and breeding heat-tolerant corals to help these imperiled marine animals, **Amy McDermott** reported in "Rebuilding reefs" (*SN: 10/29/16, p. 18*).*

Ronald Swager wondered if researchers could use genetic engineering to make heat-stressed algae nontoxic.

Gene-editing tools may help corals survive, but the research is still quite preliminary, says **Janelle Thompson**, an environmental microbiologist at MIT. Among the difficulties: Scientists do not know how exactly the algae become toxic on a molecular level and they can only guess at the role of most algal genes. "One of the main challenges is the size of the [algae] genome, which ... is on par with human genomes," **Thompson** says. And there are many genetic variations of algae, some of which are only compatible with specific corals. Researchers would have to engineer more than one type of algae.

Heat-tolerant algae exist, but so far they don't seem to perform well at normal temperatures, says **Peter Harrison** of Southern Cross University in Lismore, Australia. Assuming biologists work through the technical hurdles of genetic engineering, many people will be concerned about releasing genetically modified algae into the oceans, **Harrison** says.

Codex contention

*Once regarded as fake by some scientists, a 10-page, bark-paper book called the Grolier Codex is authentic, according to a recent study by Yale archaeologist **Michael Coe** and colleagues. It may be the oldest known manuscript of ancient America, **Bruce Bower** wrote in "Maya codex real, analysis claims" (*SN: 10/29/16, p. 16*).*

Physicist and astronomer **John Carlson** of the University of Maryland in College Park took issue with the study and *Science News*' reporting. **Carlson**'s letter has been edited for brevity.

"I was dismayed to see my own published work establishing the authenticity of the Maya 'Grolier Codex' as likely the 'oldest surviving book on paper from the ancient Americas,' presented as 'new analysis' by **Michael Coe** and collaborators.

"There was no mention of the source of the most crucial evidence — the only radiocarbon dating of the codex's bark paper — nor was I contacted for comments. My work, beginning in the late 1970s (and first published in 1983), determined that what had been known as 'page 11' was actually the lower portion of 'page 10.' That finding, with other primary sources, established a sequence of skeletal Evening Star manifestations of the planet Venus, something that could not have been known to any alleged faker in the mid-1960s when the codex was discovered. This work helped convince the majority of Mesoamericanist experts in Maya epigraphy and codex studies that the codex was genuine.

"I was able to study the codex itself carefully on three occasions and obtained the first carbon-14 dates from the actual codex, placing it in the 13th century. All of this was published in my article 'The Twenty Masks of Venus' in *Archaeoastronomy* in 2014 and presented at the Pre-Columbian Society of Washington, D.C., in November 2014. The scholarly details are available along with many other primary sources on my website: umd.academia.edu/JohnBCarlson."

In an e-mail response to *Science News*, **Michael Coe** emphasizes that his team's paper credits **Carlson** for his work on the Grolier Codex. **Coe** says that even by 1973, well before **Carlson**'s publications appeared, specialists in Maya writing were convinced that the codex was genuine. The new paper for the first time examines the full range of drawings and writings in the codex, **Coe** asserts, fitting them in with what's now known about ancient Maya religion and gods.

TENURE-TRACK POSITIONS IN PHARMACEUTICAL SCIENCES

The Department of Pharmaceutical Sciences seeks applications for up to four (4) full-time, tenure-track assistant or associate professor positions from individuals with a Ph.D, M.D., or equivalent degree and a strong history of scholarly productivity and a commitment to both research and teaching (at the professional [Pharm.D.] and graduate level) in the pharmaceutical sciences.

Applicants with postdoctoral training and current extramural funding in the broadly defined areas of immunology, biotechnology and molecular pharmacology are especially preferred. The successful applicants are expected to teach in the Doctor of Pharmacy program and establish an innovative, robust, externally-funded research program that addresses significant biomedical questions related to the Pharmaceutical Sciences. Faculty in the department engage in teaching, research and service, and the successful candidates will participate in outstanding graduate training programs (MS and PhD candidates) in Medicinal Chemistry, Pharmaceutics and Pharmacodynamics. The successful candidates will have excellent opportunities to develop collaborative interactions with the School's Moulder Center for Drug Discovery Research, the Proteomics facility, the Jayne Haines Center for Pharmacogenomics and Drug Safety, and the Current Good Manufacturing Practices Facility as well as, research institutes / centers and departments within Temple University.

