SN
SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
MARCH 17, 2018

Neandertals' Artistic Side

When Baby Brings You Down

Ants Ace Battlefield Triage

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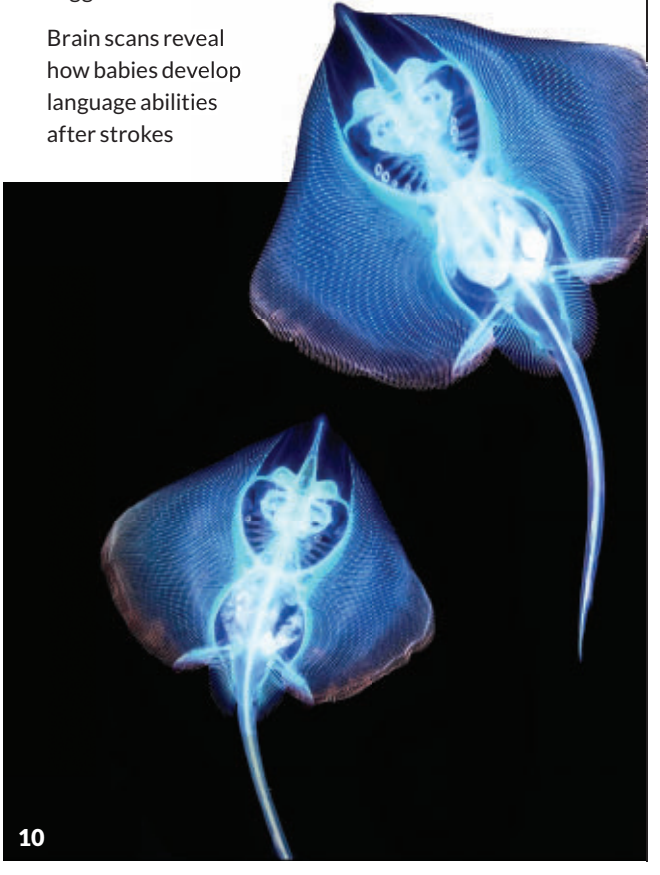
Features

News



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Departments

COVER Indonesia's peat landscapes are in trouble if agriculture continues to drain the land, boosting fire risk. *Nanang Sujana/CIFOR (CC BY-NC-ND 2.0)*

FROM TOP: JESSE ALLEN/NASA EARTH OBSERVATORY; DESIREE STOVER/NASA; JUN AN-CHEN

Discussing what matters when facts are not enough

Scientists and journalists live for facts. Our methods may be very different, but we share a deep belief that by questioning, observing and verifying, we can gain a truer sense of how the world works.

So when people question the scientific consensus on issues such as climate change, vaccine effectiveness or the safety of genetically modified organisms (*SN: 2/6/16, p. 22*), it's no surprise that one of the first inclinations of journalists and scientists has been to think, hey, these doubters just don't know the facts. Many organizations have launched fact-check operations on the premise that the skeptics are really just suffering from a fact deficit. Give them more data spelling out the correlation between increased carbon emissions and global temperature rise, the thinking goes, and they'll get it.

But there's considerable evidence that more data isn't better when it comes to science skeptics (*SN Online: 7/28/17*). And being bombarded with facts can make people dig in even more. People who feel pressured to change their beliefs are adept at defending them. They also tend to seek out evidence that supports their world view and ignore, devalue or challenge facts that don't. Emotion trumps fact.

It's time for scientists to pay attention to that piece of evidence and learn how to connect with people with differing views, climate scientist Katharine Hayhoe said February 18 at the American Association for the Advancement of Science annual meeting in Austin (see *Science News*' coverage on Pages 12 and 13). Her plenary lecture was titled bluntly: "When Facts Are Not Enough."

"We live in a situation now where the fear of solutions is greater than the fear of impacts," said Hayhoe, a professor at Texas Tech University in Lubbock. "Until we can turn this situation around ... we are not going to make the difference we want to."

There's no question that the United States' increased political polarization has made it harder to talk about science policy and find common ground, Hayhoe said. But she added that the strongest predictor of climate skepticism is not political conservatism or religious belief, but people's fears that the government will be taking away freedom by "telling me what to do."

This has deeply influenced how Hayhoe talks to people about climate change. She is an evangelical Christian and says she often talks at churches about her science and her faith. She doesn't mince words about the threat to humankind that she sees looming, but she also offers a message of hope: that together we can fix this.

We're all for finding common ground in talking about science and policy. For almost 100 years, *Science News* has been reporting the latest advances in science, such as this week's cover story by reporter Laurel Hamers, "Smoke signals" (Page 20), on how the increased frequency of bog fires worldwide is becoming a surprisingly large source of air pollution and climate-warming carbon dioxide. The story is deeply researched and fact-checked, and is just the sort of evidence-based journalism we think helps support informed, thoughtful policy debate.

— Nancy Shute, Editor in Chief

NATHAN HIRSCH PHOTOGRAPHY

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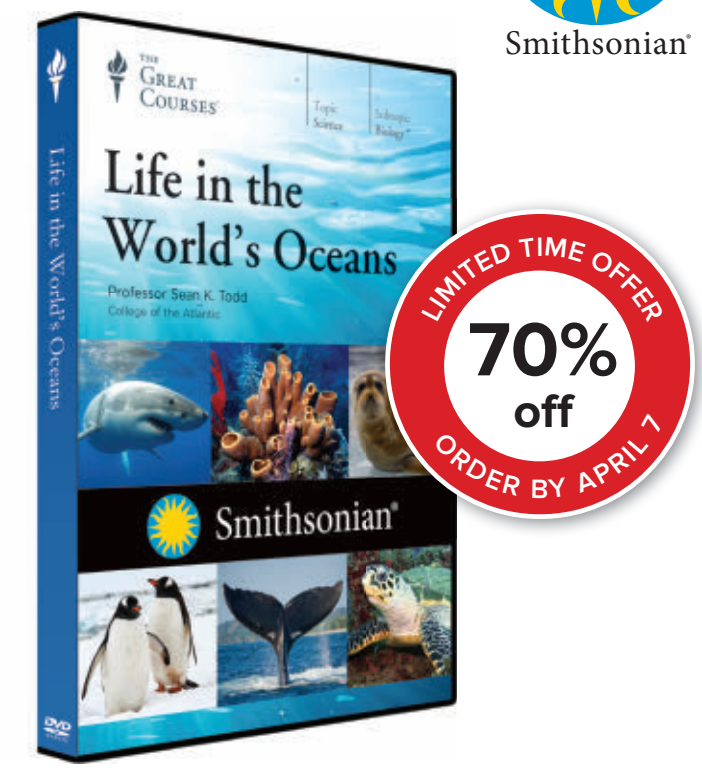

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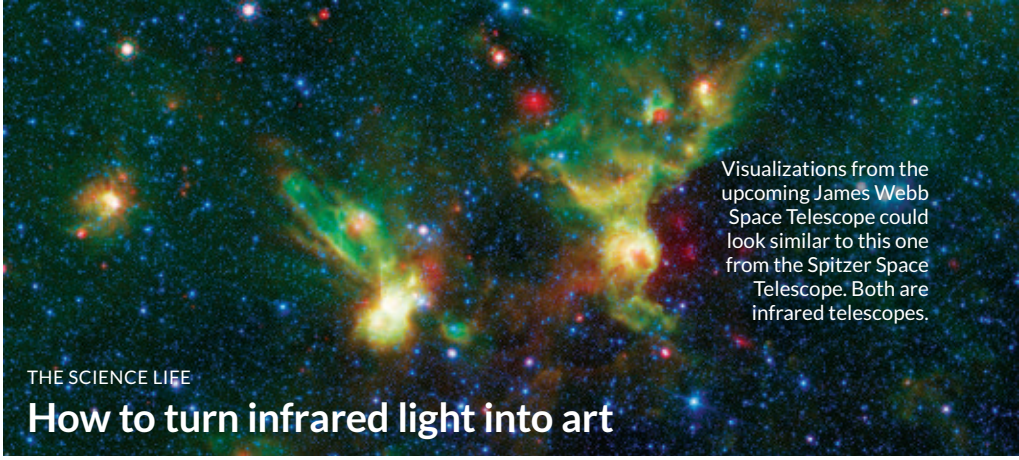
Excerpt from the March 16, 1968 issue of *Science News*

50 YEARS AGO

The strangest signals reaching Earth

The search for neutron stars has intensified because of a relatively small area, low in the northern midnight sky, from which the strangest radio signals yet received on Earth are being detected. If the signals come from a star, the source broadcasting the radio waves is very likely the first neutron star ever detected.

UPDATE: That first known neutron star's odd pulsating signature earned it the name "pulsar." The finding garnered a Nobel Prize just six years after its 1968 announcement — although one of the pulsar's discoverers, astrophysicist Jocelyn Bell Burnell, was famously excluded. Since then, astronomers have found thousands of these blinking collapsed stars, which have confirmed Einstein's theory of gravity and have been proposed as a kind of GPS for spacecraft (*SN: 2/3/18, p. 7*).



Visualizations from the upcoming James Webb Space Telescope could look similar to this one from the Spitzer Space Telescope. Both are infrared telescopes.

THE SCIENCE LIFE

How to turn infrared light into art

With an astronomer's toolkit and an artist's eye, Zoltan Levay has transformed raw data from the Hubble Space Telescope into stunning space vistas for almost a quarter century (*SN: 4/18/15, p. 4*). His next challenge: making art with light not visible to human eyes.

Levay's next charge is the James Webb Space Telescope, set to launch in 2019. Unlike Hubble, which mostly views the universe in visible light, Webb will observe in infrared wavelengths, which are too long for human eyes to detect.

The switch is worth making because the telescope will see farther back in time than Hubble — possibly to the universe's first stars and galaxies, whose light has been stretched by cosmic expansion. But the different approach makes the most common question Levay gets — "What does it really look like?" — tougher to answer.

"The most important thing for us is we don't want to make things up," says Joseph DePasquale, a science visualizer who in March 2017 joined Levay at the Space Telescope Science Institute in Baltimore. Both have academic training in astronomy and informal training in art (Levay in photography, DePasquale in painting).

The main challenge will be color, DePasquale says. The artists will employ a "chromatic ordering" strategy. Each infrared wavelength in the range captured by the telescope will be assigned a color. The longest will be red, the shortest blue and the rest in between.

The honeycomb arrangement of the James Webb Space Telescope's mirrors may leave an imprint in images of ancient stars and galaxies.

But the pair worry that Webb's images might look too fake. Hubble captures something close to real colors, but in similarly processed images from the infrared Spitzer Space Telescope, most stars appear blue because stars emit more light at visible wavelengths and in the near infrared. Spitzer images also tend to be dominated by gas in midwavelength greens, DePasquale says.

"There's nothing inherently wrong with that," he adds, but he's uncertain about the aesthetics. So the team hasn't chosen the palette for James Webb's images yet.

Another challenge with James Webb will be visualizing spectra, rainbows of split-up light that can reveal chemical composition, Levay says. Spectra are often presented as simple bands of color, which may be difficult to bring to life.

Then there are the visual side effects of the telescope itself. When Hubble's cameras create cross hairs coming out of bright stars, for instance, Levay and DePasquale let them be. "That's an artifact, but it's visually pleasing, so it stays," DePasquale says.

The honeycomb pattern of Webb's mirrors might likewise imprint itself on the stars in the images, like an artist's signature.

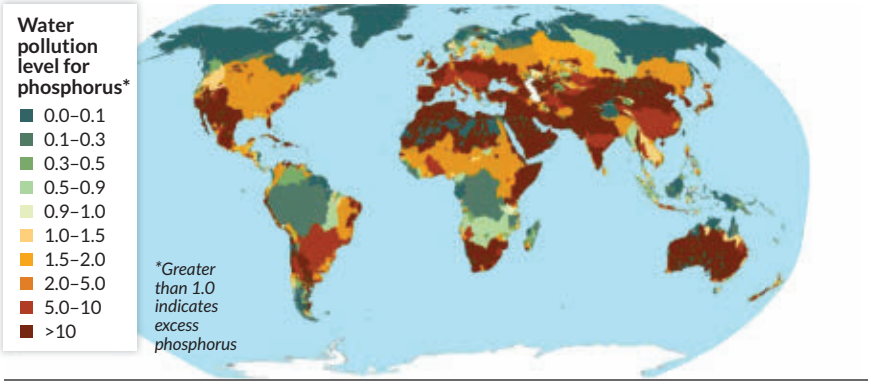
It's hard to know if Webb's images will become as iconic as Hubble's — or more so. The Webb telescope already has a Twitter presence, and it hasn't even launched yet. It has the potential to reach a huge audience from the very beginning. One thing is certain, Levay says, "we'll see some amazing images." — *Lisa Grossman*

FROM TOP: JPL-CALTECH/NASA; DESIREE STOVER/NASA

SCIENCE STATS

Freshwater is maxed out on phosphorus

Human activities are driving phosphorus levels in the world's lakes, rivers and streams to a critical point. The freshwater bodies on about 38 percent of Earth's land area (excluding Antarctica) are overly enriched with phosphorus, leading to potentially toxic algal blooms and less available drinking water, researchers report January 24 in *Water Resources Research*. The scientists tracked human phosphorus inputs from 2002 to 2010 from domestic, industrial and agricultural sources. Human sewage was responsible for about 54 percent of the 1.47 teragrams of human-driven global load; agricultural fertilizer added about 38 percent. China contributed 30 percent of the global total, India 8 percent and the United States 7 percent. — *Carolyn Gramling*



HOW BIZARRE

An eye full of worms

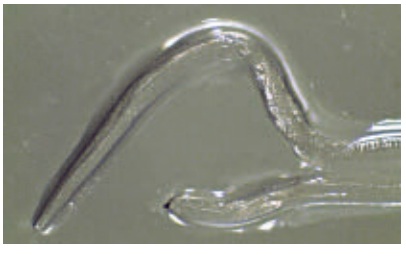
A 26-year-old woman felt something in her left eye. For days, she couldn't shake the sensation. But this was no errant eyelash or dive-bombing gnat.

A week after that first irritation, the Oregon resident pulled a translucent worm, about a centimeter long, from her eye. With that harrowing feat, she became the first reported case of a human infested with the cattle eye worm *Thelazia gulosa*. "This is a very rare event and exciting from a parasitological perspective," says medical parasitologist Richard Bradbury of the U.S. Centers for Disease Control and Prevention in Atlanta. "Perhaps not so exciting if you are the patient."

Over 20 days, the woman and her doctors removed 14 worms from her infected eye, Bradbury and colleagues report online February 12 in the *American Journal of Tropical Medicine and Hygiene*. After that, no more irritation.

T. gulosa is a nematode found in North America, Europe, Australia and Central Asia that infects the large, watchful eyes of cattle. The worm spends its larval days inside the aptly named face fly (*Musca autumnalis*). As the fly feasts on tears, it spreads the nematode larvae. Two other *Thelazia* species are known to infect humans, but rarely. This new perpetrator was a surprise, Bradbury says. The young woman had been horseback riding near cattle farms in Gold Beach, Ore., which may explain her face-to-face with the fly.

"It is just unfortunate," Bradbury says, "that she was not able to swish away that one infected fly quickly enough." — *Aimee Cunningham*



The first known person to be infected with this particular nematode probably picked it up while horseback riding near a cattle farm.

FROM TOP: M.M. MEKONNEN AND A.Y. HOEKSTRA/*WATER RESOURCES RESEARCH* 2018; CDC

RETHINK

Fishy rabbit tale debunked for Lent

Domesticated bunnies may need a new origin story.

