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ScienceNews



Special Section

14 Science News Top 25 **COVER STORY:** West Africa's Ebola epidemic captured the attention of both the scientific world, and the world at large in 2014, placing it first among the Top 25 stories of the year. Other big news included the rise and fall of a claimed detection of gravitational waves, new findings about the history of early humans from analyses of DNA, and the spectacular landing of the Rosetta spacecraft's robotic explorer Philae on comet 67P/Churyumov-Gerasimenko (shown).

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CLOCKWISE FROM TOP LEFT: NAVCAM/ROSETTA/ESA; NICKOLAY HRISTOV; KLAUS MEINERS/AAD, POST-PROCESSING: PETER KIMBALL/WHOI

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COVER The largest ever outbreak of Ebola (virus particles in blue) hit West Africa this year and took scientists by surprise. NIAID/Flickr (CC BY 2.0)



Science inspires awe – and arguments



People love lists — mostly, I think, so that they can argue about what's on them and what's not. That means much of the labor of producing this year-end issue involved arguing about what to leave out. What remains are the stories that reveal major shifts in human knowledge, reflect science's biggest challenges and highlight the compelling

and intriguing ways that science can illuminate the world around us. Or, so we would argue.

What stood out this year was the unprecedented Ebola epidemic that hit West Africa and extended its tendrils around the globe. Other standouts included the highs and lows of the search for gravitational waves, a saga that had people on the street wondering about cosmic inflation and the history of the universe. And, of course, the spectacle of landing a robotic spacecraft on a comet, an awe-inspiring moment even for those who don't consider themselves science fans. Other advances in our top five received less public attention, but are a marvel all the same. One is researchers' increasingly sophisticated ability to extract and analyze ancient DNA, which is now being used to rewrite early human history. And neuroscientists built new roads into the terra incognita of human memory this year, offering a futuristic way to take the emotional sting out of bad memories.

Our list goes on with 20 other memorable stories from 2014. But many gems were left on the cutting room floor. Why does a zebra have stripes? The better to hide from flies, one new study declared. Scientists at the National Ignition Facility finally reported forward progress toward the goal of sustainable nuclear fusion. And it's clear that human activity, such as deep wastewater storage, is triggering earthquakes in surprising places (check back next month for an in-depth report).

Many more great stories didn't make the cut. But that's understandable: Peer-reviewed scientific journals, by one estimate, number 24,000. Each publishes numerous reports every year, adding up to more than a million. There's a flood of science. Our job, all year, is to wade in those waters and net the big stories for our readers. This list is the best of those, designed to inspire some spirited discussions in your house. — *Eva Emerson, Editor in Chief*

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NOTEBOOK



Excerpt from the December 26, 1964, issue of *Science News Letter*

50 YEARS AGO

Lung cancer diagnosis

Lung cancer can be diagnosed in ten minutes by an electrical skin resistance test.... The technician attaches one electrode to the patient's leg and runs the other electrode, which is a small metal wheel, over specific skin areas. The electrical resistance of various skin sites is recorded by meters and mapped by the investigator on a drawing of the human body.... Lung cancer patients show four kinds of resistance patterns, all of them different from the normal

UPDATE: While rates of lung cancer are declining in the United States as smoking rates decrease, lung cancer is still the leading cause of cancerrelated death. Detecting lung cancer with skin electrodes never did catch on, though a 2000 study indicated that measuring the skin's electrical resistance could potentially predict lung cancer prognosis. Detection is now mainly conducted with low-dose CT scans, which use a small amount of radiation to get a clear image of the lungs.



In nighttime flying duels, Mexican freetailed bats make short, wavering sirenlike waaoo-waaoo sounds that jam each other's sonar.

These "amazing aerial battles" mark the first examples of echolocating animals routinely sabotaging the sonar signals of their own kind, says Aaron Corcoran of Wake Forest University in Winston-Salem, N.C. Many bats, like dolphins, several cave-dwelling birds and some other animals, locate prey and landscape features by pinging out sounds and listening for echoes. Some prey, such as tiger moths, detect an incoming attack and make frenzied noises that can jam bat echolocation, Corcoran and his colleagues showed in 2009 (*SN*: *1/31/09*, *p*. *10*). And hawkmoths under attack make squeaks with their genitals in what also may be defensive jamming (*SN Online: 7/3/13*). But Corcoran didn't expect bat-on-bat ultrasonic warfare.

He was studying moths dodging bats in Arizona's Chiricahua Mountains when his equipment picked up a feeding buzz high in the night sky. A free-tailed bat was sending faster and faster echolocation calls to refine the target position during the final second of an attack. (Bats, the only mammals known with superfast muscles, can emit more than 150 sounds a second.) Then another free-tailed bat gave a

INTRODUCING

A frog that mates in bamboo

In a remote, wet evergreen forest in southern India, the male white-spotted bush frog calls to lure a female into his snug bamboo-stalk love nest. Entry is granted through a narrow opening probably originally bored by insects or rodents. Once inside, the tiny frogs mate in flood-proof confines. Dad cares for the eggs, which hatch directly into froglets — no tadpole stage involved in this dry bamboo nursery.

Kadaba Shamanna Seshadri of the National University of Singapore and his team observed this unusual bamboo-based breeding among *Raorchestes chalazodes*, a species of frog so rare that it was deemed extinct until 2011. They report the findings October 24 in the *Biological Journal of the Linnean Society*. The researchers warn that unregulated harvest of bamboo by the paper and pulp industry could destroy the bamboo nesting frog's breeding habitat.

– Vijaysree Venkatraman

Male white-spotted bush frogs make a home inside a bamboo stalk and then attract females to mate there.

Mexican free-tailed bats fight sonar wars, jamming each other's echolocation signals in competitions to snatch moths out of the night sky.

slip-sliding call. Corcoran, in a grad student frenzy of seeing his thesis topic as relevant to everything, thought the call would be a fine way to jam a buzz. "Then I totally told myself that's impossible — that's too good to be true."

Five years later he concluded he wasn't just hearing things. He and William Conner, also of Wake Forest, report in the Nov. 7 *Science* that the upand-down call can cut capture success by about 70 percent. Using multiple microphones, he found that one bat jams another, swoops toward the moth and gets jammed itself.

Corcoran says that neighborly sabotage could be especially valuable for the highly sociable Mexican free-taileds (*Tadarida brasiliensis*). "If you live in a cave with a million bats," he says, "you have to go out and find food — and compete with a million bats." — *Susan Milius* HOW BIZARRE

'Family Guy' and 'Citizen Kane' improve solar cells

Using Blu-ray Discs to watch movies is so 2006. Now the once cutting-edge technology can boost the efficiency of solar cells. Imprinting the discs' data-storing etchings onto solar cells increases the cells' absorption of sunlight, according to a study published November 25 in *Nature Communications*.

Previous research has shown that making nanometer-sized etchings on a solar cell's surface helps trap more light, so Jiaxing Huang, a materials chemist at North-western University in Evanston, Ill., looked to Blu-ray Discs, which store data in the form of tiny bumps and pits. He and his team collected various movies and TV shows, and used a mold of the discs to imprint their patterns onto polymer solar cells.

The patterned solar cells that Huang's team tested absorbed nearly 22 percent more light than smooth cells. By coincidence, Huang says, the manufacturing process to compress data and prevent scratches from ruining discs creates etching patterns that help absorb light.

The results suggest that Blu-ray Discs collecting dust could cheaply improve the performance of many varieties of solar cells. It appears that any mass-produced Blu-ray will do: The PBS documentary *The Dust Bowl* works just as well as the TV cartoon *Family Guy*, and a widely panned movie (*The Room*) fares no worse than *Citizen Kane. – Andrew Grant*





Bumps and pits that encode data on a Blu-ray Disc, seen above in a false-color microscope image, can be imprinted on solar cells to improve light absorption, a new study shows.

FOR DAILY USE Cocoa antioxidant sweetens cognition in elderly

Extremely high doses of cocoa flavanols may improve older people's ability to distinguish one complex pattern from another — or at least so says a study partially funded by the chocolate company Mars Inc., which also sells a cocoa extract



high in flavanols. Thirty-seven adults ages 50 to 69 who consumed 900 milligrams of the antioxidants every day for three months experienced increased blood flow in the hippocampus, a brain area associated with learning and memory. The volunteers also were better at remembering and differentiating visual patterns than people who didn't get extra flavanols.

Alas, the study does not support eating chocolate. Most flavanols are removed during chocolate processing, and the study's dose was more than 10 times as high as the flavanol levels in most dark chocolates.

Still, the authors hypothesize that high quantities of cocoa flavanols might help prevent cognitive decline. The study appears October 26 in *Nature Neuroscience.* — *Bethany Brookshire*

Ancient hominids engraved shells

Over 400,000 years ago, *H. erectus* in Indonesia carved zigzags

BY BRUCE BOWER

A member of the now-extinct hominid species *Homo erectus* engraved a geometric design on a seashell nearly half

a million years ago, long before the earliest evidence of comparable etchings made by modern humans, researchers say.

Fossil mussel shells excavated more than a century ago at an *H. erectus* site on the Indonesian island of Java include a shell with engravings of an "M"

shape, two parallel lines and a reversed "N" shape, the scientists report December 3 in *Nature*. Another shell contains an intentionally sharpened edge with a polished surface, indicating it was used as a cutting or scraping tool, they say.

Abstract and perhaps symbolic forms of thinking associated with such creations preceded the evolutionary origins of *Homo sapiens* around 200,000 years ago, conclude archaeologist Josephine Joordens of Leiden University in the Netherlands and her colleagues.

The oldest examples of engravings made by modern humans date to around 100,000 years ago (*SN Online: 6/12/09*). These consist of geometric designs and lines carved into pieces of pigment found in South Africa.

"If *Homo erectus* carved geometric designs into shells half a million years ago, then geometric engravings cannot be considered 'modern human behavior,'" says archaeologist John Shea of Stony Brook University in New York. Science's definitions of modern behavior have become increasingly meaningless, in his view.

Joordens' team identified a single shell thought to have been decorated by

H. erectus, a species that left no other evidence of symbolic marking from 1.5 million years of wandering Africa, Asia and possibly Europe, Shea cautions.

> And the engraved shell was stored in a museum for more than 100 years, raising the possibility that someone with access could have carved the design. Only the discovery of a similarly marked shell at a new excavation will confirm *H. erectus*' status as a carver of abstract designs, Shea says.

Galaxies may be aligned across 1 billion light-years

If the marks were indeed made by *H. erectus*, then they challenge conventional wisdom that behavioral innovations in the Stone Age occurred first in Africa and

ATOM & COSMOS

then spread elsewhere, says paleoanthropologist Bernard Wood of George Washington University in Washington, D.C.

Joordens and colleagues analyzed complete shells and other remains of at least 166 freshwater mussels unearthed at Java's Trinil site in the 1890s. In addition to the engraved shell, one-third of the others contained small holes at an attachment location for a muscle that clamps the creature's shells shut.

Experiments by the researchers with living freshwater mussels indicate that *H. erectus* individuals used pointed objects (perhaps shark's teeth, which were unearthed in the same sediment as the mussel shells) to pierce shells at spots where the muscle could be deactivated.

Enough soil clung to the museum-held mussels for Joordens' group to estimate ages for the finds. Measures of the age of volcanic ash in the soil indicate that the shells date to no more than 540,000 years ago. Measures of the time since the finds were covered by soil suggest the shells are no younger than 430,000 years old.

Previous estimates placed the Trinil discoveries at anywhere between 1.5 million and 700,000 years old.

The cores of several distant galaxies, spread across roughly 1 billion lightyears, seem to align with one another (illustration above). If confirmed, the

finding could hint at an unknown mechanism shaping large cosmic structures. Damien Hutsemékers of the University of Liège in Belgium and colleagues measured the orientations of 19 quasars, disks of gas that swirl around supermassive black holes in some galaxies' centers. Each quasar lives in one of four groups that are about 13 billion light-years away. Within the groups, powerful jets of charged particles spewing from the quasars seem to point in nearly the same direction, the team reports in the December Astronomy & Astrophysics.

With only 19 quasars, the alignments could be a coincidence, says astrophysicist Mike DiPompeo of the University of Wyoming. But he says the observation is intriguing and merits further investigation. – *Christopher Crockett*



Engraved patterns on a mussel shell (top of page), shown here close-up, were made by *Homo erectus* on the island of Java at least 430,000 years ago.

