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SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
AUGUST 22, 2015

Pluto's Icy Haze

How Mosquitoes Hunt Humans

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Molecules on Demand

Glia in the Spotlight

Brain's support cells move into starring roles

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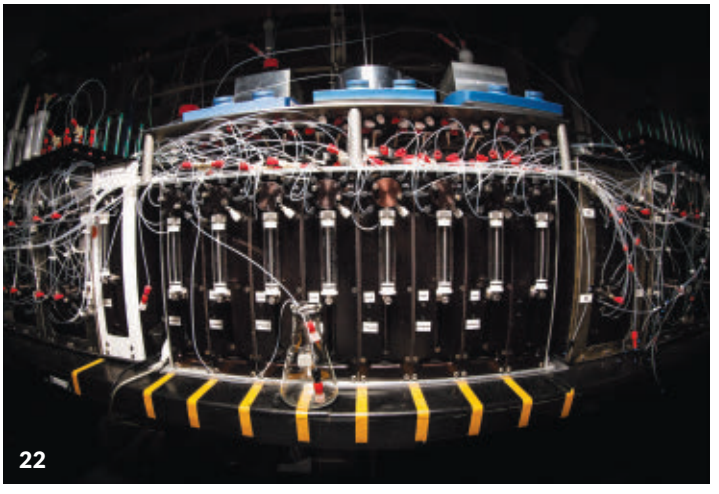
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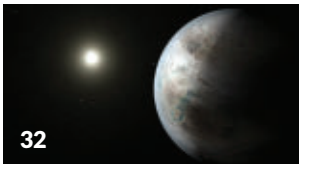
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Departments

COVER Astrocytes (orange) are a type of glial cell found in the brain; they influence nerve cell activity. *Thomas Deerinck, NCMIR/Science Source*

CLOCKWISE FROM TOP LEFT: M. BURKE/UNIV. OF ILLINOIS AT URBANA-CHAMPAIGN; T. PYLE/JPL-CALTECH/NASA; D. MARTILL/UNIV. OF PORTSMOUTH

Shifting views of brain cells, and other fresh perspectives

For far too long, the brain's cells have been divided into doers and helpers. Nerve cells, with their fancy electrochemical signals and complex circuitry, have attracted the attention and awe of scientists trying to understand the biophysical processes underlying thought and memory. Glial cells (the helpers) have seemed less interesting.

Named for glue, glial cells were considered the scaffolding, the housekeepers, the maintenance crew, the infrastructure. They worked in the background so that nerve cells could sparkle and shine.

That simplistic view has been slowly changing, as research has revealed the surprising range of roles that glial cells play. The deeper scientists look at the various types of glia, the more important these cells appear. Over the years, *Science News* has covered a steady stream of reports hinting that glial cells deserve a share of the limelight. On Page 18, Ashley Yeager describes the product of all these studies: a shift away from a neuron-centric perspective on the brain as well as a better appreciation of its diverse nature. Her story notes that glial cells can actually modulate nerve cell firing, helping to control the activity of the brain's star players. The details emerging from the latest work are sure to yield more insights as scientists continue their struggle to understand the mind.

Another type of new perspective appears in the article on Page 14 about an often-fatal freshwater amoeba. Some scientists think that the so-called brain-eating amoeba actually kills by triggering an immune reaction that swells the brain, Laura Sanders reports. That point of view suggests different tactics for treating the rare infection.

Two spacecraft also provide some unparalleled perspectives in this issue. Early data from New Horizons offer up a tantalizing view of Pluto covered by flowing ice, haze and a reddish hue (Page 7). And data just released from the comet lander Philae bring a firsthand account from the surface of a comet (Page 13). Also, just in time for summer's last hurrah, scientists have analyzed mosquitoes' redundant and persistent hunting strategies, explaining why it's so hard to avoid getting bit (Page 15). No doubt the insects gain an edge from their trusty glial cells. — *Eva Emerson, Editor in Chief*

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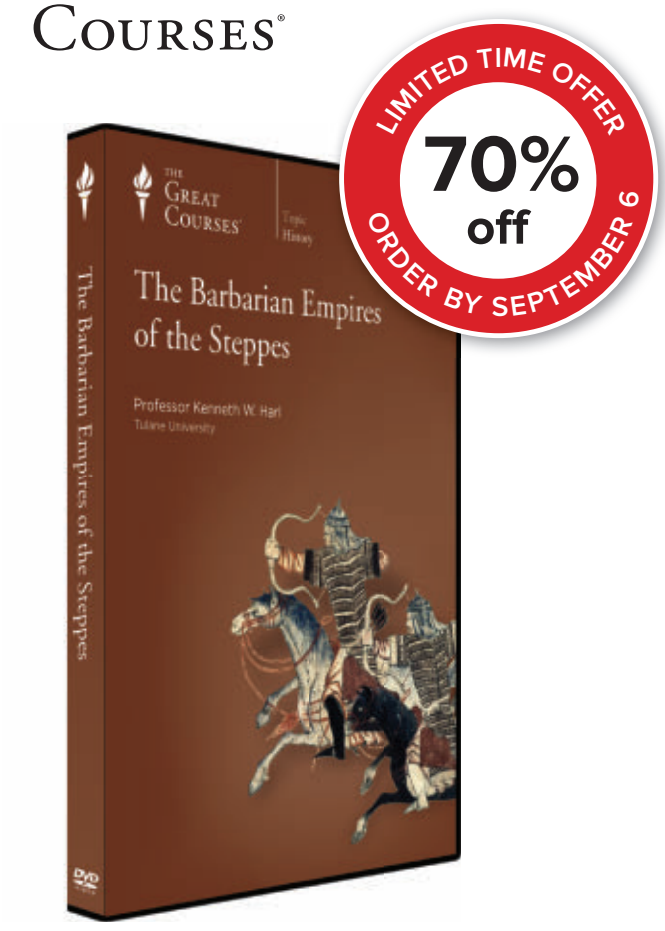

Meet History's Most Fearsome Leaders

Attila the Hun and Genghis Khan loom large in the popular consciousness as two of history's most fearsome warrior-leaders. Yet few people are aware of their place in a succession of nomadic warriors who emerged from the Eurasian steppes to seize control of civilizations.

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Excerpt from the August 21, 1965, issue of *Science News Letter*

50 YEARS AGO

Memory transfer seen

Experiments with rats, showing how chemicals from one rat brain influence the memory of an untrained animal, indicate that tinkering with the brain of humans is also possible. In the rat tests, brain material from an animal trained to go for food either at a light flash or at a sound signal was injected into an untrained rat. The injected animals then "remembered" whether light or sound meant food.

UPDATE: After this report, scientists from eight labs attempted to repeat the memory transplants. They failed, as they reported in *Science* in 1966. Science fiction authors and futurists often predict that a person's memories might be transferred to another person or a computer. But the idea will probably remain speculation, says neuroscientist Eric Kandel, who won a Nobel Prize in 2000 for his work on memory. Brain wiring is too intricate and complicated to be exactly replicated, and scientists are still learning about how memories are made, stored and retrieved.

IT'S ALIVE

Boa suffocation is merely myth

Boa constrictors don't so much suffocate prey as break their hearts. It turns out that the snakes kill like demon blood pressure cuffs, squeezing down circulation to its final stop. The notion that constrictors slay by preventing breathing turns out to be wrong.

The snakes don't need limbs, or even venom, to bring down an animal of their own size. "Imagine you're killing and swallowing a 150-pound animal in one meal — with no hands or legs!" animal ecologist Scott Boback tells his students at Dickinson College in Carlisle, Pa., to convey what extraordinary hunters snakes are. Speed matters with prey flailing claws, hooves or other weaponry the snake lacks. Embracing prey into heart failure is faster than suffocating it and appeared in different forms multiple times in snake history.

Ambushing birds, monkeys and a wide range of other animals from Mexico south to Argentina, the iconic *Boa constrictor* attacks in much the same way each time. The snake cinches a loop or two around the upper body of prey, pressing against its victim hard enough to starve organs of oxygenated blood.

Like the *Boa constrictor* (top), the rainbow boa *Epicrates cenchria* (bottom) kills its prey by cutting off its captive's blood flow, not by suffocating it.

"It's not some unbelievable amount of pressure," says Boback, whose arms get snaked now and then. "It stings a little — you can kind of feel the blood stop," he says.

Within six seconds of looping around an anesthetized lab rat, a boa constrictor squeezes enough to halve blood pressure in a rear-leg artery. Blood that should surge through the artery lies dammed behind snake coils in the rat's upper body. And back pressure keeps the rat heart from pumping out new blood. Circulation falters and fails. Boas release their grip after about six minutes on average, Boback and his colleagues report in the July 15 *Journal of Experimental Biology*.

Then the boa swallows the catch whole. A rat about a quarter of the snake's weight disappears down the gullet in a couple of minutes. Moveable bones in the head help the snake make the gulp, as does a dimple of stretchy cartilage that lets the chin open wide. But what people most often tell Boback — that snake jaws must separate at the back — is just another serpentine myth. — *Susan Milius*

HOW BIZARRE

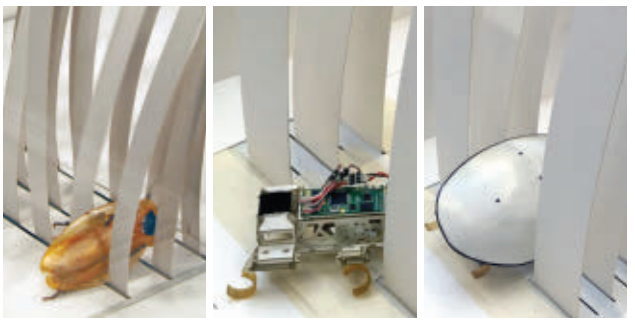
Plastic shell lets roach-bot squeeze through gaps

Cluttered terrain can't stop this cockroach-bot. A sleek, rounded shell lets the six-legged robot scurry through tight spaces, researchers from the University of California, Berkeley report in the August *Bioinspiration & Biomimetics*.

The robo-roach is short and squat, kind of like a clunky smartphone with legs. A bulky body is fine for trekking over flat surfaces, but not so much for moving in three dimensions. Bots tend to bump into obstacles and get stuck. Wearing a roach-style shell can help.

The arched plastic shell lets the roach-bot wriggle through a maze of paper strips that stand upright like blades of grass, researchers found. Like real roaches, the shell-wearing bot can "body roll," flipping sideways to shimmy through gaps.

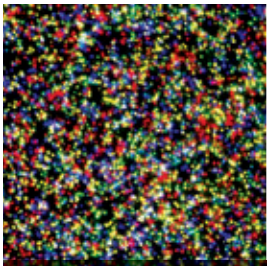
Streamlining robots' shapes could be a simple way to help machines hike through natural environments such as a forest floor littered with grass, shrubs and fungi, the study's authors suggest. — *Meghan Rosen*



A six-legged robot can get stuck as it moves through narrow gaps in an obstacle course of stiff paper strips (center). But adding a shell that mimics a cockroach's shape (left) lets the robot turn sideways (right), helping it scuttle through cracks.

SAY WHAT?

Genomical \Jheh-NOH-mih-cuhl\ adj.



Genomics is on track to overtake astronomy and capture the title of most data-rich field. Each colored spot represents one DNA molecule being sequenced.

Having a tremendous amount of something, equal to or exceeding astronomical levels.

Genetics is poised to overtake astronomy, YouTube and Twitter as a data-generating champion, say Michael Schatz, a quantitative geneticist at Cold Spring Harbor Laboratory in New York, and colleagues. Challenges for collecting, analyzing, storing and sharing genetic data are already on par with some of the most demanding big data endeavors, the researchers report July 7 in *PLOS Biology*.

The amount of genetic data doubles about every seven months. By 2025, researchers may have deciphered, or sequenced, 100 million to 2 billion human genomes — the full set of genetic instructions, each containing more than 3 billion DNA bases. Researchers are also compiling genetic data from thousands of species of microbes, animals and plants. No one knows for sure how much genetic information is currently available; thousands of laboratories around the world have DNA sequencing machines and most of the data are not yet in public databases.

If the doubling trend continues, genetics will soon catch up to radio astronomy's vast data collections, Schatz says. He proposes that "genomical" may one day replace "astronomical" as an expression of gargantuan proportions. "Whether people will adopt 'genomical,' only time will tell," he says. — *Tina Hesman Saey*

SCIENCE STATS

Wildfire seasons have lengthened

Climate change is setting the world on fire. From 1979 to 2013, the duration of wildfire seasons increased across 25.3 percent of Earth's vegetated surface, with net gains on every continent except Australia and Antarctica, researchers report online July 14 in *Nature Communications*.

Wildfire seasons encompass hot, dry times of year when vegetation readily burns. Only about one-tenth of vegetated areas saw decreases in fire season length during the same time span.

This incendiary increase comes primarily from climate change effects such as rising global temperatures and worsening droughts, the researchers say. And more wildfires could make climate change even worse by releasing extra carbon dioxide into the atmosphere. In 1997, Indonesian wildfires released the carbon equivalent of 13 to 40 percent of the world's average annual fossil fuel emissions, the researchers note. — *Thomas Sumner*

18.7
percent
Increase in average length of wildfire seasons worldwide between 1979 and 2013

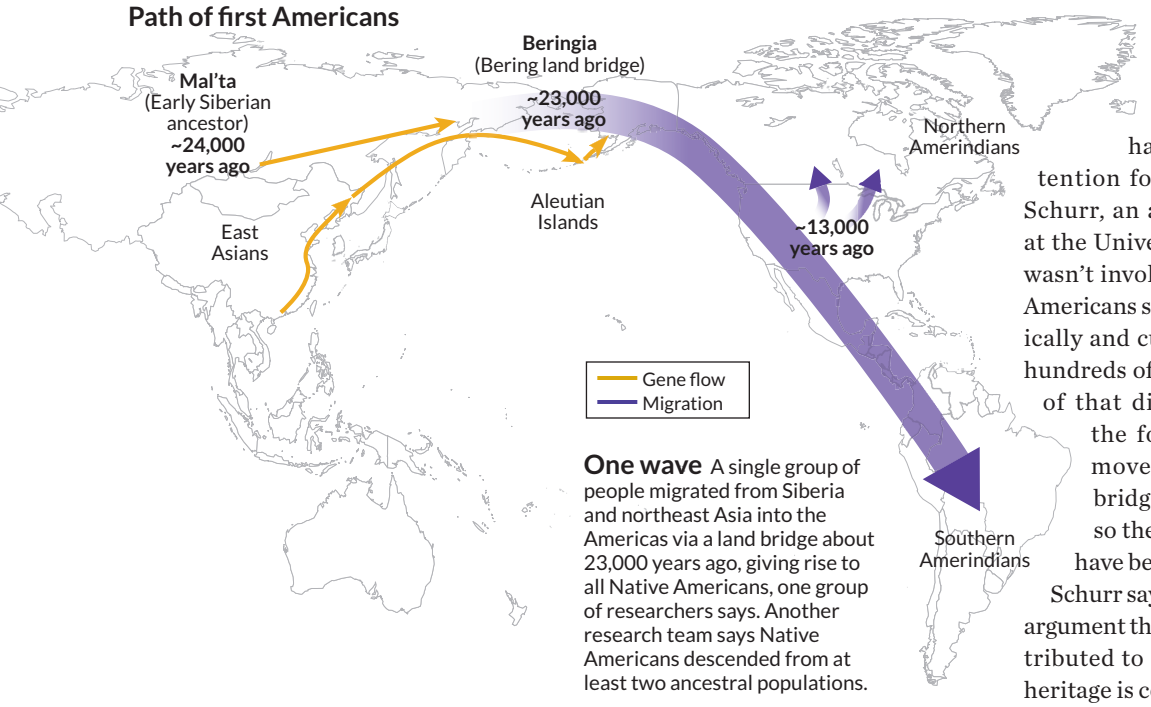
3,500,000
square kilometers
Area scorched by wildfires each year on average, an area larger than India

FROM TOP: J. SHENDURE *ET AL*/*SCIENCE* 2005; CHEN LI, COURTESY OF POLYPEDAL LAB, BIOMIMETIC MILLISYSTEMS LAB AND CIBER/UC BERKELEY; SBAYRAM/ISTOCKPHOTO

HUMANS & SOCIETY

Origins of Native Americans debated

Views differ on what DNA says about ancestral populations



One wave A single group of people migrated from Siberia and northeast Asia into the Americas via a land bridge about 23,000 years ago, giving rise to all Native Americans, one group of researchers says. Another research team says Native Americans descended from at least two ancestral populations.