An often-cited tale holds that monks in southern France domesticated rabbits after Pope Gregory the Great issued a proclamation in A.D. 600 that fetal rabbits, called laurices, are fish and therefore can be eaten during Lent, when meat was forbidden. That story no longer holds, according to a new study.

"Pope Gregory never said anything about rabbits or laurices, and there is no evidence they were ever considered fish," says archaeologist Evan Irving-Pease of the University of Oxford.

He and colleagues discovered that scientists had mixed up Pope Gregory with St. Gregory of Tours. St. Gregory made a passing reference to a man named Roccolenus who in "the days of holy Lent ... often ate young rabbits." The misattribution somehow led to the story of rabbits' domestication.

What's more, modern DNA evidence can't narrow rabbit domestication to that time period, Irving-Pease and colleagues report in the March *Trends in Ecology and Evolution*. Rabbit domestication was not a single event, but a process with no distinct beginning, the researchers say. For similar reasons, scientists have found it difficult to pinpoint when and where other animals were first domesticated (*SN: 7/8/17 & 7/22/17, p. 20*).

Geneticist Leif Andersson of Uppsala University in Sweden agrees that genetic data can't prove that rabbit domestication happened around 600. But, he says, "it is also impossible to exclude that domestication of rabbits happened around that time period."

Domestication practices were well-known by then, Andersson says. Monks or farmers in southern France with a taste for rabbit could have rounded up bunnies that eventually became the founding population for the domestic rabbit. Ancient DNA from old rabbit bones may one day help settle the debate. — *Tina Hesman Saey*

HUMANS & SOCIETY

Rock art reveals Neandertal smarts

Hominid's cave paintings imply capacity for symbolic thinking

Red horizontal and vertical lines painted in a Spanish cave date to at least 64,800 years ago. Because *Homo sapiens* had not yet reached Europe, Neandertals must have created this art, researchers argue. The age and maker of the figure shaped like an animal head (right) is unknown.

BY BRUCE BOWER

Neandertals drew on cave walls and made personal ornaments long before encountering *Homo sapiens*, two studies find. These discoveries paint bulky, jut-jawed Neandertals as the mental equals of ancient humans.

Rock art depicting abstract shapes and hand stencils in three Spanish caves dates back to at least 64,800 years ago, researchers report in the Feb. 23 *Science*. If these estimates hold up, the Spanish finds become the world's oldest known examples of cave art, preceding evidence of humans' arrival in Europe by at least 20,000 years (*SN Online: 11/2/11*).

The finds raise the possibility that "Neandertals took modern humans into caves and showed them how to paint," says archaeologist Francesco d'Errico of the University of Bordeaux in France.

Personal ornaments previously found at a coastal cave in southeastern Spain are older than the cave art, dating to around 120,000 to 115,000 years ago, scientists report February 22 in *Science Advances*. Only Neandertals inhabited Europe at that time. Those artifacts consist of pigment-stained seashells with artificial holes, presumably for use on necklaces, and seashells containing remnants of pigment mixtures, say geochronologist Dirk Hoffmann of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, and colleagues. Hoffmann is also an author of the cave art study. The new findings join previous reports of potentially symbolic Neandertal artifacts, such as a possible necklace made from eagle claws (*SN: 4/18/15, p. 7*) and bird-feather decorations.

Seashells probably intended to be strung together like a necklace date to 120,000 to 115,000 years ago, when only Neandertals were known to inhabit Europe. The shells were found in a cave on Spain's Mediterranean coast.

If Neandertals did have the capacity for symbolic thinking — crucial for using drawings or language to represent ideas and objects — that ability may have developed in the last common ancestor shared with humans, at least 500,000 years ago, the two research teams propose.

"Neandertal social life was as complex as that of [contemporaneous] humans in Africa," says archaeologist João Zilhão of the University of Barcelona, an author of both papers.

But some scientists view the new findings cautiously. Neandertals communicated in sophisticated ways, but few clearly symbolic artifacts have been linked to them, says archaeologist Nicholas Conard of the University of Tübingen in Germany. "If Neandertals regularly produced paintings or similar kinds of symbolic artifacts, researchers will eventually demonstrate it at multiple sites."

Analyses of thin mineral deposits partly covering painted cave areas gave minimum age estimates for the art, based on known decay rates of radioactive uranium in the rock. One red, rectangular painting dates to at least 64,800 years ago. One of several hand stencils in a second cave dates to at least 66,700 years ago. In a third cave, patches of red paint were applied to the walls at least 65,500 years ago, with more paintings added over a period of 25,000 years or more — signaling a long Neandertal tradition of cave art, Hoffmann and colleagues say.

Many of the dated deposits contain rock particles from external sources that can throw off age estimates. The researchers statistically corrected for such contamination, "but whether that is sufficient enough remains to be seen," says archaeologist Katerina Douka of the Max Planck Institute for the Science of Human History in Jena, Germany.

Whether uranium is sufficient enough to date the paintings is also up for debate. Last year in *Quaternary International*, researchers argued it is "nearly impossible" to generate accurate age estimates of rock art based on uranium measures alone. Depending on shifting cave conditions and varying amounts of uranium drainage from mineral deposits, the method can over- or underestimate when art was created, the scientists concluded. Other researchers defend this technique as providing valuable minimum and maximum age estimates for rock art.

At the coastal cave, dating relied on a one-two punch: uranium analyses of rock partly covering shell-bearing sediment and geologic estimates of when ancient sea levels declined enough to allow entry into the chamber. ■

FROM TOP: © P. SAURA; J. ZILHÃO

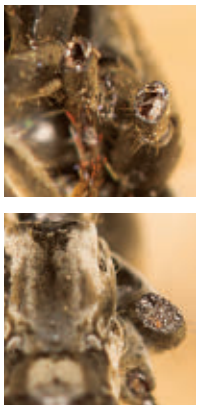
Matabele ants nurse fallen comrades

Raiders practice combat triage and successful wound care

BY SUSAN MILIUS

No wounded left behind — not quite. Ants that have evolved battlefield medevac carry only the moderately wounded home to the nest. There, those lucky injured fighters get fast and effective wound care.

Insect colonies seething with workers may seem unlikely to stage elaborate rescues of individual fighters. Yet for Matabele ants (*Megaponera analis*) in sub-Saharan Africa — with a mere 1,000 to 2,000 nest mates — treating the wounded can be worth the effort, says behavioral ecologist Erik Frank of the University of Lausanne in Switzerland.



In Matabele ants, wounds (top, ant with two severed legs) can close in as little as an hour (bottom, another ant with sealed wound). Nest mate "licking" can lower death rates.

Tales of self-medication pop up across the animal kingdom. For Matabele ants, however, nest cameras plus survival tests show insects treating other adults and improving their chances of survival, Frank and colleagues report in the Feb. 14 *Proceedings of the Royal Society B*. For treatment boosting others' survival, Frank says, the closest documented example is humans.

In Ivory Coast, Frank studied Matabele ant colonies that staged three to five termite hunts a day. He and colleagues at the University of Würzburg in Germany published research last year showing that members of a hunting party carry injured comrades home.

Frank also took a closer look at rescues after he accidentally drove over a Matabele ant column crossing a road. Survivors "were only interested in picking up the ants that were lightly injured, and leaving behind the heavily injured," he recalls.

When Frank later set injured ants in front of columns trooping home from raids, injured ants missing two legs often got picked up. Only once did an ant with five missing legs get a lift.

Ants that have lost two legs still have value to a colony, especially in a species where only about 13 ants reach adulthood per day. Four-legged ants regain almost the same speed that ants have on six legs, Frank says. In a typical hunting party, about a third of the ants have survived some injury, but most ants have at least four legs left.

Triage for a battlefield evacuation is shaped by injured ants' behavior, Frank says. Ants with only moderate injuries, such as two lost legs, emit "help me" pheromones. These ants tuck in their remaining legs and generally cooperate with rescuers. Not so with more seriously hurt ants, which may not even give off pheromones. Rescuers still stop to investigate. But the seriously injured ants often flail around instead of cooperating, and the rescuers give up.

Leaving the carnage of a battle with termites, a Matabele ant carries an injured nest mate home for treatment.

ALL: E.T. FRANK

An African Matabele ant uses its mouthparts to treat a nest mate's wounded leg in a prompt and effective insect version of health care.

Frank also has seen ants act more severely injured than they truly are. These ants stagger or lie down. But if overlooked, "they will immediately stand up and run as fast as they can behind the others," he says. "In humans, it's a very selfish behavior." For ants, exaggeration can strengthen the SOS signal, and the colony benefits from the rescues.

For injured raiders that do get home, another ant — usually not the carrier — steps in to treat the wound by repeatedly moving its mouthparts over it. When Frank isolated the ants to prevent wound licking, about 80 percent of injured ants died. When he allowed ants an hour of treatment before isolating them, only 10 percent of them died.

Based on Frank's observations, other ant researchers are now wondering if they also have seen such rescue tactics. Andy Suarez of the University of Illinois at Urbana-Champaign wants another look at big *Dinoponera australis* that he's frequently seen prowling for prey despite missing a limb. And Bert Hölldobler of Arizona State University in Tempe wonders whether the weaver ants he has seen retrieving injured nest mates after battle were rescuing them. The usual interpretation, he says, has been cannibalism.

Frank, however, used bright acrylic spots to track the fate of rescued Matabele ants. They weren't for lunch. ■

BODY & BRAIN

Plaques vanish in Alzheimer's mice

Cutting off a brain enzyme reversed protein clumping

BY AIMEE CUNNINGHAM

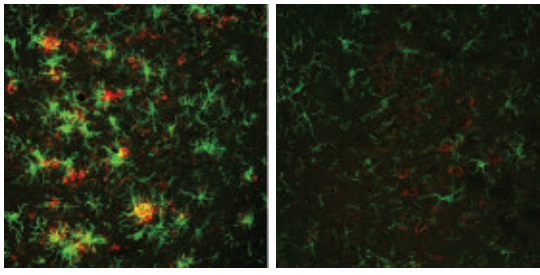
Knocking back an enzyme swept mouse brains clean of protein globs that are a sign of Alzheimer's disease. Reducing the enzyme is known to keep these nerve-damaging plaques from forming. But the disappearance of existing plaques was unexpected, researchers report online February 14 in the *Journal of Experimental Medicine*.

The brains of mice engineered to develop Alzheimer's disease were riddled with the plaques, clumps of amyloid-beta protein fragments, by the time the animals were 10 months old. But the brains of 10-month-old Alzheimer's mice that had a severely reduced amount of an enzyme called BACE1 were essentially clear of new and old plaques, according to Riqiang Yan, one of the discoverers of BACE1 about 20 years ago and a neuroscientist at the Cleveland Clinic.

Studies rarely demonstrate the removal of existing plaques, says neuroscientist John Cirrito of Washington University in St. Louis. "It suggests there is something special about BACE1," he says, but what remains unclear.

One theory to how Alzheimer's develops is called the amyloid cascade hypothesis. Accumulation of globs of A-beta protein bits, the idea goes, drives the nerve cell loss and dementia seen in the disease, which an estimated 5.5 million Americans had in 2017. If the theory is right, targeting the BACE1 enzyme, which cuts up another protein to make A-beta, may help patients.

In the study, Alzheimer's mice with normal BACE1 levels experienced a steady increase in plaques beginning at about 10 weeks old, visible in brain samples.



Protein globs linked to Alzheimer's (red) dot a brain sample of a 10-month-old mouse (left). But the globs are absent in a mouse (right) that mostly lacks a particular brain enzyme.

In Alzheimer's mice with BACE1 levels that tapered off over time, however, the number of plaques initially grew but had mostly disappeared by the time the mice were around 6 months old. By 10 months, "we hardly see any," Yan says.

"It is possible that perhaps a therapeutic agent targeting BACE1 in humans might have a similar effect," Cirrito says.

Drugs that target BACE1 are already in development. But the enzyme has other important jobs in the brain. So it may be necessary to inhibit some, but not all, of the enzyme, Yan says. ■

BODY & BRAIN

Small intestine is first stop for fructose

In mice, at least, the organ protects the liver from too much sugar

BY LAUREL HAMERS

When it comes to processing fructose, the liver pinch-hits for the small intestine.

To use fructose for energy, the body must convert it into another type of simple sugar called glucose or other smaller molecules. Scientists knew fructose could be metabolized in both the liver and small intestine, but believed the liver was mainly responsible. A study in mice suggests otherwise, showing that moderate doses of fructose — a sugar found in honey and fruit, as well as soda — are transformed in the small intestine. The liver steps in only when the small intestine gets inundated, researchers report in the Feb. 6 *Cell Metabolism*.

In that way, the small intestine shields the liver from dangerously high doses of fructose, says Joshua Rabinowitz, a metabolism researcher at Princeton University. In humans, too much fructose puts the liver at risk for conditions such as fatty liver disease and raises the overall risk of obesity and type 2 diabetes (*SN: 10/5/13, p. 18*).

But how much fructose is too much is still up in the air (*SN Online: 5/26/15*). Rabinowitz and colleagues fed mice a mixture of equal parts glucose and fructose (the ratio in basic table sugar), in which certain carbon atoms had been swapped out for a slightly heavier form of carbon. That allowed researchers to track which sugars were transformed and where the by-products, or metabolites, ended up.

At lower sugar doses, researchers found metabolites from labeled fructose molecules abundant in the small intestine, and only small amounts in the liver and in the vein that connects the two. Lots of glucose molecules were in this vein, though, and some had been chemically transformed from fructose molecules in the small intestine. At high sugar doses, the small intestine couldn't keep up: The connecting vein had a much higher ratio of fructose to glucose. That finding suggests the small intestine was passing some fructose along to the liver.

The research shows the workload breakdown between the two organs and suggests a protective role for the small intestine, says Gilles Mithieux, a nutrition researcher at the French National Institute of Health and Medical Research in Lyon who wasn't part of the study.

But translating these findings into dietary recommendations for people could be challenging, cautions Luc Tappy, a physiologist at the University of Lausanne in Switzerland. It's hard to compare sugar doses between humans and mice, which expend more energy relative to body weight than humans do.

If the results do translate, it could be good news. "This argues for sweets in moderation being OK," Rabinowitz says. So keep eating apples, but maybe cut back on the Big Gulps. ■

X. HU *ET AL/J. EXP. MED.* 2018

EARTH & ENVIRONMENT

Penguins can track Antarctic changes

Food web and climate shifts are written in feathers and eggshells

BY CAROLYN GRAMLING

Penguins preserve records of Antarctic environmental change. The birds' feathers and eggshells contain the chemical fingerprints of variations in diet, food web structure and even climate, researchers reported February 12.

Antarctica has seen dramatic changes in recent decades. Overfishing has led to a decline in krill — small crustaceans that are a key food source for birds, whales and fish in the Southern Ocean. And climate change is altering wind directions, creating open water regions in sea ice that become hot spots for life.

These changes have cascading effects on food webs and the cycling of nutrients. "Penguins are excellent bioarchives of this change," said Kelton McMahon, an oceanic ecogeochemist at the University of Rhode Island in Kingston.

Penguins' food sources have varying amounts of carbon and nitrogen isotopes, forms of the elements with different numbers of neutrons. For example, krill and fish have different amounts of nitrogen-15 relative to nitrogen-14. Penguins' feathers and eggshells preserve those proportions.

