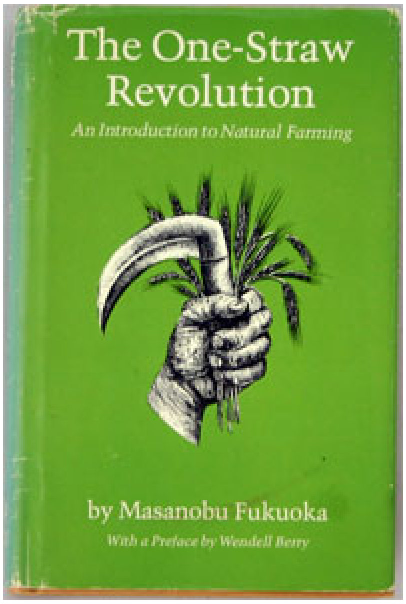
contents

Books to read

The One-Straw Revolution



Masanobu Fukuoka (1913-2008) was a farmer and philosopher who was born and raised on the Japanese island of Shikoku. He studied plant pathology and spent several years working as a customs inspector in Yokohama. While working there, at the age of 25, he had an inspiration that changed his life. He decided to quit his job, return to his home village and put his ideas into practice by applying them to agriculture.

Over the next 65 years he worked to develop a system of natural farming that demonstrated the insight he was given as a young man, believing that it could be of great benefit to the world. He did not plough his fields, used no agricultural chemicals or prepared fertilizers, did not flood his rice fields as farmers have done in Asia for centuries, and yet his yields equalled or surpassed the most productive farms in Japan.

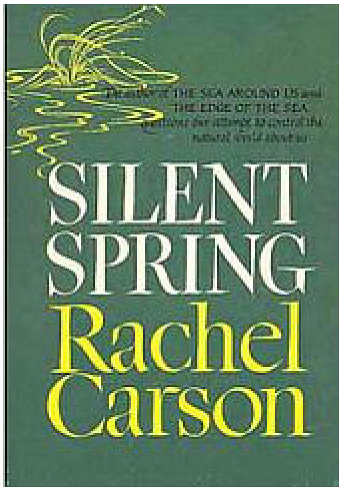
In 1975 he wrote The One-Straw Revolution, a best-selling book that described his life's journey, his philosophy, and farming techniques. This book has been translated into more than 25 languages and has helped make Mr. Fukuoka a leader in the worldwide sustainable agriculture movement. He continued farming until shortly before his death in 2008, at the age of 95.

After The One-Straw Revolution was published in English, Mr. Fukuoka travelled to Africa, India, Southeast Asia, Europe and the United States. His interest turned to rehabilitating the deserts of the world using his natural farming techniques. This work is described in detail in Sowing Seeds in the Desert (2012). Mr. Fukuoka is also the author of The Natural Way of Farming and The Road Back to Nature. In 1988 he received the Magsaysay Award, often referred to as the "Nobel of Asia," for Public Service.

Silent Spring

Silent Spring by Rachel Carson began with a "fable for tomorrow" – a true story using a composite of examples drawn from many real communities where the use of DDT had caused damage to wildlife, birds, bees, agricultural animals, domestic pets, and even humans. Carson used it as an introduction to a very scientifically complicated and already controversial subject. This "fable" made an indelible impression on readers and was used by critics to charge that Carson was a fiction writer and not a scientist.

Serialized in three parts in The New Yorker, where President John F. Kennedy read it in the summer of 1962, Silent Spring was published in August and became an instant best-seller and the most talked about book in decades. Utilizing her many sources in federal science and in private research, Carson spent over six years documenting her analysis that humans were misusing



powerful, persistent, chemical pesticides before knowing the full extent of their potential harm to the whole biota.

Carson's passionate concern in Silent Spring is with the future of the planet and all life on Earth. She calls for humans to act responsibly, carefully, and as stewards of the living earth.

Additionally Silent Spring suggested a needed change in how democracies and liberal societies operated so that individuals and groups could question what their governments allowed others to put into the environment. Far from calling for sweeping changes in government policy, Carson believed the federal government was part of the problem. She admonished her readers and audiences to ask "Who Speaks, And Why?" and therein to set the seeds of social revolution. She identified human hubris and financial self-interest as the crux of the problem and asked if we could master ourselves and our appetites to live as though we humans are an equal part of the earth's systems and not the master of them.

Carson expected criticism, but she did not expect to be personally vilified by the chemical industry and its allies in and out of government. She spent her last years courageously defending the truth of her conclusions until her untimely death in 1964.