BY TINA HESMAN SAEY

A previously hidden genetic link between native peoples in Australia and the Amazon has inspired two different research teams to reach competing conclusions about the origins of Native Americans.

One team analyzing modern genetic data finds evidence that at least two ancestral populations gave rise to Native Americans. Another team, analyzing DNA from present-day and ancient Americans, reports that Native Americans came from a single ancestral population.

Both teams agree that Native American roots stem from Asia. Both also say the other group has strong data and has analyzed it superbly. They just don't see eye-to-eye on the interpretation.

One team, reporting online July 21 in *Nature*, found that about 1 to 2 percent of DNA in some native peoples in South America is shared with native Australians and Melanesians.

"It's a small but distinct signal," says study coauthor Pontus Skoglund, a population geneticist at Harvard Medical School. He and colleagues say that data indicate that two ancestral groups populated the New World. And one of these groups, which they call Population Y, was also related to the ancestors of people who settled Australia and Melanesia.

Signs of a South America–Australia link are also present in the second team's data, reported online July 21 in *Science*. But those researchers explain the finding differently. "We see a bit, a hint, just a taste of the same signal in the Aleutian Islanders," says study coauthor Rasmus Nielsen, a computational biologist at the University of California, Berkeley.

His team concludes that a single ancestral population began migrating from Asia into the New World about 23,000 years ago. Aleutian Islanders or some of their ancestors may have later migrated along the Pacific coast and mixed with those in South America sometime after the original peopling of the Americas, bringing in the mysterious genetic signal.

Native American origins have been a matter of contention for decades, says Theodore Schurr, an anthropological geneticist at the University of Pennsylvania who wasn't involved in either study. Native Americans share ancestry but are genetically and culturally diverse, speaking hundreds of different languages. Seeds of that diversity germinated from the founding populations that moved across the Bering land bridge at the end of the Ice Age, so the ancestral population must have been a complex mix of people, Schurr says. Skoglund and colleagues' argument that more than one group contributed to Native Americans' genetic heritage is consistent with that view.

Connie Mulligan, a molecular anthropologist at the University of Florida in Gainesville, sees it differently. Much of the variation among native peoples in the Americas may have arisen after they reached the Western Hemisphere, she says. Australians and Amazonians may have randomly developed the same genetic patterns through a process known as genetic drift, she says.

Once in the Americas, native people went their own way. Nielsen's study, which argues for one founding population, finds that about 13,000 years ago, Native Americans split into two groups, one that spread through North America and continued into South America, and another that remained in North America. That's about the same time a culture known as Clovis began to dominate North America. Researchers have recently discovered that an ancient child known as Anzick-1 who was part of the Clovis culture is an ancestor to all Native Americans (*SN: 3/22/14, p. 6*).

This isn't the first time a connection

M. RAGHAVAN *ET AL*/*SCIENCE* 2015

between Australia and the Americas has been proposed. Researchers had previously noticed that skulls of ancient Americans resembled those of native Australians and Melanesians. Some researchers thought a group called Paleoamericans originated in Asia and gave rise to both the earliest settlers of the Americas and to present-day native Australians and Melanesians. In this scenario, Paleoamericans are replaced by a wave of people crossing the Bering land bridge later.

Skoglund and colleagues conclude in *Nature* that more data, particularly from ancient DNA, are needed to address that argument. In the study in *Science*, Nielsen and colleagues did just that; they examined DNA from 17 ancient people from Mexico, Chile and Argentina who had the characteristic Paleoamerican skull shape. Despite their skull shape, these ancient people didn't genetically resemble Australians — they were related to other Native Americans.

One thing that is clear is that the genetic signal isn't from ancient Australians migrating directly to South America, says anthropological geneticist Jennifer Raff of the University of Texas at Austin. She agrees that the pattern may represent a subgroup of people who lived along the now-underwater Bering land bridge, in a region known as Beringia, for thousands of years before crossing into the Americas. The two research groups' findings can be reconciled, she says. Both papers are exciting because they give researchers new hints about the first Americans. ■

ATOM & COSMOS

Flowing ice, haze spotted on Pluto

Latest New Horizons data explain dwarf planet's red hue

BY ASHLEY YEAGER

Exotic ices flow across Pluto's surface. And the dwarf planet's reddish color appears to come from a thin haze. These new finds from the New Horizons spacecraft have set scientists scrambling to construct the story of how Pluto's climate works.

A stunning image of the dwarf planet in silhouette, released July 24, reveals a layer of haze extending at least 130 kilometers above Pluto's surface. That's five times farther than predicted, Michael Summers, a New Horizons scientist at George Mason University in Fairfax, Va., said at a news conference. Still, Pluto's surface pressure has been sliced in half over the last two years, suggesting that half its atmosphere has frozen and fallen to the dwarf planet's surface.

The haze shows how the atmosphere of Pluto and its surface are connected, Summers said. The atmosphere has methane gas. When ultraviolet light from the sun interacts with methane in the upper atmosphere, more-complex hydrocarbon gases, such as ethylene and acetylene, are produced. These gases fall to lower, colder parts of Pluto's atmosphere and condense into ice particles. UV light converts these icy hazes to hydrocarbons called tholins, which fall to the ground and give the planet its dark patches. "We think this is how Pluto's surface got its reddish hue," Summers said.

One of the latest false color images of Pluto from the New Horizons spacecraft suggests that the dwarf planet's heart may push exotic ices to its edges.

With the latest data, researchers can tie the colors they see to the composition of the dwarf planet's surface, explained New Horizons deputy project scientist Cathy Olkin of the Southwest Research Institute in Boulder, Colo. Images taken as the spacecraft approached Pluto reveal banding patterns of dark and light spots that give hints of weather and seasonal patterns, which the team still doesn't fully understand. That banding pattern, Olkin noted, is abruptly interrupted by Pluto's bright heart-shaped region, which has its own story to tell.

Pluto's atmosphere reveals itself in this image of the dwarf planet backlit by the sun. The picture was taken July 15, when New Horizons was roughly 2 million kilometers past Pluto.

This landscape is right in the belly of the dwarf planet. Scientists call it the beating heart of Pluto. The region appears to be a vast reservoir that acts as the supply depot for Pluto's entire atmosphere and geology, said William McKinnon, a New Horizons coinvestigator at Washington University in St. Louis. Based on more detailed images of this heart region, mission scientists now think that nitrogen snow may be moving from the western to eastern regions of the landscape. There's also evidence of flowing ices, which appear to creep around elevated islands at the edges of the heart.

"To see geologic activity is a dream come true," McKinnon said. Flowing ice and other data support the idea that Pluto may have some kind of ocean deep below its surface. Analysis of additional New Horizons data could confirm this prediction, McKinnon said.

Currently the team has only 4 to 5 percent of the data that the New Horizons probe collected during its flyby of Pluto. Additional images and information will be released in a few weeks. "Starting in September, that's when the spigot opens again," said mission leader Alan Stern of the Southwest Research Institute. With Pluto's unfolding complexity, its atmosphere, possible ocean and moon system, it's hard not to call this world a planet, he noted. ■

BOTH: NASA, JHUAPL, SWRI

Fly over Pluto's icy terrain at **bit.ly/SN_Plutoice**

BODY & BRAIN

Boosting estrogen, only in the brain

Selective hormone treatment might minimize adverse effects

BY SARAH SCHWARTZ

A chemical can transform into a powerful hormone once inside a rat — but only in the brain, not elsewhere in the body.

A protein found in rats' brains turns that chemical, nicknamed DHED, into the hormone estrogen, scientists report July 22 in *Science Translational Medicine*. Similar proteins exist in humans, so this method could form the basis of a targeted treatment providing estrogen to the brain while avoiding potentially dangerous side effects in the body, the researchers say.

"This is an interesting breakthrough," says Bruce McEwen, a neuroendocrinologist at Rockefeller University in New York City. The idea of treatments that affect the brain but not other parts of the body, or vice versa, could be useful in treating a number of conditions, including cancer, he says. But whether such a treatment could be part of hormone replacement therapy in women is up for debate, a number of scientists say.

In menopausal women or those who have had their ovaries surgically removed, lack of estrogen in the brain can cause symptoms such as hot flashes and sleep disturbances. Taking estrogen can relieve those symptoms but can cause side effects in the rest of the body, including an increased risk of certain cancers.

The chemical DHED is nearly identical to natural human estrogen, but it has an extra oxygen atom. A specialized protein found in rodents' brains recognizes the chemical and chops off the extra oxygen, turning DHED into estrogen. The body's other organs lack this protein, so they can't turn DHED into estrogen, says study coauthor Laszlo Prokai, a chemical biologist at the University of North Texas Health Science Center in Fort Worth.

In rats that had their ovaries removed, DHED led to a measurable increase of estrogen in the brain but not in the uterus or bloodstream, Prokai and colleagues report. In mice genetically modified so their tissues light up when exposed to estrogen, DHED lit up only the animals' brains; in contrast, estrogen caused the mice's internal organs to light up. And unlike estrogen, DHED did not appear to stimulate the growth of human breast cancer cells in culture.

> The idea of treatments that affect the brain but not other parts of the body could be useful in treating a number of conditions.

In a simulation of hot flashes, rats undergoing morphine withdrawal experienced temporary increases in skin temperature on their tails. DHED-turned-estrogen decreased this temperature increase in rats just like doses of actual estrogen did, says study coauthor Istvan Merchenthaler, a neuroendocrinologist at the University of Maryland School of Medicine in Baltimore.

Prokai and Merchenthaler think that the chemical could someday be used to treat people for neurological symptoms associated with estrogen deficiencies — not only hot flashes, but also depression and anxiety.

Other scientists say the mechanism for turning the chemical into the hormone is intriguing, but they question the advantages of a brain-only treatment when it comes to estrogen.

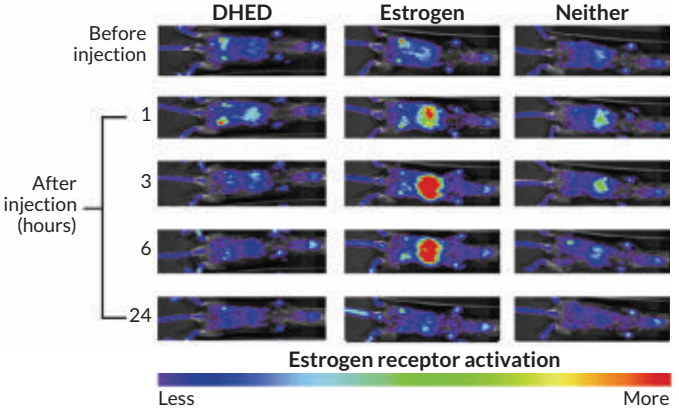
"This is an interesting area of research, and I think it does warrant further study," says endocrinologist JoAnn Manson of Harvard Medical School and Brigham and Women's Hospital in Boston. But, she says, it remains unclear whether estrogen can help treat mood disorders like depression.

"The jury is still out on the effects of estrogen on cognition," she says. "The trial results have been mixed." Manson also notes that in the human body, estrogen protects bone and heart health — benefits that would be lost if estrogen was produced only in the brain. It may be more important to understand ways to maximize the health benefits and minimize the risks of full-body estrogen treatment, she says.

Estrogen itself often behaves differently in animals and humans, says neuroscientist and psychiatrist Natalie Rasgon of the Stanford School of Medicine. "We have tens of thousands of papers on very positive effects of estrogen in animals and in the [petri] dish. We do not see similar results in humans," she says. "It's a very complex biology."

Longer-term studies of DHED's effect on the body would also be required, says Lila Nachtigall, a reproductive endocrinologist at New York University Langone Medical Center. "It might have some potential down the line, but it needs an awful lot of work," she says.

Still, if DHED is proven to affect only the brain, it could have implications in treating a variety of brain disorders, says Rasgon. "This sounds very promising." ■



L. PROKAI *ET AL*/*SCIENCE TRANSLATIONAL MEDICINE* 2015

Targeted effect The chemical DHED produces estrogen in the brain but not elsewhere in the body. In mice with tissues genetically modified to light up when exposed to estrogen, pure estrogen produces a bright glow around internal organs (center). But mice given DHED (left) do not light up more than untreated mice (right), indicating that DHED does not produce additional estrogen in their bodies.

MATTER & ENERGY

Tiny spheres turn cells into lasers

Light-emitting implants can help track cellular activity

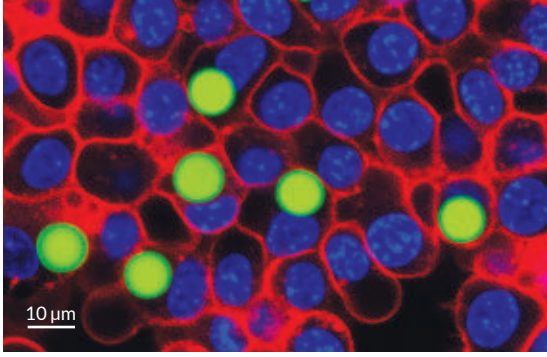
BY ANDREW GRANT

Biologists often use lasers to probe cells. Now, for the first time, cells have returned fire.

Harvard researchers have created intracellular lasers by implanting microscopic beads and oil droplets into animal cells. When energized by an outside laser pulse, an implant traps and amplifies light, then emits a laser pulse of its own. "It's a wonderful way of coupling optics to cells to learn about biological processes," says chemist Richard Zare of Stanford University. The lasers, reported July 27 in *Nature Photonics*, could allow scientists to track the motion of thousands of individual cells.

The technique is not the first to coax cells to generate light. Biologists scrutinize cells under the microscope with the help of fluorescent dyes and proteins that glow when energized by an external laser (*SN Online: 10/8/14*). But those cells emit light with a range of wavelengths, says physicist Seok-Hyun Yun. That can make it difficult to separate the cells' glow from background illumination. Yun and Matjaž Humar set out to implant cells with lasers that emit light at specific wavelengths.

The lasers had to be small and simple to function unobtrusively inside a cell, so the physicists used either plastic beads or dyed oil droplets. These implants are like fluorescent dyes — add energy with an external laser and they radiate light. But rather than producing an immediate broad-spectrum glow, the droplets and beads trap light inside. The light circles repeatedly around the orbs' circumference, each revolution coaxing the production of even more light. After about a nanosecond, millions of photons escape as laser light. "You could see a single cell lasing with the naked eye," Yun says.



Six of these rodent immune cells contain lasers in the form of plastic beads (green). The cells are enclosed in red; the nuclei are blue.

The component wavelengths of the laser depend on the sphere's size, Yun says. The rigid beads could be used to tag individual cells. By using beads that differ in diameter by as little as 2 nanometers, Yun says, individual cells could be distinguished by their laser signature. ■

EARTH & ENVIRONMENT

Climate change drove Ice Age die-offs

Abrupt rises in temperature coincide with timing of extinctions

BY THOMAS SUMNER

Rapid climate change put mega-sized Ice Age mammals on the ropes before ancient humans delivered the final blow, new research indicates.

During the last glacial period, around 12,000 to 110,000 years ago, woolly mammoths, sedan-sized armadillos and other massive mammals walked the land. Over time, these megafauna mostly died out. The instigator of these extinctions has been hotly debated among scientists, with fingers pointed at both ancient humans and sustained frigid temperatures.

After analyzing an exhaustive record of both animal population and climate changes, researchers report online July 23 in *Science* that neither suspect was the primary megafauna killer. Die-offs in Eurasia and the Americas largely coincided with short bursts of intense warming, the researchers found. Extinction rates jumped, however, once humans entered the scene and finished off species made vulnerable by the climate shifts, says earth scientist Chris Turney of the University of New South Wales in Sydney.

"Abrupt climate change alone can drive a mass extinction," he says, "but humans can make it a lot worse."

Sudden temperature spikes called interstadials punctuated the last glacial period. During an interstadial, regional average temperatures rose by as much 16 degrees Celsius in just a few decades. Other times, temperatures reached extreme lows, though these cooldowns were less abrupt.

Connecting changes in climate with changes in animal populations is tricky because the two datasets use different timelines. Climate scientists date the Greenland ice cores used to reconstruct climate history by counting seasonal variations in the ice. Paleontologists determine the age of a fossil using carbon dating. Uncertainties in the two techniques make it difficult to match them up and determine the climate conditions when an animal died.