Researchers had previously noted a big shift in isotopic values in penguin tissues in the last 80 years. McMahon and colleagues created a tool to distinguish between shifts in diet versus climate-related shifts in the isotopic values of the microscopic creatures at the base of the food web — and ultimately to track environmental changes through time.

The team focused on the isotopic values of individual amino acids, the building blocks of proteins. Some of these values are significantly altered as food is digested and incorporated into an animal's body; others are little changed.

To understand what penguins had been eating through time, the team first developed a set of chemical fingerprints for the isotopic values of a dozen different amino acids by mapping how the values found in herring, a dietary staple, changed in penguins' bodies after digestion. The researchers acquired these data by precisely monitoring what, when and how much a captive population of penguins ate. Comparing the chemical fingerprints with wild penguin tissues revealed what the wild birds must have eaten in the past.

Over the last 80 years, the penguins have shifted from eating mostly fish to eating primarily krill and then back to fish, the team reported. There is probably a straightforward historical explanation, McMahon said. In the late 1800s to the mid-1900s, whalers extensively hunted marine mammals that tend to dine on krill. With the loss of competitors, penguins probably took advantage of the resulting krill surplus. But from the 1970s to 1990s, krill harvesting ramped up, and penguins shifted back to a fish-heavy diet.

But there's more to the story. Certain amino acids in the penguins' food pass through the body with their isotopic values essentially unchanged. In fact, the isotopes in those amino acids are thought to reflect the original isotopic values of the creatures at the base of the Antarctic food web: phytoplankton. Because climate drives phytoplankton's isotopic values, the isotopes in those amino acids are a record of climate change.

For nitrogen, higher nitrogen-15 values relative to nitrogen-14 in phytoplankton are probably linked to more open water spaces in sea ice that have formed due to changes in wind, McMahon said.

The study highlights the power of this amino acid isotope technique to track environmental change through animal tissues, said Seth Newsome, an animal ecologist at the University of New Mexico in Albuquerque.

McMahon's team now plans to look farther back in time. Excavations have revealed penguin eggshells as old as 10,000 years that have a story to tell. ■

Both feathers and eggshells offer insights into what penguins have eaten and how their environments are changing.

K. MCMAHON

MEETING NOTE

Strong gusts send seal pups on longer migrations

Native American fishermen in Alaska have long said that seal pups go with the wind rather than struggle against it. Science now confirms that wisdom. Northern fur seal pups migrate hundreds of kilometers farther in blustery years than in milder ones, researchers reported February 14.

These pups begin a voyage from Alaska's Pribilof and Bogoslof islands through the Bering Sea and North Pacific that can last for 20 months before the seals return. Noel Pelland of the National Oceanic and Atmospheric Administration's Alaska Fisheries Science Center in Seattle and colleagues compared the migrations of 168 pups in five years from 1996 to 2015 with winds matching the years pups left on their migrations.

On average, pups moved farther downwind when wind speeds were higher and tended to move to the right of the wind direction — probably following wind-driven ocean currents.

Longer, more physically challenging and potentially deadly journeys in some years may explain why depleted fur seal populations have not rebounded recently despite a hunting ban. — *Carolyn Gramling*

LIFE & EVOLUTION

Wiring for walking dates way back

Little skates and mice share genes for nerve development

BY DAN GARISTO

These fins were made for walking, and that's just what these fish do — thanks to wiring that evolved long before vertebrates set foot on land.

Little skates use two footlike fins on their undersides to move along the ocean floor. With an alternating left-right stride powered by muscles flexing and extending, the movement looks a lot like that of many land-based animals.

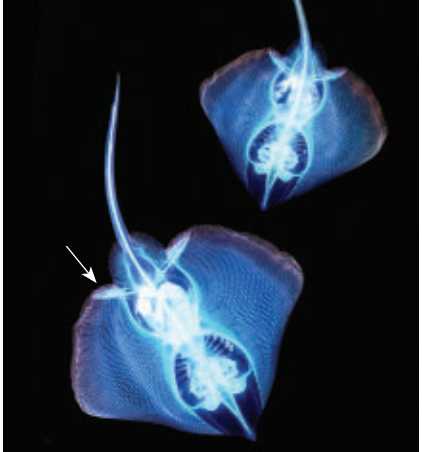
Now tests show why: Little skates and land vertebrates share the same genetic blueprint for development of the nerve cells, or neurons, needed for limb movement, researchers report in the Feb. 8 *Cell*. This work is the first to look at the origins of the neural circuitry needed for walking, the authors say.

"Neurons essential for us to walk originated in ancient fish species," says Jeremy Dasen, a neuroscientist at New York University School of Medicine. Based on fossil records, Dasen's team estimates that the common ancestor of all land vertebrates and skates lived around 420 million years ago — perhaps tens of millions of years before vertebrates moved onto land (*SN: 1/14/12, p. 12*).

Little skates (*Leucoraja erinacea*) belong to an evolutionarily primitive group. Skates haven't changed much since their ancestors split from the fish that evolved into land rovers, so finding the same neural circuitry in skates and land vertebrates was surprising.

The path to discovery started when Dasen and Heekyung Jung, now at Stanford University, saw YouTube videos of little skates walking. "I was completely flabbergasted," Dasen says. "I knew some species of fish could walk, but I didn't know about these."

Most fish swim by undulating their bodies and tails, but the spines of little skates remain relatively straight.



Little skates are cartilaginous fish that use their pelvic fins (arrow) to amble along the ocean floor.

Instead, little skates flap pancake-shaped pectoral fins and walk on two fins tucked along the pelvis. Measurements of these movements found that they were "strikingly similar" to bipedal walking, says Jung, who did the work while at NYU.

To investigate how that similarity arose, the researchers looked to motor neurons, which control muscles. Each kind of movement requires different kinds of motor neurons, Dasen says.

The building of that neural circuitry is controlled in part by *Hox* genes, which help set the body plan, where limbs and muscles and nerves should go. By comparing *Hox* genes in *L. erinacea* and mice, the researchers discovered that both have *Hox6/7* and *Hox10* genes and that these genes have similar roles in both.

Hox6/7 is important for the development of the neural circuitry used to move the skates' pectoral fins and the mice's front legs; *Hox10* plays the same role for the footlike fins in little skates and hind limbs in mice. Other genes and neural circuitry for motor control were also conserved, or unchanged, between little skates and mice. The findings suggest that both skates and mice share a common ancestor with similar genetics for locomotion.

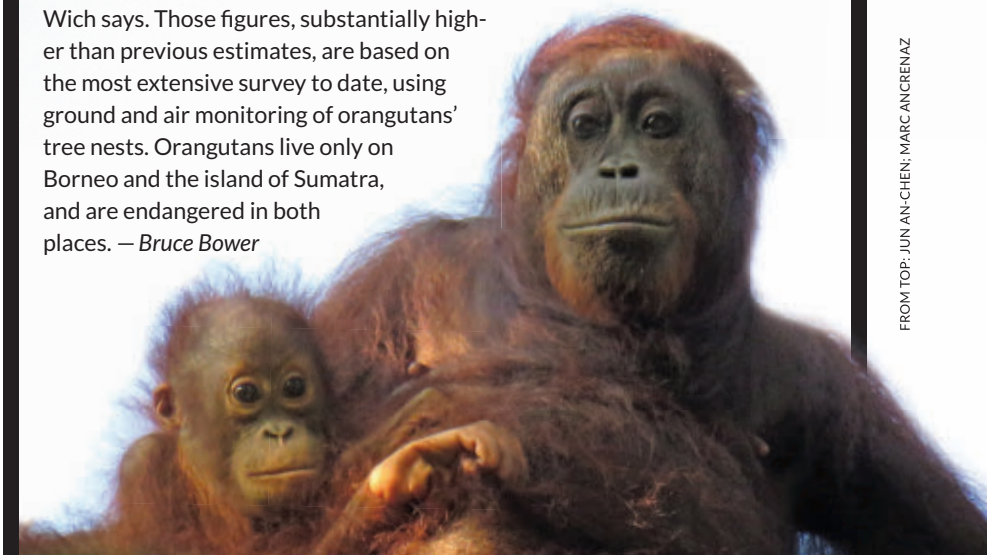
"Evolution works by tinkering," says Ted Daeschler, a vertebrate paleontologist at the Academy of Natural Sciences in Philadelphia. "We're all using what we inherited — a tinkered version of circuitry that began 400-plus million years ago." ■

HUMANS & SOCIETY

Hunting is top threat to Borneo's orangutans

Orangutan numbers on the Southeast Asian island of Borneo plummeted from 1999 to 2015, more as a result of human hunting than habitat loss, researchers report online February 15 in *Current Biology*. Over those years, Borneo's orangutan population declined by about 148,500. A majority of those losses occurred in the intact or selectively logged forests where most orangutans live. "Orangutan killing is likely the number one threat to orangutans," says study coauthor Serge Wich, a biologist and ecologist at Liverpool John Moores University in England. Still, smaller populations in deforested areas faced the severest rates of decline, up to a 75 percent drop in one region.

Between roughly 70,000 and 100,000 orangutans currently live on Borneo, Wich says. Those figures, substantially higher than previous estimates, are based on the most extensive survey to date, using ground and air monitoring of orangutans' tree nests. Orangutans live only on Borneo and the island of Sumatra, and are endangered in both places. — *Bruce Bower*



FROM TOP: JUN AN-CHEN; MARC ANCRENAZ

Silicon enters quantum computing race

Simple 2-qubit machine demonstrates technology's potential

BY EMILY CONOVER

For quantum computers, silicon's springtime may finally have arrived.

Silicon-based technology is a late bloomer in the quantum computing world, lagging behind other methods. Now, scientists have performed simple algorithms on a silicon-based quantum computer, physicist Lieven Vandersypen and colleagues report online February 14 in *Nature*.

The computer has just two quantum bits, or qubits, so it can perform only rudimentary computations. But the demonstration is "really the first of its kind in silicon," says quantum physicist Jason Petta of Princeton University.

Scientists want to build a quantum computer that can perform complex calculations impossible for standard computers. Other technologies are further along than silicon: Quantum computers made of superconducting materials, for example, have reportedly been made with up to 50 qubits (*SN: 12/9/17, p. 18*).

But silicon qubits may have advantages, such as an ability to retain their quantum properties longer than other types of qubits. Plus, because silicon is used in traditional computer chips, manufacturers are already adept at working with the material, potentially allowing such quantum computers to scale up more quickly. Vandersypen, of QuTech at Delft University of Technology in the Netherlands, and colleagues have partnered with Intel on some of their work.

In standard computers, units of information called bits can be set to either 0 or 1. Qubits, however, can exist in a limbo between 0 and 1 known as a quantum superposition. To create silicon qubits, scientists trap a single electron in a tiny bit of silicon called a quantum dot. The value of the qubit — 0, 1 or a superposition — depends on the direction of the electron's spin, a quantum property analogous to the spinning of a top.

Vandersypen and his collaborators created a device consisting of two quantum dots and executed a pair of standard quantum algorithms, including one called Grover's search. In a larger quantum computer, Grover's search could be used to dig up information in a database more quickly than traditional computers (*SN: 7/8/17, p. 28*). "It is a big symbolic step," Vandersypen says.

Typically, silicon qubits must be next to one another to interact. But by adding a miniature magnet into the mix, Petta and colleagues made these qubits interact with particles of light, or photons, in a separate study reported online February 14 in *Nature*. In the future, photons might allow for communication between distant silicon qubits, a necessity for scaling the computers up. ■

EARTH & ENVIRONMENT

Consumer goods pollute urban air

In cities, everyday products rival cars as sources of smog

BY LAUREL HAMERS

To reduce your impact on air quality, you might expect to trade in your gas-guzzling clunker of a car — but unplugging those air fresheners makes sense, too.

In urban areas, emissions from consumer goods such as paint, cleaning supplies and personal care products now contribute as much to ozone and fine particulate matter in the atmosphere as do emissions from burning gasoline or diesel fuel, a new study concludes.

The finding is largely a sign of success, chemist Brian McDonald said during a news conference on February 15. Steps taken to clean up car exhaust over the last few decades have had a huge effect. And as a result, "the sources of air pollution are now becoming more diverse in cities," said McDonald, of the Cooperative Institute for Research in Environmental Sciences in Boulder, Colo.

Spyros Pandis, a chemical engineer at Carnegie Mellon University in Pittsburgh who wasn't involved in the research, agrees. "When you have a big mountain in front of you, it's difficult to know what lies behind it," he says. Now, other sources of air pollution are more visible.

The new study, also published in the Feb. 16 *Science*, focused on volatile organic compounds, or VOCs, that are derived from petroleum. These are a diverse array of hundreds of chemicals that easily vaporize and make their way into the atmosphere. Some VOCs can be harmful when directly inhaled — molecules released by bleach and paint make people light-headed, for instance.

Beyond their immediate effects, VOCs react with other molecules in the air, such as oxygen and nitrogen oxides, to generate ozone as well as fine particulate matter. (Those nitrogen oxides come, in large part, from vehicle exhaust.) High levels of fine particulate matter make it hard to breathe and contribute to chronic lung problems (*SN: 9/30/17, p. 18*). And while ozone high in the atmosphere helps shield Earth from the sun's ultraviolet radiation, at ground level, ozone mixes with fine particulates to form harmful smog.

Over a period of six weeks, McDonald and colleagues collected air samples in Pasadena, located in the notoriously smoggy Los Angeles area. The researchers also evaluated indoor air quality measurements made by other scientists. The team traced the molecules found in these air samples to their original sources using databases that show the specific volatile organic compounds released by specific products.

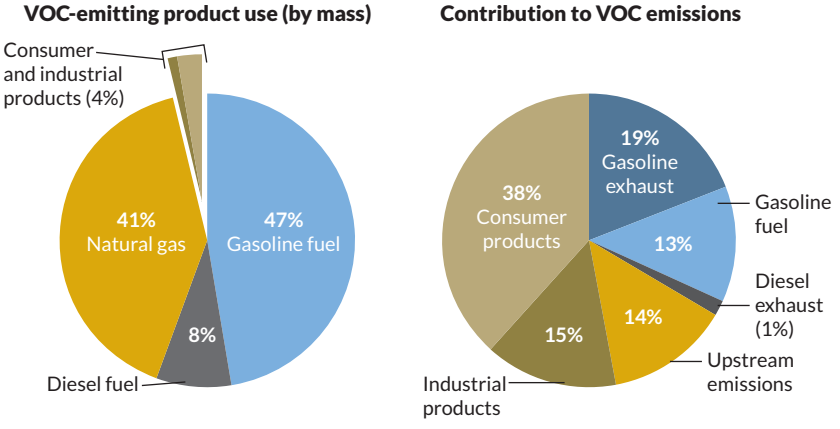
Consumer products that emit VOCs have an outsize effect on air pollution, the team found. About 15 times as much oil and natural gas is used as fuel than ends up in consumer products ranging from soaps, shampoos and deodorants to air fresheners, glues and cleaning sprays. And yet these everyday products were responsible for 38 percent of the VOC emissions, the researchers found, while gasoline and diesel emissions accounted for only 33 percent. Consumer products also contributed just as much as fuels to chemical reactions that lead to ozone and fine particulate matter. The emissions from consumer products also dwarfed those from the production of oil and gas, called upstream emissions.

Regulations on VOCs vary by state, but most consumer products are regulated only for their potential contribution to ground-level ozone, not fine particulate matter. This study makes it clear that even though most volatile emissions from consumer products happen indoors, that air eventually gets vented outside, where it can contribute to larger-scale atmospheric pollution in multiple ways, McDonald said.