Surprising brain growth may reveal why we get better at recognizing faces as we age

By Michael PriceJan. 5, 2017 , 2:00 PM

As we age, we get progressively better at recognizing and remembering someone's face, eventually reaching peak proficiency at about 30 years old. A new study suggests that's because brain tissue in a region dedicated to facial recognition continues to grow and develop throughout childhood and into adulthood, a process known as proliferation. The discovery may help scientists better understand the social evolution of our species, as speedy recollection of faces let our ancestors know at a glance whether to run, woo, or fight.

The results are surprising because most scientists have assumed that brain development throughout one's life depends almost exclusively on "synaptic pruning," or the weeding out of unnecessary connections between neurons, says Brad Duchaine, a psychologist at Dartmouth College who was not involved with the study. "I expect these findings will lead to much greater interest in the role of proliferation in neural development."

Ten years ago, Kalanit Grill-Spector, a psychologist at Stanford University in Palo Alto, California, first noticed that several parts of the brain's visual cortex, including a segment known as the fusiform gyrus that's known to be involved in facial recognition, appeared to develop at different rates after birth. To get more detailed information on how the size of certain brain regions changes over time, she turned to a recently developed brain imaging technology known as quantitative magnetic resonance imaging (qMRI). The technique tracks how long it takes for protons, excited by the imaging machine's strong magnetic field, to calm down. Like a top spinning on a crowded table, these protons will slow down more quickly if they're surrounded by a lot of molecules—a proxy for measuring volume.

Grill-Spector and Jesse Gomez, a graduate student at Stanford, along with a team of colleagues, used the technique to investigate the fusiform gyrus as well as a nearby area of the brain known as the collateral sulcus, which is involved in recognizing familiar places and locations. They recruited 22 children, ages 5 to 12, and 25 adults, ages 22 to 28, and asked them to look at images of faces and places. They then used functional MRI to map out the brain regions that lit up in response and qMRI to figure out the volume of the brain tissue in those regions across both age groups.

There was virtually no difference in tissue volume between the children and the adults in the place recognition areas of the brain, the team reports today in Science. In the facial recognition areas, however, the qMRI results revealed that adults had, on average, about 12% more volume than the children.

“It’s quite surprising that this part of the brain continues to develop and change after infancy and into adulthood,” Grill-Spector says, “especially when just 2 centimeters away, in the place-recognizing region, this doesn’t occur.”

To see whether this increase in brain volume might lead to better facial memory, she and Gomez gave a computer-based facial recognition quiz to the participants. Here, the children and adults saw a face from three different angles, then were asked to identify it within a panel of similar-looking faces. Those with higher tissue volume in their fusiform gyrus performed better than those with lower volume, the researchers found. The results suggest that, in combination with synaptic pruning, a major reason children improve so dramatically in their ability to recognize faces as they age is that their fusiform gyrus continues to develop into adulthood.

Grill-Spector speculates evolution might have bestowed this special developmental adaptation because precise facial recognition is critical to growing up in large, social communities. When you’re young, you might only need to know the faces of your parents and close relatives, but as you grow older, the number of important faces you encounter continues to increase, she says. Compared with other types of visual information, recognizing faces might require extra processing power because each visage has the same basic layout with only relatively minor differences between people, she adds.

So what’s driving this increase in brain tissue volume as people age? It’s not the growth of new neurons, Grill-Spector says. Numerous studies have shown that the number of neurons in the brain remains remarkably consistent from birth to death. One possible explanation is that dendrites—branches that extend outward from neurons and receive signals from other nearby cells—within the neurons of the fusiform gyrus are expanding and increasing its volume, Gomez says. He likens it to a forest maturing: Its overall size might remain the same, but the trees’ branches grow denser and more complex.

Further research into this brain region’s continued development might shed light on disorders such as prosopagnosia, also known as face blindness, and autism spectrum disorder, the researchers say.

Is wood a green source of energy? Scientists are divided

By Warren CornwallJan. 5, 2017 , 9:00 AM

It took half a century for an acorn to grow into the 20-meter-tall oak tree standing here in a North Carolina hardwood forest near the banks of the Northeast Cape Fear River. But it takes just seconds to turn the oak into fuel for the furnace of a European power plant.

A logging machine—a cross between a tank and a one-armed crab—grabs the tree with a metal claw. With a screech, a spinning blade bites through the trunk. Ultimately, the thickest bits of this tree and hundreds of others from this forest will be sliced into lumber. But the limbs from large trees like this, along with entire small or crooked trees, go to a specialized mill to be squeezed into tiny wood pellets. Shipped across the Atlantic Ocean, they will likely end up fueling a giant power plant in the United Kingdom that supplies nearly 10% of the country's electricity.