Turney and colleagues reconciled the timelines using marine sediments off Venezuela. As seafloor sediments accumulate, each layer's composition reflects the regional climate. When combined with carbon dating of plankton in each layer, the sediments provide markers of climate shifts. The sediments form a 56,000-year bridge between climate changes seen in ice cores and animal population changes seen in the fossil record.

The datasets let the team investigate the causes of 31 different megafauna population shifts and extinctions. The die-offs closely aligned with episodes of abrupt warming. The abruptness of the climate shifts was probably more lethal than whether it warmed or cooled, says coauthor Konrad Hughen, a paleoclimatologist at the Woods Hole Oceanographic Institution in Massachusetts.

The work provides more nuance on how climate influences extinctions and could help scientists predict how species will respond to current climate change, says paleobiologist Paul Koch of the University of California, Santa Cruz. ■

M. HUMAR AND S.-H. YUN/*NATURE PHOTONICS* 2015

LIFE & EVOLUTION

Snake fossil with four limbs found

Specimen suggests serpents evolved from land reptiles

BY MEGHAN ROSEN

The worldwide hunt for a fossil link between snakes and lizards has succeeded — in a museum.

The fossil, a four-legged snake, hints that the ancestors of modern snakes may have evolved on land rather than at sea, researchers report in the July 24 *Science*.

"It's a tremendously important fossil, because it's the classic missing link," says paleontologist Michael Lee of the South Australian Museum and the University of Adelaide. "It's got a snakelike body but four little lizardlike legs."

Not everyone is convinced. "Finding the first example of a four-legged snake would be very exciting," says Michael Caldwell, a paleontologist at the University of Alberta in Canada. "But I just don't think this is a snake."

The history of early snakes is fuzzy. Some scientists think that modern snakes evolved from marine reptiles; others think that snakes started out on land as burrowing lizards. Fossil evidence that snakes evolved from four-legged lizards is limited. A few snake fossils have nubby hind legs, but until now no one has found a fossil that so clearly connects snakes and lizards, Lee says.

The fossil had been hiding in plain sight. Paleobiologist David Martill of the University of Portsmouth in England discovered the specimen three years ago while touring a museum in Germany. After seeing the snake (labeled "unknown fossil"), "my jaw just dropped to the floor," he says. "I thought, 'Bloody hell, it's got legs!' I was absolutely gobsmacked."

This fossil may be the first snake discovered to have four limbs (hind legs shown). The animal's toes may have helped it grip prey.

The roughly 120-million-year-old fossil rests in a bed of fine-grained limestone. Translucent orange-brown bones coil around a squashed skull, and a lanky body stretches into a short, curving tail. Stubby hind legs with slender toes protrude from the tail's base, and tucked just behind the head lay two dainty forelimbs. Inside the snake's belly are remnants of a Cretaceous snack: the bones of a frog, perhaps, Martill says.

The snake may have squeezed its prey to death, says study coauthor Nicholas Longrich of the University of Bath in England. It has the slinky, coiling spine of a constrictor, he says, with legs that potentially helped it grip prey.

GENES & CELLS

Zebrafish spark mutation debate

Disparity in methods muddles quest to determine gene's job

BY TINA HESMAN SAEY

Some confusing results from studies of zebrafish are fueling a debate about how to determine what a gene does. How the debate shakes out may affect the search for causes of human genetic diseases.

Scientists have long relied on genetic mutations to reveal the processes in which certain genes are involved. For instance, if an organism has a mutation in a gene and then doesn't develop eyes, researchers surmise the gene helps build eyes. Recently, some scientists have tried a different trick: using an artificial molecule called a morpholino to block protein production from certain genes.

Morpholinos resemble nucleic acids, such as RNA, and can seek out specific RNAs produced from targeted genes. Once a morpholino locates its target, it zippers itself to the RNA. That either prevents RNA instructions from being used to build the protein encoded by the gene or blocks other important interactions. Blocking protein production ought to have the same effect as a mutation does. But researchers are finding that the results don't always match up.

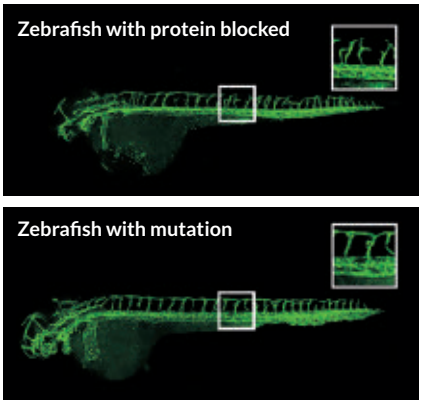
That's what happened to scientists in Didier Stainier's lab at the Max Planck Institute for Heart and Lung Research in Germany. When the researchers treated zebrafish with a morpholino that targets the *egfl7* gene, the fish developed blood vessel defects. But disabling the same gene with a mutation had no effect; blood vessels grew normally.

Stainier's team reports the source of the discrepancy online July 13 in *Nature*.

Fish with mutations in *egfl7* boosted activity of the *Emilin2* and *Emilin3* genes, the team found. The extra emilin proteins filled in for the missing egfl7 protein, allowing blood vessels to develop normally. The team says the morpholino unmasked the true effect of not having the egfl7 protein.

If the same mechanisms that allow zebrafish to compensate for their defective genes also work in humans, it could explain why some people with a genetic mutation develop severe disease while others with the same mutation don't.

"It's potentially really fascinating



Building blood vessels When researchers blocked production of a protein called egfl7 (top), zebrafish embryos had a hard time making small blood vessels (green, upper inset). But when researchers made a mutation that alters the *egfl7* gene (bottom), fish made normal blood vessels (lower inset).

FROM TOP: D. MARTILL/UNIV. OF PORTSMOUTH; A. ROSSI *ET AL*/*NATURE* 2015

Martill thinks the snake, named *Tetrapodophis amplectus*, lived on land because it was found with other fossilized land-dwellers, such as spiders and scorpions. And comparing the specimen's skeleton with those of hundreds of other animals convinced the team that the four-legged fossil actually was a snake.

"There's no doubt that this thing is a snake," Longrich says. "It's got snake scales, snake vertebrae, snake jaws, snake teeth and little bones in its belly where it swallowed an animal whole."

Caldwell disagrees. The head is too crushed to draw any conclusions, he says. Plus, the skeleton is missing key snakelike bony bits on the vertebrae. Earlier this year, Caldwell reported the discovery of even older snake fossils (*SN: 2/21/15, p. 11*) and suggested that they might have had four legs. But those specimens, mostly fragmentary skulls and teeth, were in much worse shape than the current find. ■

how genomes deal with their own weaknesses," says Cecilia Moens, a developmental geneticist at the Fred Hutchinson Cancer Research Center in Seattle.

But she disagrees that morpholinos uncover the truth about a gene's function, arguing that discrepancies between mutant and morpholino experiments are due to side effects of morpholinos interacting with RNAs other than the ones they are supposed to inhibit. The mutants create the real effect, say Moens and other researchers, including developmental biologist Nathan Lawson of the University of Massachusetts Medical School in Worcester.

Exactly what triggers the fish to compensate for the mutation and why the same mechanism doesn't work when protein production is blocked is unknown. Lawson says this may be a special case and that compensation is probably rare.

But developmental geneticist Stephen Ekker of the Mayo Clinic says such compensatory mechanisms are probably widespread and may affect how human genetic diseases develop. ■

MATTER & ENERGY

Elusive particle appears in 'semimetal'

Weyl fermions detected in tantalum arsenide, physicists say

BY ANDREW GRANT

A kind of particle first predicted to exist before the discovery of Pluto has been spotted on Earth within a compound of tantalum and arsenic.

The newly discovered particle, known as a Weyl fermion, resembles a massless electron that darts around and through the material in unusual and exciting ways, physicists report online July 16 in *Science*.

"It's definitely a big deal," says Leon Balents, a condensed matter theorist at the University of California, Santa Barbara.

The behavior of Weyl fermions makes tantalum arsenide a metal-like compound that shares desirable features with graphene and topological insulators, materials that have attracted a torrent of research attention over the last decade or so. "There are a lot of reasons to be interested in these materials," Balents says.

Materials like tantalum arsenide could enable future electronic devices to feature fast-moving current that easily circumvents bumps and valleys in its path. Physicists will be able to study the properties of the material-bound particles to explore the possibility that free-floating varieties of Weyl fermions exist.

Electrons, neutrinos and a host of other subatomic particles belong to a family called fermions. All the known fermions behave according to an equation devised in 1928 by English theoretical physicist Paul Dirac. But at least in theory, there are two other kinds of fermions, both proposed soon afterward: Majorana fermions and Weyl fermions. Unlike Dirac and Majorana fermions, members of the Weyl class — named after German mathematician and physicist Hermann Weyl — are massless.

Physicists have failed to discover Weyl fermions in any particle detector or accelerator. But researchers have suggested that collective interactions of electrons in certain materials would make propagating ripples of energy that behave just as Weyl fermions would in free space.

Earlier this year, Su-Yang Xu and Zahid Hasan of Princeton University and colleagues proposed that tantalum arsenide could host Weyl fermions. In the new study, the researchers fired radiation at crystals of the compound to probe the energies and motion of the electrons inside. High-energy X-rays that pierced deep into the material revealed the signature of massless particles that fit the profile of Weyl fermions.

By housing Weyl fermions, tantalum arsenide becomes the first experimentally confirmed Weyl semimetal, a metal-like material with exotic and potentially useful features. Weyl semimetals resemble topological insulators, materials that are insulating inside but allow electrons to run laps undisturbed around the surface (*SN: 5/22/10, p. 22*). Despite lacking an insulating interior, tantalum arsenide also has protected high-speed electron highways on its surface. The twist, Xu says, is that the surface electrons don't race around a closed track; instead, they move from one side to the other before disappearing into the bulk and reemerging on the opposite surface.

Weyl semimetals also resemble atom-thick sheets of carbon called graphene, Balents says. Both materials allow electrons to zip around at tremendous speed and behave as if they were massless (*SN: 8/13/11, p. 26*). All these features make Weyl semimetals an enticing candidate for future electronics, Hasan says, and for shuttling electrical current without resistance at room temperature.

The discovery of the second of the three types of fermions may lead to finding the third, Xu says. In recent years physicists have found hints of Majorana fermions, which are theorized to be their own antimatter counterparts (*SN: 11/15/14, p. 8*). The properties of Weyl semimetals make them good candidates to produce not only Weyl fermions but Majorana particles as well, Xu says. ■

BODY & BRAIN

Potential pain reliever explained

In mice with nerve damage, bone marrow cells ease agony

BY SARAH SCHWARTZ

Scientists think they have a new understanding of a potential long-lasting, targeted treatment for chronic pain.

When injected into the spinal fluid of a mouse with nerve damage, cells extracted from mouse bone marrow flock to injured cells and produce a pain-relieving protein, researchers report online July 13 in the *Journal of Clinical Investigation*. The results may lead to better chronic pain treatments.

The specialized cells homed in on their ultimate destination by following chemical signals released by the injured nerve cells. There, the injected cells produced an anti-inflammatory protein, transforming growth factor beta 1, which provided long-term pain relief for the mice. Scientists had known that the marrow cells relieved pain but didn't know how, says study coauthor Ru-Rong Ji, a neurobiologist at Duke University Medical Center.

"These cells make drugs at sites of injury," says biologist Arnold Caplan of Case Western Reserve University in Cleveland. "They're drugstores."

Ji and colleagues found that they could relieve chronic nerve pain in mice by injecting 250,000 cells or fewer into the narrow space under the spinal cord membrane. This site is protected by the blood-brain barrier, preventing immune attacks on the injected cells and allowing these cells to live longer, Ji says. Some clinical trials inject cells like these into the bloodstream, Caplan says, which requires many more cells, many of which get stuck in the lungs and liver.

By following chemical signals, therapeutic cells (pink) extracted from bone marrow can deliver pain-relieving proteins to a mouse's nerve cells (blue) in the spine.

GANG CHEN/DUKE UNIV.

The marrow cells relieved pain in less than one day, and the effect lasted for over a month, whether the cells were administered at four or 14 days after injury. A mouse's pain was measured as increased sensitivity to touch and increased time spent in a chamber that mice had learned to associate with a pain-killing drug.

What works for mice may not work for humans, says neuroepidemiologist John Farrar of the University of Pennsylvania. But, Caplan says, these data could be used as the basis for a clinical trial using human cells. Because cells injected into the spinal fluid are protected from the immune system, Ji thinks that humans could receive cells from unrelated donors, or even different species.

Future work must determine if these treatments have unpredicted effects over time, Farrar says. TGF-beta-1 is associated with cell growth; too much of this protein could cause injected cells to grow out of control and become cancerous. But in this study, Ji says, cancer seemed to pose a small risk: The injected cells never incorporated into spinal tissue, and they completely disappeared from the spine within three months. ■

EARTH & ENVIRONMENT

Carbon dating could soon mislead

Flood of fossil fuel emissions may make method unreliable

BY THOMAS SUMNER

The accuracy of carbon dating may soon be a thing of the past.

Fossil fuel emissions threaten the method's ability to definitively pinpoint the age of organic materials, new research suggests. The extra carbon flooding the atmosphere dilutes the relative number of radioactive carbon atoms that are vital to the dating method. By 2050, the age of fresh organic matter will appear indistinguishable from material created in A.D. 1050, predicts atmospheric scientist Heather Graven of Imperial College London. Her work appears online July 20 in the *Proceedings of the National Academy of Sciences*.

"By the end of the century, the atmosphere will look a couple thousand years [older than it is]," she says. "Some of the ways that we use radiocarbon now will be less effective." Carbon dating can identify how long ago a living thing died going back some 50,000 years. The method can also detect newer objects passed off as old, such as counterfeit relics.

In the air, cosmic rays convert stable nitrogen-14 into radioactive carbon-14. Organisms absorb radioactive carbon alongside stable carbon. When something dies, its radioactive carbon decays, leaving behind stable carbon. Comparing the number of stable and radioactive carbon atoms can determine an object's age.

The method assumes that atmospheric carbon-14 concentrations remain relatively steady. That assumption was muddled by a carbon-14 spike following Cold War–era nuclear testing (*SN: 2/21/15, p. 4*). Now, an increase in fossil fuel emissions threatens to muddy the picture even more. Carbon atoms inside fossil fuels are so old that all the radioactive carbon has decayed and only stable atoms remain. As these ancient atoms saturate the atmosphere, they thin the concentration of carbon-14 atoms. Graven calculates that carbon emissions currently "age" the atmosphere by 30 years annually. Objects without sufficient clues to rule out modern origins will soon give ambiguous results, she says.

Researchers should investigate alternative dating techniques, says geochemist Kevin Uno of Columbia University. "It's going to be a game of creativity." ■

Philae offers first close-up of a comet

Ice and dust inside, 67P marked by variety of surface terrains

BY CHRISTOPHER CROCKETT

During its brief time awake on comet 67P/Churyumov-Gerasimenko, the Philae lander documented a diverse world. New analyses of lander data reveal the comet as uniform on the inside, but full of variety on the outside. Pebbles, boulders, cliffs and pits blanket the forbidding landscape. Complex organic molecules float above a surface that is as soft as sand in some places and as hard as rock in others.

Not too shabby for a lander that bounced, tumbled, bounced again, fell in a hole and landed on its side. For nearly 60 hours, Philae learned all it could about its new home before running out of power and slipping into a seven-month slumber from which it only recently awoke. The specifics of Philae's rough landing along with a first look at data from last year appear in eight papers in the July 31 *Science*.

"Every time we take a good look at a comet, it looks totally different than what we've looked at before," says Anita Cochran, a planetary scientist at the University of Texas at Austin. "This is no exception."

The European Space Agency's Rosetta spacecraft arrived at comet 67P last August and released Philae on November 12 (*SN: 12/27/14, p. 18*). The plan was for Philae to touch down gently on a smooth plain and secure itself with harpoons. The harpoons failed to fire, sending Philae on a two-hour trek across the comet. Along the way, it nicked the rim of a crater and bounced once more before settling into a Philae-sized pit.

"The lander didn't do what it was supposed to do, but it did do something spectacular," says Cochran, who is not involved with the Rosetta mission.

The multiple landings turned out to be a mixed blessing: Mission scientists got to prod the surface at two additional sites. The first site is soft like fine sand, says Jens Biele, a physicist at the German Aerospace Center in Cologne. The other two are as hard as pumice.

"That was a stunning difference," Cochran says.