More work needs to be done to see whether other cities show the same pattern, the researchers add, as well as to figure out which kinds of VOCs might be of greatest concern. Because there are so many VOCs and they all react differently in the atmosphere, there's still a lot to learn about which VOCs might be most likely to form fine particles and therefore be the best targets for reduction.

Part of the challenge with many of these volatile-emitting products is that they're specifically designed to evaporate as part of their job, said study coauthor Jessica Gilman, an atmospheric chemist at the National Oceanic and Atmospheric Administration in Boulder. For some products, like paints, low-VOC formulations are available. But finding replacements for key ingredients in other products can be difficult. Picking unscented versions of personal care products when possible and using the minimum amount necessary can help reduce the impact on air quality. ■

Extra emissions Consumer goods like paints, perfumes and cleaning supplies make up only a tiny sliver of the products releasing volatile organic compounds into the atmosphere (left). But, as data from the Los Angeles area suggest, these products have an outsize impact, contributing about as much to VOC emissions as gasoline and diesel do (right). SOURCE: B.C. MCDONALD *ET AL*/*SCIENCE* 2018



HUMANS & SOCIETY

Americans might welcome news of E.T.

People would react positively to microbial aliens, survey finds

BY MARIA TEMMING

If alien microbes crash-land on Earth, they may get a warm welcome.

When asked how they would react to the discovery of extraterrestrial microbial life, U.S. survey participants gave mostly positive responses, researchers reported at a news conference February 16.

Those reactions suggest that if microbes are found elsewhere in the solar system, "we'll take the news rather well," said social psychologist Michael Varnum of Arizona State University in Tempe.

Varnum and colleagues asked about 500 online volunteers in the United States to describe how they would react if they learned scientists had found alien microbes. Varnum's team analyzed each response using software that determined the fraction of words indicating positive emotion, such as "nice," and negative emotion, like "worried." The program also scanned for reward- and risk-focused words, such as "benefit" and "danger."

People generally used more positive and reward-oriented words than negative and risk-oriented ones. The same held true when participants were asked how other people would take the news.

In another study, Varnum's team asked about 500 U.S.-based volunteers to read one of two newspaper articles. One from 1996 reported the discovery of evidence for fossilized Martian microbes in a meteorite. The second, from 2010, announced the creation of a synthetic bacterial cell.

Both groups responded favorably to the articles, but the people who read about Martians had a more positive reaction. This suggests that while people feel good about discoveries of any previously unknown life-forms, people are especially keen on finding aliens, Varnum said.

"Any finding that comes from one population — like Americans — you have to take with a grain of salt," Varnum said. His group now hopes to gather responses from participants of different cultures.

Psychologist Douglas Vakoch, who heads the San Francisco–based nonprofit organization Messaging Extraterrestrial Intelligence, says scientists should also gauge reactions to different discovery scenarios. The Martian meteorite "has been on Earth for a long time and nothing bad has happened," Vakoch said. "That's a really safe scenario." But would people be as gung ho about finding live microbes on other planets or aboard meteorites?

Seth Shostak, an astronomer at the SETI Institute in Mountain View, Calif., points out that the response to news of intelligent aliens might be different, too. Knowing that human intelligence isn't special after all could provoke a much different emotional response than finding "pond scum in space," he said.

To gauge how people might feel about intelligent aliens, Varnum analyzed news reports that an interstellar asteroid could be an alien spaceship. The articles took a largely positive angle. So the broader public might also take kindly to the discovery of little green men, Varnum said. ■

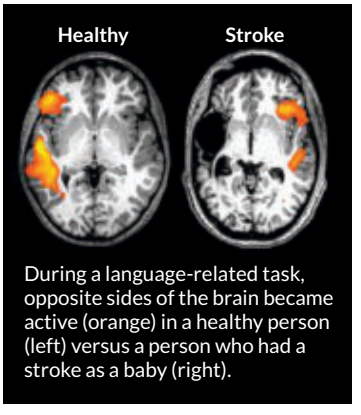
E. NEWPORT

MEETING NOTES

Babies can recover language skills after a stroke

Babies' stroke-damaged brains can pull a mirror trick to recover.

A stroke on the left side of the brain often damages language-processing areas, resulting in the loss of language. But people who have this stroke just before or after birth recover language abilities in the mirror image spot on the right side, a study of teens and young adults shows. Those stroke survivors had normal language skills, even though as much as half of their brains had withered away, researchers reported February 17.



During a language-related task, opposite sides of the brain became active (orange) in a healthy person (left) versus a person who had a stroke as a baby (right).

Neurology researcher Elissa Newport of Georgetown University Medical Center in Washington, D.C., and colleagues recruited 12 people who had a stroke in the brain's left hemisphere just before or after birth. Functional MRI scans of their healthy siblings showed activity in language centers in the left hemisphere when the participants heard speech. Recovered stroke patients showed activity in the same areas — just on the opposite side of the brain.

Young children usually show language activity in the same areas on both sides of the brain, Newport noted, and the left side becomes more dominant over time. So in the case of a left-side stroke, the corresponding areas on the right side might already be primed to take over. — *Laurel Hamers*

Fake organ mimics what happens in the blink of an eye

For the first time, researchers have used human cells to build a model of the surface of the eye that's equipped with a fake eyelid that mimics blinking.

Dan Huh, a bioengineer at the University of Pennsylvania, and colleagues grew a ring of conjunctival cells — tissue that covers the white part of the eye — around a circle of corneal cells on a contact lens–shaped platform. A faux eyelid made of a thin hydrogel film covers and uncovers the eye to spread tear fluid over the cells, Huh reported February 16 at a news conference.

This fake eye could help researchers study eye diseases and injuries such as corneal ulcers, as well as potential treatments, Huh said. — *Maria Temming*

The GERDA experiment at the Gran Sasso underground laboratory in Italy is using the element germanium to hunt for neutrinoless double beta decay.

K. FREUND/GERDA COLLABORATION

ATOM & COSMOS

Striving to solve antimatter mystery

Quest to identify nature of neutrino's alter ego heats up

BY EMILY CONOVER

Galaxies, stars, planets and life. All are formed from one essential substance: matter.

But the abundance of matter is one of the biggest unsolved mysteries of physics. The Big Bang, 13.8 billion years ago, spawned equal amounts of matter and its bizarro twin, antimatter. Matter and antimatter partners annihilate when they meet, so an even stephen universe would have ended up full of energy — and nothing else. Somehow, the balance tipped toward matter in the early universe.

A beguiling subatomic particle called a neutrino may reveal how that happened. If neutrinos are their own antiparticles — that is, if the neutrino's matter and antimatter versions are the same thing — the lightweight particle might help explain the universe's glut of matter.

So scientists are hustling to find evidence of a hypothetical kind of nuclear decay that can occur only if the particles that researchers observe as neutrinos and antineutrinos are one and the same. Four experiments have recently reported results showing no hint of the process, known as neutrinoless double beta decay (*SN: 7/6/02, p. 10*). But another attempt, set to begin soon, may have a fighting chance of detecting this decay, if it occurs. Meanwhile, planning is under way for a new generation of experiments that will make even more sensitive measurements.

"Right now, we're standing on the brink of what potentially could be a really big discovery," says Janet Conrad, a neutrino physicist at MIT who is not involved with the experiments.

A league of its own

Each matter particle has an antiparticle, a partner with the opposite electric charge. Electrons have positrons as partners; protons have antiprotons. But it's unclear how this pattern applies to neutrinos, which have no electric charge.

Rather than having distinct matter and antimatter varieties, neutrinos might be the lone example of a theorized class of particle dubbed a Majorana fermion (*SN: 8/19/17, p. 8*), a particle that is its own antiparticle. "No other particle that we know of could have this property; the neutrino is the only one," says neutrino physicist Jason Detwiler of the University of Washington in Seattle, who is a member of the KamLAND-Zen and Majorana Demonstrator neutrinoless double beta decay experiments.

Neutrinoless double beta decay is a variation on standard beta decay, a relatively common radioactive process that occurs naturally on Earth. In beta decay, a neutron within an atom's nucleus converts into a proton, releasing an electron and an antineutrino. The element thereby transforms into another one further along the periodic table.

In certain isotopes of particular elements — species of atoms characterized by a given number of protons and neutrons — two beta decays can occur simultaneously, emitting two electrons and two antineutrinos. Although double beta decay is exceedingly rare, it has been detected. If the neutrino is its own antiparticle, a neutrino-free version of this decay might also occur: In a rarity atop a rarity, the antineutrino emitted in one of the two simultaneous beta decays might be reabsorbed by the other, resulting in no escaping antineutrinos.

Such a process "creates asymmetry between matter and antimatter," says Stanford University physicist Giorgio Gratta, who works on the EXO-200 neutrinoless double beta decay experiment. In typical beta decay, one matter particle emitted — the electron — balances out the antimatter particle — the antineutrino. But in neutrinoless double beta decay, two electrons are emitted with no corresponding antineutrinos. Early in the universe, other processes might also have behaved in a similarly asymmetric way.

On the hunt

To spot the unusual decay, scientists are building experiments filled with carefully selected isotopes of certain elements and monitoring the material for electrons of a particular energy, which would be released in the neutrinoless decay.

If any experiment observes this process, "it would be a huge deal," says particle physicist Yury Kolomensky of the University of California, Berkeley, a member of the CUORE neutrinoless double beta decay experiment. "It is a Nobel Prize–level discovery."

The latest results won't garner any Nobels. In a paper accepted in *Physical Review Letters*, the GERDA experiment spotted no signs of the decay. Located in the Gran Sasso underground lab in Italy, GERDA looks for the decay of the isotope germanium-76. (The number refers to the quantity of protons and neutrons in the

atom's nucleus.) Since GERDA didn't spot the decay, if the process occurs, it must be extremely rare, the scientists concluded, and its half-life in germanium-76 must be long: over 80 trillion trillion years.

Three other experiments have also recently come up empty. The Majorana Demonstrator experiment, located at the Sanford Underground Research Facility in Lead, S.D., which also looks for the decay in germanium, reported no evidence of neutrinoless double beta decay in a paper accepted in *Physical Review Letters*. Meanwhile, EXO-200, located in the Waste Isolation Pilot Plant, underground in a salt deposit near Carlsbad, N.M., reported no hints of the decay in xenon-136 in a paper published in the Feb. 16 *Physical Review Letters*.

Likewise, no evidence for the decay materialized in the CUORE experiment, in results reported in a paper accepted in *Physical Review Letters*. Composed of crystals containing tellurium-130, CUORE is also at the Gran Sasso lab.

The most sensitive search thus far comes from the KamLAND-Zen neutrinoless double beta decay experiment located in a mine in Japan, which found a half-life longer than 100 trillion trillion years for the neutrinoless double beta decay of xenon-136. That result means that, if neutrinos are their own antiparticles, their mass has to be less than about 0.061 to 0.165 electron volts depending on theoretical assumptions, the KamLAND-Zen collaboration reported in a 2016 paper in *Physical Review Letters*. (An electron volt is particle physicists' unit of energy and mass. For comparison, an electron has a much larger mass of half a million electron volts.)

Neutrinos, which come in three different varieties and have three different masses, are extremely light. But exactly how light is unknown. Mass measured by neutrinoless double beta decay experiments is an effective mass, a weighted average of the three neutrino masses. The smaller that mass, the lower the rate of the neutrinoless decays (and therefore the longer the half-life), and the harder the decays would be to find.

KamLAND-Zen has looked for such decays of xenon-136 dissolved in a tank of liquid. Now, KamLAND-Zen is embarking on a new incarnation of the experiment, using about twice as much xenon, which will reach down to even smaller masses, and even rarer decays. Finding neutrinoless double beta decay may be more likely below about 0.05 electron volts, where neutrino mass has been predicted to lie.

Antimatter whodunit

KamLAND-Zen's new experiment is a start. Decades more work may be needed before scientists clinch the case for or against neutrinos being their own antiparticles. But, says KamLAND-Zen member Lindley Winslow, a physicist at MIT, "sometimes nature is very kind to you." The experiment could begin taking data as early as this spring, says Winslow, who is also a member of CUORE.

To keep searching, experiments must get bigger, while remaining extremely clean, free from any dust or contamination that could harbor radioactive isotopes. "What we are searching for is a decay that is very, very, very rare," says GERDA collaborator Riccardo Brugnera, a physicist at the University of Padua in Italy. Anything that could mimic the decay could easily swamp the real thing, making the experiment less sensitive. Too many of those mimics, known as background, could limit the ability to see the decays, or to prove that they don't occur.

In a 2017 paper in *Nature*, researchers deemed the GERDA experiment essentially free from background — a first among such experiments. Reaching that milestone is good news for the future of these experiments. Scientists from GERDA and the Majorana Demonstrator are preparing to team up on a bigger and better experiment, called LEGEND. Many other teams are also planning scaled-up versions of their detectors.

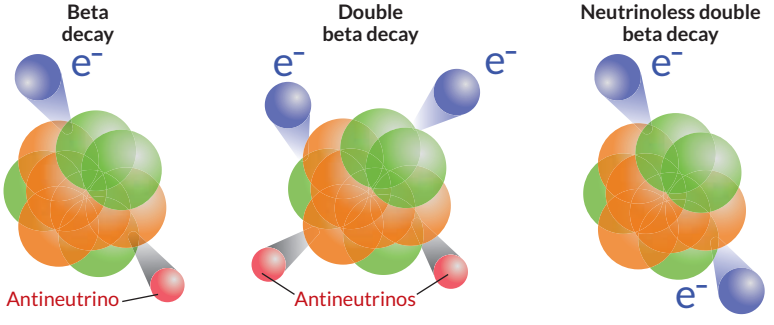
If physicists conclude that neutrinos are their own antiparticles, that could reveal why antimatter is scarce. It could also explain why neutrinos are so lightweight. "You can kill multiple problems with one stone," Conrad says.

Theoretical physicists suggest that if neutrinos are their own antiparticles, undetected heavier neutrinos might be paired up with the lighter neutrinos that we observe. In what's known as the seesaw mechanism, the bulky neutrino would act like a big kid on a seesaw, weighing down one end and lifting the lighter neutrinos to give them a smaller mass. At the same time, the heavy neutrinos — theorized to have existed at the high energies present in the young universe — could have given the infant cosmos its early preference for matter.

Discovering that neutrinos are their own antiparticles wouldn't clinch the seesaw scenario. But it would provide a strong hint that neutrinos are essential to explaining where the antimatter went. And that's a question physicists would love to answer.

"The biggest mystery in the universe is who stole all the antimatter," Conrad say. "There's no bigger theft that has occurred than that." ■

Beta decay, three ways The standard type of beta decay (left) occurs when a neutron in an atom's nucleus converts into a proton and releases an electron (e^-) and an antineutrino. For certain species of atoms, two such decays can happen at once (middle). If the neutrino is its own antiparticle, those double beta decays could also occur without any emitted antineutrinos (right).



C. CHANG

From **Joy** to **Anguish**

Depression among new mothers gets much-needed attention

By Laura Beil

On the hormonal roller coaster of life, the ups and downs of childbirth are the Tower of Power. For nine long months, a woman's body and brain absorb a slow upwelling of hormones, notably progesterone and estrogen. The ovaries and placenta produce these two chemicals in a gradual but relentless rise to support the developing fetus.

With the birth of a baby, and the immediate expulsion of the placenta, hormone levels plummet. No other physiological change comes close to this kind of free fall in both speed and intensity. For most women, the brain and body make a smooth landing, but more than 1 in 10 women in the United States may have trouble coping with the sudden crash. Those new mothers are left feeling depressed, isolated or anxious at a time society expects them to be deliriously happy.