Over the roar of the logging, Bob Abt, a forest economist at North Carolina State University (NC State) in Raleigh, explains why this trans-Atlantic trade in wood pellets is booming: a push by policymakers, industry groups, and some scientists to make burning more wood for electricity a strategy for curbing carbon dioxide (CO_2) emissions. Unlike coal or natural gas, they argue, wood is a low-carbon fuel. The carbon released when trees are cut down and burned is taken up again when new trees grow in their place, limiting its impact on climate.

The idea is attractively simple, says Abt, a member of an expert panel that is studying the concept for the U.S. Environmental Protection Agency (EPA). "Another tree will grow here and sequester carbon again. So we're just recycling carbon."

Yet moves by governments around the world to designate wood as a carbon-neutral fuel—making it eligible for beneficial treatment under tax, trade, and environmental regulations—have spurred fierce debate. Critics argue that accounting for carbon recycling is far more complex than it seems. They say favoring wood could actually boost carbon emissions, not curb them, for many decades, and that wind and solar energy—emissions-free from the start—are a better bet for the climate. Some scientists also worry that policies promoting wood fuels could unleash a global logging boom that trashes forest biodiversity in the name of climate protection.

Some trees cut from a logging site in Duplin County in North Carolina will be squeezed into wood pellets, to be burned in power plants.

© Katie Bailey

"It basically tells the Congo and Indonesia and every other forested country in the world: 'If you cut down your forests and use them for energy, not only is that not bad, it's good,'" says Tim Searchinger, a senior fellow at the World Resources Institute in Washington, D.C., who has studied the carbon impacts of wood energy.

Oak trees in North Carolina are heading for a U.K. power plant largely because of a single number: zero. That's the amount of CO_2 that European power plants can claim they emit when burning wood. It's not true, of course, and in some cases wood-burning furnaces actually puff more CO_2 from their smokestacks per unit of electricity produced than those burning coal or natural gas. (In part, that's because wood can have a higher water content than other fuels, and some of its energy goes to boiling off the water.) But under the European Union's ambitious 2009 plan to produce 20% of its electricity from renewable resources by 2020, regulators endorsed an earlier decision to designate wood as a carbon-neutral fuel for the purposes of emissions accounting.

In response, some countries—including the United Kingdom, Belgium, Denmark, and the Netherlands—have built new wood-fired plants or converted coal-fired plants to wood. The United Kingdom has been one of the most enthusiastic, with the government providing subsidies for wood pellets that make them competitive with fossil fuels. At the country's largest power station, a 4000-megawatt behemoth in North Yorkshire, owner Drax Group has converted half of the furnaces to burn wood pellets.

For fuel, Drax and other firms have been eyeing forests around the world. Those of North Carolina and other states in the southeastern United States, filled with fast-growing pines as well as hardwoods and just a short freighter trip from Europe, have become a major source of wood pellets. U.S. exports, nearly all from the southeast, grew from zero in 2005 to more than 6.5 million metric tons in 2016, according to Forisk Consulting, a firm in Athens, Georgia. Pellet exports are expected to grow to 9 million metric tons by 2021.

The boom has caught the attention of U.S. policymakers. Lawmakers in Congress, with backing from parts of the forest products industry, have proposed legislation that would follow the European Union's lead and declare wood pellets a carbon-neutral fuel, which might encourage U.S. power companies to shift to wood. So far, those proposals haven't made it into law, in part because of skepticism from the Obama administration.

But they have alarmed some environmental groups and divided scientists. This past February, 65 scientists, many from major universities, penned a letter to Senate leaders warning that the carbon-neutral label would encourage deforestation and drive up greenhouse gas emissions. But a month later, more than 100 scientists took the opposite view in a letter to EPA, stating that "the carbon benefits of sustainable forest biomass energy are well established."

Economist Bob Abt has been examining the economic and ecological implications of wood fuels.

© Katie Bailey

Abt and his colleagues on the EPA expert panel are trying to sort out those starkly different perspectives. The son of a forester for a Georgia logging company, Abt can deftly switch from talking about machinery with a logger to describing the complex computer models he builds to simulate what might happen in a world with more wood-fired power plants. The bottom line, researchers say, depends on multiple assumptions about forest ecology and the economic behavior of landowners, as well as on the time horizon of the calculations. "There are four or five different approaches that you can use in order to measure the greenhouse gas implications of forest biomass energy," says Madhu Khanna, an environmental economist at the University of Illinois in Champaign, and chair of the EPA expert panel. "There are huge differences in the answers you can get."

One species of model focuses on the biological picture, tallying how much carbon is emitted when biomass is burned, and how long it will take for an ecosystem to reabsorb that carbon. The calculations are relatively straightforward. But the details—such as what kinds of trees are cut, and whether the new trees are fast-growing pines or slow-growing hardwoods—can influence how big that initial carbon debt appears to be, and how long it will take to pay back.