Seven cameras on Philae got a good look at its final stop. A cracked cliff lies one meter away, casting a shadow that prevented the lander's solar panels from recharging its batteries and cutting short its observations. One of its three legs is pointing up; the other two are resting on the surface. Three of the cameras see mostly shadows. Boulders and pebbles are strewn about a sharp, speckled terrain.

"We had no idea what comets looked like close up," says Scott Sheppard, a planetary scientist at the Carnegie Institution for Science in Washington, D.C. "These are the first images that show things like that."

As Philae dropped toward 67P, it saw a landscape shaped by erosion on a world devoid of wind and running water. Impacts from tiny meteorites might sandblast the surface, the researchers speculate, and erupting gases could create gentle winds. The lander also got a whiff of organic molecules, some of which had never before been detected on a comet.

Philae blasted radio waves through the comet that were picked up on the other side by the Rosetta orbiter. The strength and delay of the signal gave researchers a peek through a narrow slice of the comet, revealing what it's made of and how it's put together.

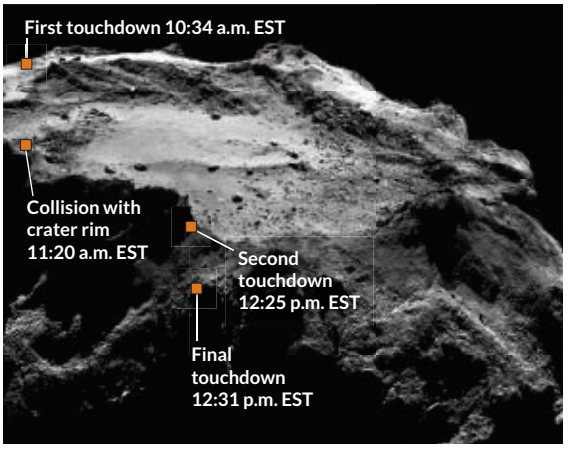
"It's the first time that's ever been done," Sheppard says. The interior appears to be assembled from primordial ice and dust, which researchers have long assumed. "But it's a good thing to have it finally confirmed," he says.

The insides appear uniform, suggesting that the comet formed from similar building blocks rather than a hodgepodge of material. The comet is a snapshot of a particular time and place roughly 4.6 billion years ago as the solar system came together.

"I am very happy that the experiment worked," says Wlodek Kofman, a planetary scientist at the Institut de Planétologie et d'Astrophysique de Grenoble in France. "It shows what's possible for the next missions to explore asteroids and comets," he adds.

The probe woke up on June 13 once its solar panels started receiving enough sunlight to recharge its batteries, and has been in intermittent contact with Rosetta ever since. If mission scientists can get the radar experiment working again, Kofman says, then they could start to piece together a 3-D image of the inside of the comet. "I hope that we have this chance," he says, "but I'm not so sure."

Recent data from the lander indicate it may have shifted as the comet has cracked and crumbled on its race toward its closest approach to the sun on August 13. Rosetta is out of contact for a few weeks while it scopes out the comet's southern hemisphere, but will move back north in late August. With any luck, Philae will be waiting and ready to work. "The lander has surprised us before," Biele says. ■



IDA/DASP/UPM/INTA/SSO/IAA/LAM/UPD/MPS FOR OSIRIS TEAM MPS/ROSETTA/ESA

After its initial touchdown on comet 67P, Philae nicked a crater rim, bounced one more time and then settled in a rocky landscape. During its journey, Philae recorded a lot of data about the comet's surface. SOURCE: J. BIELE *ET AL*/*SCIENCE* 2015

BODY & BRAIN

How brain-eating amoebas really kill

Infection with *Naegleria fowleri* triggers fatal immune response

BY LAURA SANDERS

On July 9, just a few days after swimming in Minnesota's Lake Minnewaska, 14-year-old Hunter Boutain was dead. Doctors believe the culprit was the water-dwelling amoeba called *Naegleria fowleri*. Most people know it by its other name: the brain-eating amoeba.

It's the stuff of horror films — the tiny amoeba crawls up the nose to the brain, where it wreaks havoc, ultimately killing 97 percent of its victims. But calling the amoeba a "brain eater" may not be quite right. The real killer, some scientists suspect, is the immune system's response to the infection — not the amoeba itself.

Single-celled *N. fowleri*, which thrives in warm freshwater, is "destructive," says physiologist Abdul Mannan Baig of Aga Khan University in Karachi, Pakistan, where numerous *N. fowleri* infections have been reported. But it needs a new name, he says. Brain-eating amoeba is a "tabloid term."

N. fowleri sparks a brain infection called primary amebic meningoencephalitis. Only 133 cases were reported in the United States from 1962 to 2014, says the Centers for Disease Control and Prevention. While most cases come from the South, officials have noted the amoeba creeping northward. And since the infection can be hard to diagnose, the real number of cases may be higher.

Its rarity makes the infection — first signaled by headache, fever, nausea and perhaps even an altered sense of smell — difficult to study. Animal and cell experiments have suggested that the amoeba damages tissue directly by releasing harmful proteins, says cell biologist Jesús Serrano-Luna of the National Polytechnic Institute in Mexico City.

But Baig and others think that death is actually an "inside job" caused by the immune system's attempt to fight the amoeba, he writes in the August *Acta Tropica*. When immune cells were absent from a lab dish, *N. fowleri* took eight hours longer to damage cells from human blood vessels, Baig reports.

Baig says that aggressively blunting the immune response, and the brain swelling that goes with it, might help more patients survive. Reducing brain swelling caused by inflammation may have been part of the reason 12-year-old Kali Hardig survived the amoeba in 2013.

"She was the first U.S. survivor in 35 years," says the CDC's Jennifer Cope, who consulted on Hardig's case. Cope says several aspects of treatment saved Hardig's life, including a quick diagnosis, a new antiamoeba drug and an emphasis on lowering the pressure inside her skull.

When *N. fowleri* attacks the brain, it sets off a cascade of inflammation that leads to dangerous brain swelling and death, Cope says. "'Brain-eating' is not entirely a misnomer," she says. "But it's also not the whole story." ■

LIFE & EVOLUTION

Hormone guides root microbes

Plants' salicylic acid attracts some bacteria, repels others

BY TINA HESMAN SAEY

Plants help tend their own gardens. Salicylic acid, a plant hormone that fights microbial infections in leaves, also helps plants select which bacteria colonize their roots, researchers report online July 16 in *Science*.

The finding provides an unexpected piece to an unsolved puzzle in plant biology: why some microbes flock to the roots of certain plants regardless of soil type.

Researchers thought there were two possibilities for how specific collections of microbes get together with roots, says Cara Haney, a microbiologist at Massachusetts General Hospital in Boston. "Either plants are just sticks in the mud that certain bacteria like to eat, or plants play a role in shaping that community."

New experiments with a weed called *Arabidopsis thaliana* indicate that plants play an active role. The plants normally attract Actinobacteria and Firmicutes bacteria, but the soil around their roots have less Acidobacteria, Bacteroidetes and Verrucomicrobia than surrounding soil, Sarah Lebeis of the University of Tennessee in Knoxville and colleagues discovered.

The collection of microbes that live in and around the root may help keep plants healthy and spur their growth. In some plants, such as legumes, bacteria that live in root nodules convert nitrogen from the atmosphere into a form plants can use. Learning how plants interact with their microbes may lead to new fertilizers and pesticides, Haney suggests.

In the study, Lebeis and colleagues created mutant *Arabidopsis* plants that lacked the ability to make one or a combination of three defense hormones: salicylic acid, jasmonic acid and ethylene. The team found that some microbes that normally get into roots were barred from the plants that didn't make salicylic acid while some bacteria that are normally kept at bay invaded those plants' roots.

Arabidopsis thaliana (shown) makes a hormone called salicylic acid that lures some bacteria to the plant's roots while shooing others away.

HERMANNFALKNER/SOKOL/FLICKR (CC BY-NC-SA 2.0)

Growing bacteria in the lab revealed that growth of some groups is less robust in the presence of salicylic acid; others grow better. Researchers don't yet know the mechanisms by which the hormone controls root microbes. ■

Good luck outsmarting a mosquito

Interactions of sensory clues help bloodsucker find meals

BY SUSAN MILIUS

Holding your breath all summer, even if possible, wouldn't keep mosquitoes from finding you. Nor would breath-holding plus invisibility. Studies of how mosquitoes find people to bite reveal a set of preferences and tricks that are "annoyingly robust."

So says, literally, a report published in the Aug. 17 *Current Biology*. The carbon dioxide exhaled by animals, the look of high-contrast objects and the warmth of bitable bodies all attract mosquitoes, but in interacting ways that make the system hard to beat. "The independent and iterative nature of the sensory-motor reflexes renders mosquitoes' host-seeking strategy annoyingly robust," the authors conclude.

Biologists have known that mosquitoes follow plumes of CO_2 wafting away from a breathing target. It doesn't take much. In research published earlier this year, blood-hunting mosquitoes proved sensitive to the merest whiffs of CO_2.

In that study, chemical ecologist Ben Webster applied human odors to gauze pads by wearing them in his socks. (To keep from confounding the experiment, he couldn't use scented soaps during the study.) He then placed the pads in a cage with *Anopheles gambiae* mosquitoes.

The odor that the pads picked up didn't attract many female mosquitoes to settle down as if preparing for a blood meal. But adding some extra CO_2 to the air blowing through the cage triggered considerable landing, Webster and his University of California, Riverside colleagues reported in the January *Journal of Chemical Ecology*.

Those preferences make sense for a species that lurks in human homes, says Webster, now at the University of Sheffield in England. The scent of a human is great for finding the right location for an ambush. But caution about landing and biting prevents wasting effort on trying to suck blood from sofas and socks. Breath betrays a living target, and boosting CO_2 by just 0.015 percent above regular air triggered mosquitoes to land on the gauze, Webster says.

But following a CO_2 plume is not enough by itself to guide a mosquito to its target, Floris van Breugel of Caltech and colleagues note in the *Current Biology* study. In the breezy outdoors, plumes break into scattered floating puffs. A lag in the insect's nervous system can cause a mosquito to fly through the puff before finishing a turn toward the source. Van Breugel's earlier computer simulations of flies searching through a plume suggest that mosquitoes can get close to the plume source but need other senses to find a bite site.

So in wind tunnel tests, van Breugel was not surprised to see mosquitoes fly out of perfectly good CO_2 plumes to investigate other sensory clues. Tracking equipment let the researchers record the flight waverings and swoops of individual insects in the tunnel. The experiments were designed to look at how sensory cues interact.

The team found that CO_2 triggers female *Aedes aegypti* mosquitoes to start exploring a visual contrast. When there was no extra CO_2 in the tunnel air, females flew here and there but didn't pay special attention to contrasty objects on the floor. Adding an extra whiff of CO_2 to tunnel air inspired the mosquitoes' interest in features that stood out — plastic filters or dark spots that contrasted with the flooring.

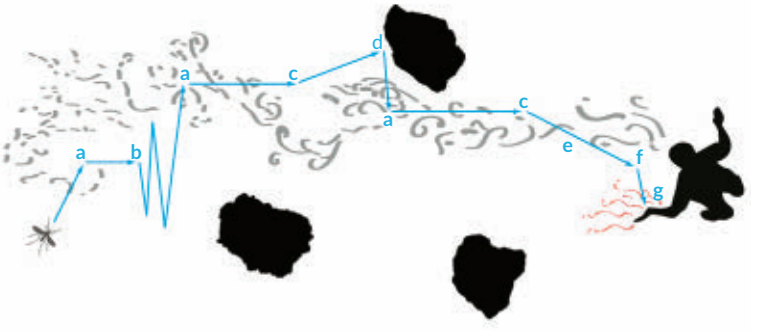
Heating glass squares attracted mosquitoes even when the lures blended in against the floor background. And the interest in warm objects didn't require the puff of CO_2 as a trigger.

The interactions of these clues mean that a mosquito catching an exhalation of CO_2 can fumble along until some visually interesting or warm object invites closer scrutiny, the researchers say.

Webster welcomes the new study. "Relatively little is known about how mosquitoes use visual cues," he says.

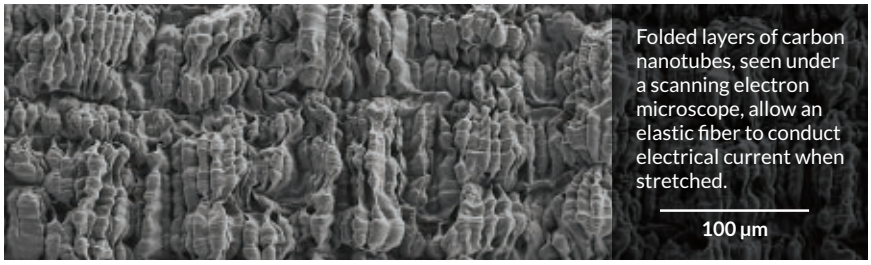
Effective as vision and other search cues are, mosquitoes need another factor to become so annoyingly robust. The insects make mistakes, says Michael Dickinson, a neuroscientist at Caltech and coauthor of the *Current Biology* study. But when they fly to a rock instead of a person, they pull back and try again. And again. "It's the relentlessness that ensures success," he says. ■

Gotcha A mosquito (lower left) mixes strategies and clues as it homes in on its next blood meal.



Range		Stimulus	Action
>10 meters	a	Encounter CO_2 plume	Turn upwind
	b	Lose CO_2 plume	Zigzag crosswind
5–10 m	c	Recent encounter with CO_2 plume	Approach visual feature
	d	Lack of host cues (e.g. heat, moisture)	Resume plume tracking
0.01–1 m	e	Detect host skin volatiles	Follow skin volatile plume
20 cm	f	Encounter heat plume	Continue toward feature; track heat, moisture and additional odors
~3 cm	g	Sufficient host cues (e.g. heat, moisture)	Land and begin probing

F. VAN BREUGEL ET AL/CURRENT BIOLOGY 2015



Folded layers of carbon nanotubes, seen under a scanning electron microscope, allow an elastic fiber to conduct electrical current when stretched.

MATTER & ENERGY

Stretchy fiber lets electrons flow

A carbon-wrapped rubber rope keeps electrical current flowing even when stretched, twisted and bent. The flexible fiber, reported in the July 24 *Science*, could inspire flexible electronic displays, better pacemaker leads and stretchable power cords.

Elasticity and current-carrying prowess don't usually go together: Conventional wires have little give, while adjustable fibers tend to lose electrical conductance as they stretch. Zunfeng Liu, a materials scientist at the University of Texas at Dallas, and colleagues stretched a 2-millimeter-diameter rubber fiber to about 15 times its original length and wrapped it in conductive sheets of carbon nanotubes (*SN: 12/4/10, p. 20*). When the rubber returned to its relaxed state, the carbon sheets buckled but didn't break, creating an accordion-like coating. The fiber maintained its conductance as it was elongated to 11 times its initial length, and it didn't wear down even when stretched and relaxed thousands of times. — *Andrew Grant*

LIFE & EVOLUTION

Stinkbugs are color conscious when it comes to their eggs

Stinkbug moms appear to carefully choose the color of their eggs.

A female *Podisus maculiventris* stinkbug can lay eggs in a range of colors from pale yellow to black. And she can control the color of the eggs she lays, seemingly pairing darker eggs with darker surfaces, researchers report online July 23 in *Current Biology*. This is the first time an animal has been shown to control the color of its eggs at will, the scientists say.

Eggs laid on the tops of leaves were more than two times as dark, on average, as those laid on a leaf's pale underside, the researchers report. Darker eggs protected developing stinkbugs from the sun's harmful ultraviolet rays, which are probably most intense on a leaf's sun-exposed top surface.

It's still a mystery what chemical the bugs use to darken their eggs; the scientists were surprised to discover that the eggs weren't colored with the compound melanin, which produces most dark colors in insects. — *Sarah Schwartz*

Stinkbugs lay darker eggs on the top surfaces of leaves (left) and lighter eggs on the undersides (right). The darker color may shield the eggs from the sun's ultraviolet light.

BODY & BRAIN

Antibody that fights MERS found

By mining the immune cells of a patient who beat the MERS virus, scientists have identified a protein that could help prevent and treat the deadly disease.

When tested in mice, the protein targeted the virus that causes Middle East respiratory syndrome. The protein could be used to develop vaccines or treatments to protect people from MERS, an international team of researchers report online July 27 in the *Proceedings of the National Academy of Sciences*.