This has always been so. Mental struggles following childbirth have been recognized for as long as doctors have documented the experience of pregnancy. Hippocrates described a woman's restlessness and insomnia after giving birth. In the 19th century, some doctors declared that mothers were suffering from "insanity of pregnancy" or "insanity of lactation." Women were sent to mental hospitals.

Modern medicine recognizes psychiatric suffering in new mothers as an illness like any other, but the condition, known as postpartum depression, still bears stigma. Both depression and anxiety are thought to be woefully underdiagnosed in new mothers, given that many women are afraid to admit that a new baby is anything less than a bundle of joy. It's not the feeling they expected when they were expecting.

Treatment — when offered — most commonly involves some combination of antidepression medication, hormone therapy, counseling and exercise. Still, a significant number of mothers find these options wanting. Untreated, postpartum depression can last for years, interfering with a mother's ability to connect with and care for her baby.

Although postpartum depression entered official medical literature in the 1950s, decades have passed with few new options and little research.

Even as brain imaging has become a common tool for looking at the innermost workings of the mind, its use to study postpartum depression has been sparse. A 2017 review in *Trends in Neurosciences* found only 17 human brain imaging studies of postpartum depression completed through 2016. For comparison, more than four times as many have been conducted on a problem called "internet gaming disorder" — an unofficial diagnosis acknowledged only five years ago.

Now, however, more researchers are turning their attention to this long-neglected women's health issue, peering into the brains of women to search for the root causes of the depression. At the same time, animal studies exploring the biochemistry of the postpartum brain are uncovering changes in neural circuitry and areas in need of repair.

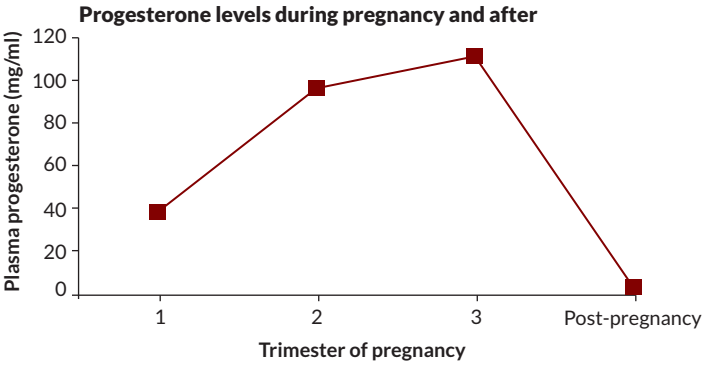
And for the first time, researchers are testing an experimental drug designed specifically for postpartum depression.

GAIAMOMENTS/ISTOCKPHOTO

Early results have surprised even the scientists.

Women's health experts hope that these recent developments signal a new era of research to help new moms who are hurting.

"I get this question all the time: Isn't it just depression during the postpartum period? My answer is no," says neuroscientist Benedetta Leuner of Ohio State University. "It's occurring in the context of dramatic hormonal changes, and that has to be impacting the brain in a unique way. It occurs when you have an infant to care for. There's no other time in a woman's life when the stakes are quite as high."



Rise and fall The hormone progesterone rises far above typical levels during pregnancy, then plummets after childbirth. Researchers are investigating how this and other changes contribute to postpartum depression. SOURCE: K.D. PENNELL, M.A. WOODLIN AND P.B. PENNELL/*STEROIDS* 2015

Brain drain

Even though progesterone and estrogen changes create hormonal whiplash, pregnancy wouldn't be possible without them. Progesterone, largely coming from the ovaries, helps orchestrate a woman's monthly menstrual cycle. The hormone's primary job is to help thicken the lining of the uterus so it will warmly welcome a fertilized egg. In months when conception doesn't happen, progesterone levels fall and the uterine lining disintegrates. If a woman becomes pregnant, the fertilized egg implants in the uterine wall and progesterone production is eventually taken over by the placenta, which acts like an extra endocrine organ.

Like progesterone, estrogen is a normal part of the menstrual cycle that kicks into overdrive after conception. In addition to its usual duties in the female body, estrogen helps encourage the growth of the uterus and fetal development, particularly the formation of the hormone-producing endocrine system.

These surges in estrogen and progesterone, along with other physiological changes, are meant to support the fetus. But the hormones, or chemicals made from them, cross into the mother's brain, which must constantly adapt. When it doesn't, signs of trouble can appear even before childbirth, although they are often missed. Despite the name "postpartum," about half of women who become ill are silently distressed in the later months of pregnancy.

Decades ago, controversy churned over whether postpartum depression was a consequence of fluctuating hormones alone or something else, says neuroscientist Joseph Lonstein of Michigan State University in East Lansing. He studies the neurochemistry of maternal caregiving and postpartum anxiety. Lonstein says many early studies measured hormone levels in women's blood and tried to determine whether natural fluctuations were associated with the risk of postpartum depression. Those studies found "no clear correlations with [women's] hormones and their susceptibility to symptoms," he says. "While the hormone changes are certainly thought to be involved, not all women are equally susceptible. The question then became, what is it about their brains that makes particular women more susceptible?"

Seeking answers, researchers have examined rodent brains and placed women into brain scanners to measure the women's responses to pictures or videos of babies smiling, babbling or crying. Though hormones likely underlie the condition, many investigations have led to the amygdalae. These two, almond-shaped clumps of nerve cells deep in the brain are sometimes referred to as the emotional thermostat for their role in the processing of emotions, particularly fear.

The amygdalae are entangled with many structures that help make mothers feel like mothering, says neuroscientist Alison Fleming of the University of Toronto Mississauga. The amygdalae connect to the striatum, which is involved in experiencing reward, and to the hippocampus, a key player in memory and the body's stress response. And more: They are wired to the hypothalamus, the interface between the brain and the endocrine system (when you are afraid, the endocrine system produces adrenaline and other chemicals that get your heart racing and palms sweating). The amygdalae are also connected to the prefrontal cortex and insula, involved in decision making, motivation and other functions intertwined with maternal instinct.

Fleming and colleagues have recently moved from studies in postpartum rodents to human mothers. In one investigation, reported in 2012 in *Social Neuroscience*, women were asked to look at pictures of smiling infants while in a functional MRI, which images brain activity. In mothers who were not depressed, the researchers found a higher amygdala response, more positive

Beyond mom

Postpartum depression doesn't weigh down just mom. Research suggests it might have negative effects on her offspring that can last for years. Risks include:

Newborns

Higher levels of cortisol and other stress hormones

More time fussing and crying

More "indeterminate sleep," hovering between deep and active sleep

Infants and children

Increased risk of developmental problems

Slower growth

Lower cognitive function

Elevated cortisol levels

Adolescents

Higher risk of depression

ADAPTED BY T. TIBBITTS

feelings and lower stress when women saw their own babies compared with unfamiliar infants.

But an unexpected pattern emerged in mothers with postpartum depression, as the researchers reported in 2016 in *Social Neuroscience*. While both depressed and not-depressed mothers showed elevated amygdala activity when viewing their own babies, the depressed mothers also showed heightened responses to happy, unknown babies, suggesting reactions to the women's own children were blunted and not unique. This finding may mean that depressed women had less inclination to emotionally attach to their babies.

Mothers with postpartum depression also showed weaker connectivity between the amygdalae and the insula. Mothers with weaker connectivity in this area had greater symptoms of depression and anxiety. Women with stronger connectivity were more responsive to their newborns.

While there's still no way to definitely know that the amygdalae are responding to postpartum chemical changes, "it's very likely," Lonstein says, pointing out that the amygdalae are influenced by the body's reaction to hormones in other emotional settings.

Maternal rewards

While important, the amygdalae are just part of the puzzle that seems to underlie postpartum depression. Among others is the nucleus accumbens, famous for its role in the brain's reward system and in addiction, largely driven by the yin and yang of the neurotransmitters dopamine and serotonin. In studies, mothers who watched films of their infants (as opposed to watching unknown infants) experienced increased production of feel-good dopamine. The women also had a strengthening of the connection between the nucleus accumbens, the amygdalae and other structures, researchers from Harvard Medical School and their collaborators reported in February 2017 in *Proceedings of the National Academy of Sciences*.

That's not entirely surprising given that rodent mothers find interacting with their newborn pups as neurologically rewarding as addictive drugs, says Ohio State's Leuner. Rodent mothers that are separated from their offspring "will press a bar 100 times an hour to get to a pup. They will step across electrified grids to get to their pups. They've even been shown in some studies to choose the pups over cocaine." Mothers find their offspring "highly, highly rewarding," she says.

When there are postpartum glitches in the brain's reward system, women may find their babies less satisfying, which could increase the risk for impaired mothering. Writing in 2014 in the *European Journal of Neuroscience*, Leuner and colleagues reported that in rats with symptoms of postpartum depression (induced by stress during pregnancy, a major risk factor for postpartum depression in women), nerve cells in the nucleus accumbens atrophied and showed fewer protrusions called dendritic spines — suggesting weaker connections to surrounding nerve cells compared with healthy rats. This is in contrast to other forms of depression, which show an increase in dendritic spines.

Unpublished follow-up experiments conducted by Leuner's team also point to a role for oxytocin, a hormone that spikes with the birth of a baby as estrogen and progesterone fall. Sometimes called the "cuddle chemical," oxytocin is known for its role in maternal bonding (*SN Online: 4/16/15*). Leuner hypothesizes that maternal depression is associated with deficits in oxytocin receptors that enable the hormone to have its effects as part of the brain's reward system.

If correct, the idea may help explain why oxytocin treatment failed women in some studies of postpartum depression. The hormone may simply not have the same potency in some women whose brains are short on receptors the chemical can latch on to. The next step is to test whether reversing the oxytocin receptor deficits in rodents' brains relieves symptoms.

Leuner and other scientists emphasize that the oxytocin story is complex. In 2017, in a study reported in *Depression & Anxiety*, women without a history of depression who received oxytocin — which is often given to promote contractions or stem bleeding after delivery — had a 32 percent higher likelihood of developing postpartum depression than women who did not receive the hormone. In more than 46,000 births, 5 percent of women who did not receive the hormone were diagnosed with depression, compared with 7 percent who did.

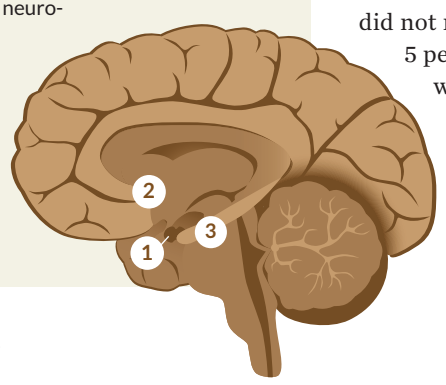
"This was the opposite of what we predicted," says Kristina Deligiannidis, a neuroscientist and perinatal psychiatrist at the Feinstein Institute for Medical Research in Manhasset, N.Y. After all, oxytocin is supposed to enhance brain circuits

Brain changes Research in rodents, along with imaging studies in new mothers, are finding areas of the brain that could be involved in postpartum depression. Among them:

1. Amygdalae Sometimes called the body's "emotional thermostat," these two structures are deep in the brain, one on each side. Studies suggest that, among other things, depressed mothers have heightened amygdala responses to an unfamiliar baby, perhaps blunting the response to their own child.

2. Nucleus accumbens Famous for its role in reward, pleasure and addiction, this area showed less ability to change in a study of rats with symptoms of postpartum depression.

3. Hippocampus This region contains receptors for neurosteroids, potent products of the hormone progesterone. During pregnancy, the number of neurosteroid receptors typically drops, presumably to protect the brain from high levels of progesterone and estrogen circulating at the same time. When progesterone drops immediately following loss of the placenta after birth, the receptors repopulate. But depressed women may not experience this rebound.

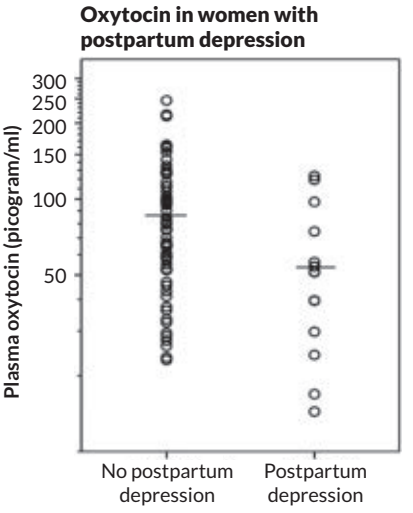


ALILA MEDICAL MEDIA/SHUTTERSTOCK, ADAPTED BY T. TIBBITTS

involved in mothering. "We had a whole group of statisticians reanalyze the data because we didn't believe it," she says. While the explanation is unknown, one theory is that perhaps the women who needed synthetic oxytocin during labor weren't making enough on their own — and that could be why they are more prone to depression after childbirth.

But postpartum depression can't be pinned to any single substance or brain malfunction — it doesn't reside in one tidy nest of brain cells, or any one chemical process gone haywire. Maternal behavior is based on complex neurological circuitry. "Multiple parts of the brain are involved in any single function," Deligiannidis says. "Just to have this conversation, I'm activating several different parts of my brain." When any kind of depression occurs, she says, multiple regions of the brain are suffering from a communication breakdown.

Looking further, Deligiannidis has also examined the role of certain steroids synthesized from progesterone and other hormones and known to affect maternal brain circuitry. In a 2016 study in *Psychoneuroendocrinology* involving 32 new mothers at risk for postpartum depression and 24 healthy mothers, Deligiannidis and colleagues reported that concentrations of some steroids that affect the brain, also called neurosteroids, were higher in women at risk for developing depression (because of their past history or symptoms), compared with women who were not. The higher levels suggest a system out of balance — the brain is making too much of one neurosteroid and not enough of another, called allopregnanolone, which is thought to protect against postpartum depression and is being tested as a treatment.



Cuddle chemical
In one study, women with depressive symptoms in the first two weeks after delivery had lower levels of the hormone oxytocin in the third trimester than women without depression. (Each circle is one woman; horizontal lines are means.) But the story is complicated because other studies have shown that giving artificial oxytocin during labor does not alleviate symptoms.

> Postpartum depression doesn't reside in one tidy nest of brain cells, or any one chemical process gone haywire.

Treating pregnancy withdrawal

Tufts University neuroscientist Jamie Maguire, based in Boston, got interested in neurosteroids during her postgraduate studies in the lab of Istvan Mody at UCLA. Maguire and Mody reported in 2008 in *Neuron* that during pregnancy, the hippocampus has fewer receptors for neurosteroids, presumably to protect the brain from the massive levels of progesterone and estrogen circulating at that time. When progesterone drops after birth, the receptors repopulate.

But in mice genetically engineered to lack those receptors, something else happened: The animals were less interested in tending to their offspring, failing to make nests for them.

"We started investigating. Why are these animals having these abnormal postpartum behaviors?" Maguire recalls. Was an inability to recover these receptors making some women susceptible? Interestingly, similar receptors are responsible for the mood-altering and addictive effects of some anti-anxiety drugs, suggesting that the sudden progesterone drop after childbirth could be leaving some women with a kind of withdrawal effect.

Further experiments demonstrated that giving the mice a progesterone-derived neurosteroid — producing levels close to what the mice had in pregnancy — alleviated the symptoms.