Applicants must provide a cover letter, curriculum vitae, statements of research plans and teaching philosophy along with contact information for three references to: Daniel J. Canney, Ph.D., Chair, Department of Pharmaceutical Sciences, Temple University School of Pharmacy, care of Janet Malkowski, 3307 N. Broad St., Philadelphia, PA 19140.

Electronic submissions supplied as a single pdf file will be accepted at jmalko@temple.edu.

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Reusable rockets' red glare

The era of reusable rockets is poised for liftoff.

As of December 7, the aerospace company SpaceX had reported six successful landings — two on land and four at sea — of its reusable Falcon 9 rocket. The August 14 launch of one of the rockets from Cape Canaveral Air Force Station in Florida (left) delivered a commercial communications satellite into orbit around the Earth.

Reusable rockets could make future spaceflights cheaper and more efficient. Typically, rocket stages, which house the engines, drop off once their fuel is spent and are lost at sea. But the first stage of SpaceX's two-stage rocket makes a controlled descent once the second stage detaches to deliver the payload into orbit.

In the August 14 mission, engines blaze to slow the first stage down as it nears the landing zone (middle), and four slender legs deploy to help it stand (shown below on a sea barge). SpaceX has yet to reuse any of its recovered Falcon 9 stages but plans to in early 2017.

Blue Origin, a rocket company, relaunched and landed on firm ground the same rocket booster of its reusable New Shepard spacecraft five times since November 2015. A capsule atop the booster is designed to ferry paying passengers to suborbital space, an easier goal than reaching orbit, perhaps as early as 2018.

This year also brought setbacks: Two sea landings of Falcon 9 rockets failed, and in September, one exploded in a fireball on its Florida launchpad during routine prelaunch tests (*SN Online: 9/1/16*). — *Emily DeMarco*

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"It took me a LONG time to admit I had some hearing loss, even to myself. The signs were there: Shirley, my wife, "mumbled", everyone complained that the TV was too loud, I hated going out to eat with our friends because it was too noisy to understand anything.

This began to take a toll. As much as I hate to admit it, I became a grump — depressed and withdrawn. My daughter, Susan, suggested a hearing aid might help. She had done some research and said, "You've got to try the MDHearingAid *AIR*. It was developed by a board-certified doctor and it costs less than my new cell phone."

You have to hear it to believe it!

The **MDHearingAid® *AIR*** offers the same advanced technology and features of a $3,500 hearing aid — for 90% less.

The next afternoon bowling, I told the guys what my daughter said. Rick chuckled, turned his head and said, "Like this?" That son of a gun was wearing one! None of us had noticed! After making his next spare, he told us all about his *AIR* — the sound is fantastic, the price is downright affordable, plus if he had questions, he just grabbed the phone to call their hearing aid professionals.

- ✓ People are ***no longer mumbling!***
- ✓ Gave my ***social life*** a boost!
- ✓ Put the spark back in my ***marriage!***
- ✓ I can ***enjoy time*** at church, with friends, and with my grandchildren!
- ✓ ***Saved me*** $3,500!

I called MDHearingAid as soon as I got home. It's the best phone call I've ever made. The *AIR* worked right out of the box and it has changed my life. Goodbye grumpy old man, hello new me! Now Shirley and I go out with friends, to the movies, to church. Heck, it feels like we're newlyweds again. Our morning walks are much more enjoyable now that she doesn't have to repeat herself or scream at me.

Thank you, MDHearingAid, for giving me back all the best sounds of life!"

- Bob Mitchell

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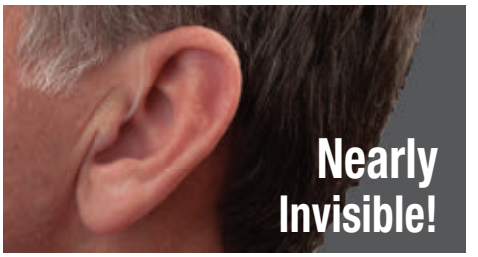

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This knife boasts a full tang blade, meaning the blade doesn't stop at the handle, it runs the full length of the knife. According to *Gear Patrol,* a full tang blade is key, saying "*A full tang lends structural strength to the knife, allowing for better leverage ...think one long steel beam versus two.*"

BONUS! Call today and you'll also receive this genuine leather sheath!

With our limited edition ***River Canyon Bowie Knife*** you're getting the best in 21st-century construction with a classic look inspired by legendary American pioneers. What you won't get is the trumped up price tag. We know a thing or two about the hunt— like how to seek out and capture an outstanding, collector's-quality knife that won't cut into your bank account.

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