The protein, an antibody named LCA60, seems to latch onto the MERS virus, preventing it from infecting a cell. When given to infected mice, LCA60 dramatically reduced the amount of the MERS virus in the lungs within days. Even in the worst-case scenario, for every 100 viruses at the start of treatment, only one remained after three days. In most mice, the virus became undetectable within five days of treatment.

In another recent development in the fight against MERS, researchers developed experimental vaccines that combat the virus in mice and monkeys. The injections, made from MERS virus DNA and protein, triggered the production of virus-attacking antibodies, and may inform the design of human MERS vaccines, the researchers report July 28 in *Nature Communications*. — *Sarah Schwartz*

ATOM & COSMOS

New 'habitable zone' planet ID'd

NASA's Kepler space telescope has discovered a "cousin" of Earth 1,400 light-years away.

The exoplanet Kepler 452b orbits a sunlike star at about the same distance as Earth orbits the sun, scientists reported at a news conference July 23. The discovery is the first confirmed planet among 500 candidates newly identified by the Kepler mission. Although the new planet bears many similarities to Earth, experts say much about it remains a mystery.

Kepler 452b is about 60 percent larger in diameter than Earth, and about 5 percent farther from its sun. The planet's size and distance place it in a zone that could support an atmosphere and liquid water, conditions needed for life on Earth. Unlike other planets found in "habitable zones," the new planet orbits a star that is close to the same size and brightness as the sun.

Even if Kepler 452b were identical to Earth in its size and orbit, it might not be able to support life, says astrophysicist Stephen Kane of San Francisco State University. While the planet's size suggests that it could be rocky like Earth, it's also possible that the planet is mostly gas (see Page 32). Kepler 452b is too far away to detect information about its atmosphere, Kane says. — *Sarah Schwartz*

FROM TOP: THE ALAN G. MACDIARMID NANOTECH INSTITUTE; P.K. ABRAM *ET AL*/*CURRENT BIOLOGY* 2015

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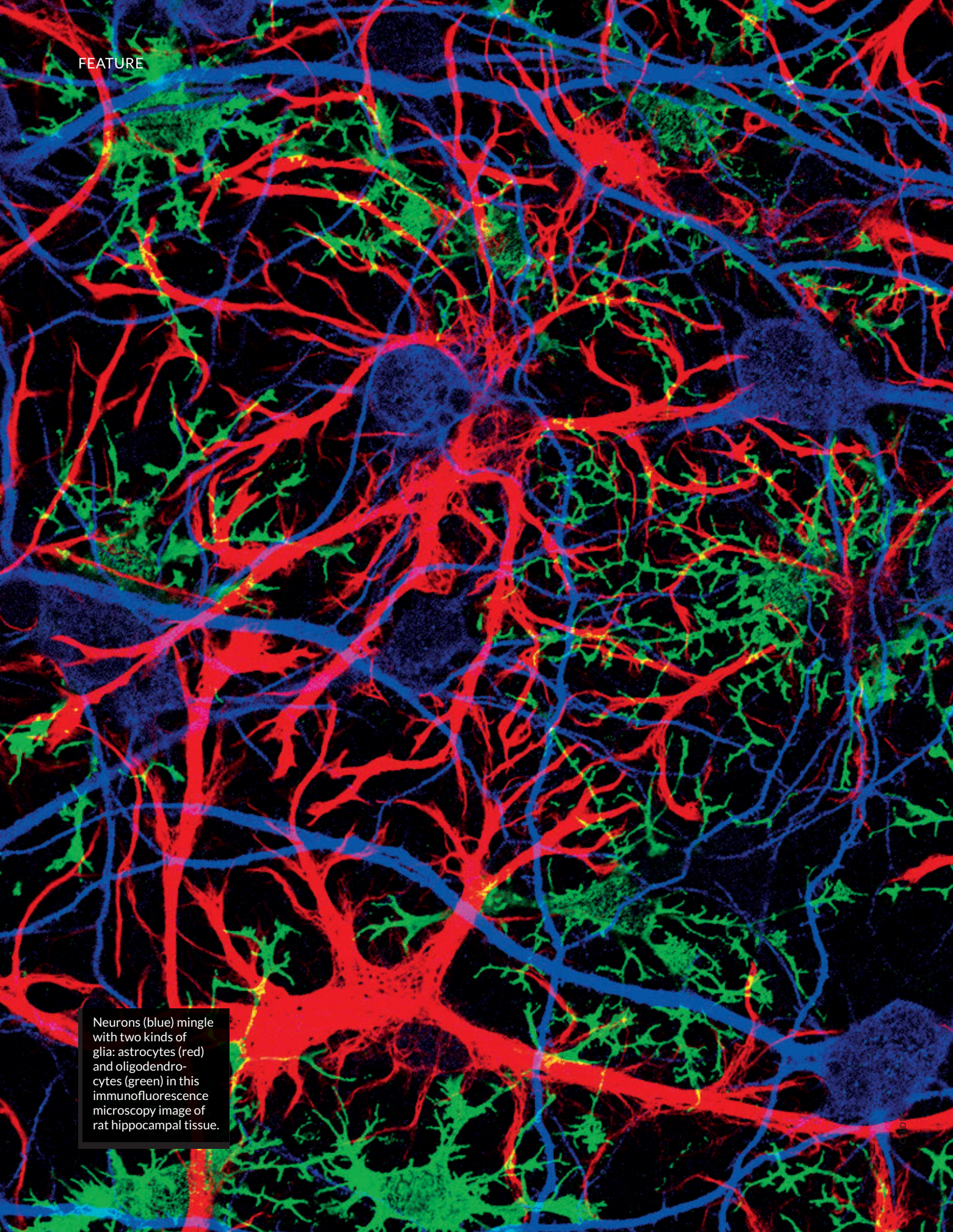


Neurons (blue) mingle with two kinds of glia: astrocytes (red) and oligodendrocytes (green) in this immunofluorescence microscopy image of rat hippocampal tissue.

Maestros of Learning and Memory

Glia prove to be more than the brain's maintenance crew

By Ashley Yeager

A mouse scurries across a round table rimmed with Dixie cup–sized holes. Without much hesitation, the rodent heads straight for the hole that drops it into a box lined with cage litter. Any other hole would have led to a quick fall to the floor. But this mouse was more than lucky. It had an advantage — human glial cells were growing in its brain.

Glia are thought of as the support staff for the brain's nerve cells, or neurons, which transmit and receive the brain's electrical and chemical signals. Named for the Greek term for "glue," glia have been known for nearly 170 years as the cells that hold the brain's bits together. Some glial cells help feed neurons. Other glia insulate nerve cell branches with myelin. Still others attack brain invaders responsible for infection or injury. Glial cells perform many of the brain's most important maintenance jobs.

But recent studies suggest they do a lot more. Glia can shape the conversation between neurons, speeding or slowing the electrical signals and strengthening neuron-to-neuron connections. When scientists coaxed human glia to grow in the brains of baby mice, the mice grew up to be supersmart, navigating tabletops full of holes and mastering other tasks much faster than normal mice. This experiment and others suggest that glia may actually orchestrate learning and memory, says neuroscientist R. Douglas Fields.

"Glia aren't doing vibrato. That's for the neurons," says Fields, of the National Institute of Child Health and Human Development in Bethesda, Md. "Glia are the conductors." They may be telling neurons when and where to send their signals and how loud those signals should be. Scientists are beginning to get a sense of how glia coordinate the brain's intricate symphony of signals, Fields says.

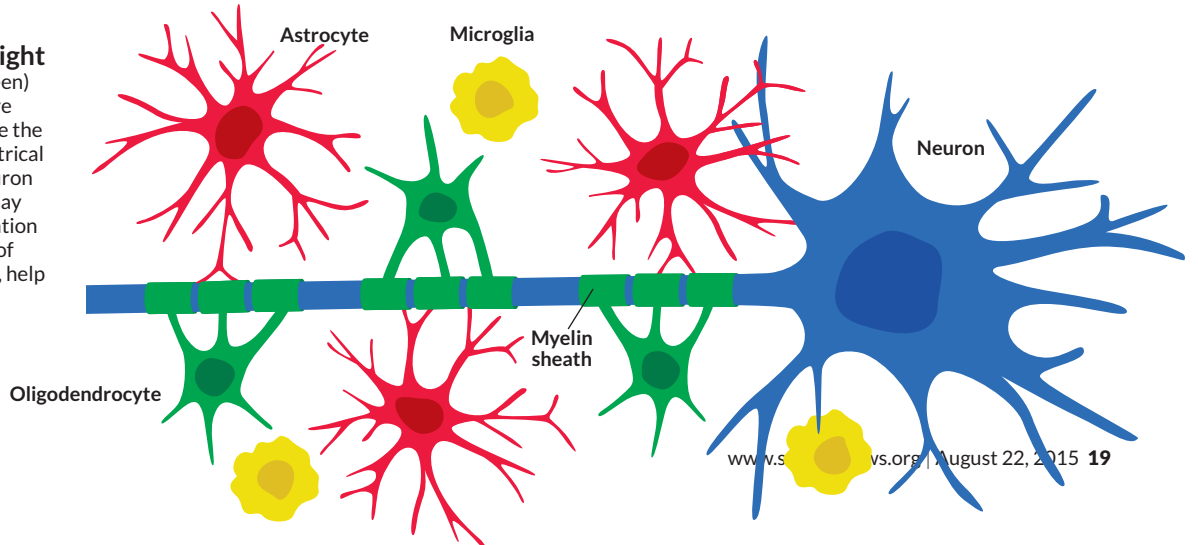
Accepting glia's role in learning and memory has been a gradual progression, says Andrew Koob, a neurobiologist at the University of Wisconsin–River Falls. Neuroscientists have been focused on neurons because neurons tend to be bigger than glial cells and their electrical signals have been easier to study. And much research on the brain's information processing is focused on synapses, the communication junctions where chemical messages are passed between neurons.

2 million
Synapses that can be influenced by one human astrocyte

"The popularization and perception that the neuron is the only active cell type in the central nervous system is very pervasive. It is learned early on," Koob says. "This leads into the long-held belief that learning and cognition are solely the domain of neurons."

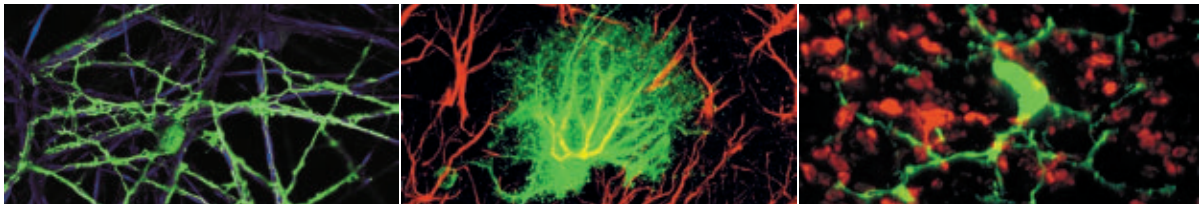
But even though neurons are often bigger, and definitely more famous, glia outnumber nerve cells in the brain. Glia come in three varieties: microglia, astrocytes and oligodendrocytes. Tiny microglia puff up and pounce on invaders that enter the brain, using chemical warfare to kill infiltrators, while devouring dead and dying cells. Microglia also prune and clear away unnecessary nerve cell connections (*SN: 11/30/13, p. 22*).

Astrocytes nestle some of their pointed projections against synapses, playing a role in how neurons make connections. Other astrocyte projections connect to nearby capillaries, helping to bring oxygen-rich blood to the



Sharing the spotlight
Oligodendrocytes (green) and astrocytes (red) are glial cells that influence the way chemical and electrical signals travel from neuron to neuron (blue) and may shape the way information is stored. A third type of glia, microglia (yellow), help protect the brain.

OPPOSITE PAGE: JONATHAN COHEN; THIS PAGE: E. OTWELL



Glial cell	Oligodendrocytes (green)	Astrocytes (red and green)	Microglia (green)
Roles	■ Form myelin around neurons, substantially increasing signal speed ■ Provide vital metabolic support for axons ■ Problems with these cells are implicated in multiple sclerosis, amyotrophic lateral sclerosis and inhibition of repair after spinal cord injury	■ Wrap around synapses, influencing signaling and nerve birth and growth ■ Respond to injury by producing proteins ■ When dysfunctional, implicated in many neurological and psychiatric disorders, such as epilepsy and schizophrenia	■ Travel and respond to nervous system injury and infection ■ Monitor electrical activity in neurons and prune synaptic connections ■ Their dysfunction is involved in almost all nervous system diseases and in certain psychiatric conditions, including obsessive-compulsive disorder

Shaping the brain The three types of glia have different roles in the brain. When these cells don't work properly, neurological disorders and diseases can result. SOURCE: R.D. FIELDS/*NATURE* 2013

neurons. The third glial class, oligodendrocytes, supports neurons by wrapping the neurons' long, wiry fibers called axons in myelin, a fatty protective substance better known as the brain's white matter. It may take several oligodendrocytes to cover one long axon with the myelin it needs.

Beyond glue

Neuroscientists began to notice in the early 1990s that glia are more than just the support crew for neurons. A group of researchers including Stephen Smith, now at Stanford University, had a hunch that glia could communicate via chemical signals, as neurons do. Smith and his colleagues dribbled glutamate — a chemical messenger commonly used by neurons — into a dish containing astrocytes modified to glow when calcium levels go up. Where the drops hit, the cells immediately flashed. After a short delay, more cells flashed and waves of fluorescence moved through the dish. The glutamate was spurring astrocytes to release fluorescent-tagged calcium ions, signals that the glia were using to communicate, Smith's team reported in *Science* in 1990.

Four years later, Maiken Nedergaard, now at the University of Rochester Medical Center in New York, showed that astrocytes not only talked among themselves using calcium signals, but also used the signals to communicate with neurons.

In the two decades since then, neuroscientists have been studying astrocytes and their signaling in various animals. Human astrocytes are 2.6 times longer than mouse astrocytes and move calcium-ion waves through the brain at speeds five times faster than rodent astrocytes do. Humans also have subtypes of astrocytes that don't appear to exist in mouse and rat brains, Nedergaard and colleagues reported in 2009 in the *Journal of Neuroscience*. Interlaminar astrocytes, for example, extend long fibers through the cortex, the outer part of the brain, which is involved in higher thought processes such as learning, memory and creativity.

Based on differences in mouse and human astrocytes, Nedergaard and colleagues wondered if inserting human glia into mice would change the way mouse brains worked. It did.

Human glial progenitor cells placed in mouse brains multiplied and then matured into astrocytes. Over several months, newly developing human astrocytes started to replace the mice astrocytes. As the human astrocytes took over, the level of calcium signals in the brain increased threefold.

The mice with human cells also exhibited greater levels of long-lasting enhancement in neuron-to-neuron communication, suggesting that the human astrocytes were strengthening neuronal connections and communication. When tested on a battery of learning and memory tasks, such as identifying the safe hole on a circular table, the mice with human glial cells quickly outperformed their mouse-brained counterparts, the team reported in *Cell Stem Cell* in 2013 (*SN: 4/6/13, p. 16*).

Neuroscientists Robin Franklin and Timothy Bussey of the University of Cambridge argued in the same issue that the results offered compelling evidence that humans' superior learning and memory skills are at least in part due to glia.

"This is a very sexy notion," says Marc Freeman, a neurobiologist at the University of Massachusetts Medical School in Worcester. He cautions, though, that the biology of how these glial cells work is not completely clear. There may be other explanations for the results.

Freeman, who studies astrocytes in fruit flies, is searching for the genes that fly astrocytes rely on to nudge neurons' electrical signals along or slow them down. If those genes are also found in mice and humans, that means they've been conserved across species, suggesting that the genes play an essential role in the brain, Freeman says. In flies, he and others are manipulating these genes to see exactly what they do and how they affect behavior and possibly learning and memory, he says. "We are on the cusp of the glia field becoming extremely interesting."