Today, Maguire is on the scientific advisory board of Boston area–based Sage Therapeutics, which is testing a formulation of allopregnanolone called brexanolone. Results of an early clinical trial published last July in *The Lancet* assessed whether brexanolone would alleviate postpartum symptoms in women with severe postpartum depression. The study involved 21 women randomly assigned to receive a 60-hour infusion of the drug or a placebo within six months after delivery.

At the end of treatment, the women who received the drug reported a 21-point reduction on a standard scale of depression symptoms, compared with about 9 points for the women on a placebo. "These women got better in about a day," says Deligiannidis, who is on the study's research team. "The results were astonishing."

In November, Sage Therapeutics announced the results of two larger studies, although neither has been published. Combined, the trials involved 226 women with severe or moderate postpartum depression. Both groups showed similar improvements that lasted for the month the women were followed. The company has announced plans to request approval from the U.S. Food and Drug Administration to market brexanolone in the United States. This is an important first step, researchers say, toward better treatments.

"We are just touching on one small piece of a bigger puzzle," says Jodi Pawluski, a neuroscientist at the Université de Rennes 1 in France who coauthored the 2017 review in *Trends in Neurosciences*. She was surprised at the dearth of research, given how common postpartum depression is. "This is not the end, it's the beginning." ■

Explore more

- Jodi L. Pawluski, Joseph S. Lonstein and Alison S. Fleming. "The neurobiology of postpartum anxiety and depression." *Trends in Neurosciences*. February 2017.

M. SKRUNDZ *ET AL*/*NEUROPSYCHOPHARMACOLOGY* 2011

SMOKE SIGNALS

Burning peatlands have environmental researchers on alert

By Laurel Hamers

In 2015, massive wildfires burned through Indonesia, sending thick smoke and haze as far as Thailand.

These fires were "the worst environmental disaster in modern history," says Thomas Smith, a wildfire expert at King's College London. Smith estimates that the fires and smoke killed 100,000 people in Indonesia and neighboring countries and caused billions of dollars in damage. The fires were costly for the rest of the planet, too: At their peak, the blazes belched more climate-warming carbon dioxide into the atmosphere each day than did all U.S. economic activity.

Two years later and 13,000 kilometers away, a fire smoldered on the fringes of a barren, northern landscape. The remote blaze could have gone unnoticed. But Jessica McCarty and other fire researchers actively monitor satellite imagery of Earth the way some people check Facebook. One Sunday in August, McCarty, of Miami University in Ohio, was surprised to see massive plumes of what appeared to be white smoke over a swath of Greenland. The giant landmass had not been on her fire radar. It's mostly ice, and the parts that aren't have sparse vegetation.

The settings of these two blazes couldn't have been more different, but scientists suspect the two had something important in common: plenty of decaying organic matter known as peat.

Peatlands — which include bogs, other swampy wetlands and, yes, Greenland's icy soil — are ecosystems rich in decayed organic matter.

In their healthy, soggy state, peatlands are quite fire resistant. So when it comes to fire risk, peat-heavy landscapes haven't historically gotten the same attention as, say, the dry pine forests of the western United States. But with those devastating peat fires in Indonesia, the spotlight has turned to the planet's other peatlands, too.

Worldwide, peatlands store massive amounts of carbon in thick blankets of wet organic matter accumulated in the ground over centuries. And though they cover just 3 to 5 percent of Earth's land surface, peatlands store a quarter of all soil carbon. That adds up to more carbon than all of the world's forests combined.

Peatland fires in Riau Province, Indonesia, burned in August 2016, releasing stored carbon into the atmosphere.

ZUMA PRESS INC./ALAMY STOCK PHOTO

But changes in land use — draining the water to plant acres of crops that demand drier soil, a common practice in tropical regions, or building a road through an area — can dry out the peat. And then, a single carelessly tossed cigarette or an errant lightning strike can ignite a fire that will smoke and smolder for months, releasing thousands of years of stored carbon as carbon dioxide into the atmosphere.

Or fires set to clear land for agriculture can get out of hand, like they've done in Indonesia: Over the last few decades, the country has drained many of its peatlands to grow oil palms and other crops. Now, the country is seeing the worst-case scenario of what can happen when peatlands are disrupted and desiccated. In northern latitudes, meanwhile, thawing permafrost exposes peat that has been buried for years, which can fuel fires like those seen in Greenland last summer.

In the short term, peat fires clog the air with deadly smoke and smog. In densely populated areas such as Indonesia, blazes can devour homes and businesses and claim lives. But the fires' impact lingers long after the flames die down. Peat fires reshape entire ecosystems. Once the peat burns away, it can take thousands of years to build up again. And all of the carbon that was once neatly stored away is instead floating around in the atmosphere, contributing to climate change much like burning coal does.

Now, scientists are trying to get a better handle on peatlands and the effects of agriculture, development and a climate that's shifting toward warmer and drier. Recent discoveries of hidden peatlands in Africa and South America expand the extent of peat around the world, and up the stakes for protecting those carbon stores. New research is making it increasingly clear that, without a shift in approach, humans might strip away healthy peatlands and get, in return, a lot of climate-warming carbon dioxide.

Meet peat

Bogs don't conjure warm, fuzzy feelings for most people. The landscapes are often associated in popular culture with witches, Europe's mummified "bog bodies" and dreary weather. It's perhaps telling that "quagmire" — another word for a bog — is also used to refer to a sticky predicament. But to the scientists who study them, bogs are far from bleak.

"Most people walk far, far out of their way to avoid walking through these things, but I love them," says Merritt Turetsky, a peat researcher at the University of Guelph in Canada. The bogs that she studies in Canada and Alaska look like "hobbit ecosystems," she says, with all of the action happening low to the ground: stunted trees studding a colorful carpet of mosses and lichens. And, she points out, bogs play a crucial role in keeping our planet healthy.

Carbon is constantly being recycled throughout the world: It's taken in by plants as carbon dioxide, for example, and is dissolved in the oceans. But excess circulating carbon can throw ecosystems out of whack. Too much carbon dioxide in the atmosphere makes the planet heat up; too much dissolved in the ocean makes the water more acidic. Long-term carbon stores in ocean sediments and rocks such as limestone pull carbon out of the short-term cycle, cloistering it where it can't do harm. The same goes for peatlands; dig down many meters into a bog, and you'll find carbon that's been buried for thousands of years.

And while the untrained eye might look at a bog and see nothing but a soggy morass that calls for waterproof waders, peatlands can be surprisingly diverse. In the tropics, where swamp forests are filled with large, leafy trees, blankets of peat are typically built up by decayed woody plants. Temperate peatlands, like those in the northern United States and Canada, sport scrubbier vegetation and are made mostly from decayed sphagnum moss.

Peat is "not exactly nonrenewable, but it accumulates so slowly," Turetsky says. "A fire can burn through a dry bog and literally release thousands of years of carbon in a couple minutes of combustion." She learned that firsthand as a graduate student.

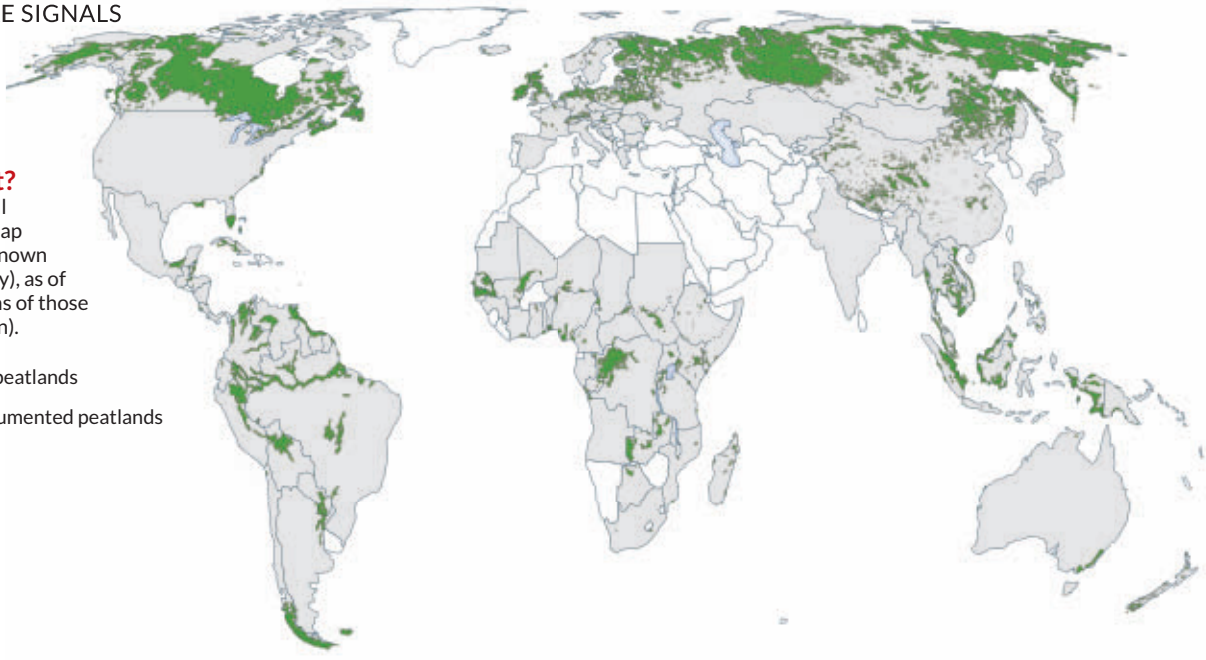
Almost 20 years ago, she buried small bags of peat in a Canadian bog to study their decomposition. When she returned two years later to dig up

The streets of Palangka Raya, Indonesia, are obscured by smoke from peat fires in this photo taken on October 16, 2015.

AULIA ERLANGGA/CIFOR

"A fire can burn through a dry bog and literally release thousands of years of carbon in a couple minutes of combustion."

MERRITT TURETSKY



Where's the peat?
Peatlands are found all over the world. This map points out countries known to have peatlands (gray), as of 2017, and the locations of those peat-filled lands (green).

Known location of peatlands

Countries with documented peatlands

the samples, her entire field site had gone up in smoke. Her precious data were gone.

"I was devastated for about a day," Turetsky says. "But then I started thinking about it: We were shocked that this system had burned."

The very next day, she started collecting new data, this time observing how the bog recovered from the fire. Back then, she says, people assumed that the only thing slowing down the accumulation of peat was its inevitable natural decomposition over time. "It was the first time I realized that decomposition wasn't the only process leading to peat loss," Turetsky says. "Fire also reduces peat by combusting it."

3.4x

Rough increase in tropical peat when newfound areas in Africa, South America and Asia are included

Hidden deposits

With an increased awareness of the threats to bogs has come a greater push to identify and protect the resources contained in these ecosystems. Recently, large new peat-rich spots have been discovered around the world. In January 2017, British and Congolese scientists announced in *Nature* that huge tracts of peat have been hiding in a lush expanse of forest straddling the equator in the Central Congo Basin. The area is home to groups of indigenous people but difficult for outsiders to access, so nobody had surveyed its peat resources until recently.

The researchers, led by Simon Lewis and Greta Dargie of University College London and the University of Leeds in England, trekked into the basin to extract "cores" to measure how deep the peat went in dozens of places. Based on those long cylindrical cross sections of soil, the researchers calculated that the peat deposits found in the jungle, some as deep as 5.9 meters, boost the global estimated amount of peat in the tropics by 36 percent. Then the team used satellite data to measure the boundaries of the peat. From there, the researchers estimated that the carbon stored in Central Congo Basin's peat is equivalent to about 20 years of fossil fuel emissions from the United States, at current rates.

Other groups have quantified existing peatlands remotely. A study published in August 2017 in *Global Change Biology* used data on where water accumulates and how it flows across the landscape to predict where peat might be hiding in tropical regions.

The analyses suggest that South America may be home to far more peat than previously known. A network of smaller peatlands in the Amazon Basin adds up to 629,000 square kilometers, an even larger area than the Congo find, says study coauthor Louis Verchot of the International Center for Tropical Agriculture in Cali, Colombia. This newfound South American peat plus the Congo area and some new finds in Asia boost known tropical peatlands from 440,000 square kilometers to 1.5 million.

Logging and mining already threaten the carbon stored in the trees of tropical forests. The peat-rich soil has value as well.

Out of balance

When dug up, peat is inherently flammable and is used in some places as a source of fuel. But in their natural, wet state, peatlands are resistant to fires. Even after months of drought, healthy peatlands stay moist. So scientists are trying to understand

LEVI WESTERVELD/GRID-ARENDAL

what factors change that dynamic — and what that means for fires and carbon storage.

It can be hard to test the effect of drying over time in a controlled way, but in one instance, Turetsky got lucky. In 1983, part of a fen, or marshland, in Alberta, Canada, was drained for a forest management project. The water table dropped roughly a quarter of a meter, a moderate amount. Eighteen years later, a wildfire burned in the area.

Turetsky and colleagues saw an opportunity for a natural experiment to answer a few open questions. The researchers tracked how drainage followed by fire affected the peatland over time, compared with areas that burned but weren't drained or parts that were drained but didn't burn.

The drained area was far more vulnerable than the undrained area to big changes after a fire, the researchers reported in 2015 in *Scientific Reports*. The combination of drainage and wildfire invited different plant species to move in over the next decade. The new plants changed the ecosystem from fire-resilient to one that was liable to burn again and again. And the leafy canopy of the broadleaf trees that took up residence in place of the once-dominant black spruces blocked out the sunlight necessary for peat-producing mosses to return.

The change Turetsky saw, from a fairly modest disturbance, was much bigger than she expected. She knew that completely drying out such a landscape would make it extremely fire-vulnerable — dramatic changes like those seen in Southeast Asia. But the change in the Alberta fen was much smaller, and yet still had a substantial effect.

Compared with areas that hadn't been drained, the areas that had been drained lost almost 500 more years' worth of accumulated peat, she says. (She calculated the figure based on the amount that burned and the rate at which peat accumulates.) That's 500 additional years of locked-away carbon released back into the atmosphere in a matter of weeks.

Farming's future

Draining the land plus "slash and burn" techniques to clear areas for agriculture are the main reasons that tropical peatlands are catching fire, says Alexander Cobb, an environmental scientist at the Singapore-MIT Alliance for Research and Technology. To make room for oil palm plantations and other crops, companies will raze existing trees (the source of future peat) and drain the water to dry out the soil.

In 2017, 139 scientists signed a letter to the editor in *Global Change Biology* arguing that draining tropical peatlands for agriculture is unsustainable. Denying the effects that agriculture has on these landscapes will have long-term consequences, such as more frequent and more devastating fires, the researchers wrote.

Now, Indonesia is working to restore its peatlands. It's not as simple as prohibiting crops in peat-rich areas, though. In densely populated island nations, space is at a premium and people still need to eat, says Susan Page, a tropical bog expert at the University of Leicester in England and one of the letter's signers. Solving the problem might require finding crops that can grow in soggier soil so bogs wouldn't have to be drained. But solutions are a long way off.

"A lot of the economic support for alternative crops doesn't really exist yet," Page says. "We're in the in-between stage of knowing we want crops but not having a suitable list of species."

Even in places where peatlands are protected from agriculture, there are other potential threats. Cobb and colleagues spent months figuring out how to bushwhack through dense trees with exposed roots as tall as a human to reach a rare, untouched peatland in Brunei, a small, wealthy Southeast Asian nation that Cobb says has been more proactive about protecting its peatlands than neighboring countries. The researchers plunged measuring devices into the soil to determine the depth of peat and how wet it was. With those data, the team created a model of the way rainfall affects the amount of peat that can build up in any particular place, published last June in *Proceedings of the National Academy of Sciences*.