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BODY & BRAIN

New drugs allow cells to fight cancer

Neutralizing key protein awakens immune response to tumors

BY NATHAN SEPPA

A new type of drug can unleash immune system troops to battle cancers that have become impervious to chemotherapy. In several studies in the Nov. 27 *Nature*, scientists describe surprising results

in patients using a novel approach that puts cancer cells on the radar screen of immune cells.

The drugs neutralize proteins that suppress the immune system response.

"This is a whole new class of weapon" against cancer, says Roy Herbst of Yale Cancer Center. The new drugs produced stunning success stories in some patients, but many people receiving them didn't benefit in these studies.

Cancer cells display genetic mutations and rogue behavior, which would seem easy for the immune system to detect. But

Negative mass may be possible

Repulsive matter could have played a role in early universe

BY ANDREW GRANT

Matter with negative mass, a seeming impossibility, could actually have existed in the early universe, a new study shows.

A novel solution to Einstein's equations for gravity permits the existence of negative mass in a rapidly expanding universe like our own, physicists Manu Paranjape of the University of Montreal and Saoussen Mbarek, now at the University of Waterloo in Canada, report November 14 in *Physical Review D*.

Although the research doesn't prove that such exotic particles once floated around the cosmos, it suggests that negative mass could have played a role in the



Melanoma tumor tissue (blue) and CD8+ T cells (stained brown) are shown before and after treatment with a new drug. tumors take advantage of a natural signaling process that balances two types of proteins — some revving up an immune response and others suppressing it. The slowdown signalers are called "checkpoints" because they prevent run-

away immune reactions. Cancer can trip these immune checkpoints and escape surveillance.

By interfering with the checkpoint process, drugs in the new class restore some lost immune diligence.

Past attempts to enlist the immune system using therapeutic cancer vaccines have been "underwhelming," Herbst says. Targeting immune checkpoints is fundamentally different. While cancer vaccines are designed to trigger an immune response against cancer itself (*SN: 11/1/14, p. 18; 5/7/11, p. 20*),

epoch called inflation, when the universe ballooned in size just after the Big Bang.

If negative mass particles exist, they would accelerate toward someone who pushed them, and they would gravitationally repel all other matter (*SN Online: 9/22/13*). Previous studies, however, suggested that the existence of such particles would violate some rules of general relativity, Einstein's theory of gravity.

But Paranjape noticed that those analyses didn't consider the fact that the universe is expanding at an increasing clip. So Paranjape and Mbarek explored the possibility of negative mass in simulations of a universe like ours.

Their study consisted mainly of plugging values into Einstein's relativity equations — there were no attempts to experimentally produce or observe negative mass particles. Paranjape and Mbarek found that on a sheet of spacetime with an exponentially increasing expansion rate, general relativity allows the new class of drugs inhibits particular immune proteins to reawaken natural defenses that do the fighting.

In one of the new studies, 67 patients received a drug called MPDL3280A, an antibody engineered to reverse an immune checkpoint signal. The patients had cancer of the bladder or nearby tissues that in most cases had spread to other organs. Two patients staged dramatic recoveries. Sixteen patients showed substantial improvement, with tumors shrinking by at least 30 percent. The other patients' tumors were stable or failed to respond to the drug.

In another study, Herbst and colleagues tested the same drug against lung cancer, melanoma, kidney cancer and other malignancies. These patients had dwindling options before the study, but 32 of 175 showed substantial tumor shrinkage. A few seemed to vanquish their cancer entirely, Herbst says.

In both studies, severe side effects were rare with MPDL3280A, which is made by the pharmaceutical company Roche of Basel, Switzerland. Common problems were fatigue and low-grade fever.

for the existence of negative mass.

Under certain conditions, they discovered, regions of space would behave like negative mass particles, at least to an observer outside the region. The existence of those negative mass bubbles, Paranjape says, is tied to the strength of the cosmological constant, which describes a repulsive force that drives spacetime's accelerating expansion.

"It's an interesting result," says Richard Hammond, a physicist at the University of North Carolina at Chapel Hill. Sabine Hossenfelder, a theoretical physicist at the Nordic Institute for Theoretical Physics in Stockholm, says that Paranjape and Mbarek still must propose a plausible and stable mechanism for actually producing particles of negative mass.

Paranjape says he is particularly interested in the period of inflation — a mysterious, short-lived era less than a second after the Big Bang when the universe doubled in volume dozens of times. The The checkpoint that ratchets down the body's defenses gets triggered when receptor proteins on the immune system's T cells are tripped like a switch when a partner protein called a ligand binds to the receptor. Tumor cells can also release a ligand that latches onto a T cell receptor to mute immunity.

MPDL3280A neutralizes these ligands, short-circuiting the tone-itdown signal. MPDL3280A also thwarts the ligands produced by T cells themselves. Patients who benefited the most from MPDL3280A had tumors that had attracted a lot of T cells.

"The army is standing there, a little stunned by the tumor," says oncologist Jedd Wolchok of Memorial Sloan Kettering Cancer Center in New York City, who was not involved in the studies.

A third study indicates that T cells called CD8+ T cells awaken and carry the load in this fight. In melanoma patients given pembrolizumab, one of the new drugs, those with tumor shrinkage were more apt to have ample CD8+ T cells in or near their tumors.

connection that Paranjape discovered between the cosmological constant and negative mass suggests that physicists need to consider the possible contribution of negative mass particles to the runaway expansion during inflation, he says.

Paranjape wants to explore the possibility that the young universe contained a plasma of particles with both positive and negative mass. Such a plasma would surely have had an impact on the universe's evolution and almost certainly would have influenced the signatures of inflation that experiments such as BICEP2 are seeking (*SN: 10/18/14, p. 7*).

Despite having reservations about the study, Hossenfelder agrees with Paranjape's intuition that negative mass could have played a pivotal role in the early universe. The relevance of negative mass to the evolution of the universe "has in my opinion so far not gotten the attention it deserves," she says. "This is a promising direction of study."

HUMANS & SOCIETY Golden Fleece voyage may be no myth Legend possibly inspired by villagers collecting gold in sheepskins

BY BRUCE BOWER

Jason and the Argonauts' mythic quest for the Golden Fleece took inspiration from an actual voyage sometime between 3,300 and 3,500 years ago, scientists say. Jason went from Greece to a kingdom near the Black Sea renowned for using sheepskins to collect gold grains and flakes from mountain streams.

Mountain streams in the Svaneti region of Georgia carry bits of gold and gold-specked gravel that erode out of bordering rock formations, say geologist Avtandil Okrostsvaridze of Ilia State University in Tbilisi, Georgia, and colleagues. Local villagers put sheepskins in these streams to catch floating gold, a technique that goes back thousands of years suggesting that the region is the province of the ancient Colchis Kingdom, the Argonauts' destination in Greek mythology, the researchers conclude November 20 in *Quaternary International*.

"Our results show that the geological situation in the Svaneti region is the same now as it was 3,300 to 3,500 years ago, when the Argonauts traveled to the kingdom of Colchis," Okrostsvaridze says.

Today, miners place entire sheepskins in streambeds within 500 meters of gold deposits. Rocks and ropes hold down each sheepskin. Pieces of gold erode out of rocky deposits, wash downstream and get trapped in the animals' coats.

Further downstream, miners strain gold through oval, perforated wooden vessels. Historical descriptions of both techniques for mining Colchis' "gold sands" go back about 2,000 years.

Archaeologists have found no remnants of Colchis, leading some to conclude that it was mythical. Earthquakes and landslides destroyed evidence of the kingdom, the researchers suspect.

It's not surprising that Svaneti contains rich gold sources, remarks Robert Blair, a consulting economic geologist in Denver. But the new findings "make a strong case for abundant gold in an area connected to the legend of Jason."

Previous discoveries, including two shipwrecks, documented trading for gold and other materials between the Mycenaean civilization of ancient Greece — the source of the Golden Fleece myth — and societies around the Black Sea, says archaeologist Robert Tykot of the University of South Florida in Tampa. The study supports the view that many myths from ancient Greece and other civilizations drew on actual events, he says.

An epic Greek poem about Jason's voyage to Colchis, written more than 2,800 years ago, contains many factual nuggets, says Stanford University historian of science Adrienne Mayor. For instance, archaeologists have discovered graves of warrior women near Tbilisi and a goddess worship site on a Black Sea island supporting the poem's description of Colchis as a stronghold of the Amazons, she says.

Okrostsvaridze's team used remote sensing to pinpoint areas in the Svaneti region where gold deposits had eroded into adjacent streams during ancient and modern times. The researchers analyzed the gold content and other trace metals in over 1,000 samples. Bedrock in an area located near the Svaneti region's primary river system contains 65 to 70 metric tons of gold, the researchers estimate.



The myth of the Golden Fleece may have been based on a real voyage to a region near the Black Sea. People in villages there (one shown) still use sheepskins to catch stream-borne gold.

EARTH & ENVIRONMENT

Antarctic sea ice plot thickens

Robotic subs' measurements differ from older methods

BY THOMAS SUMNER

The sea ice surrounding Antarctica may be thicker than previously thought.

Earlier estimates using shipboard observations and drill cores suggested that the Southern Ocean ice pack was about 1 meter on average. New measurements, reported November 24 in *Nature Geoscience*, show ice floes with average thicknesses ranging from 1.4 to 5.5 meters, with some areas as thick as 16 meters.

"We have a fairly good sense that this ice may represent a significant portion of the pack," says study coauthor Ted Maksym, an oceanographer at the Woods Hole Oceanographic Institution in Massachusetts.

Thicker ice is less prone to melting.

So the improved measurements – made during the first extensive use of robotic submarines in the Antarctic – could help explain why the ice pack has expanded since 1979 despite rising water and air temperatures (*SN Online: 11/5/12*).

Gauging ice pack thickness poses a challenge because roughly 90 percent of the ice hides beneath the sea surface. Satellites can measure the extent of sea ice but can't estimate the volume without on-the-ice estimates for calibration.

Previous surface measurements relied on hand-cranked drills and tape measures as well as visual observations made from icebreaker ships. For safety reasons, ships avoid areas with denser ice, so most expeditions focused on Measurements made by remote-controlled submarines suggest that scientists have underestimated the thickness of Antarctic sea ice.

the thinner ice farther out to sea. This approach bypassed thick ice closer to land and ice that is deformed when strong winds force two ice floes to overlap and refreeze as one thicker chunk.

Maksym and colleagues repurposed autonomous underwater vehicles, or AUVs, to probe the underside of the ice using sonar. By measuring the depth of the ice below the surface, the team could calculate the total ice thickness.

The AUVs mapped 10 ice floes during two expeditions in 2010 and 2012. On average, the floes were 1.48 meters thick, but the limited area covered prevents researchers from making estimates for the Southern Ocean ice pack as a whole. Measuring the floes using conventional methods would have underestimated ice thickness by at least 20 to 25 percent, says coauthor Guy Williams of the University of Tasmania in Hobart, Australia.

"This is a huge leap forward," he says, "and I don't think it'll be possible to go back to those other methods."

GENES & CELLS Nerves grow from transplanted eye

Manipulating electric charge could help organs wire properly

BY TINA HESMAN SAEY

Wiring replacement organs into the body may be as easy as discharging a biological battery, new experiments with tadpoles suggest.

Scientists cut an eye from one tadpole's head and transplanted it to another's flank. Tweaking electrical charges in the body cells of the recipient tadpole stimulated nerve growth from the transplanted eye, researchers report December 1 in *Neurotherapeutics*. The study could be an early step toward getting replacement eyes, ears and other organs to wire into a body properly and it might lead to a method for spinal cord repair.

It's a feat scientists didn't think was possible, says Silvia Chifflet, a cell biolo-

gist at the Universidad de la República in Montevideo, Uruguay. "We used to think that the nervous system, once severed, would not regenerate," says Chifflet, who was not involved with the work.

Researchers in Michael Levin's lab at Tufts University in Medford, Mass., transplanted left eyes from donor tadpoles to other tadpoles' bodies. The eyes grew but rarely sent out axons, long protrusions that nerve cells use to connect with other nerve cells or muscles.

But when Levin's group bathed the tadpoles in a drug that lowers the electric charge of cell membranes, the transplanted eyes grew a veritable bush of axon branches. That finding suggests that "the issue of getting axons to grow out



Nerve cells (red) from an eye transplanted to a tadpole's side reach out into the surrounding tissue, but they won't stray beyond an electric fence of highly charged cells (green).

might be more solvable than people have expected," says Amy Sater, a developmental biologist at the University of Houston.