FROM LEFT: R.D. FIELDS; ULRIKA WILHELMSSON, ERIC BUSHONG AND MARK ELLISMAN; BETH STEVENS

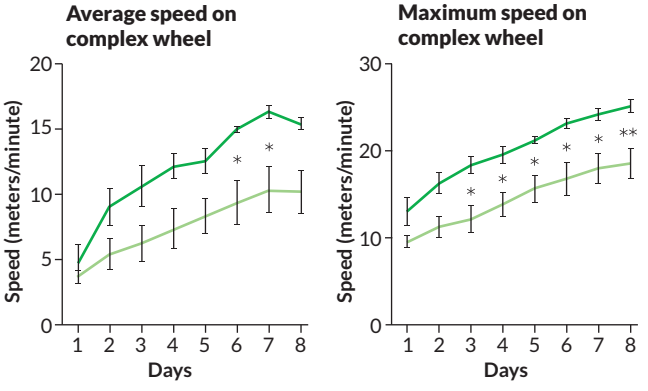
Setting the pace

Astrocytes and oligodendrocytes may influence learning and memory by helping neurons keep their electrical signals flowing at a healthy rhythm. Groups of neurons fire electrical signals in rhythmic patterns called oscillations. A rhythm of roughly 25 to 80 pulses per second may be important for learning and memory, some studies indicate. Last year, an international team of researchers working with mice found that astrocytes' release of brain chemicals, including glutamate, is essential to maintaining a rhythm of 25 to 60 surges per second. When scientists engineered mice so their astrocytes could not release glutamate and other brain chemicals, the rodents' regular surges deteriorated. Without the oscillations, the mice spent less time than healthy mice exploring new objects, the researchers reported in the *Proceedings of the National Academy of Sciences*.

Oligodendrocytes, on the other hand, may influence neuronal signaling rhythms via myelin rather than brain chemicals. Scientists first speculated that oligodendrocytes were important for learning and memory when MRI brain scans revealed structural changes in the myelin-wrapped white matter in children, teens and adults learning to play piano and in adults who learned to juggle. The jugglers' brains showed increased white matter at the back of their right intraparietal sulcus — a crease at the back of the brain that helps with visually guided grasping of objects. Individuals who weren't learning the new skill showed no changes.

> "We've been stuck in the synapse for 150 years. It's time to move out to the enormous unexplored space that's out there."
>
> R. DOUGLAS FIELDS

As an adult learns a new skill like juggling, the brain may be churning out new oligodendrocytes, which then wrap extra myelin around the axons of the neuronal circuits being built. A recent study in mice supports the idea. Adult mice learning to run on a wheel with oddly spaced rungs made oligodendrocytes more quickly than mice with no wheel to run on. And engineered mice that could not make new oligodendrocytes were unable to master running on the more complex wheel, William Richardson of University College London and colleagues reported in *Science* in 2014. Adult brains in mice, and possibly in humans, need to make new glia and myelin to learn and remember, Richardson and colleagues argue.



Learning the wheel Mice engineered so they could not make new oligodendrocytes (light green line) reached slower average (left) and maximum (right) speeds running on an oddly runged wheel compared with engineered mice that could make new myelin-producing glia (dark green line). Asterisks show statistically significant differences. SOURCE: I.A. MCKENZIE *ET AL*/*SCIENCE* 2014

Rethinking wrapping

Recent work by Fields and colleagues at NICHD suggests that oligodendrocytes may help the brain continually adapt to incoming information. When neurons in a lab dish aren't firing, oligodendrocytes will wrap myelin around any of the neurons' axons. But when sets of neurons start firing as a circuit, oligodendrocytes actively wrap myelin around the axons of firing neurons and snub the inactive nerve cells, Fields' group reported August 4 in *Nature Communications*.

Myelin speeds the transmission time of electrical signals along axons. It takes a signal 30 milliseconds to cross from the left to the right side of the brain on myelinated axons. A similar signal takes about 300 milliseconds on unmyelinated axons. Slight changes in the thickness of myelin layers on axons may tweak the timing of the brain's electrical signals just enough to bolster learning and memory or do damage, Fields and colleagues calculated.

Synchronizing these signals is essential to getting sets of neurons in different regions of the brain to fire at almost exactly the same time, a coordination that sets the foundation for brain circuits to store information. Delays shorter than even a millisecond could prevent a signal from arriving at exactly the right time, Fields and colleagues reported in *Neuroscience* in 2014. They suggest that signal delays can disrupt synchronization, something that may contribute to autism by destroying the consistency of brain rhythms. Certain rhythms are also slower in one region of the brain in individuals with schizophrenia, the researchers note. These and other data suggest that some neurological disorders may result from damaged glia rather than damaged neurons.

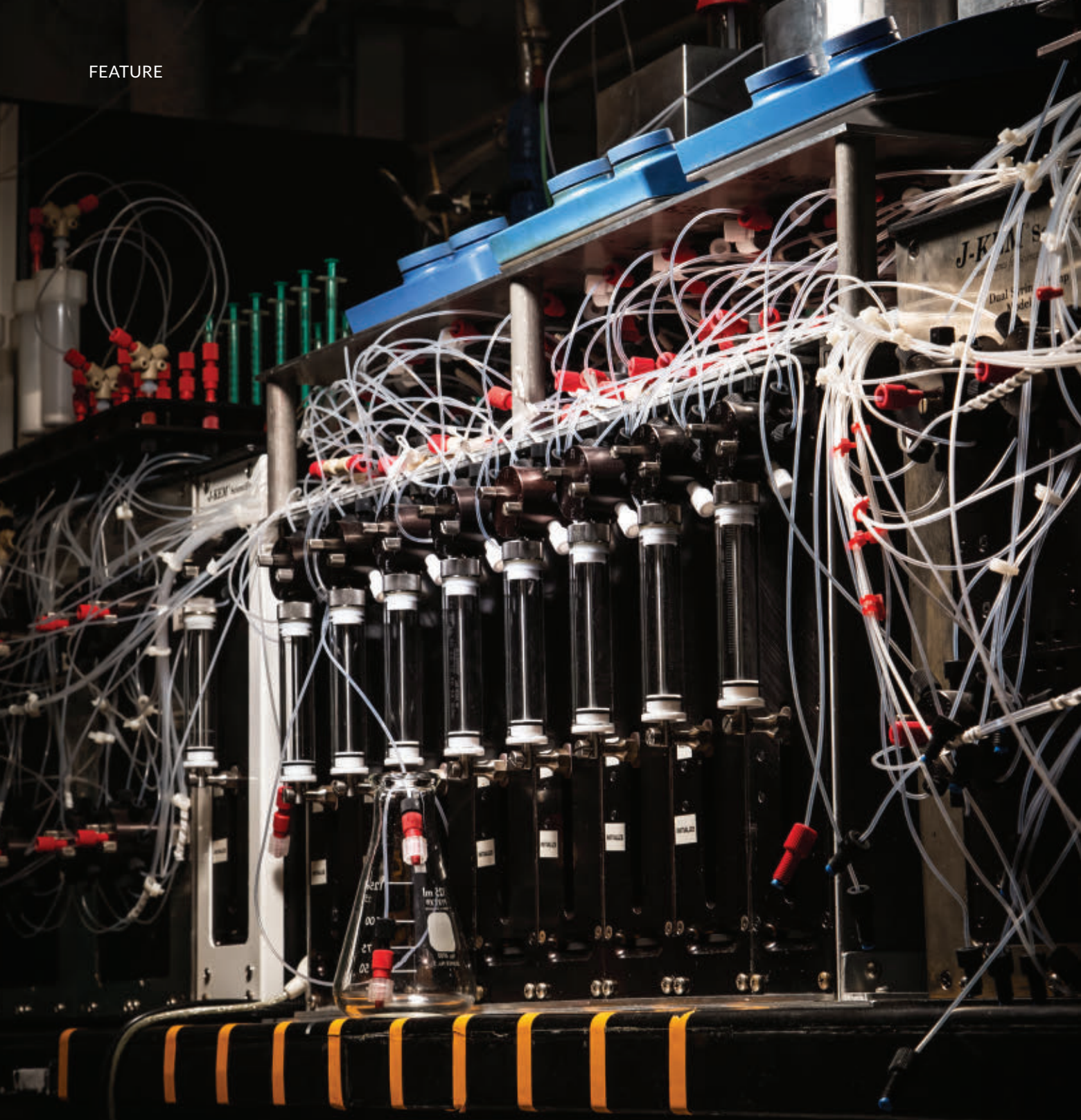
The weight of all this recent research has forced neuroscientists to rethink the hierarchy among cells in the brain. Glia are coming out of the shadows. Neurons and their synaptic connections might need to start sharing the spotlight.

"We've been stuck in the synapse for 150 years," Fields says. "It's time to move out to the enormous unexplored space that's out there." ■

Explore more

- P.G. Haydon and M. Nedergaard. "How do astrocytes participate in neural plasticity?" *Cold Spring Harbor Perspectives in Biology*. March 2015.

To see mice try to master an awkward wheel, visit **bit.ly/SN_glia**



Hands-free Chemistry

New tricks and tech may help turn the tide for automated molecular synthesis

By Beth Mole

CREDIT

Mother Nature is a lazy chemist. Occasionally, she produces an organic molecule that's a winning drug. But more often, a nature-made chemical's medicinal powers are coupled with flaws, such as brutal side effects. Until recently, upping the safety of those drugs by retooling their parts was a lot like assembling Ikea furniture.

Take amphotericin B, a lifesaving but toxic antifungal medicine. To build a better version, chemists would need to translate a series of tauntingly simple stick-figure diagrams into actual chemistry, coming up with chemical reactions to attach and rejigger dozens of atomic parts. This hands-on approach could take more than 100 steps.

Enter automation. A new technique can snap a potential new drug together in just a few steps. The system is like chemistry's Easy-Bake oven: assembling premade ingredients and serving up custom small molecules at the push of a button.

It's just one of several high-tech ways chemists are beginning to make new molecules in record time. One setup performs classic chemical reactions with programmable robotic arms, shakers and other gizmos. Another builds molecules by unleashing streams of chemical cocktails through dizzying obstacle courses of hoses, pumps and valves.

"If we can deliver on-demand small molecule synthesis to the world, this would be absolutely transformative," says chemist Martin Burke of the University of Illinois at Urbana-Champaign, who recently unveiled his prototype. Those on-demand molecules could be the next lifesaving drugs or new materials for reaping solar energy.

Yet many chemists are reluctant to embrace such technologies. Some say it's time they catch up. "The automotive industry did it in the '70s," says biochemist Andrew Mesecar of Purdue University in West Lafayette, Ind., alluding to Detroit's machine- and robot-enhanced assembly lines. "Chemistry," he says, "is lagging behind."

Doubt among chemists that automation will be truly useful is a factor, Mesecar says. Plus, there's lingering skepticism and bitterness over past machine-based efforts. In the 1990s, technologies capable of gushing hundreds of arbitrarily generated molecules promised an end to tedious, painstaking, step-by-step synthesis. But, after investing time and money, most chemists who fished through the resulting deluge of compounds came up empty-handed.

Those early tech backers did themselves in by overpromising, says medicinal chemist Craig Lindsley of Vanderbilt University Medical Center in Nashville.

But a small band of researchers, including Burke and Mesecar, never gave up on automation. Instead of mass producing a flood of random molecules, these researchers turned to automated systems that make artisanal molecules — fast and cheap. Learning from the past, the new automation champions pitch the technology as a useful tool, rather than a cure-all.

"It's not been easy," says synthetic chemist Steven Ley of the University of Cambridge. Minus the hype, more scientists are now open to what modern, technology-assisted chemistry could look like. "What you're seeing is a sea change."

Snappy charm

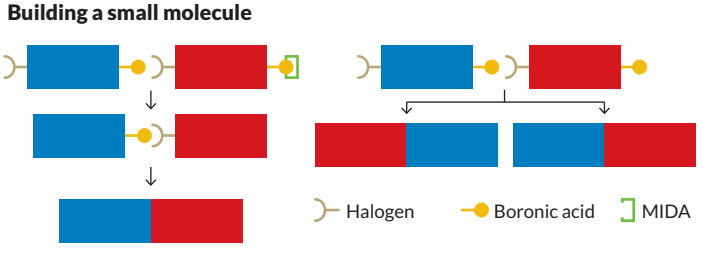
Chemists are accustomed to crafting molecules through dozens of arduous steps that might yield a blockbuster drug, but more often result in pharmaceutical flops. On white boards and scraps of paper, researchers sketch hexagons and zigzags, the backbones of molecules. By drawing an additional oxygen atom on one side of a molecule or squeezing a nitrogen group onto the other, for example, chemists try to subtly change the design to make better molecules. Maybe those improvements will knock out a drug's side effects or beef up a material's toughness. But once they are moved from the drawing board into round-bottom flasks, forging and sculpting those modified molecules can take years of trial and error.

Burke was eager to move more quickly. In the late 1990s, he realized that the antifungal amphotericin B, also known as AmB, needed tweaking. The potent drug can wipe out systemic fungal infections in critically ill patients. But it has severe side effects, including kidney damage. He wanted to make a safer version without delay.

He started with a well-known chemical trick and then developed one of his own to make the chemistry hands-free. The old flask-based chemistry scheme allowed him to snap fragments of molecules together like Lego building blocks. The method works by forging carbon-carbon bonds between molecular fragments. Each block has a linker. In a chemical reaction, the linkers help bring the two molecular fragments together and connect their carbons.

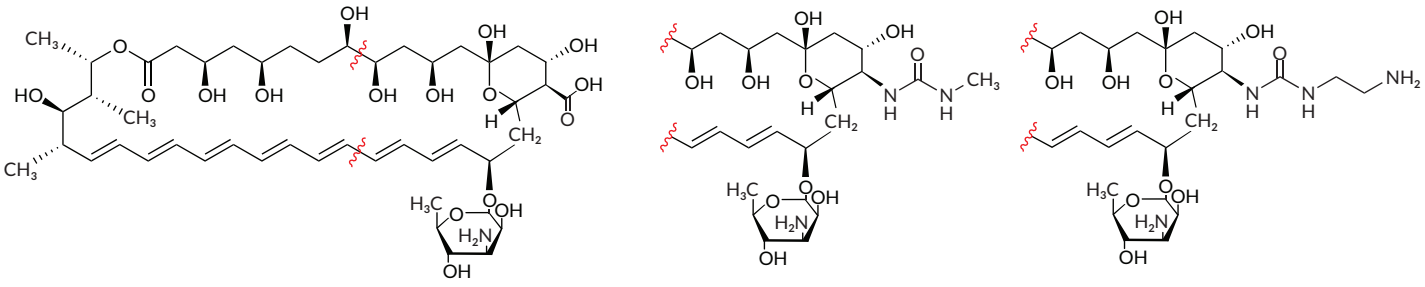
By adding a compound with a halogen (elements such as bromine and chlorine) as a linker on one side of a molecular fragment and a boronic acid on the other, the building blocks can snap together like train cars. But with two essentially sticky ends on each block there was no way to control which ends were coupling and in what order.

Clever caps Using a chemical cap called MIDA, researchers can control the assembly of potential drugs using linkable molecular fragments, shown here as blocks. Each block has a boronic acid linker on one end and a halogen-containing linker on the other. With the removable MIDA cap covering the boronic acid, the blocks can snap together in only one way (left). With no cap, the blocks have two options (right), which is problematic. SOURCE: J. LI *ET AL*/*SCIENCE* 2015



This mess of tubing and pumps snaps together molecules from chemical building blocks. Developer Martin Burke imagines the automated system freeing up chemists' time to dream up the next blockbuster drug.

OPPOSITE PAGE: M. BURKE/UNIV. OF ILLINOIS AT URBANA-CHAMPAIGN



Helpful tweaks The antifungal medication amphotericin B, or AmB (left), comes with dangerous side effects, but has been difficult to improve using traditional chemical methods. Some new tricks allow researchers to quickly and easily modify the drug's structure. That work guided the design of two new AmB variants (above), both better at specifically targeting fungus, thus reducing toxicity in mice.
SOURCE: S.A. DAVIS *ET AL/NATURE CHEMICAL BIOLOGY* 2015

In 2007 in the *Journal of the American Chemical Society*, Burke and Eric Gillis, now at Bristol-Myers Squibb, reported their trick to control coupling: a removable cap, called MIDA (*N*-methyliminodiacetic acid), that fits over the boronic acid to keep it from hooking up until desired.

With around 200 building blocks already commercially available for snappy assembly — and more coming — the team estimates that their method could quickly make thousands of druglike compounds. The technique also allows researchers to make tiny adjustments to existing drugs, including AmB. Earlier this year, Burke and colleagues reported in *Nature Chemical Biology* that, using a mix of automated and traditional methods, they created versions of AmB that have less-severe side effects in mice.

The cap also paved the way for machines to take a larger role. Burke's team designed an automated apparatus that links the building blocks, purifies coupled blocks, strips MIDA caps off new blocks and then continues linking. The researchers revealed their synthesizer in a paper published in *Science* in March.