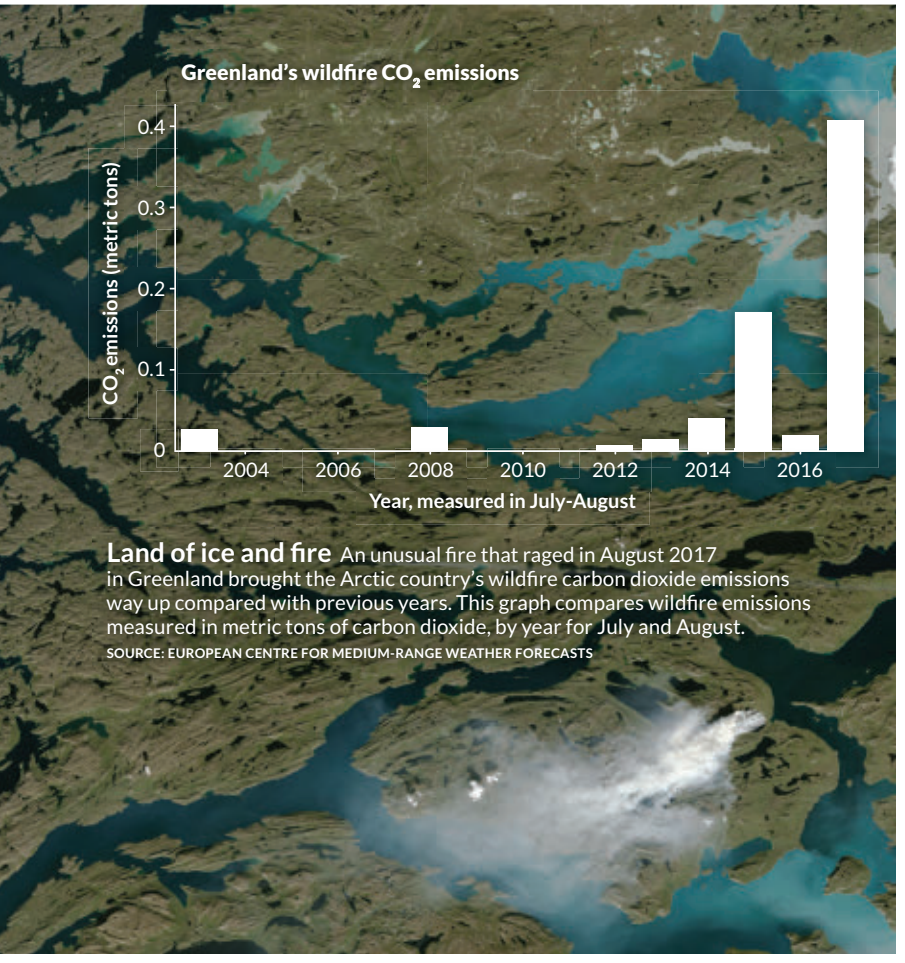
The conclusion: Along with total rainfall, timing of that rainfall matters. If rainfall becomes more irregular, as it's predicted to in the future, "then with the same average rainfall, the peatland can support less peat," Cobb says.

"A lot of the economic support for alternative crops doesn't really exist yet."

SUSAN PAGE

Northern peatlands like this bog in Algonquin Provincial Park in Ontario, Canada, are dominated by colorful mosses and short plants, rather than the lush tree canopies seen in tropical peatlands.

ORCHIDPOET/ISTOCKPHOTO



Land of ice and fire An unusual fire that raged in August 2017 in Greenland brought the Arctic country's wildfire carbon dioxide emissions way up compared with previous years. This graph compares wildfire emissions measured in metric tons of carbon dioxide, by year for July and August.
SOURCE: EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

Safe if frozen

Peatlands in cold places face challenges in a changing climate, too. In northern latitudes, including the Arctic, peat has been entombed for centuries in permafrost. Arctic warming is now exposing that peat, raising the risk of once-uncommon fires.

Last summer's Greenland fire is one such example. When McCarty spotted what she thought was a fire, she posted the satellite data on Twitter. Over the coming weeks, she and other scientists virtually checked in on the fire multiple times each day, becoming convinced that the smoke was fueled by peat.

For one thing, there's very little vegetation in the region that could provide fuel. Peat in the soil was one of the few options. Plus, the fire lingered for several weeks, but barely traveled. That's very characteristic of a peat fire, McCarty says. If the fire's not moving, it's probably smoldering, slowly burning through dense organic matter with a lot of smoke and minimal flames.

Scientists have not scoped out the Greenland fire site in person, says Guillermo Rein, a fire scientist at Imperial College London. But he's part of a team that's trying to organize an expedition to the remote area, to study the soil and confirm that peat was the fire's main driver.

Arctic peat has what Rein calls "dormant flammability." That is, when it's frozen, it's safe. But if the permafrost begins to thaw, these long-entombed carbon stores are exposed to the air and suddenly vulnerable to burning.

It would be easy to dismiss the Greenland fire as a one-off event, a fluke. But really, it's just one match in a whole box. Peat blazes have been recorded in Alaska and Siberia, as well as across Canada. Evidence suggests that fires like these will become more common. The National Oceanic and Atmospheric Administration's annual Arctic Report Card, released December 12, showed that ground-level air in the Arctic is warming twice as fast as the global average surface air temperature. By the end of this century, carbon release from Arctic burning is likely to quadruple, according to a 2016 study in *Environmental Research Letters*. Plus, fires and permafrost thaw can start a feedback cycle that hastens future thawing, McCarty says.

The precise long-term consequences of such thawing on peat stores in the Arctic are still unclear. While peat emerging from frozen permafrost initially dries and cracks, the area might eventually flood and rewet as ice melts elsewhere, according to a 2015 paper in *Scientific Reports*. But until then, the dried-out peat is a fire risk.

These Arctic and high-latitude peat fires might not immediately affect as many people as tropical peat fires, because for the most part the fires aren't in agricultural hot spots or urban centers. But the global consequences, in terms of carbon release, could be just as severe.

Some researchers expect that as climate change pushes agriculture and human populations farther north, "people are going to come more in contact with these mostly pristine landscapes" and disturb them in ways that could increase fire risk, Page says. In Canada, she says, "decades down the line, we could see a similar fire dynamic as we're seeing in Southeast Asia" — uncontrolled fires causing irreparable damage to long-term carbon stores.

"There's more and more talk in the north about draining northern soils," Turetsky adds. "We already know what's going to happen." ■

Explore more

- NOAA's Arctic Report Card 2017: *bit.ly/arcticreportcard2017*
- Global Wetlands Map: *bit.ly/globalwetlands*

JESSE ALLEN/NASA EARTH OBSERVATORY

One Strange Rock contains gorgeous images of Earth, such as these colorful hydrothermal fields in Dallol, Ethiopia.

GRAHAM BOOTH/NATIONAL GEOGRAPHIC

TELEVISION

Embracing the wonderful unlikeliness of Earth

"The strangest place in the whole universe might just be right here." So says actor Will Smith, narrating the opening moments of a new documentary series about the wonderful unlikeliness of our own planet, Earth.

One Strange Rock, premiering March 26 on the National Geographic Channel, is itself a peculiar and unlikely creation. Executive produced by Academy Award–nominated Darren Aronofsky and narrated by Smith, the sprawling, ambitious 10-episode series is chock-full of stunningly beautiful images and CGI visuals of our dynamic planet. Each episode is united by a theme relating to Earth's history, such as the genesis of life, the magnetic and atmospheric shields that protect the planet from solar radiation and the ways in which Earth's denizens have shaped its surface.

One Strange Rock
PREMIERES MARCH 26
NATIONAL GEOGRAPHIC CHANNEL

The first episode, "Gasp," ponders Earth's atmosphere and where its oxygen comes from. In one memorable sequence, the episode takes viewers on a whirlwind journey from Ethiopia's dusty deserts to the Amazon rainforest to phytoplankton blooms in the ocean. Dust storms from Ethiopia, Smith tells us, fertilize the rainforest. And that rainforest, in turn, feeds phytoplankton. A mighty atmospheric river, fueled by water vapor from the Amazon and heat from the sun, flows across South America until it reaches the Andes and condenses into rain. That rain erodes rock and washes nutrients into the ocean, feeding blooms of phytoplankton called diatoms. One out of every two breaths that we take comes from the photosynthesis of those diatoms, Smith adds.

As always, Smith is an appealing everyman. But the true stars of the series may be the eight astronauts, including Chris Hadfield and Nicole Stott, who appear throughout the series. In stark contrast to the colorful images of the planet, the astronauts are filmed alone, their faces half in shadow against a black background as they tell stories that loosely connect to the themes. The visual contrast emphasizes the astronauts' roles as outsiders who have a rare perspective on the blue marble.

"Having flown in space, I feel this connection to the planet," Stott told *Science News*. "I was reintroduced to the planet." Hadfield had a similar sentiment: "It's just one tiny place, but it's the tiny place that is ours," he added.

Each astronaut anchors a different episode. In "Gasp," Hadfield describes a frightening moment during a spacewalk outside the International Space Station when his eyes watered. Without gravity, the water couldn't form into teardrops, so it effectively blinded him. To remove the water, he was forced to allow some precious air to escape his suit. It's a tense moment that underscores the pricelessness of the thin blue line, visible from space, that marks Earth's atmosphere. "It contains everything that's important to us," Hadfield says in the episode. "It contains life."

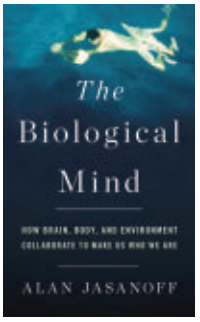
Stott, meanwhile, figures prominently in an episode called "Storm." Instead of a weather system, the title refers to the rain of space debris that Earth has endured throughout much of its history — including the powerful collision that formed the moon (*SN: 4/15/17, p. 18*). Stott describes her own sense of wonder as a child, watching astronauts land on our closest neighbor — and how the travels of those astronauts and the rocks they brought back revealed that Earth and the moon probably originated from the same place.

It's glimpses like these into the astronauts' lives and personalities — scenes of Hadfield strumming "Space Oddity" on a guitar, for example, or Stott chatting with her son in the family kitchen — that make the episodes more than a series of beautiful and educational IMAX films. Having been away from the planet for a short time, the astronauts see Earth as precious, and they convey their affection for it well. Stott said she hopes that this will be the ultimate takeaway for viewers, for whom the series may serve as a reintroduction to the planet they thought they knew so well. "I hope that people will ... appreciate and acknowledge the significance of [this reintroduction]," she said, "that it will result in an awareness and obligation to take care of each other."

— *Carolyn Gramling*

BOOKSHELF

How biology breaks the 'cerebral mystique'



The Biological Mind
Alan Jasanoff
BASIC BOOKS, $30

At a small eatery in Seville, Spain, Alan Jasanoff had his first experience with brains — wrapped in eggs and served with potatoes. At the time, he was more interested in finding a good, affordable meal than contemplating the sheer awesomeness of the organ he was eating. Years later, Jasanoff began studying the brain as part of his training as a neuroscientist, and he went on, like so many others, to revere it. It is said, after all, to be the root of our soul and consciousness. But today, Jasanoff has yet another view: He has come to see our awe of the organ as a seriously flawed way of thinking, and even a danger to society.

In *The Biological Mind,* Jasanoff, now a neuroscientist at MIT, refers to the romanticized view of the brain — its separateness and superiority to the body and its depiction as almost supernatural — as the "cerebral mystique." Such an attitude has been fueled, in part, by images that depict the brain without any connection to the body or by analogies that compare the brain to a computer. Admittedly, the brain does have tremendous computing power. But Jasanoff's goal is to show that the brain doesn't work as a distinct, mystical entity, but as a ball of flesh awash with fluids and innately in tune with the rest of the body and the environment. "Self" doesn't just come from the brain, he explains, but also from the interactions of chemicals from our bodies with everything else around us.

To make his case, Jasanoff offers an extensive yet entertaining review of the schools of thought and representations of the brain in the media that led to the rise of the cerebral mystique, especially during the last few decades. He then tears down those ideas using contrary examples from recent research, along with engaging anecdotes. For instance, his clear, lively writing reveals how our emotions, such as the fight-or-flight response and the suite of thoughts and actions associated with stress, provide strong evidence for a brain-body connection. Exercise's effect on the brain also supports this notion. Even creativity isn't sacred, often stemming from repeated interactions with those around us.

Jasanoff is critical of how the cerebral mystique reduces problems of human behavior, such as drug addiction or eating disorders, to problems of the brain. Such problems are no longer viewed as "moral failings" but as a result of "broken brains." This shifting view, its advocates argue, reduces the stigma associated with psychiatric disorders. But it also leads to other problems, Jasanoff notes: Society views broken brains as harder to fix than moral flaws, making life even more challenging for individuals already struggling with mental illness. People could benefit from a more comprehensive view of the brain, one that includes how biology, environment and culture shape behavior.

> Our awe of the brain is a seriously flawed way of thinking, and even a danger to society.

When mental processes are seen as transcending the body, society perceives people as "more independent and self-motivated than they truly are," and that minimizes "the connections that bind us to each other and to the environment around us," Jasanoff writes. As a result, he argues, we're living in an age of self-absorption and self-centeredness, driven in part by our fascination with the brain.

In reality, the brain isn't a miraculous machine, but instead a prism refracting countless internal and external influences. A few more specifics on how this prism works — details of what is going on at the cellular or molecular level, for instance — might have helped support Jasanoff's arguments.

But he does leave readers with a thought-provoking idea: "You are not only your brain." Grapple with that, he contends, and we could move toward communities that are much more socially minded and accepting of our interconnectedness.
— Ashley Yeager

BOOKSHELF

The Earth Gazers
Christopher Potter
The experiences of the 24 Apollo astronauts anchor this rich history of the U.S. space program.
Pegasus Books, $28.95

A Wilder Time
William E. Glassley
A geologist vividly recounts his expeditions to Greenland and research into the origin of plate tectonics. *Bellevue Literary Press, $17.99*

Close Encounters With Humankind
Sang-Hee Lee with Shin-Young Yoon
A collection of breezy, bite-sized stories provides an accessible introduction to the evolution of our species. *W.W. Norton & Co., $26.95*

The Birds at My Table
Darryl Jones
Why people love to feed birds, and how that provisioning affects the animals, is the central question of this well-researched book.
Comstock Publishing Assoc., $19.95

Why I Volunteer at the Intel International Science and Engineering Fair

By Scott Duke Kominers

ISEF 2005, STS 2005

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Harvard Business School

FACULTY AFFILIATE
Harvard Department of Economics and Harvard Center of Mathematical Sciences and Applications

CO-CHAIR
Mathematics Grand Awards Judging, ISEF

My ISEF project back in 2005 was in quadratic form representation theory — and a world expert in the field was on one of the judging panels.

Before judging started in earnest, he dropped by just to tell me how excited he was that I was studying quadratic forms. We had a high-bandwidth conversation about recent developments in the field. It was electrifying. This judge treated me like a colleague. I was in high school — he was tenured faculty at a top research university — yet he recognized me as a mathematician.

Judge after judge engaged me as a scholar, learning about my work and simultaneously welcoming me into the mathematics community. What a gift.

I signed up to be an ISEF judge as soon as I became eligible so that I could give that same gift to the next generation of scholars. I judge at ISEF every year I can and recruit my friends and colleagues as judges too.