Levin has previously shown that electrical signals can cause transplanted eyes to work on tadpoles' tails (*SN Online: 2/28/13*), suggesting that electricity is important in development.

"Our future goal is to sculpt the electrical topography of the environment and make nerves go where we want them to," Levin says.

ATOM & COSMOS

A more precise picture of the cosmos

Planck fine-tunes estimates for universe's age, composition

BY CHRISTOPHER CROCKETT

From a palace in Ferrara, Italy, cosmologists have unveiled the most detailed maps yet of the infant universe. The announcement, on December 1, kicked off a weeklong conference showcasing the latest findings from the European Space Agency's Planck satellite. The new results largely confirm earlier measurements of the makeup of the cosmos, but they also rule out some ideas about dark matter, the elusive substance thought to bind galaxies together.

There are no major surprises, says Princeton University cosmologist David Spergel. Compared with Planck's first results, released in 2013 (*SN:* 4/20/13, *p.* 5), not much has changed. We live in a 13.8 billion-year-old universe where particles making up atoms account for only 4.9 percent of all mass and energy. Dark matter makes up 26.6 percent, and 68.5 percent resides in the even more enigmatic dark energy, a repulsive force speeding up the expansion of the cosmos.

Planck's value for the Hubble constant — which quantifies the current rate of cosmic expansion — holds steady in the new results at 67.3 kilometers per second per megaparsec. This value has been at odds with a slightly higher number obtained through observations of supernovas (*SN*: 4/5/14, *p. 18*), but some analyses suggest the results from the two methods may eventually be resolved.

Planck spent more than four years gathering light from the cosmic microwave background, the first light released into the universe, about 380,000 years after the Big Bang. Previously released results relied just on Planck's first year or so of data — measurements of subtle differences in the intensity of microwaves coming from different points on the sky. Those variations map density fluctuations in the early universe, which in turn can be used to calculate the fundamental numbers that describe the cosmos.

The new results incorporate not only data taken in subsequent years but also polarization maps, which trace how microwaves align with one another. The additional data allow researchers to home in on the most precise measurements of cosmological components to date.

"We're squeezing" the data, says Planck team member Joanna Dunkley, an astrophysicist at the University of Oxford. Planck's previous value for the amount of dark energy in the universe was good to about 2 percent; the new analysis tightens the uncertainty to 1 percent.

Planck doesn't see evidence for collisions of dark matter particles as suggested by the Fermi and PAMELA satellites. That doesn't rule out the existence of dark matter but puts constraints on the mass of such particles.



LIFE & EVOLUTION

Iguanas' one-way airflow undermines usual view of lung evolution

The green iguana, which does not fly or do anything more athletic than an occasional sprint, has the simplest lungs yet observed with a version of birds' high-performance one-way airflow. A green iguana's lungs look deceptively simple, says Colleen G. Farmer of the University of Utah in Salt Lake City. Each Iguana iguana lung is just a two-chambered bag with a single air tube to bring air in and out. Using an endoscope on iguanas breathing theater fog, Farmer and colleagues made the first measurements of air moving through the animals' lungs. The shapes of the inner landscape keep air flowing in just one direction along a lung's wall, where blood vessels hug the lung to rid themselves of waste gases and pick up fresh oxygen. Air flowing in an efficient one-way path has been thought to be an innovation that evolved as birds developed the sustained athletics of flight. Farmer and colleagues have challenged that scenario, finding one-way flow in alligators (SN: 2/13/10, p. 11) and monitor lizards. Now the simpler lung of a notvery-athletic iguana suggests that something besides flight drove the evolution of one-way lungs, the team says November 17 in the Proceedings of the National Academy of Sciences. – Susan Milius

Vulture guts filled with noxious bacteria

Vultures' guts are full of microbes that sicken other creatures, a new study finds. Conditions in the birds' intestines are so harsh that most other bacteria that pass through get destroyed. Gary R. Graves, an ornithologist at the National Museum of Natural History in Washington, D.C., and his team examined DNA from recent meals on the faces and in the guts of 50 black and turkey vultures. In the gut. DNA from the meals was broken down by extreme acidic conditions, Graves and colleagues report November 25 in Nature Communications. On average, the birds' faces contained about seven times as many bacteria species as did the animals' guts. The most abundant bacteria were



the fecal microbes *Fusobacteria* and Clostridia, the group that causes food poisoning and tetanus in humans. Although the microbes are toxic to other animals, vultures tolerate these bacteria, which may benefit the birds by breaking down carrion in their bellies. – *Kate Baggaley*

EARTH & ENVIRONMENT

Warming may spell wet future for Africa A flood of greenhouse gases into the atmosphere may trigger downpours in certain parts of Africa. Greenhouse gases play a large role in boosting rainfall in northern and southeastern areas of the continent, scientists report in the Dec. 5 Science. The finding may portend how climate change will alter access to water and help scientists understand other climate data that predict surges in African rainfall. Between around 21,000 and 14,700 years ago, Africa experienced a soggy era over a northern belt across the width of the continent and in a southeastern region around northern Tanzania. Using a computer simulation to re-crzeate that period, researchers led by Bette Otto-Bliesner of the National Center for Atmospheric Research in Boulder, Colo., individually added and removed variables that could have spurred the showers. These factors include an uptick in greenhouse gases noted during that time frame and changes to the Earth's tilt and orbit. which alter the amount of sunlight that reaches the planet's surface. Increases in greenhouse gases - to levels near to those of preindustrial times – was behind much of the northern region's extra moisture and nearly all of it in the southeastern region, the researchers conclude. – Beth Mole

BODY & BRAIN

Old drug reduces herpes symptoms An antidepressant drug suppresses the herpes simplex virus. Tranylcypromine, marketed since the 1960s as Parnate. inhibited initial herpes infection in animal tests, reduced flare-ups in previously infected animals and rendered them less infectious to others, researchers report in the Dec. 3 Science Translational Medicine. Tranylcypromine blocks the activity of LSD1, a protein found in humans and other mammals. The herpesvirus uses LSD1 to activate some of its own genes to infect a host and later to awaken from its dormant state in the host's sensory nerve cells. The activation unleashes the virus, causing symptoms. Tranylcypromine blocks such viral gene activation by making an epigenetic change in the virus -achange in gene activity that doesn't alter the underlying DNA structure. Since tranylcypromine targets a host protein and not the virus, it might limit the rise of drug-resistant viral strains, say researchers at the National Institute of Allergy and Infectious Diseases in Bethesda, Md., and other institutions. Tested in rabbits, mice and guinea pigs, the drug prevented some initial herpes infections and genital flare-ups. In guinea pigs, tranylcypromine reduced the amount of virus transmittable to other animals. - Nathan Seppa

ATOM & COSMOS

Starlight depletes a galaxy's raw materials Starlight may be robbing a distant galaxy of the ingredients needed to make future stars. A few billion suns' worth of carbon monoxide is streaming out of SDSS J0905+57, about 8 billion light-years away, astronomer James Geach of the University of Hertfordshire in England and colleagues report in the Dec. 4 Nature. Astronomers have debated whether starlight, stellar explosions or supermassive black holes force gas out of galaxies, shutting down the star-building factories. These new results indicate that, while black holes and supernovas may still play a part, light from newborn stars within a galaxy is enough to drive out the gas and curtail future generations of stars. – Christopher Crockett





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Science's good, bad, ugly year

n the race for Top Science Story of 2014, some of the contenders stumbled before reaching the finish line.

A South Pole-based experiment called BICEP2 appeared to hit a Nobel-winning home run in March, with researchers proclaiming the detection of gravitational wave imprints in radiation left over from the Big Bang. But upon further review, galactic dust may have been responsible for the signal instead. In November, the Rosetta mission's robotic comet lander Philae appeared to score a touchdown, but there was a flag on the play. Rather than anchoring itself securely on the comet's surface, Philae bounced twice, ending up in the shade of a cliff. Without the sunshine needed to recharge its batteries, Philae's mission was drastically shortened. And a supposed advance in stem cell research announced in January turned into a tragic case of science insufficiently scrutinized. The papers were retracted in July.

Still, there was plenty of good science news in 2014. The planet-hunting space probe Kepler, given up for dead the previous year, was revived by a clever plan to restore its balance using pressure from sunlight. Analysis of Kepler data already collected provided hundreds of new planets to contemplate, while the new K2 mission began to search for even more planets and to study asteroids and star clusters. And evidence for active plate tectonics on Europa buoyed hopes that the solar system possesses another place besides Earth that might support some form of life.

Along with the good, though, came some bad and ugly. Danger signs were raised for both the supposedly safe antimicrobial agent triclosan and the smoking substitutes called e-cigarettes.

As for the year's top story, it combined bad with sad. An epidemic of Ebola struck West Africa and initiated an epidemic of fear elsewhere, as scientists grappled with both medical and policy issues. The Ebola outbreak was a sign not only of science and society's combined shortcomings, but of the need for more and better science to confront the problems that society faces. — *Tom Siegfried, Managing Editor*

Science faces Ebola epidemic

Spread of deadly virus challenges researchers, public health workers **By Nathan Seppa**

West Africa's 2014 Ebola epidemic demonstrated what can happen when a contagious virus emerges amid a population served by a broken medical system, and where cultural practices, public fears and porous borders fuel the spread of disease.

The outbreak also laid bare an inadequate scientific understanding of the Ebola virus. By the time the World Health Organization and others mobilized to confront the crisis in the middle of the year, public health workers in the field had already started to fall far behind Ebola's spread. Scientists scrambled to determine how it operates once inside the body.

With only animal studies to go on, researchers also had to pursue a crash course in vaccine and drug testing to get products into the field quickly to fight a virus that has no cure. This unorthodox approach rapidly gained consensus as the death toll mounted.

Although Ebola has been recognized as a dangerous pathogen since it first surfaced in 1976, in the past it had caused mainly rural outbreaks that fizzled out on their own. Not this time. Arising at a crossroads of Liberia, Sierra Leone and Guinea, the outbreak jumped from that remote region to spawn stray cases in Europe and North America. The arrival in Dallas of a visitor from Liberia who was diagnosed with Ebola and later died underscored the global nature of infectious diseases today (*SN Online: 9/30/14*). As of early December, the epidemic had claimed 6,346 lives and infected at least 17,834 people — more than all previous Ebola outbreaks combined over 38 years. Roughly 35 percent of infected people have died.

Ebola is a fearsome hemorrhagic virus that spreads through contact with bodily fluids. The illness shows up as fever, headache, vomiting and weakness caused by leakage from blood vessels. Patients experience severe internal bleeding and can lose more than five liters of fluids a day. The Ebola virus, shown in red in this micrograph, infected more than 17,000 people in 2014.

The Dallas case led to speculation about whether Ebola could go airborne. But researchers had reported in

July that monkeys don't pass Ebola to each other through the air, indicating that it is extremely unlikely that people do (*SN: 9/6/14, p. 7*). Ebola's natural reservoir isn't known, but fruit bats are suspected since they carry the virus (*SN Online: 8/11/14*).

By sequencing the genome of viruses isolated from 78 patients, researchers traced the strains responsible for the current epidemic to a 2004 outbreak of *Zaire ebolavirus* in Central Africa (*SN: 9/20/14, p. 7*). How the virus crossed the continent without triggering an outbreak en route is unclear.

To get a handle on why some people survive infection, scientists compared mice resistant to Ebola with those susceptible to it and discovered that a gene in charge of blood vessel leakiness might play a part in the disease's severity (*SN Online: 11/5/14*). Another study, published in *mBio*, found that the Ebola virus can edit its genetic material, adding extra RNA building blocks. These changes may affect how the virus grows in humans (*SN Online: 11/4/14*).

Ebola has always been stealthy, with outbreaks appearing and then melting into the jungle. In West Africa, officials found that having forewarning helps. After the epidemic began, nearby countries were on high alert, and a small outbreak in Nigeria caused by a sick traveler from Liberia was vanquished

Going viral The Ebola epidemic has infected more people than all previous known Ebola outbreaks combined (cases in Guinea, Liberia and Sierra Leone shown). Declines are due to revisions in the case counts.



Spain, Senegal) by October thanks to prompt isolation of sick individuals and

monitoring of hundreds who might have been exposed. Nigeria's actions offer hope. "It's proof that this disease can be stopped in its tracks, using tried-and-true infection control and public contact tracing methods," says Jeffrey Duchin, an epidemiologist at the University of Washington in Seattle. An unrelated outbreak in rural Democratic Republic of the Congo flared in August and by November was extinguished using this approach. But it killed 49 people first.