The chemistry and the machine are "really cool," says organic chemist Damian Young of Baylor College of Medicine in Houston. Carbon-carbon bonds are one of the harder bonds to make. They're the reason some synthetic methods remain "a bit of a black box," he says, keeping custom molecules out of reach for some researchers.

But Burke's method has limitations. Users will be restricted by the types of building blocks available and the reaction conditions, such as the nature of the solvent, that the machine can handle, says Amy Ripka. She is executive director of medicinal chemistry at WuXi AppTec, a drug and medical device company based in Shanghai.

Ripka is generally skeptical of automated chemistry. "I think it's like the housing bubble," she says. "People get all excited about these new technologies." Then, she says, the technology doesn't solve all problems and optimism bursts.

Lindsley acknowledges the concerns and reiterates the caveats of automation proponents: It's more a tool in an arsenal than a panacea.

Tubes and time machines

One system is already proving that automation can be a crucial time-saver, according to Mesecar and his colleague, Purdue organic chemist Sarah St. John. The pair partnered with pharmaceutical giant Eli Lilly, based in Indianapolis, to use the company's fully robotic, remote-controlled chemistry lab, the Automated Synthesis Lab. Without a human in sight, the lab can run dozens of standard chemical reactions, popping oxygen or nitrogen atoms onto molecules as needed.

Mesecar and St. John are making small molecules to cripple coronaviruses, a family of viruses that can cause respiratory diseases such as SARS and MERS. Like Burke's work with AmB, the researchers had a starting point: molecular structures that they wanted to tweak. Their molecules attacked a vital coronavirus enzyme but were too weak to stop the virus.

From her university lab, St. John remotely programmed all of the chemical steps needed to modify the molecule and yield more potent assailants. At Lilly's automated lab a couple

More than 200 researchers worldwide have made chemical compounds using a fully automated, remote-controlled synthesis lab at Eli Lilly in Indianapolis.

FROM TOP: M. TELFER; ELI LILLY AND CO.

of towns away, robotic arms swung into action, starting reactions, adding chemical ingredients and ultimately creating around 50 molecules within a month. It took a lot of front-end programming, St. John says. But it paid off. Six of the compounds can hamper the enzyme in all 10 coronaviruses that she has tested. A few other molecules foil the enzyme of one virus.

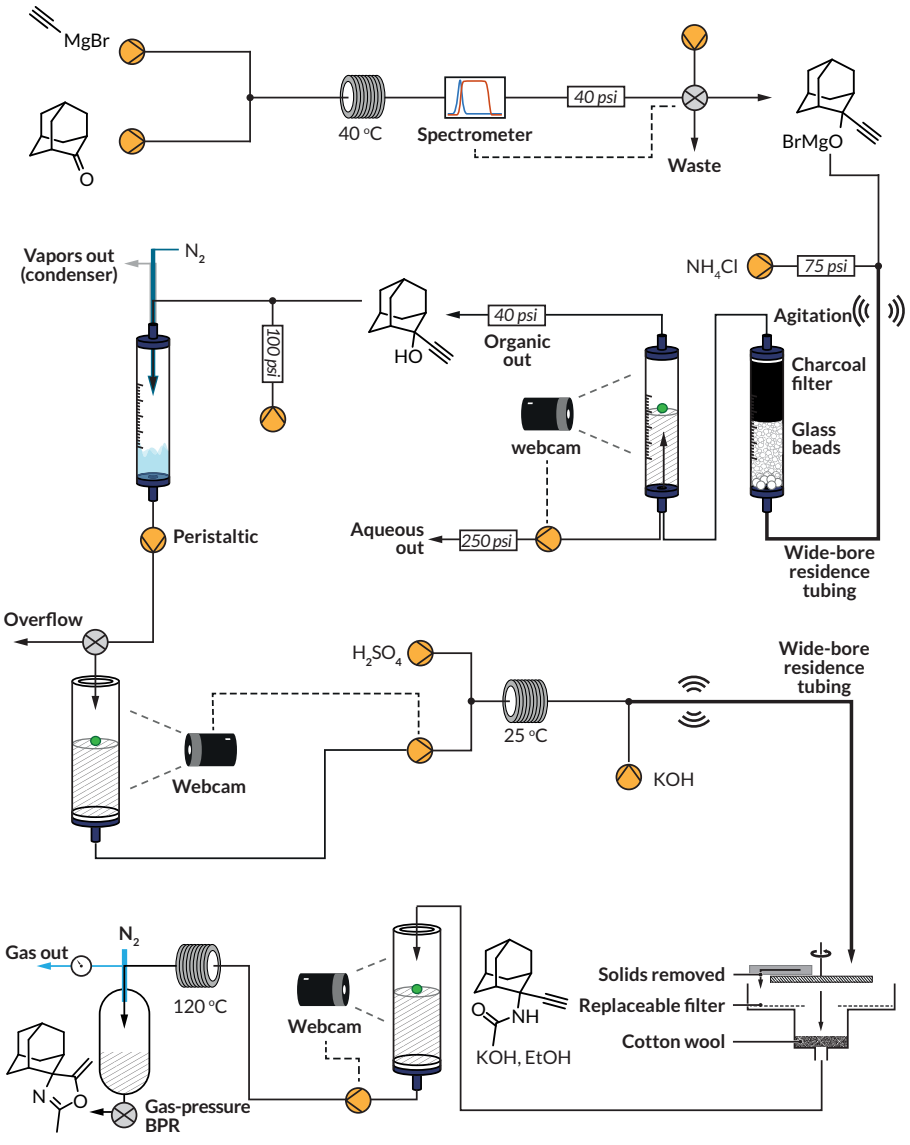
With her time freed up to do other experiments, St. John estimates the robotic help saved her three to six months of work.

Few researchers, however, have this kind of help. Fully robotic labs, such as Eli Lilly's, are expensive to build and therefore rare outside of well-funded pharmaceutical companies.

Some scientists think they can do better anyway. Robotic help is too much like an automotive assembly line: not modern enough. Says Ley, of Cambridge, "It's a little boring and a little bit conservative."

Ley and others are trying to develop cheaper machines that can also do more challenging chemistry feats. He's particularly focused on flow chemistry, which carries out reactions as solutions stream through tubes and swirl together to make new compounds. The fluid system allows chemists to set up a chain of chemical reactions that progress without assistance as the chemicals gush through the pipes. The tightly controlled series of reactions can be safer than conventional methods, avoiding vats of unpredictable reactions.

New gadgets and technologies can plug into the labyrinth of piping to carefully control and monitor reactions. In January, Ley and colleagues described a flow system that performed seven steps in one go to produce a druglike molecule. That work was reported in *Angewandte Chemie International Edition*.



Swoosh Researchers are building molecules by streaming chemicals through networks of tubes, pumps and columns. The method, called flow synthesis, runs a series of automated reactions as the chemicals spurt through an obstacle course–like setup (one outlined above). By plugging computers and cameras into the network, researchers can control and monitor the progress of reactions.

What's most exciting, he says, is just bringing more tech to the bench. Ley belongs to a network called "Dial-a-Molecule" that shares this aim. Spearheaded by organic chemist Richard Whitby of the University of Southampton, the group's ultimate goal is to develop powerful machines to quickly and automatically design and create any molecule a chemist could think up. One specific emphasis of the group is to design software that can predict which chemical reactions will work and even come up with step-by-step assembly plans. It would remove the need for much human trial and error.

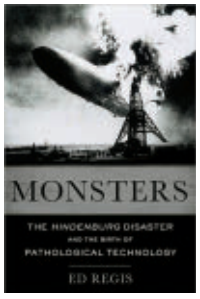
Last year, Ley and colleagues reported in *Beilstein Journal of Organic Chemistry* how to program a cheap, simple computer called Raspberry Pi to run networks of chemical equipment, monitor complex reactions and upload data to the Internet.

"We could take a huge step forward," Whitby says of the growing effort to add more tech to the lab. Any automation naysayers are going to be left in the dust, he predicts. To which he adds: "I have no sympathy." ■

Explore more

- Junqi Li *et al.* "Synthesis of many different types of organic small molecules using one automated process." *Science*. March 13, 2015.

S.V. LEY/UNIV. OF CAMBRIDGE



Monsters
Ed Regis
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BOOKSHELF

Lessons from the *Hindenburg*

It took just over 30 seconds for the *Hindenburg* to go from flying technological marvel to smoldering wreckage on an airfield in Lakehurst, N.J. Horrified onlookers watched as electricity in the atmosphere ignited a plume of hydrogen gas escaping from the rear of the airship. The fire tore through the *Hindenburg* and brought it crashing to the ground, killing 36 people.

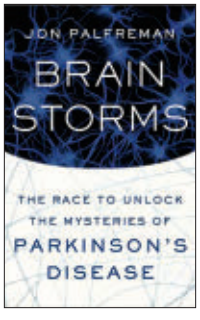
As shocking as it was, the 1937 catastrophe was just one incident in a long, disastrous history for airships, notes science writer Ed Regis in *Monsters,* an engaging account of humankind's technological hubris. In the decades before the *Hindenburg*, accidental fires downed 26 airships and killed 250 people. Airships also had an alarming tendency to crash, break apart or simply blow away in the wind.

Zeppelins are a prime example of what Regis calls a pathological technology — one in which the infatuation with a new invention blinds people to obvious risks. Humongous, difficult to control and often filled with flammable gas, airships were flawed from the get-go, Regis says. Because they were so enamored with the massive and awe-inspiring zeppelins, Britain, Germany and the United States continued building them long after their failings became clear.

Nowadays, engineers don't pump passenger vehicles full of millions of cubic feet of hydrogen gas. But Regis uses the cautionary tale of the *Hindenburg* to examine other, more recent love affairs with pathological technologies.

After World War II, the U.S. government devised a number of peacetime uses for nuclear devices under a program called Project Plowshare, including using hundreds of blasts to carve a new canal across Central America. The program was scrapped in the 1970s, but not before the government set off 35 underground nuclear tests during the planning stages. Regis also sees echoes of airship fervor in today's speculative but enthusiastic plans for manned interstellar expeditions.

Monsters isn't condemning all large-scale scientific endeavors that carry risks. Instead, Regis emphasizes the need to learn from the *Hindenburg* and take a critical look at the real costs and benefits of new technologies — before they end in disaster. — *Allison Bohac*



Brain Storms
Jon Palfreman
SCIENTIFIC AMERICAN/FARRAR, STRAUS AND GIROUX, $26

BOOKSHELF

A voyage into Parkinson's disease

In 2011, science journalist Jon Palfreman saw a doctor about a tremor in his left hand. The doctor diagnosed Palfreman, then 60, with Parkinson's disease. The disorder, which is newly diagnosed in 60,000 Americans each year, promised a crippling future of tremors, loss of mobility, dementia and more. Palfreman decided to use his reporting expertise to investigate how Parkinson's disease affects the body and learn about efforts to find a cure.

With *Brain Storms,* Palfreman follows Parkinson's history from the careful observations of 19th century physicians to today's cutting-edge research.

Palfreman relates complex research studies as gripping medical mysteries. He describes how scientists connected Parkinson's with the dramatic loss of the brain chemical dopamine and with tenacious protein knots called Lewy bodies that are a hallmark of the disease. Palfreman also explores treatments past and present, including the widely used drug levodopa that restores motion (sometimes uncontrollably), gene therapies, brain surgeries and promising experimental antibody treatments that attack and dissolve misfolded Parkinson's-related proteins.

Ultimately, *Brain Storms* is about more than Parkinson's disease; it's about the people living with the disorder. Palfreman describes patients who must teach themselves to walk without falling over or who freeze in place. He writes about a researcher driven to search for a cure after the disease affects his own father.

There's also Palfreman himself, navigating his dual roles as patient and reporter with candor, curiosity and enduring hope that a cure is on its way. Finding a cure is "everyone's business," Palfreman writes. Sixteen percent of the world's population will be older than 65 by 2050, putting them at risk for age-related diseases such as Parkinson's. As Palfreman writes, "There's no time to waste." — *Sarah Schwartz*

BOOKSHELF

Prehension
Colin McGinn
A philosopher argues that the evolution of the hand accounted for the transition from early to contemporary humans. *MIT, $24.95*

The Annihilation of Nature
Gerardo Ceballos, Anne H. Ehrlich and Paul R. Ehrlich
With the aid of photos and stories of animals at risk of extinction, three biologists make an impassioned plea for conservation. *Johns Hopkins Univ., $29.95*

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

Windows look onto the lost lives of astronauts. Also on exhibit are fragments of the two destroyed space shuttles.

EXHIBIT

Paying tribute to lost space shuttle crews

With the blessings of all 14 families of lost astronauts, a new memorial to the *Challenger* and *Columbia* space shuttle disasters opened in June at the Kennedy Space Center in Florida. The permanent exhibit includes the first pieces of shuttle wreckage ever on public display, but fittingly focuses more on the lives lost.

"Forever Remembered" is housed inside the space center's new $100 million exhibit about the space shuttle *Atlantis*. Below the nose of the intact shuttle, visitors enter a hall lit by tributes to each astronaut from the lost missions, those from *Challenger* on the left and *Columbia* on the right. Each display includes glimpses of the astronaut's life. Items include plans for remodeling the home of *Challenger* pilot Michael Smith and a recovered page in Hebrew from the *Columbia* flight journal of Ilan Ramon, a payload specialist and the first Israeli astronaut.

Past the hall, visitors enter a small gallery with a single piece of each shuttle: a body panel from *Challenger* (shown at left) and cockpit window frames from *Columbia*. There are no extended written descriptions or flashy videos. In short, it's a place for pondering rather than learning. As a ninth-grader in school 50 miles away when *Challenger* exploded in 1986 and as an adult who waited for a telltale sonic boom that never came when *Columbia* was lost during re-entry in 2003, I found the effect powerful.

Forever Remembered
ON PERMANENT DISPLAY
KENNEDY SPACE CENTER, FLA.

The exhibit's exit hallway reveals the tragedies from multiple perspectives on video displays. One video details the massive efforts to recover the wreckage and remains from the disasters, from the ocean for *Challenger* and from land for *Columbia*. Others focus on the emotional tolls and the critical shuttle launches that followed each completed investigation.

Michael Curie, Kennedy Space Center's news chief, says family members have been both supportive and grateful for the exhibit. "They feel that it humanizes their family members in a way that never has been done before," he says. Indeed, "Forever Remembered" is an effective reminder of the very real risks each astronaut willingly and bravely faced. — *Mark Schrope*

TO DO

O Columbia

SEPTEMBER 23–24, 2015
A new chamber opera places space travel in the context of American exploration, tragedy and perseverance.
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Loop, Arch or Whorl

ONGOING
The forensic science exhibit is the latest hands-on activity at a museum that calls itself an amusement park for the mind.
WONDERWORKS, PIGEON FORGE, TENN.

Monster Fish: In Search of the Last River Giants

THROUGH OCTOBER 11, 2015
Life-size sculptures of freshwater fish up to 6 meters long dot an exhibit that also features (smaller) live fish in aquariums.
NATIONAL GEOGRAPHIC MUSEUM, WASHINGTON, D.C.

LEFT BOTH: NASA KENNEDY/FLICKR (CC BY-NC 2.0); RIGHT: MARK THIESSEN/NATIONAL GEOGRAPHIC

From left, Qing Liu and Fay Huang of PHEI, John Moore of Media Solutions, Guo Jingyao of PHEI and Mike Mills, associate publisher of *Science News*, at PHEI in Beijing in July.

Science News heads to China

The Society for Science & the Public announced in July that it has reached an agreement with one of the top publishing houses in China to publish Chinese-language translations of collected works from *Science News*. The compilations will be for sale in mainland China.

The agreement, with Beijing-based Publishing House of Electronics Industry, calls for 10 compilations to be published through 2018. Books will be sold in traditional retail channels throughout China, including 4,000 national and private bookstores and online. Topics under consideration will include "Body and Brain," "Humans and Society" and "Atom and Cosmos."

PHEI was selected from more than a dozen publishers in China who expressed interest in licensing *Science News* content for translation.

"We're thrilled to be working with PHEI to bring *Science News* to China," says Maya Ajmera, chief executive officer and president of the Society and publisher of *Science News*. "Their commitment to excellence, creative thinking, marketing channels and track record with international publishers put them at the head of the pack."