Judging is a great way to give back. It lets you be part of the community of research competitions — and of student science more generally.

I've had the honor of serving on judging panels alongside people who judged me back in 2005. And many of the students I've met in my years as a judge have stayed in touch, reaching out to me for course and career advice. I'm sure some of them will be judging alongside me one day.

Top: In 2012, judge and alumnus Scott Duke Kominers (right) poses with ISEF alumni Sara Volz (left) and Jonah Kallenbach (middle).

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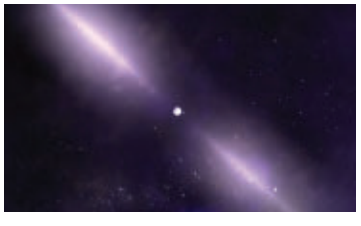
SOCIAL MEDIA

Stellar directions

Dead stars known as pulsars (one illustrated below) emit beams of radiation that sweep past Earth at regular intervals. Those signals could allow a spacecraft to determine its location in space, like a stellar version of GPS, **Emily Conover** reported in "Spaceships could use blinking dead stars to chart the way" (*SN: 2/3/18, p. 7*). Twitter user **@Scott98390** suggested a name for the potential pulsar-based navigation system — GPS: Galactic Positioning Stars.



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Memory lane

*Inspired by flatworm memory experiments from the 1950s, researchers are on the hunt for the elusive engram — the physical mark that a memory leaves on the brain — **Laura Sanders** reported in "Traces of memory"* (SN: 2/3/18, p. 22).

Readers flooded *Science News* with their thoughts and questions on the topic.

Elizabeth Elliott wondered if Alzheimer's disease might affect how memories are stored deep in the brain.

MIT neuroscientist **Susumu Tonegawa** has pulled up silent engrams — memories that aren't readily accessible — from the brains of mice with signs of Alzheimer's disease, **Sanders** says. "It's quite possible that Alzheimer's-related memory impairments could turn out to be problems of retrieval, not storage."

Flatworm experiments that showed worms could retain a memory after losing and regrowing their heads reminded reader **Will Juncosa** of a similar science fair experiment that he and his brother attempted. "Imagine two dozen dying platyhelminthes ... subjected to two dumb teenagers with a razor blade," **Juncosa** wrote. "The question of memory and the 'location' of consciousness has intrigued me for over a half-century since then."

Charged up

*The existence of hypothetical particles called magnetic monopoles would explain why electric charge comes in integer multiples of the charge of an electron instead of a continuous range of values, **Emily Conover** reported in "Search for elusive magnets goes on"* (SN: 2/3/18, p. 10).

If an electron's charge is fundamental and cannot be divided, reader **James Smith** wondered, how can charges of particles such as quarks be fractions of an electron's charge? "This has puzzled me for a long time," he wrote.

Conover agrees that the concept is confusing. "While you're correct that quarks have charges a fraction of the electron's charge, the unusual thing about quarks is that they never appear alone," she says. Quarks are always paired up with other quarks, such that their total charge is an integer multiple of the electron's charge. "So we can never observe a single particle with a fractional charge," **Conover** says. "As a result, scientists still consider the electron's charge to be the fundamental unit of electric charge."

Bubble over

*Researchers proposed that blowflies might cool themselves by hanging a liquid droplet from their mouths and then, once the droplet has cooled some, take it in again, **Susan Milius** reported in "Blowflies use drool to keep their cool"* (SN: 2/3/18, p. 12).

Reader and insect physiologist **John Stoffolano** objects to the researchers calling the process "drooling" and doubts that blowflies need cooling.

This process is called "bubbling," says **Stoffolano**, of the University of Massachusetts Amherst who has published on the process. The blowflies are dangling droplets of liquid food that have been stored in a special organ called a crop, **Stoffolano** says. Water evaporates from exposed droplets, reducing a meal's weight and concentrating nutrients, important considerations for a flying insect, he says.

The researchers who proposed the cooling idea are working bubbling into their thinking. "The fact that the behavior might be primarily dedicated to something else makes the story even more interesting," says **Denis Andrade** of the Universidade Estadual Paulista in Brazil.

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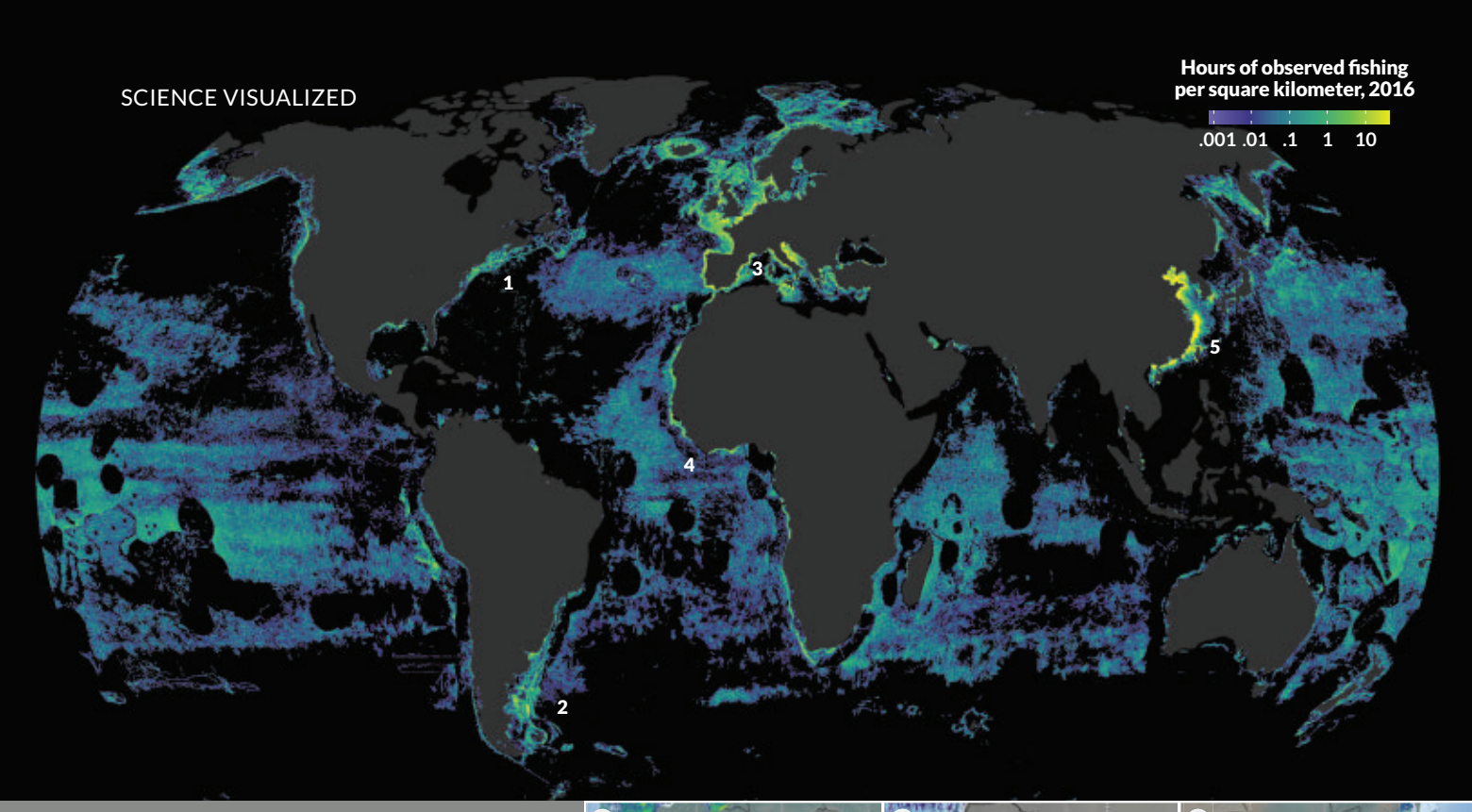

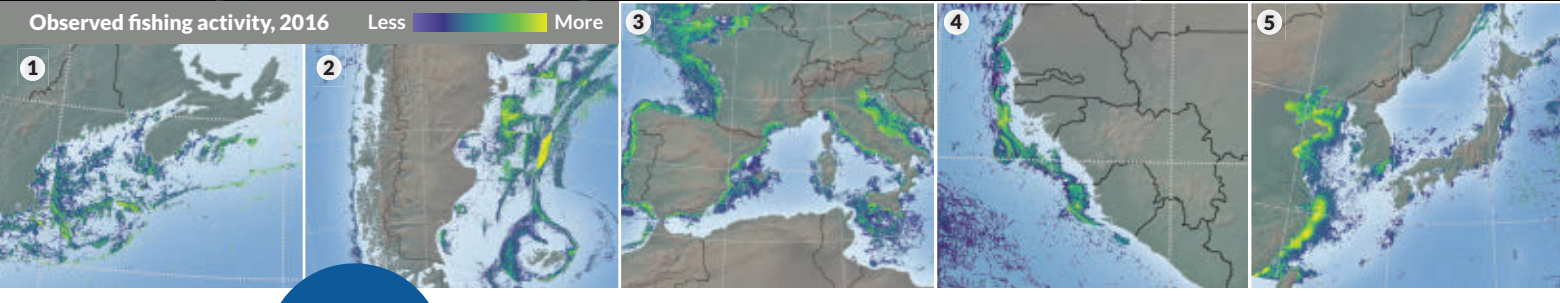

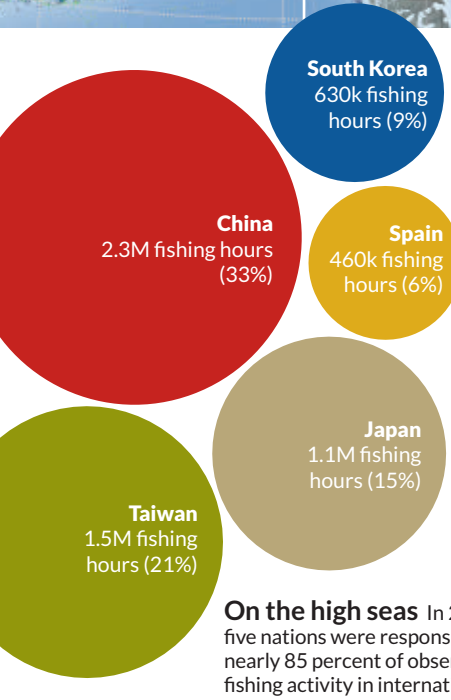

On the high seas In 2016, five nations were responsible for nearly 85 percent of observed fishing activity in international waters, which can be particularly vulnerable to overfishing.

SOURCE: D.A. KROODSMA *ET AL*/*SCIENCE* 2018

Follow the fishing boats

Fishing has left a hefty footprint on Earth. Oceans cover more than two-thirds of the planet's surface, and industrial fishing occurred across more than 55 percent of that ocean area in 2016 (see map at top), scientists report in the Feb. 23 *Science*. In comparison, only 34 percent of Earth's entire land area is used for agriculture or grazing.

Previous efforts to quantify global fishing have relied on scant data. But over the last 15 years, most commercial-scale ships have been outfitted with automatic identification system, or AIS, transceivers, a tracking system that helps ships avoid collisions. In the new study, the scientists examined 22 billion AIS positions from 2012 to 2016. Using a computer trained with a type of machine learning, the team then identified more than 70,000 fishing vessels and tracked their activity.

Much of the fishing was concentrated in countries' exclusive economic zones — ocean regions within about 370 kilometers of a nation's coastline (see zoom-in views 1, 3 and 5) — and in certain hot spots farther out in the open ocean. Such spots included nutrient-rich upwelling regions off the coasts of South America and West Africa (2 and 4). Surprisingly, just five nations — China, Spain, Taiwan, Japan and South Korea — accounted for nearly 85 percent of observed fishing in 2016 on the high seas, the regions outside of any country's exclusive economic zone.

Tracking fishing's footprint, the researchers note, can help guide marine environmental protections and international conservation efforts for fish. That may be particularly important in a time of rapid change due to rising ocean temperatures and increasing human activity on the high seas. — *Carolyn Gramling*

MAPS: GLOBAL FISHING WATCH; GRAPHIC: C. CHANG

GEOLOGIC ROAD TRIP OF THE MONTH

PETRIFIED FOREST, ARIZONA

Although commonly referenced as the Grand Canyon State, in the minds of many visitors Arizona is a land of sand, sun, and minimal rainfall. Meteorological facts support these impressions: sections of the state receive less than 3 inches of precipitation per year, and long-standing records show that Arizona is the sunniest of all US states, basking under the light of the sun more than 80 percent of the time. Scroll back through the chapters of deep time, however, and a different climate scene emerges.

About 225 million years ago Arizona was 10 degrees north of the equator, along the southwest edge of the supercontinent Pangaea. The landscape resembled that of present-day Costa Rica—humid, lush, verdant, and blanketed by forests. The curtain had recently dropped on the Permian Period, bringing an end to some 96 percent of all marine species and 70 percent of all terrestrial vertebrates—the greatest extinction event in Earth's history. The dawn of the dinosaurs was underway, and early forms of these "terrible" lizards populated the countryside in combative harmony with emerging species of crocodile-like reptiles.

Covered with ferns, horsetails, and cycads, the forest floor was shaded by galleries of ginkgoes and conifers, some of which grew to 10 feet in diameter and towered 180 to 200 feet in the sky. The land was drained by an Amazon-like, northwest-flowing river system that undercut the forest giants during floods and carried them downstream, denuding the trunks of branches and roots. While the majority of the trees eventually decomposed and disappeared, some clumped together as massive logjams, were buried in volumes of river sediment and blankets of ash spewed from distant western volcanoes, and became part of the geologic record.

Old Faithful, a 35-foot-long 44-ton root system, accentuates the midsection of the 0.4-mile-long Giant Logs Trail, located behind the Rainbow Forest Museum.

Once the logjams were buried, time and water chemistry worked their magic, dissolving silica from the ash and depositing it in the logs' fibrous hollows and cell interiors, a process that preserved many exact details of the original surfaces and interiors of the trees. One petrified giant bears a finger-width burrow that interrupts its surface, the mark of an insect that ate its way into the tree.

Traces of iron and magnesium combined with quartz to embellish the now-petrified logs with a rainbow of colors—red, yellow, orange, purple, black, gray, and white. The final result of this multimillion-year episode of destruction and preservation is Petrified Forest National Park, a 229-square-mile, semiarid, grass-covered plain and badland region of northeast Arizona. It is acclaimed as one of the best locales in the world to examine the fossil record of the Late Triassic Period.

Multihued, turned-to-stone remnants of a once-thriving forest litter the floor of Petrified Forest National Park, framed by badland topography sculpted from the Chinle Formation by wind and rain. —Courtesy NPS/Andrew Kearns

Twelve genera of petrified trees have been identified, the most prominent being *Araucarioxylon*, *Woodworthia*, and *Schilderia*, all recognized as extinct conifer-like trees that reproduced with seed-bearing cones. Clusters of broken logs are distributed across four well-marked trail regions within the park: Jasper Forest, Crystal Forest, Long Logs, and Giant Logs. The trees have weathered out of conglomerate of rounded pebbles, brown-and-white cross-bedded sandstone, and red-toned shale layers of the Chinle Formation. Radioactive age dating suggests the trees died between 218 and 211 million years ago.

Any visit to Petrified Forest National Park, which is open on a daily basis, should begin at the Rainbow Forest Museum, where exhibits of fossil wood and prehistoric vertebrates make this extinct sylvan world come alive.

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