Transmission control was lacking early in the West Africa epidemic. Many sick people refused treatment, staying home and unwittingly infecting their families. Traditional burial customs, including touching the bodies, spread the virus to the living. Rumors emerged that foreign workers were spreading the disease. Without any drugs or vaccines to offer and

with inadequate IV fluid replacement and disinfectant supplies, health care workers were underequipped to handle overwhelming caseloads.

A sick person can shed the virus for weeks. The intense risk of fluid contact became clear when some health care workers wearing biohazard suits fell sick. The specific exposure route in these cases is rarely traceable to a needle stick or another obvious breach, says The outbreak laid bare an inadequate scientific understanding of the Ebola virus.

Daniel Bausch, a Tulane University physician who worked with people who became infected despite precautions. "It's much more subtle than that," he says. "You touch something and scratch your eye or adjust your mask." And that's it.

In response to these dire conditions, WHO and others delivered makeshift clinics, protective suits, cleaning products, lab equipment and other supplies. They also sanctioned use of untested drugs in a few Ebola patients starting in August. But supplies quickly ran out, and the results shed little light on the prospective drugs' value. By December, regulators were finalizing plans to deliver several experimental Ebola drugs to patients while gauging the compounds' effectiveness. Antibodies from survivors' blood are being used as a treatment option as well. And vaccine testing in healthy people had set the stage for use in the field (*SN Online: 11/26/14*).





Ancient ripples in the fabric of space square off against soot in the galaxy **By Christopher Crockett**

Gravitational waves from the Big Bang captured worldwide attention in 2014. But then interstellar dust clouds stole the show.

Detection of such waves — ripples in the fabric of space — would be direct evidence for the theory of cosmological inflation, a brief epoch immediately after the Big Bang when the visible universe abruptly swelled to at least 10^{75} times its initial volume.

In March, astrophysicists thought they had captured their elusive gravitational wave quarry. Researchers with the BICEP2 project reported swirling patterns in the alignment of electromagnetic waves in the cosmic microwave background, or CMB, the primordial light released into the universe about 380,000 years after the Big Bang (*SN:* 4/5/14, p. 6). Those patterns supposedly reflected the influence of gravitational waves launched during the epoch of inflation.

In the wake of the announcement, as cosmologists popped champagne bottles and spoke of Nobel Prizes, others struggled to make sense of the data. BICEP2's signal was much stronger than anyone had expected.

Astronomers knew that interstellar dust, sootlike grains of carbon and silicon, could produce a signal mimicking gravitational waves. The BICEP2 scientists had estimated the effect of dust on their data in reaching their conclusions. But when other researchers took a closer look at BICEP2's dust calculations, the results were discouraging, suggesting that dust, not gravitational waves, might account for the whole signal (*SN*: *6*/2*8*/14, *p*. 20).

"That's when people got really depressed," says astrophysicist Katherine Mack of the University of Melbourne in Australia.

BICEP2's discovery was further dimmed in September by measurements from the Planck satellite, a mission designed to probe the CMB in unprecedented detail. Planck's dust data were consistent with the possibility that BICEP2's supposed gravitational wave signal was entirely due to dust. Cosmology's biggest result in years may turn out to be nothing more than Milky Way soot (*SN: 10/18/14, p. 7*).

"We're kind of bummed," says Mack, who is not involved with BICEP2 or Planck. A confirmed detection of primordial gravitational waves "would have been really nice."

But the saga is not over. Planck and BICEP2 researchers plan to publish a joint analysis of their data, which could clarify how difficult it will be for future projects to find gravitational waves. And half a dozen other experiments are planning to release results in the coming year that could show whether inflationary gravitational waves are really there. Planck data do not rule out the existence of the waves; cosmologists may just need to dig a little deeper.

Meanwhile, astronomers want to know what they can learn from this episode and how it affects science communication. Some accused the BICEP2 team of doing "science by press release," announcing results before submitting them to a scientific journal. Others argue that the researchers were right to shout from the rooftops — it was a huge discovery and the added attention triggered a much wider peer review.

Mack thinks the lesson for researchers is to be candid about how science works. Astronomers took an initial result, discussed it, got more data and came to a consensus. The BICEP2 measurement was exquisite, she says, and the team worked with the best information it had. But the researchers needed to stress that the results were preliminary. Science is always evolving. "When we present results as monolithic answers," she says, "that's when people distrust science."

Not-so-clear skies

The signal that BICEP2 researchers interpreted as gravitational waves may be due to interstellar dust. The Planck satellite mapped dust in the entire sky. The map shows the sky above the plane of the Milky Way (left) and below the galaxy's plane (right). Planck found areas heavily contaminated by dust (red) and regions that are relatively clean (blue). The black box shows where BICEP2 searched for gravitational waves.





Old humans reveal secrets DNA analyses rewrite stories of ancient times

Scientists probed the complete genetic secrets of an unprecedented number of ancient humans this year, revealing insights into how people, ideas and disease spread around the world.

By Tina Hesman Saey

Researchers have gotten so good at working with ancient scraps of DNA that, this fall, they unveiled the entire genetic makeup of a man who lived in Siberia near Ust'-Ishim about 45,000 years ago (*SN*: 11/29/14, *p. 8*).

The ancient Siberian's bones are the oldest modern human remains found outside Africa. Two weeks after the details

of Ust'-Ishim man's genome were reported, other scientists revealed DNA from a more than 36,000-year-old skeleton, known as Kostenki 14 (skull shown), from western Russia.

Ust'-Ishim man is related to East Asians and ancient European huntergatherers; the younger Kostenki 14 man is related to western Eurasians and the

ancient hunter-gatherers. Both men's DNA may help pinpoint when eastern and western Eurasians went their separate ways.

These and other ancient remains are revealing that early settlers spread out in multiple directions over wide swaths of Europe and Asia into Siberia. Interbreeding and migration occurred repeatedly — maybe even continually — forming what was essentially one large population of Stone Age people.



Also written in the men's DNA are accounts of interbreeding between modern humans and Neandertals. Based on the length of DNA segments shared between the Ust'-Ishim man and Neandertals (whose genome was reconstructed in 2010), researchers estimated that the two hominid species mostly interbred between 50,000 and 60,000 years ago. Analysis of the Kostenki 14 man's Neandertal ancestry similarly estimates the hookup at about 54,000 years ago.

Researchers are also reading other new versions of old stories in ancient DNA. The prehistories of Europe, Siberia and the Americas in particular are undergoing revision. Scientists can glean information from DNA that old bones or relics don't reveal, such as what people looked like and their genetic relationship to people who came before or after them.

Hunter-gatherers who first settled Europe may have had dark skin far longer than previously thought, for instance (*SN Online: 5/2/14; SN: 2/22/14, p. 14*). And blue eyes may have evolved before light skin, researchers learned from examining the DNA of a 7,000-year-old Spaniard (*SN: 2/22/14, p. 14*).

Ancient DNA may also help settle a debate about how agriculture spread (*SN: 5/17/14, p. 26; SN Online: 4/24/14*). Hunter-gatherers were replaced and assimilated into farming populations as migrants spread agriculture, DNA isolated from 5,000- to 7,500-year-old skeletons in Sweden showed. That finding suggests that agriculture was not a viral idea but rather a cottage industry that moved along with people.

Ancestry has also come under genetic scrutiny. Ancient Siberians were discovered to be ancestors of both Europeans (*SN: 5/17/14, p. 26*) and native groups in North and South America (see Page 29). Even standard history may need a little rewriting in light of DNA evidence: Anglo-Saxons may have imposed language and culture on Briton but didn't leave much of a genetic legacy, new research hints (*SN: 11/29/14, p. 13*).

Plant DNA pulled from permafrost up to 50,000 years old suggests that shifts in vegetation contributed to the demise of Ice Age mammals, such as woolly mammoths (*SN: 3/22/14, p. 13*). Overhunting has often been blamed for the extinction of large animals, but the study suggests that the real story of Ice Age

extinctions was far more complicated.

Still, humans aren't off the hook. A genetic analysis found that giant flightless birds called moa thrived in New Zealand before people arrived (*SN:* 4/19/14, p. 15). DNA from long-dead chickens hinted that early Polynesians may not have reached South America (*SN Online: 3/19/14*). But modern

Easter Islanders and Native Americans share genetic ties, indicating that Polynesians and indigenous South Americans mated between 1280 and 1495 (*SN: 11/29/14, p. 12*). Ancient DNA from Pacific Islanders and South Americans may clarify the matter.

Whether or not Polynesians colonized South America before Columbus set sail, seals seem to have brought tuberculosis there long before Europeans arrived (SN: 9/20/14, p. 16).



Rosetta mission hits its target

Lander bounces onto comet, sends some data before lack of sunlight puts it into sleep mode

By Ashley Yeager

With a hop and a skip, a robot called Philae bounded onto comet 67P/Churyumov-Gerasimenko, perhaps a bit too eager to explore the alien world.

The touchdown on November 12, amid cheers and tears on Earth, marked the first time scientists have set a probe on a comet. But the jubilation was short-lived. Philae's boisterous bounces landed the robot slightly sideways in the shadow of a cliff, making it impossible for its solar panels to get enough sunlight to recharge its batteries. After about 50 hours of scratching and sniffing 67P's surface, Philae transmitted its last batch of data and settled in for a long, potentially permanent, sleep.

If all had gone perfectly, Philae would have studied the comet's surface until March 2015. But the lander's apparent early retirement didn't mark the end of the European Space Agency–led mission to get an in-depth look at the 4-kilometer-long hunk of dust and ice (*SN Online: 11/13/14*). The Rosetta spacecraft (illustration, inset) arrived at the comet on August 6 carrying Philae (*SN: 9/6/14, p. 8*). The craft is still zooming around 67P, doing its own set of studies, scrutinizing the comet's hazy atmosphere, snapping images of the surface and trying to pinpoint the lander's final resting place.

Even in its brief life on 67P, Philae offered hints about some of the comet's secrets. The lander beamed back evidence supporting the idea that comets carried, and possibly even spread, organic molecules throughout the early solar system (*SN:* 12/13/14, p. 6). The robot also hammered just 10 to 20 centimeters into the surface of the comet and hit a surprisingly hard

layer of material, thought to be ice. The discovery suggests that some of the dust ejected from 67P when it approaches the sun and heats up stays gravitationally bound to the comet and falls back to form a thin surface layer. The finding also hints that 67P's core may be layered.

"There are a number of different ideas about how the nucleus of the comet could be structured — whether it's layered, whether it's one bound entity or a group of aggregated bodies together that are covered in a surface," says Rosetta project scientist Matt Taylor, who is based in Noordwijk, Netherlands.

Understanding the comet's structure and composition could give scientists clues to how the planets formed and whether comets brought water and other ingredients for life to Earth (*SN*: 11/1/14, p. 22). Observations may also reveal what's in the cauldron of chemicals that's created when the comet shoots out gas and dust as it nears the sun, Taylor says.

Rosetta is slated to stay with 67P until December 2015 and will be ringside for the comet's closest approach to the sun, in August. Rosetta may also relay any messages that Philae ekes out as the comet nears the sun and exposes the lander's solar panels to more light, potentially enough to revive it.

Data from 67P will force scientists to rethink what they know about comets, says ESA scientist Mark McCaughrean, who is also based in Noordwijk. This mission will certainly not be the last word on these unpredictable beasts, he says. "You can be damn sure that the people working off the back of this will be thinking of what to do next."

Memories vulnerable to manipulation

Experiments reveal how brain forms, stores recollections

By Laura Sanders

Memories can often seem hazy, but the brain creates and destroys them with exacting precision. New experimental results reported in 2014 helped bring scientists closer to underduring early life. But just how these newborn cells contribute to memory hasn't been clear. The new study suggests that early on, the flood of newborn cells might destabilize memories, which could explain why humans, rats and other animals

standing how the brain manipulates memories to make sense of the world.

The results have practical implications, too: By picking apart the memory process, scientists may ultimately be able to intervene in cases when bad memories become problematic. "Right now it may sound like science fiction," says neuroscientist Susumu Tonegawa of MIT. But in the next few decades. scientists and clinicians may develop sophisticated ways of tapping into certain brain regions to ease bad memories that can contribute to problems such as post-traumatic stress disorder or depression, he says.

This year, Tonegawa and his

colleagues transformed bad mouse memories into good ones (SN: 10/4/14, p. 6). Relying on a technique called optogenetics, the researchers selectively tagged the nerve cells that stored a bad memory of foot shocks. Those tags allowed the researchers to evoke the bad memory at any time by shining a laser light onto the cells via implanted optical fibers.