Established in 1982, PHEI is one of the most prominent presses in China, publishing 2,800 new books each year. The group specializes in popular science, children's books and computer and technical titles.

Ajmera says the Society is working on additional licensing arrangements for *Science News* and *Science News for Students* elsewhere in Asia and other global markets. "Our mission — to promote the understanding and appreciation of science and the vital role it plays in human advancement — is a global mission," she says.

Writer takes home AIP award

Science News physics writer Andrew Grant won the American Institute of Physics' 2015 prize in the Science Writing — Articles category for "The mysterious boundary" (*SN: 5/31/14, p. 16*), his feature about what happens at the entrance to a black hole. Grant's win marks the third year in a row that AIP has honored *Science News* writers with this science communication award. Contributing correspondent Alexandra Witze earned the prize in 2014 for her feature "Spinning the core" (*SN: 5/18/13, p. 26*), and managing editor Tom Siegfried won in 2013 for his essay on the discovery of the Higgs boson, "Nature's secrets foretold" (*SN: 7/28/12, p. 28*).

Checking in with alumni

It has been an exciting summer for past participants of the Intel International Science and Engineering Fair and the Intel Science Talent Search. Here's what some of the Society's alumni have been up to.

Duy Phan, who participated in Intel ISEF in 2012, 2013 and 2014 and was an Intel STS 2014 semifinalist, and Clara Fannjiang, a participant in Intel ISEF 2011 and Intel STS 2012, are research interns at the Janelia Research Campus of the Howard Hughes Medical Institute in Ashburn, Va., this summer. Phan is a student at Johns Hopkins University and Fannjiang is a rising senior at Stanford University.

Harshu Musunuri, Shreya Ramayya, Ethan Novek and Ashwin Datta won a trip to visit NASA's Jet Propulsion Laboratory and Caltech in Pasadena, Calif., at this year's Intel ISEF. They toured the Resnick Sustainability Institute, Shapiro Lab, Kavli Nanoscience Institute and the thermoelectrics and CubeSat labs, among other activities.

At the 2015 Intel ISEF, 11 students — Nitya Mani, Krithika Iyer, Kavita Selva, Jasmine Sumpter, Julia Sakowitz, Shashank Dholakia, Shishir Dholakia, Mihir Garimella, Francisca Vasconcelos, Sahil Abbi and Suvir Mirchandani — won a June trip to tour CERN, the European physics laboratory near Geneva.

In July, Kehan Yang traveled to the Pacific Astronomy and Engineering Summit in Hilo, Hawaii, as part of an award she won at the 2015 Intel ISEF. This award was offered by the Thirty Meter Telescope and also included a visit to the telescopes of Mauna Kea and a tour of the TMT building site.

If you have an alumni update you would like to share with the Society, please contact Carolyn Carson at ccarson@societyforscience.org.

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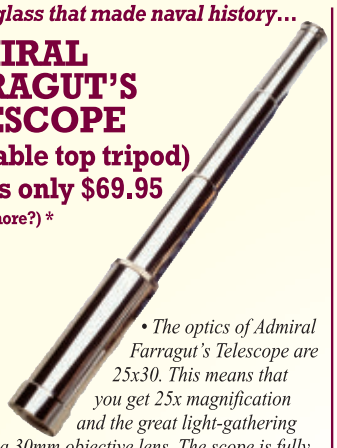

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JUNE 27, 2015

SOCIAL MEDIA

Tweets for New Horizons

Between updates on New Horizon's flyby, *Science News* staffers tweeted their own reactions to the encounter with Pluto. See all of *SN*'s Pluto coverage at bit.ly/SN_PlutoMission

CHRISTOPHER CROCKETT
@CosmicThespian
That might be one of the most exhilarating moments I've experienced in a long time. My hands are shaking.

ASHLEY YEAGER
@AshleyJYeager
Whales, doughnuts, hearts. Pluto's got a lot to offer!

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New Horizons phones home

In "Pluto: Explored" (SN: 6/27/15, p. 16), ***Christopher Crockett*** *chronicled New Horizons' long journey to the dwarf planet. He followed up with a report on the successful flyby in "Pluto's icy landscape comes into view"* (SN: 8/8/15, p. 6).

"Having read that early images of Pluto encoded in radio waves would take 4.5 hours to reach Earth from the New Horizons space probe, I was surprised to read further on that 'the data won't finish downloading until late 2016,'" wrote **Greg Skala**. "Why the long delay for the later data?"

It's not light's travel time that's holding up the data, says **Crockett**. New Horizons gathered a lot of data during its short flyby of Pluto, some of it quite complex. Now it has to deliver all that information through what amounts to a really cruddy Internet connection. "The amount of data you can stuff through a radio link depends strongly on how much power is left in the signal by the time it hits the receiver. The signal coming from Pluto is really weak. New Horizons has a download bandwidth of a whopping two kilobits per second. The dial-up modem I had in high school could transfer data about 28 times faster than that," he says. "The spacecraft has something like 50 gigabits of data onboard. That alone would take several months to download."

Crockett adds that the mission also has to share the Deep Space Network of radio antennas with every other spacecraft in the solar system. New Horizons got priority during the flyby, but for the download period, it has to get back in line with everyone else.

The inventive brain

Creativity may get a boost from a surprising part of the brain. The cerebellum, usually associated with body movements, lit up in brain scans when people played Pictionary, ***Laura Sanders*** *reported in "Cerebellum may foster creativity"* (SN: 6/27/15, p. 11).

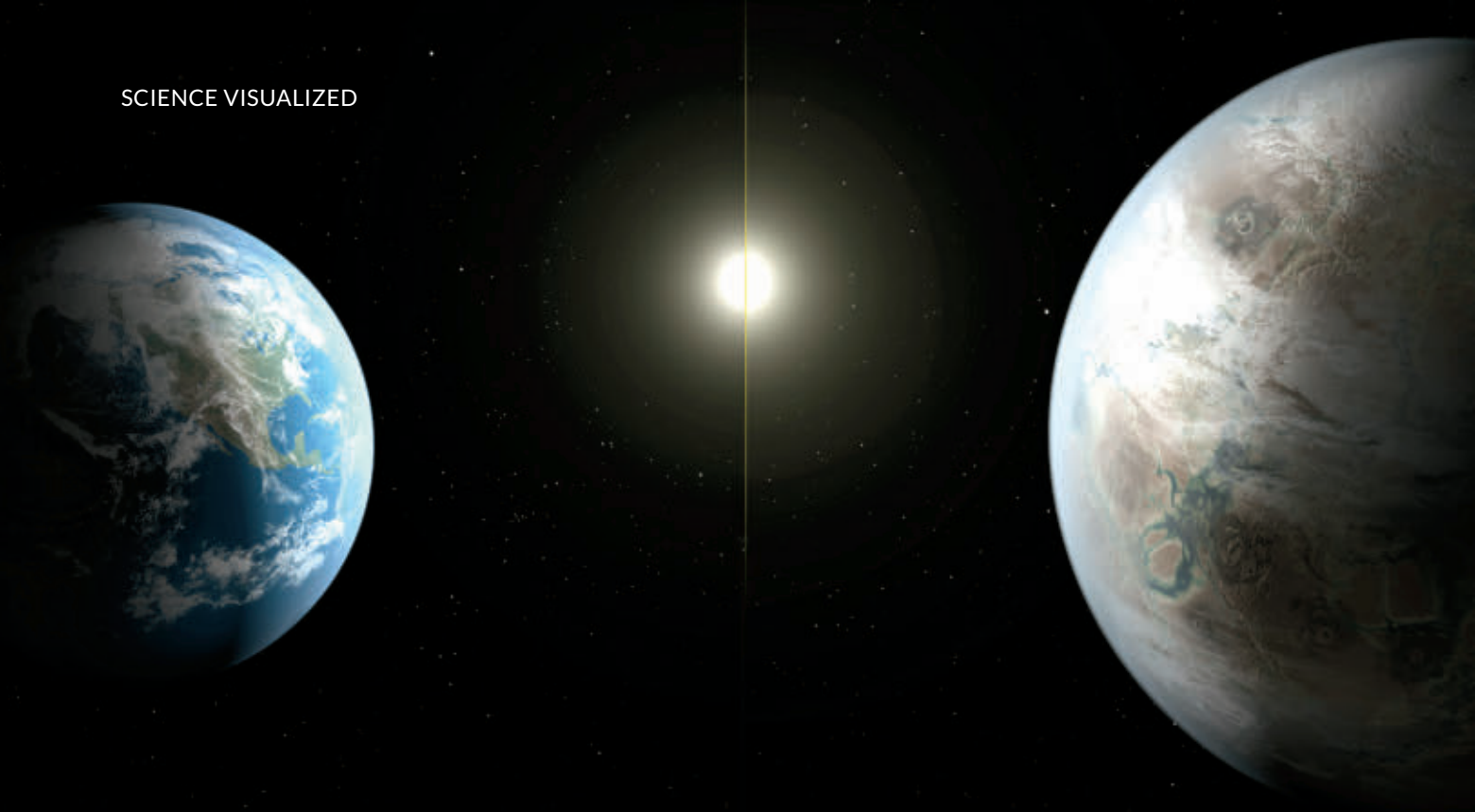
Skeptical about the findings, some readers offered other explanations for what might be going on in the brain. "The cerebellum is being activated in drawing because its role in motor control is to make error corrections," argued **Charles Muncal** on Facebook. "The more you draw, the more precise your motor control becomes. This is what is occurring when the cerebellum is lighting up." In an e-mail, **John Lord** asked, "Isn't drawing a muscular activity? Doesn't that always activate the cerebellum, creative or not?"

Drawing relies on movements, and the cerebellum does become active when the body moves, **Sanders** says. In the study, the researchers attempted to compensate for this by having the participants draw a zigzag, which required motion but not creativity. The researchers found that the cerebellum's activity increased with creativity, even though people were drawing and moving all the while. But it is possible that the findings could be explained by differences in the drawing motions, particularly those movements needed to draw scenes more elaborate than a zigzag.

One hominid or two?

In "Hominid family gets a new member" (SN: 6/27/15, p. 7), ***Bruce Bower*** *described jaw fossils from Ethiopia that suggest Lucy shared her neighborhood with another early human relative.*

Scientists are still debating whether the find represents a new species or just a variation on Lucy's. "There is a tendency amongst some paleoanthropologists to give every specimen a new name," observed **Tim Cliffe**. "It's also true that some have equally vigorously adopted the opposite agenda — that is, they always see new specimens as merely indicating variation within previously described species. Both these tendencies should be viewed as provisional. There is variation within species; there are also separate species. I suppose this will sort itself out eventually as more specimens round out the picture. But my impression is that DNA evidence will be hard or impossible to get in this multimillion-year-old time range, so the arguments will probably not end soon."

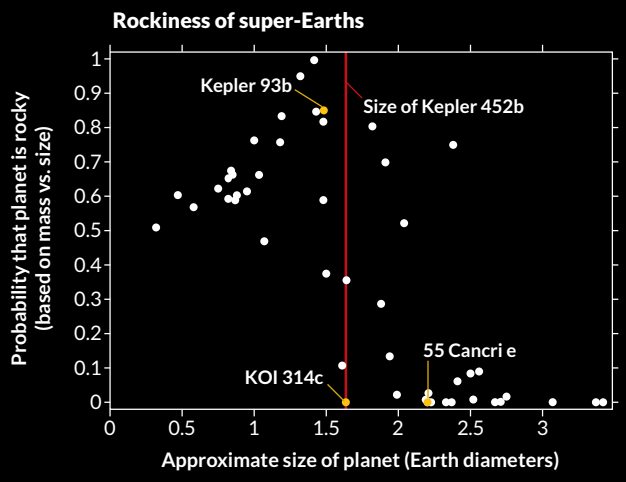


New exoplanet: Big Earth or small Neptune?

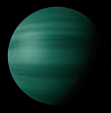
If Kepler 452b applied for the position of most Earthlike exoplanet, it would boast an impressive résumé. The newly discovered world (illustrated, top right) mimics our planet with a 385-day orbit around a sunlike star (see Page 16). But there's a hitch: Kepler 452b may not be made of rock. The planet is about 1.6 times as wide as Earth, and researchers couldn't measure its mass. As a result, nobody knows if water on Kepler 452b has a solid surface on which to pool.

Kepler 452b is a super-Earth, falling between Earth and Neptune in girth. There are no super-Earths in our solar system but many around other stars. The ones scientists know the most about — worlds with known diameter and mass — tightly orbit stars smaller than the sun. Caltech astronomer Leslie Rogers analyzed several dozen of these planets (see graph) and found that most with diameters at least 1.6 times as large as Earth's are gaseous, not rocky.

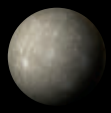
The results suggest Kepler 452b is a bit wide for rockiness. But Rogers says the rules governing the worlds she studied may not apply to planets orbiting larger stars. And due to measurement uncertainties, Kepler 452b may actually be 1.9 times Earth's diameter (and probably gaseous) or 1.4 times, enhancing its candidacy to be an Earthlike world. — *Andrew Grant*



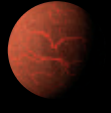
Searching for solids Of a subset of exoplanets with measured size and mass, most that are less than 1.6 times Earth's diameter are probably rocky (left side of graph). Most above that threshold are gaseous (right side). But some planets show the rules aren't clear-cut:



KOI 314c
Discovered last year, KOI 314c is nearly the same size as Kepler 452b. Its low mass suggests that it is composed largely of gas.



Kepler 93b
This planet is about 1.5 times as wide and four times as massive as Earth. It probably consists of a rocky blend of iron, magnesium, silicon and oxygen.



55 Cancri e
The wild card of the bunch, the 2.2-Earth-diameter planet 55 Cancri e isn't massive enough to be rocky but may be made of water or even diamond.

CLOCKWISE FROM TOP: T. PYLE/JPL-CALTECH/NASA; KOI 314C & 55 CANCRI E: PHL/UPR ARECIBO; KEPLER 93B: PARAMETER/ISTOCKPHOTO; L.A. ROGERS/*ASTROPHYSICAL JOURNAL* 2015, ADAPTED BY S. EGTS

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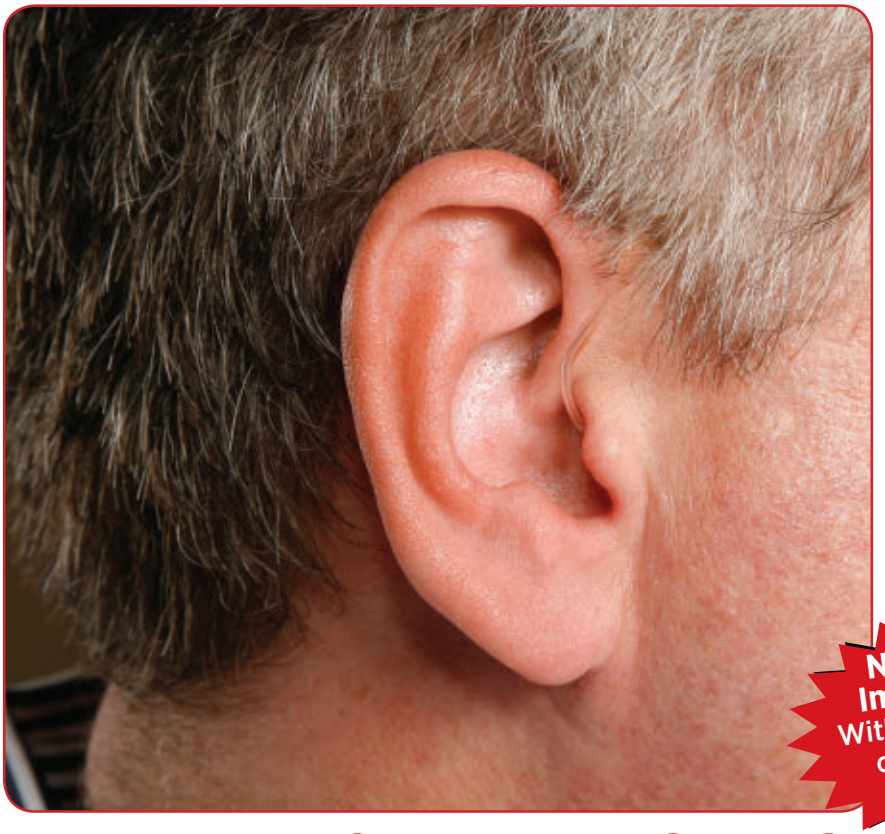

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