By calling up the bad memory while male mice were in a pleasant situation (in the enjoyable presence of females), the researchers took some of the sting out of the formerly traumatic memory. Similarly, the researchers sullied a good memory by calling it up as the mice were shocked.

The cells manipulated in this memory switch were in a particular spot of the hippocampus, a brain structure involved in all sorts of memories. One notable example comes from the hippocampus's "place cells," which recollect precise physical locations. The discovery of those cells won John O'Keefe of University College London a share of this year's Nobel Prize in physiology or medicine (SN: 11/1/14, p. 15).

While certain kinds of hippocampus cells are important for remembering, others may be important for forgetting, a provocative study of mice found (SN: 6/14/14, p. 7). Unlike many other regions of the brain, the hippocampus continually churns out newborn nerve cells, or neurons, particularly their infancy. Mouse pups that had been treated to produce fewer neurons better remembered a room where they received shocks than did pups that churned out the normal number of neurons, Sheena Josselyn of the Hospital

don't remember much from

for Sick Children in Toronto and her colleagues found. Cranking up the neuron birthrate made adult mice more forgetful. In contrast, young guinea pigs and degus, rodents whose brains don't churn out new neurons early in life, didn't show signs of amnesia.

Newborn neurons may elbow out the preexisting infrastructure that held memories in place,

causing the animal to forget. When the birthrate of these neurons slows down, the brain's memory machinery may become more stable, capable of forming long-lasting memories.

Most memory manipulations have occurred in lab animals, which can be genetically engineered and given drugs to change brain cell behavior. A counterexample comes from a small study on depressed humans who received electroconvulsive therapy:

The electric jolt weakened memories that had been called to mind just before treatment, a team led by Marijn Kroes of Radboud University Nijmegen in the Netherlands found (SN: 2/8/14, p. 10).

Electroconvulsive therapy is unlikely to become a treatment for people suffering from intrusive negative memories. Nor do clinicians have the ability to specifically manipulate neurons

that store a memory or selectively dial up or down neuron birth in people. But scientists are working on new techniques that might ultimately allow clinicians to tap into these memory processes and fix them when they go awry, Tonegawa says.

The electric jolt weakened memories that had been called to mind just before

treatment.



The hippocampus (blue, mouse brain shown) churns out neurons

(white) early in life that may disrupt memories from infancy.

Kepler gets second chance at life Planet hunter spots hundreds of new worlds

By Christopher Crockett

The Kepler space telescope is not quite dead. NASA's planet-hunting space observatory got a second chance at life this year. And mission scientists analyzing already-collected data unearthed hundreds of new worlds, including a potentially habitable Earth-sized planet.

For four years, Kepler stared at one patch of sky in the constellations Cygnus and Lyra and monitored roughly 150,000 stars for tiny dips in starlight — silhouettes of orbiting planets. Kepler's goals included counting planetary systems and stars hosting planets the size of Earth.

In April, the Kepler team reported the smallest potentially habitable exoplanet known: Kepler 186f, about 490 light-years away. It is just 10 percent wider than Earth and orbits its dim, red star at a distance where liquid water could exist (*SN*: *5*/*17*/*14*, *p*. *6*). But astronomers

don't know if the planet can support life.

Astronomers also determined that the rocky planet Kepler 10c is a "mega-Earth," 2.4 times as wide as Earth but 17 times as massive, roughly the mass of Neptune (*SN: 7/12/14, p. 10*). Researchers thought

In the zone Earth-sized Kepler 186f sits much closer to its star than Earth does to the sun. But because its star is much cooler and fainter than the sun, the exoplanet may still be habitable and home to liquid water. SOURCE: NASA



that anything heavier than 10 Earth masses should become a gassy planet like Jupiter. Theorists are puzzling over how such a massive rock could form.

Kepler's biggest discovery of the year wasn't

any one planet — it was 715 of them (*SN*: 4/5/14, *p*. 15). The haul was the largest to date, raising the number of known exoplanets above 1,700.

Such discoveries came amidst concern over Kepler's supposed death. After four years, it could no longer keep its balance, and was forced into retirement last year (SN: 9/21/13, p. 18). But throughout winter and spring of 2014, engineers tested an ingenious solution: point the peak of the solar panel roof toward the sun and use the balanced pressure from sunlight to steady the telescope. The successful test persuaded NASA to fund a new mission for Kepler. Rechristened as "K2," the mission will scan for exoplanets along with asteroids, star clusters and galaxies (SN: 6/28/14, p. 7).

Risks of e-cigarettes emerge

Vaping is better than smoking but not benign

By Janet Raloff

Electronic cigarettes are marketed as a safer alternative to inhaling the combustion products of tobacco. And to some extent, that's correct.

"There's no question that a puff on an e-cigarette is less toxic than a puff on a regular cigarette," says Stanton Glantz of the University of California, San Francisco.

But that's an advantage only for people already addicted to nicotine, he warns. In fact, his research shows, manufacturers target their electronic cigarettes to nonsmokers too — including teens and tweens. Electronic devices dispense water vapor laced with flavors and often a hefty dose of nicotine. These



vapors may be far from benign, studies in 2014 suggested.

Researchers in Italy reported that people exhale less nitric oxide, indicating lung inflammation, right after vaping (*SN: 7/12/14, p. 20*). RTI International in Research Triangle Park, N.C., reported that the median diameter of vaping particles runs between 200 and 300 nanometers, comparable in size to cigarette smoke particles. And particles that people inhale while vaping are likely to settle deep in the lung, RTI's team concluded.

Inhaled e-cig vapors also make some germs hard to kill, researchers reported in May. Methicillin-resistant *Staphylococcus aureus*, or MRSA, grew faster in rodents exposed to e-cigarette vapors. In test tubes, MRSA bacteria exposed to vapors developed coatings that made them difficult to kill by one of the body's natural antibiotics.

A solvent used in many flavored e-cig liquids can transform into a family of carcinogens that includes acetaldehyde and the suspected carcinogen formaldehyde, Maciej Goniewicz of the Roswell Park Cancer Institute in Buffalo, NY, and colleagues reported. So-called second-generation e-cigarettes that run hotter — to dispense more flavor and nicotine — pose the biggest risk, his team showed (*SN: 6/28/14, p. 9*). And e-cigarette vapors can contain nitrosamines, agents suspected of triggering lung cancer in smokers.

Nicotine is also not benign. It can change the brain's structure as it develops into young adulthood, notes Glantz. That's one reason why he is concerned by federal data reported in 2014 showing that from 2011 to 2013, the number of U.S. children in grades 6 through 12 who had tried vaping doubled — to 6.8 percent (*SN for Students: 3/19/14*).



Young blood aids old brains

Brain cells in

old mice whose

circulatory

systems were

linked to young

mice showed signs

of improvement.

Studies in mice offer hope for alleviating aging

By Laura Sanders

Ingredients in young blood can rejuvenate old mice's bodies and brains. A group of papers published in 2014 detail how youthful plasma can improve some signs of deterioration (*SN*: 5/31/14, p. 8).

The findings evoke thoughts of eternally young and bloodthirsty vampires, but in reality, the results are pointing to new treatments that may stave off the ravages of aging. Already, scientists have begun a small clinical trial to study whether

plasma from young donors can improve symptoms in people with Alzheimer's disease.

Brain cells in old mice whose circula-

tory systems were surgically linked to young mice showed signs of improvement: gene behaviors changed and neurons sprouted more connecting points, Tony Wyss-Coray of Stanford University School of Medicine

> and colleagues found. Another study discovered that young blood increases the birthrate of nerve cells in a part of older brains, leading to better smelling abilities, and remodels blood vessels in a way that boosts blood flow.

Such improvements could be achieved even without drastic surgery: Old mice that received a series of injections of young plasma appeared to have stronger memories than did old mice that received old plasma. The benefits of young plasma disappeared when the plasma was heated before injection, suggesting that certain heat-sensitive compounds in the plasma were behind the improvements.

Young blood may be packed with substances that keep the body and brain strong. One candidate molecule, called GDF11, popped up in two studies as a potential do-gooder. On its own, GDF11 benefited both the brains and muscles of mice.

Drugs designed to mimic GDF11 or other beneficial molecules in young blood may prevent some of the negative effects of aging. In the meantime, some scientists are hedging their bets by using plasma from young donors in studies. A clinical trial, led by Stanford University scientists and the biomedical company Alkahest, cofounded by Wyss-Coray, involves injecting a unit of plasma from men age 30 or younger once a week into 18 elderly people with Alzheimer's. The trial began in September, and scientists plan to have results in about a year.



1. Ebola

Analysis of 99 Ebola virus genomes helped scientists pinpoint the origin of Sierra Leone's outbreak to a healer who had contracted the disease in Guinea, confirming that the virus spread through contact with infected humans, not animals (SN: 9/20/14, p. 7).

2. Antarctic midge 3. Loblolly pine

With just 99 million

chemical subunits of

DNA, the genome of

this petite polar bug

is the smallest of any

known insect. Life

in a bitterly frigid

climate may have

shrunk the midge's

genetic blueprints,

researchers suggest

(SN: 9/20/14, p. 4).

Besting the Norway spruce – last year's titleholder for largest genome – by just 2 billion DNA subunits, the skyscraping loblolly pine holds the new record for lengthiest genetic instruction book, with 22 billion letters of DNA code (*SN: 5/17/14, p. 4*).

4. Housefly

The common housefly may be somewhat of a superbug. Researchers unveiled a genome full of DNA snippets that could help the insect thrive in dirty dwellings – buzzing between dung and decomposing carcasses without getting sick (SN Online: 10/15/14).

5. Orchid

Scientists decoded the genome of a plant metabolically adapted to a low-water life. The boldly colored orchid *Phalaenopsis equestris* may use a slew of duplicated genes to "breathe" carbon dioxide while staying hydrated. – *Meghan Rosen*

Gut reacts to artificial sweeteners

Microbe-saccharin mix disturbs metabolism

By Rachel Ehrenberg

It wasn't a bittersweet year for saccharin - just bitter. An elaborate study demonstrated that the artificial sweetener messes with the body's ability to metab-

olize glucose, a condition that often obesity and other metabolic problems (SN: 10/18/14, p. 6). The kicker: Microbes

"There is now more and presages diabetes, more evidence that artificial sweeteners are not metabolically inert." **KRISTINA ROTHER**

in the gut seem to mediate this off-kilter metabolism, although scientists don't know how.

Israel-based researchers first established that blood sugar levels in mice got wonky after the mice consumed artificial sweeteners, then used antibiotic treatments to probe the saccharin-gut microbe connection. The team gathered genetic data on those microbes and even transplanted the fecal microbial community of mice - and of two

humans - into other mice.

The study got a lot of attention, probably buoyed by a growing interest in gut microbes' influential reach,

> says endocrinologist Kristina Rother of the National Institutes of Health in Bethesda, Md. "People are much more aware that what we

eat and what our intestinal flora looks like contribute to health - the microbiome is so hot right now."

The new study was not the first to find that artificial sweeteners don't pass through the gut unnoticed, she says. For years, scientists have been dissolving the sweeteners' sugar-coating, revealing that the sweet substitutes interact much more with the body than anticipated and often with metabolic consequences. Just stimulating gut cells that respond to sweet taste can have downstream metabolic effects, researchers reported in 2007. The link with altered gut microbes was made in rats back in 2008.

Yet in a world where calories are criminal, artificial sweeteners have been presented as good guys or at worst innocent bystanders. "There is now more and more evidence that artificial sweeteners are not metabolically inert," Rother says. "But I still hear people, even at the NIH, say, 'What do you mean they affect metabolism? They have no calories!""

While the scientific evidence mounts that artificial sweeteners alter metabolism in potentially problematic ways, consumers have little recourse. Google can help searchers find the acceptable daily amount of the sweeteners, but nutrition labels don't give a percentage of daily dose. In fact, people who prefer not to eat artificial sweeteners often inadvertently choose products laden with them because those foods are often labeled as "low sugar" or "no sugar added," says Rother. "The FDA and industry are a step behind what the consumer would like. But the pressure is rising." ■

Tectonics active on Europa Churning icy plates explain young surface By Thomas Sumner

A frozen world hundreds of millions of kilometers away is starting to look a bit like home. This year researchers discovered active plate tectonics reshaping the surface of Jupiter's icy moon Europa (shown). The finding marks the first evidence of active plate tectonics on another world (SN: 10/4/14, p. 10).

The researchers made the discovery while scrutinizing an area of Europa's surface mapped by NASA's Galileo spacecraft in 1998. In the moon's northern hemisphere, a hunk of landscape the size of New Jersey had vanished. Like a torn photograph placed so the pieces overlap, Europa's crisscrossing surface fractures didn't properly line up. The researchers

propose that this missing region dived beneath other ice layers in a process analogous to subduction on Earth, in which one tectonic plate slides beneath another.

Europa's surface is broken into a mosaic of these shifting ice slabs, the researchers suggest. If the subduction rate is similar to Earth's, the moon's entire surface could recycle itself in less than 90 million years, says planetary scientist Simon Kattenhorn of the University of Idaho in Moscow. This periodic renewal could explain Europa's unusually young surface. Even though Europa formed more than 4 billion years ago, its icy surface appears to be only about

40 million to 90 million years old.

The blending of exterior and interior ice could benefit any life lurking in the moon's subsurface ocean, Kattenhorn says. Radiation from Jupiter could spark formation of energy-packed organic nutrients from simpler chemicals on Europa's outer shell. The tectonic blending offers a way for such surface nutrients to cycle into the liquid ocean below. "These geological cycles could be partially responsible for powering a biosphere," says astrobiologist Britney Schmidt of Georgia Tech in Atlanta.

The finding comes at an opportune time. NASA's proposed Europa Clipper mission recently entered early design stages in preparation for a 2022 launch. In July, NASA asked scientists to send ideas for instruments for the mission. The agency plans to choose which ideas to develop

next April. 🔳



Life thrives under Antarctica

Thousands of microbe varieties found

By Thomas Sumner

An unseen ecosystem flourishes in the darkness, entombed beneath 800 meters of ice. In 2014, researchers shed light on this microbial community.

Rivers and about 400 subglacial lakes traverse the land sealed beneath Antarctica's 14-million-square-kilometer ice sheet. For decades, scientists speculated about what strange creatures might lurk in the frigid waters. In 1999, researchers found life in an ice core drilled above Lake Vostok in East Antarctica. But critics said the scarce cells were simply contamination from the drilling process.

Since then, researchers from Russia, the United Kingdom and the United States have sought more convincing proof of life. In January 2013, the U.S. team reported finding live cells in water from Lake Whillans, 800 meters below the West Antarctic ice sheet (*SN: 3/9/13, p. 12*). In August, the team announced that it had found not only life but a thriving ecosystem there (*SN: 9/20/14, p. 10*).

The team identified genetic traces of 3,931 microbial species or groups of species in water from the lake (bacteria cultured from the lake are shown above). The abundance of bacteria and singlecelled organisms called archaea was a surprise. Project scientist Brent Christner of Louisiana State University compared the number of microbes to that found in a typical surface lake or ocean.

The finding bolsters the idea that life exists elsewhere in the solar system, Christner says, such as under Mars' polar ice caps or in a subsurface ocean on Jupiter's frozen moon Europa.



Asian cave art got an early start Hand stencils revise painting history By Bruce Bower

Ancient cave art went global in 2014. Scientists reported that Stone Age cave painting began at about the same time in Southeast Asia as in Europe. These findings suggest the need to rethink a decades-old conviction that Western Europeans cornered the market on creativity with their cave paintings about 40,000 years ago, millennia before groups elsewhere started drawing on rock walls.

Famous cave paintings in France and Spain were taken down a notch in significance thanks to new dates for a couple of human hand outlines previously dis-

covered inside caves on the Indonesian island of Sulawesi. Archaeologists Maxime Aubert and Adam Brumm, both of Griffith University in Southport, Australia, led the effort that dated one Sulawesi hand stencil to

at least 39,900 years ago and another to at least 39,400 years ago (*SN: 11/15/14, p. 6*). Stone Age islanders made those and many other hand stencils by blowing, spraying or spitting liquid pigment around an outstretched hand pressed against a cave wall.

Other examples of Sulawesi cave art include a drawing of a fruit-eating pig called a pig-deer, or babirusa, from at least 35,400 years ago and a portrait of a piglike creature dating to 35,700 years ago or more.

Painted images and symbols appear on cave walls and rock shelters through-



Hand stencils found in Indonesia were painted more than 39,000 years ago, researchers determined in 2014. That age makes the cave art nearly as old as Europe's earliest rock art.

out the world. But researchers have had a tough time identifying how long ago various instances of rock art were created. Radiocarbon analyses of bits of paint removed from cave paintings have yielded inconsistent results.

Aubert and Brumm's team opted for a technique called uranium-series dating. This method estimates the time needed for mineral deposits to form and par-

> tially cover some examples of cave art, providing a minimum age for those images. Another team recently used uraniumseries dating to show that cave painting began in Western Europe by 40,800 years ago.

If further research confirms that cave art appeared at the same time in Western Europe and Southeast Asia, these practices must have started in Africa before modern humans spread to Europe and Asia 60,000 years ago, Aubert suspects.

More uranium-series dates for Southeast Asian rock art are in the works. Aubert has already scouted caves and rock shelters on Borneo that contain potentially ancient paintings. He plans to do the same in New Guinea. Sulawesi contains more than 100 cave art sites, "and more are discovered every year," he says.

Genes linked to tameness Studies illuminate animal domestication By Tina Hesman Saey

Domesticated animals transitioned from wild beasts into furry friends thousands of years ago, but scientists have not yet fully explained how taming also altered animals' appearances. In 2014, researchers took steps toward the answer.

In July, three scientists presented the idea that slight alterations in some cells could account for physical attributes that go hand-in-hand with tameness (*SN:* 8/23/14, p. 7). The cells, called neural crest cells, migrate through embryos and contribute to the development of many parts of the body, including the face, pigment cells and adrenal glands — the source of the fight-or-flight response.

Humans choosing companionable animals unwittingly selected creatures with slight impairments in neural crest cell function, the scientists reasoned. That explains why domesticated animals display other effects of faulty neural crest cells: white-spotted coats, floppy ears and juvenile faces, traits collectively called

domestication syndrome.

Previous explanations for individual domesticated traits often didn't explain why tame animals had other associated features, says Greger Larson, a geneticist at the University of Oxford. The neural crest cell hypothesis may not be

correct, but it does give researchers an idea to test, he says.

Researchers studying cat domestication discovered variants in many genes that set house cats apart from wild cats. But it wasn't obvious why those genetic tweaks would be linked to domestication, says Wesley Warren, a geneticist at Washington University in St. Louis. But the neural crest cell paper "started to help us make sense of some things we were seeing," he says. Warren and colleagues realized that five genes they identified as domestication signatures are important for neural crest cell func-

> tion (*SN: 12/13/14, p. 7*). Those findings support the emerging hypothesis.

> Not everyone is convinced that neural crest cells explain tame animals' features. People probably weren't picking animals based on tameness alone, says Leif Andersson, a

geneticist at Uppsala University in Sweden. Humans may have chosen animals with coat colors that made them easier to spot in a field, for instance.

Genes involved in

neural crest cell

development that

differ between wild

and domesticated

cats

Insect history A new family tree gave origin dates for (from left) springtails; jumping bristletails; silverfish; dragonflies/damselflies; crickets/katydids; true bugs/cicadas/plant lice; snakeflies; beetles; sawflies/wasps/bees/ants; moths/butterflies; true flies; caddisflies; cockroaches; and scorpionflies.



Insect, bird evolution revisedGenetic analyses produce new family treesBy Susan Milius

Biologists in 2014 saw what an astronomical amount of data could do for evolutionary questions — and what it couldn't.

Bernhard Misof of the Zoological Research Museum Alexander Koenig in Bonn, Germany, and 100 coauthors, published an evolutionary family tree of insects and close relatives based on the subset of some 1,478 genes shared by 144 kinds of organisms (*SN: 12/13/14, p. 8*).

This project, called 1KITE (for 1,000

Insect Transcriptome Evolution), arranged branches on the new tree in ways that looked familiar, but details of certain insect orders differed. Project coleader Karl Kjer of Rutgers University says he has abandoned some of his earlier ideas on branches near the base of the tree as a result of the findings. And Kevin Johnson of the Illinois Natural History Survey in Champaign is rethinking whether the parasitic lifestyle really did evolve twice in Psocodea louse history, as he and colleagues had proposed.

Louse history still poses questions. The new tree puts the origins of parasitic lice at about 53 million years ago, well after dinosaurs died out. Vincent Smith of the Natural History Museum in London, who has proposed that lice nipped dinosaurs, points out that the new study still has considerable uncertainty in its time estimates for louse ancestors.

Another ambitious project redrew the bird genealogical tree based on the full genomes for 48 bird species. Published in December, this work, like the insect family tree, received funding from the Chinese genetic institute BGI.

Easy stem cells a no go STAP cell papers raise publishing issues By Tina Hesman Saey

An incredibly easy method for making stem cells turned out to be too good to be true, again tainting stem cell research with controversy and stirring up disquiet over some scientific publishing policies.

In January, scientists claimed to have made ultraflexible stem cells, known as STAP cells, by dipping mature cells into acid or by putting the cells under gentle pressure (*SN: 2/22/14, p. 6*). Had it worked, stem cell production could have been a breeze instead of a meticulous

endeavor. But within weeks it was clear that STAP cells were not as easy to make as claimed (*SN Online: 3/10/14*).

An internal investigation at Japan's RIKEN found lead author Haruko Obokata guilty of scientific misconduct for manipulating

images and plagiarizing text. In July, the authors retracted the papers (*SN Online:* 7/2/14). And in August, coauthor Yoshiki Sasai hanged himself in Japan.

Still some of the researchers continued to assert that STAP cells are real. Obokata claimed to have produced STAP cells more than 200 times but was not able to reproduce her results. Two other coauthors, Charles Vacanti and Koji Kojima, released a revised protocol in September. They stated that STAP cells aren't easy to make but claimed that the new instructions should improve the likelihood of creating the elusive cells.

The STAP cell saga exposed possible weaknesses in scientific publishing and peer review (*SN: 7/26/14, p. 7*). The journal *Nature*, where the STAP papers appeared, contended that peer reviewers could not have spotted the papers'

The STAP cell saga exposed possible weaknesses in scientific publishing and peer review.

fatal flaws. In September, however, copies of reviews from *Nature* revealed that peer reviewers had grave concerns over the work and didn't recommend it for publication. One reviewer called the STAP cell method a "magical" approach that wasn't supported by exper-

imental evidence. It is not clear how much revision the papers underwent before being published in their final form.

Some researchers say the story isn't over and that scientists need to examine this case to ensure that stem cell research won't be marred by such incidents again.



The nose knows a trillion odors

Scent tests show precision of human olfactory power

By Bruce Bower

In the movie *Roxanne*, Steve Martin plays a lovesick guy who mocks his own huge schnoz by declaring: "It's not the size of a nose that's important. It's what's in it that matters." Scientists demonstrated the surprising truth behind that joke this year: People can whiff an average of more than 1 trillion different odors, regardless of nose size (*SN: 4/19/14, p. 6*).

No one had systematically probed how many scents people can actually tell apart. So a team led by Leslie Vosshall of Rockefeller University in New York City asked 26 men and women to discriminate between pairs of scents created from mixes of 128 odor molecules. Volunteers easily discriminated between smells that shared as much as 51 percent of their odor molecules. Errors gradually rose as pairs of scents became chemically more alike.

Vosshall's group calculated that an average participant could tell apart a minimum of more than 1 trillion smells made up of different combinations of 30 odor molecules. Really good smellers could have detected way more than 1 trillion odor mixtures, the scientists said.

Smell lags behind sight and hearing as a sense that people need to find food, avoid dangers and otherwise succeed at surviving. Still, detecting the faint odor of spoiled food and other olfactory feats must have contributed to the success of *Homo sapiens* over the last 200,000 years.

Perhaps many animals can whiff the difference between a trillion or more smells. For now, odor-detection studies modeled on Vosshall's approach have been conducted only with humans.

Roster of dinosaurs expands

Evidence suggests warmer, fuzzier beasts

By Meghan Rosen

Dinosaurs roared into the news this year with the discovery of several new species and a few dogma-shaking revelations.

One skyscraping goliath found in Argentina was a plant eater that reached about as tall as a two-story building at its shoulders and weighed more than seven T. rexes (SN Online: 9/4/14). Scientists named the giant Dreadnoughtus (for "fears nothing") schrani.

Another beast, dug up in Portugal, was a new T. rex-like species called Torvosaurus ("savage lizard")

gurneyi. It might have been the biggest predator to stalk through Europe during the late Jurassic period, 161 million to 145 million years ago (SN Online: 3/6/14).

Though these big dinos evoke Godzilla, people can probably dump the popular image of dinosaurs as lumbering, lizardlike swamp creatures. Instead, they may have been a bit more warm and cuddly. In 2014, researchers found more evidence that dinosaurs all wore

> Dreadnoughtus schrani is one of the largest dinosaurs ever found. It weighed about 60 metric tons.

some type of feathery coat (SN: 8/23/14, p. 15). Fuzzy filaments covered the body and limbs of a new species unearthed in Siberia. Because the dinosaur was only distantly related to the ancestors of birds, downy dino plumage may have been the norm.

Although 50 million years of continual shrinking transformed dinosaurs into birds (SN Online: 7/31/14), Tyrannosaurus, Allosaurus and their cousins probably didn't share the flying animals' rapid metabolisms. Instead, researchers proposed in June, dinosaurs fell somewhere in between warmblooded birds and cold-blooded lizards (SN: 7/12/14, p. 6).

And rather than lurking just in balmy lagoons, dinosaurs settled in many different environments, including the ancient Arctic, with a climate similar to today's Pacific Northwest. Herds of duck-billed dinosaurs may have made homes there year-round (SN: 8/9/14, p. 20). One type of dinosaur probably even preferred an aquatic home. Spinosaurus, a sailbacked predator first described in 1915, may be the only known dinosaur to have dwelled in and out of water, perhaps even hunting sharks (SN:10/18/14, p. 10). ■

The year in microbiomes

Scientists have long known that people are cozy homes for bacteria – but figuring out the myriad roles of bacteria in the body is still a work in progress. This year, scientists pegged microbes as important players in several aspects of human health, including obesity and cancer. Highlights from 2014 include:

1. Obesity

2. Jet lag

Blasting away babies' gut bacteria could boost weight gain later in life. Infant mice dosed with antibiotics chunked out as adults: researchers blame the bulge on the mice's microbial makeup, which differed from that of drug-free mice (SN: 9/20/14, p. 12).

Messing with gut microbes' schedules may make people fat. After crossing a few time zones, travelers housed more bacteria linked to obesity than they did before the trip. In mice, jetlagged gut microbes prompted weight gain (SN: 11/29/14, p. 12).

3. Colon cancer

Gut microbes might explain the link between eating a Western diet and developing colon cancer. Bacteria that feast on sugar may churn out a chemical that turns on tumor growth, a study in mice suggested (SN: 8/23/14, p. 12).

4. Placenta

Babies get their first brush with bacteria in the womb, an analysis of microbes in the placentas of 48 women found. Scientists once believed placentas to be sterile, but they are home to some of the same bacteria found in people's mouths (SN: 6/28/14, p. 6).

5. Drugs

Microbes in people may be tiny drug mills, making thousands of chemicals including antibiotics. scientists found after peeking into the genetic blueprints of 2.430 bacteria collected from the human body (SN: 10/18/14, p. 8). – Meghan Rosen



Neutrinos leave tracks in ice Scientists map particles' birthplaces By Andrew Grant

In the dark depths of an Antarctic glacier, flashes of light triggered by wispy particles called neutrinos are providing rare clues about the universe's most extreme environments. After discovering the first high-energy neutrinos from beyond the solar system late last year, researchers with the IceCube Neutrino Observatory spent 2014 tracing the particles' origins to the locations of the mysterious violent objects that produced them.

"For the first time, I can point to an area in the sky and say there's an ultrahigh-energy object there," says IceCube astrophysicist Nathan Whitehorn of the University of California, Berkeley. The next step, he says, is using the neutrino data to identify those objects.

For decades, scientists have puzzled over the origins of speedy charged subatomic particles, some of which pelt Earth with about 100 million times the energy of particles whizzing around the best human-made accelerator. Even the most powerful gamma-ray burst should not be able to accelerate particles to those speeds. Scientists can't trace the particles back to their sources because magnetic fields skew the particles' paths. But high-energy neutrinos, which also form near the universe's most violent objects, travel in a straight line. Neutrinos have no charge, so they are unaffected by magnetic fields and pass through gas clouds and galaxies unperturbed.

Since 2010, IceCube has hunted for cosmic neutrinos beneath the surface of the Antarctic ice sheet. Nearly 5,500 sensors spread over a cubic kilometer detect flashes of light when neutrinos hit atoms in the ice. IceCube has detected at least 37 high-energy neutrinos from beyond the solar system (*SN Online:* 4/7/14).

In unpublished work this year, Ice-Cube scientists mapped the birthplaces of a subset of neutrinos. The collision of an atom with one type of neutrino produces a muon, which physicists can track as it burrows through the ice. Researchers used each muon track to trace the path of the parent neutrino and pinpoint the area of the sky from which it arrived.

Preliminary data reveal that highenergy neutrinos bombard the planet from all directions evenly, suggesting that the particles are produced by many distant objects rather than a few nearby ones (*SN*: 5/17/14, p. 8).

Ocean may power Enceladus' geysers

Evidence favors sea under Saturnian moon's surface

By Christopher Crockett

The case for a saltwater ocean — and a potentially habitable environment beneath the icy crust of Saturn's moon Enceladus keeps getting stronger.

Enceladus has been dribbling hints about a subsurface sea since the Cassini spacecraft first visited the moon in 2005. Salty ice geysers erupt through cracks in the south polar ice sheet. Heat wells up through the fissures, presumably from a deep, warm reservoir. But all evidence for an interior sea had been limited to surface observations — until this year.

In April, Luciano Iess of Sapienza University of Rome and colleagues used Cassini data to map an ocean hiding under the moon's south pole (*SN*: 5/3/14, *p. 11*). The sea holds about as much water as Lake Superior.

Iess' data couldn't pinpoint what powers the surface geysers. Three months later, however, Carolyn Porco of the Space Science Institute in Boulder, Colo., and colleagues found evidence connecting the fountains to an underground water supply (*SN: 9/6/14, p. 15*). Using Cassini images and maps, Porco found that warm spots at the base of each geyser are too small to power the jets, so the spray couldn't originate at the surface. Most likely, Saturn's gravity repeatedly opens and closes the fissures, allowing water and heat to escape from the interior and vent into space.

The findings suggest that water jetting out of Enceladus probably comes from a warm, briny, subsurface sea atop a rocky core. There's no evidence for life, but many of the ingredients seem in place.

The post-pigeon centuryBuildings, cars and cats take toll on birdsBy Susan Milius

News of bird troubles received an eerie emphasis in 2014 when biologists marked the 100th anniversary of the death of the last known passenger pigeon.

For the occasion, the slim, coffee-andcream-colored taxidermy mount of that final pigeon, named Martha, came out of storage at the National Museum of Natural History in Washington, D.C. (*SN: 8/23/14, p. 28*). Visitors puzzled anew at how a species once numbering several billion birds vanished in decades.

Readers of the 2014 State of the Birds report from government and private

sources may wonder about perils to today's abundant birds. Among the report's somber assessments is a list of 33 "common birds in steep decline" (*SN: 11/1/14, p. 4*). Common grackles, eastern meadowlarks and northern bobwhites, among others, are still too abundant to classify as threatened. Yet each has lost more than half its population during the last 40 years.

"I am more concerned than ever about our state of the birds," says Peter Marra of the Smithsonian Migratory Bird Center in Washington, D.C. "I think we need to move faster than ever to understand the declines and to try and stop them."

Today's biggest threat to birds is habitat loss, the report says. Papers by Marra and collaborators also calculated the tolls of more direct — and possibly more controllable — ways that humankind causes bird deaths.

Between 365 million and 988 million birds in the United States each year die crashing into windows and buildings, Marra and colleagues estimated (*SN:* 3/22/14, p. 8). Other bird killers include automobiles, smashing up to 200 million birds annually, and wind turbines, taking an estimated 234,000. Not even buildings, however, approached the death toll for birds caught by cats, estimated by Marra and colleagues at 1.3 billion to 4.0 billion (*SN:* 2/23/13, p. 14).



spectacle. On October 19, comet Siding

Spring whizzed past Mars at a distance

of just under 140,000 kilometers, a near



Business booming on Mars Rovers, orbiters add to Red Planet data

By Alexandra Witze

Mars is getting crowded. The Red Planet now has seven robots studying it, following the arrival of two new orbiters in September: NASA's MAVEN (Mars Atmosphere and Volatile Evolution) and MOM (Mars Orbiter Mission), the Indian space agency's first Mars spacecraft.

Both showed up just in time for a rare



(Marsmiss in planetary terms. As a precautionon) andagainst the high-speed dust particlesIndianflying off the comet, MAVEN and twoother NASA orbiters temporarily hun-r a rarekered down on the far side of the planet.They survived unscathed, and one sentback pictures of the comet's nucleus, thefirst ever seen in a pristine comet fromthe farthest reaches of the solar system(SN Online: 10/22/14).

MAVEN, the first probe dedicated to studying the Martian upper atmosphere, embarked on a year-long mission to measure how the solar wind strips that atmosphere away. Over billions of years, this atmospheric erosion has transformed the planet from warm and wet – and presumably more hospitable to life – to cold and dry (*SN Online: 10/15/14*).

For all the excitement in orbit, there was still plenty of action on the surface. NASA's decade-old Opportunity rover discovered evidence for the most ancient Martian environment where life could have existed, roughly 4 billion years ago (*SN: 2/22/14, p. 10*). Opportunity's odometer also turned over 40 kilometers, breaking a Soviet moon rover's record for longest distance driven on an extraterrestrial body.

Meanwhile, NASA's Curiosity reached Mount Sharp, a 5-kilometer-high pile of sediments that the rover had been driving toward since landing in 2012. Curiosity suffered wheel damage from rock punctures but continued to gather rock and soil samples to flesh out the picture of where and when Mars might have been conducive to life.

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Genes, bones tell new Clovis stories

Studies reveal range, legacy of early North Americans

By Bruce Bower

A long-dead but undeniably colorful cast of characters provided new insights this year into the genetic legacy, geographic range and hunting habits of ancient North America's Clovis people.

ClovisFest 2014 began with an analysis of DNA from a 1-year-old Clovis baby who died over 12,500 years ago (*SN: 3/22/14, p. 6*). The child's DNA indicates that Clovis people, whose culture peaked roughly 13,000 to 12,600 years ago, were ancestors of today's Native Americans.

An ancient teenager named Naia then surfaced in Mexico with a genetic profile that also points to links between Clovisera Americans and modern Native Americans. Her DNA included Asian-derived gene variants previously found only among people now living in North and South America (*SN: 6/14/14, p. 6*). Studies of Naia's bones suggested that she lived between 13,000 and 12,000 years ago.

Naia can't conclusively be tied to Clovis culture. But Clovis people – best known as hunters of North America's Great Plains – also lived in parts of Mexico around Naia's time. There they killed elephant-like creatures called gomphotheres, Clovis spearpoints (one shown above) found with bones indicate (SN: 8/9/14, p. 7).

Clovis people weren't the only ancient Americans. Two successive Siberian populations, the Dorset and Thule cultures, settled North America's Arctic regions starting around 5,000 years ago (*SN:* 10/4/14, p. 12). Neither group was related to Clovis folk or to modern Native Americans, new genetic evidence suggests.

Climate warnings heat up

Carbon emission cuts are planned

By Beth Mole

Climate change is here and the world is unprepared, scientists and policy makers declared multiple times in 2014. Meanwhile, researchers continued to tally the environmental fallout of rising greenhouse gas levels while searching for signs of missing heat from Earth's surface.

In March, the Intergovernmental Panel on Climate Change reported that the world is generally unprepared to protect vulnerable communities from outcomes such as food shortages and flooding. In April, another IPCC report suggested strategies to cool global warming's consequences, including adopting more alternative energy sources and capturing more greenhouse gases (*SN: 9/6/14, p. 22; SN Online: 4/13/14*). In November, the IPCC reemphasized that human activities are to blame for climate change and that a global response is urgently required.

In June, President Barack Obama released a plan to cap carbon pollution from power plants. By 2030, the proposed rule would reduce U.S. emissions by 30 percent compared with 2005. In October, European Union leaders agreed to slash greenhouse gas emissions by 40 percent in 2030 compared with 1990. And in November, Obama announced a deal with China to cut carbon pollution in the United States by 2025 and in China by 2030. China is the world's top carbon emitter; the United States is second.

The carbon-cutting plans came after a new record for atmospheric carbon dioxide: April was the first month in recorded history in which average carbon dioxide levels in the Northern Hemisphere were at or above 400 parts per million (*SN: 6/28/14, p. 18*).

Throughout 2014, scientists continued to uncover climate change effects. One analysis found that bouts of extreme heat on land are on the rise (*SN:* 4/5/14, *p.* 12). Researchers also discovered that West Antarctic glaciers have reached unstoppable melting (*SN:* 6/14/14, *p.* 11). The West Antarctic ice sheet's demise could boost global sea level by as much as 4 meters in coming centuries.

Uncertainty lingers about where all of the heat is, exactly. Since around 2000, researchers have noted a plateau in global surface temperatures despite rising greenhouse gas levels. Scientists suggested that strong winds over the Pacific shoved heat deep into the water (*SN*: 3/22/14, p. 12). Another study suggested that natural heat-moving conveyor belts in the Atlantic and Southern oceans have switched into overdrive, concealing the bulk of the warmth (*SN*: 9/20/14, p. 10).



Speed up The collapse of West Antarctica's glaciers may be unavoidable, and the ice sheet's demise could raise global sea level by as much as 4 meters, researchers reported. In recent years, the flow of these glaciers into the ocean has largely accelerated (red), which exacerbates melting.

Life's complexity recoded Scientists create variants of natural DNA By Rachel Ehrenberg

Scientists made serious headway this year in tackling why life is both so darn complicated and so darn simple. Researchers upped life's genetic complexity by coaxing a strain of the bacterium *E. coli* into using two synthetic genetic letters in addition to the standard four to build strands of DNA. Another team took a minimalist approach, creating a pared-down version of a yeast chromosome.

"These are big achievements," says Ross Thyer of the University of Texas at Austin. Future work may produce unforeseen engineering marvels, he says.

The researchers working with *E. coli* added two new molecular building

blocks to the four that make up the rungs in DNA's double helix. Ordinary DNA building blocks, or bases, pair up to connect DNA's two helical strands. In the *E. coli*, the two artificial bases, the awkwardly named d5SICS and dNaM, paired up to form a new rung in the helix (*SN: 6/14/14, p. 14*). The feat may help scientists understand why the standard double helix is so simple.

"Why don't we have more base pairs in nature?" asks Thyer. Every living thing uses the same genetic alphabet to transmit information from one generation to the next. These few building blocks yield incredible diversity, from earthworms to human beings.

Microbes exploit their killer Triclosan promotes antibiotic resistance By Beth Mole

Microbes have turned our pharmaceutical weapons into allies. This year, triclosan, an antimicrobial agent, topped the list of chemical traitors, aiding rather than deterring germs.

Leaked from products such as toothpaste and hand soap, low doses of triclosan promote drug resistance in germs that cause difficult-to-treat infections. In the environment, the chemical can disrupt hormone regulation in some animals, such as fish. (Data are lacking on health effects in humans.)

Despite the ongoing battle against antibiotic-resistant microbes (SN: 10/4/14, p. 22), triclosan remains omnipresent in household and personal care products. Humans take up the antimicrobial agent by ingesting it or absorbing it through skin. Washed down the drain, triclosan amasses in sewage and seeps into the environment.

In people, the chemical shows up

in blood, urine, breast milk, umbilical cords and snot. The health risks of prenatal doses of triclosan are unknown. In the nose, however, researchers found that triclosan-laced snot helps *Staphylococcus aureus* bacteria invade the body (*SN: 5/17/14, p. 12*). Such invasions increased the risk of staph infections, which can cause pneumonia.

In wastewater treatment plants, triclosan can sabotage the microbial cleaners responsible for breaking down sewage, killing off some beneficial

Nasal invasion

People with high concentrations of triclosan in their nostrils are more likely to harbor *Staphylococcus aureus* bacteria in their noses than are people with low levels of the antimicrobial chemical, a study in 2014 found.

SOURCE: A.K. SYED ET AL/MBIO 2014

Other researchers this year took a different approach: simplifying a relatively complicated life-form. The team, which included a small army of college students, assembled a synthetic veast chromosome and showed that it works fine in living yeast cells (SN: 5/3/14, p. 7). At 272,871 base pairs long, the synthetic chromosome is a streamlined version of the 316,617-base pair original. Although scientists have built bacterial genomes from scratch (SN: 6/19/10, p. 5), the yeast chromosome is the first step in building a synthetic genome of a eukaryote, an organism, such as a human, that stores its DNA in a nucleus.

When yeast's other 15 chromosomes are synthesized, scientists will be closer to understanding what's essential for making a complicated living thing. "It's an excellent way to understand the minimal components required for the complexity of life," Thyer says.

microbes and spurring drug resistance in others (SN: 7/26/14, p. 9).

Some of the 100 metric tons of triclosan that enters U.S. sewage plants each year lingers after treatment. Treated wastewater and sewage-based fertilizers can then spread the antimicrobial chemical. When such treated water is used on farmland, small amounts of triclosan accumulate in vegetables (*SN Online: 9/19/14*).

The U.S. Food and Drug Administration is reviewing the use of triclosan in personal care products. But some legislators and manufacturers aren't waiting. In May, Minnesota banned triclosan from certain products, effective in 2017. And Johnson & Johnson and Procter & Gamble plan to remove the antimicrobial agent from their products.







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EXPERIENCES

Evolve and Linkage turn science into games

Game night is fun and competitive. Now it can also be scientific thanks to games based on fundamental principles of biology.

In Evolve, players build fantastical creatures to adapt to ever-changing environments and survival challenges. Linkage is a strategy game based on copying DNA instructions into RNA, a process known as transcription.

To play Evolve, players combine cards depicting the heads, bodies and tails of various mammals, birds and insects into zany creatures such as one with the head of a crocodile, the body of a zebra and the tail of a wasp. Some body parts add special abilities such as climbing skills, camouflage or insulation. An adaptation slot allows players to add features such as opposable thumbs, sharp vision or migratory lifestyle.

A set of biome cards provides a wide variety of environments that creatures must adapt to, sometimes transitioning from jungles to frozen wastelands to deserts. Yet another set of cards presents challenges such as meteors, flooding or angry farmers. Players win or lose points based on how well their creatures' characteristics match the environment. A player wins by having the most points when the "dying sun" biome signals the end of the sometimes-hilarious game.

Meanwhile, in Linkage, players match cards to build an accurate RNA version of a common DNA template. Each correct match earns points, with bonuses for multiple correct cards in



a row. Strategy comes into play when competitors decide whether to add to their growing line of cards, repair incorrect matches, sabotage another player's hand or even change the common DNA template that everyone is trying to copy. Players can buy an extra move by giving up some cards in their hand.

Both games are fun but suffer from confusing instructions. Evolve is too complicated for its target age group of 9 years and older. (Linkage is billed as being for 10 years and up.) Evolve has its fans, but it does little to teach lessons about evolution. It is best suited for larger groups.

Linkage is the better game, and it proves educational. Its technical language may turn off nonscientists, but two who tried it found it easy to learn, fast and fun to play. Linkage is also more interactive than Evolve and not as complicated, making it a better party game.

Both games were launched with



Evolve's players mix and match animals' bodies and adaptive abilities to create outlandish creatures.

crowd-funded campaigns and are available for order online. Evolve is a product of New Horizon Games and is available at bit.ly/Evolve_game. Linkage can be purchased from Genius Games at bit.ly/Linkage_game. – Tina Hesman Saey

BOOKSHELF



The Patient Will See You Now Eric Topol A health care revolution approaches as individuals gain access to reams of

their own health data, a cardiologist argues. *Basic Books*, \$28.99



The Lost Elements Marco Fontani, Mariagrazia Costa and Mary Virginia Orna Nearly 200 years of attempts to discover elements missing

from the periodic table repeatedly resulted in errors and dead ends. *Oxford Univ.*, \$39.95



Adventures in the Anthropocene Gaia Vince A journalist travels the world cataloging people's extraordinary responses

to human-caused environmental change. *Milkweed Editions*, \$30

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Online favorites of 2014

More than 150,000 people visit the *Science News* website each week, and tracking that traffic lets us know which news stories and blog posts catch readers' attention. The favorites sometimes mirror editors' picks in our Top 25 list, but there are always a few surprises.

Top magazine news stories

Health risks of e-cigarettes emerge (#7 in Top 25) While vaping is less detrimental

to your health than smoking, it comes with the risk of inhaling toxic chemicals and promoting antibiotic-resistant bacterial infections (*SN*: 6/28/14, p. 9).

Earliest pants worn by horse riders

Two pairs of ancient wool trousers, roughly 3,000 years old, protected the legs of Asian nomads while they straddled horses during long journeys and mounted warfare (*SN: 6/28/14, p. 16*).

Forecast: Cloudy, 100% chance of ash

A simulated eruption of the big volcano under Yellowstone National Park in Wyoming predicts a pileup of ash across the country. Depths range from a couple of millimeters in New York and Atlanta to more than a meter in nearby states (*SN*: 10/4/14, *p. 32*).

A tale of touching tubes

A decades-old math puzzle about how to arrange seven cylinders so each touches all the others finally receives a satisfying solution (*SN*: *5/3/14*, *p*. *15*).

Artificial sweeteners may tip scales toward diabetes (#9 in Top 25)

Saccharin comes under scrutiny in a study that shows how the sugar substitute can disrupt the gut's microbial communities, potentially kicking off problems with the body's metabolism (*SN*: 10/18/14, p. 6).

Top blog posts

CONTEXT Top 10 things everybody

should know about science

The crucial principles of science are so simple you could tweet them, as managing editor Tom Siegfried demonstrates in this helpful list (*SN Online: 5/9/14*).

GORY DETAILS

The most (and least) realistic movie psychopaths ever

Forensic psychiatrists reviewed 126 films to figure out which psychopath portrayals are most true to life (SN Online: 1/14/14).

GROWTH CURVE

A timeline of a baby's first hour

Infants have a lot to do when they arrive in the world, and examining these early moments may help hospitals develop better methods to encourage breastfeeding (SN Online: 10/9/14).

SCICURIOUS

Addiction showcases the brain's flexibility

The brain has an amazing ability to adapt, a trait that's vital to understanding the complex neuroscience behind addiction (*SN Online: 8/5/14*).

SCIENCE TICKER

Siberian crater mystery may be solved Methane gas pooling under thawing permafrost might be to blame for the 30-meter-wide hole that opened up in Siberia in July (*SN Online*: 8/1/14).

WILD THINGS

After 2,000 years, Ptolemy's war elephants are revealed

A genetic study sheds light on an ancient account of a battle between African and Asian war elephants (*SN Online:* 1/21/14).

Some science never dies

Occasionally, an article will have long-lasting appeal. Here are a few of this year's most-viewed stories that weren't written in 2014.

A prayer for Archimedes (2007)

A newly uncovered text by the Greek mathematician reveals the early development of calculus. **bit.ly/SN_Archimedes**

The anorexic brain (2013)

Brain scans expose the neurological roots of the eating disorder. **bit.ly/SN_anorexia**

Immersed in Klein bottles (2001)

An astronomer sets out to create a real-world version of an odd mathematical shape with just one side. **bit.ly/SN_Klein**

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Bees, up close and personal

It's easy to miss the shiny face of *Augochloropsis anonyma* without a microscope — the bee grows to only about 8 millimeters long. But this iridescent bee native to the southeastern United States is one of the insects finally getting appreciation thanks to the unexpected popularity of technical

documentation for monitoring bees.

Unlike birds or butterflies, the 4,000 or so bee species buzzing around the United States don't have identification traits that amateur enthusiasts can spot without collecting specimens. "Basically you need dead bees and a microscope to play the game,"

says Sam Droege, who runs the U.S. Geological Survey's Bee Inventory and Monitoring Laboratory in Beltsville, Md. So efforts to look for trends in bee populations haven't had help from a coast-to-coast network of savvy amateurs like those who have long recorded birds.

To encourage the subtle art of bee identification, Droege and his colleagues began posting identification keys and images of bee specimens to the photo website Flickr. To

> Droege's surprise, the online gallery has already attracted over 27 million viewers. That's not bad for pictures illustrating such technical points as "supraclypeal area shining and nearly impunctate."

This bee specimen was collected and photographed as part of an ongoing project to monitor how bees in 47 national parks respond to climate change. *A. anonyma* is a sweat bee, one of a variety of species that are attracted to human sweat. Scientists have not settled the question of what function the bees' colorful luster might have. – *Susan Milius*





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