Because of the lag between emissions and uptake, studies taking this approach often find that widespread use of wood fuel will cause emissions spikes that could last for decades, hastening the pace of global warming. Researchers working with the Natural Resources Defense Council (NRDC), an environmental group, concluded that a wood-burning plant would have higher net carbon emissions than a comparable coal plant for the first 4 decades or more of operations. A similar study in the Journal of Sustainable Forestry in 2013 found that greenhouse gases from a power plant fired by wood from New England forests would outrank emissions from a similar coal-fired power plant for nearly half a century.

The bottom line for climate can shift depending on how far into the future researchers peer. The EPA panel on which Abt and Khanna sit has endorsed a long view. In its latest draft, the group recommends doing carbon accounting over a 100-year timeframe, based on research suggesting that it takes that long for the planet to feel the full impact of cumulative greenhouse gas emissions. Such long tallies give new forests plenty of time to mature and recapture carbon, making wood appear closer to carbon neutral.

But some scientists object that such long timescales gloss over the risk that the near-term spike in emissions produced by large-scale wood burning will cause damage that can't be undone. "If we melt Arctic ice in the next 20 years, that's not going to come back," says William Schlesinger, a biogeochemist and president emeritus at the Cary Institute of Ecosystem Studies in Millbrook, New York, who sits on EPA's Science Advisory Board.

Such issues suggest policymakers should proceed with caution, says Sami Yassa, a forestry scientist with NRDC in Kittery, Maine. "Our belief," he says, "is that these uncertainties need to be resolved in favor of avoiding damage" to today's forests.

We see this biomass industry as one of the biggest threats, if not the biggest threat, to these forests.

Adam Macon,

Roanoke River National Wildlife Refuge

Meanwhile, Abt and some other researchers are pursuing modeling approaches that attempt to take into account the important role that economics and human behavior play in shaping future forests. At one extreme, logged forest might be converted into farmland or housing lots, never getting a chance to regrow and soak up carbon. Or a booming pellet trade could have the opposite effect: encouraging farmers to plant trees where crops or pasture grasses once grew, amplifying the carbon benefits.

One study using Abt's approach has offered a counterintuitive conclusion: that an expansion of the southeast's pellet industry might offer a net benefit, in terms of carbon, in the long run. That's because it could prompt landowners to plant more trees, leading to more carbon storage. And shipping pine pellets to Europe to produce electricity can make both economic and environmental sense, Abt and Khanna concluded in a 2015 study in Environmental Research Letters. Compared with coal, wood fuel cut carbon emissions by 74% to 85% when they took into account the entire life cycle of both fuels, including emissions from production and transportation, and possible land-use shifts. The point, Abt says, is that "you can't just tell a biological story. My thesis is that ignoring markets gives you more of a wrong answer."

That's a view seconded by Tommy Norris, a North Carolina timber supplier in Rocky Point. His company, Tri-State Land & Timber LLC, bought the rights to log the Duplin County site. Demand for wood, he says, creates incentives for landowners to manage forests for the long term, and can prevent them from being converted to other uses. "If you don't have markets," he says, "people are just going to ignore their forests."

Roughly 160 kilometers northeast of the logging site, NC State ecologist Asko Noormets is investigating what he believes is another important—and often overlooked—part of the wood fuel puzzle. It's right beneath his feet. Under loblolly pines on a plantation owned by timber giant Weyerhaeuser, Noormets crouches next to a white plastic pipe embedded in the forest floor. A motor whines as a mechanism drops a small plastic dome over the end of the pipe, and a sensor takes a deep breath of the CO_2 inside, rising from the soil.

The measurements, taken every 30 minutes for the last 11 years, have Noormets worried. They suggest that logging, whether for biofuels or lumber, is eating away at the carbon stored beneath the forest floor. Every square meter of this forest is losing roughly 125 grams of carbon annually into the atmosphere, the data suggest. Over time, he predicts, logging could wear this fertile, peat-based soil down to the sandy layer below, releasing much of its carbon and destroying its long-term productivity.

When he has looked at emissions from other managed forests around the world, he's found similarly elevated rates of soil carbon loss. Noormets isn't certain what's driving the losses, but he suspects that by disturbing the soil, logging alters the activity of soil microbes that release CO_2.

Wood pellets

© Tatyana Aleksieva-Sabeva

/Alamy Stock Photo

The soft-spoken scientist tends toward technical jargon. But he says that when he first saw the numbers a few years ago, "I was terrified." That's because soil carbon accounts for a significant portion of the total carbon stored in forests, so over time a decline could have major implications for the climate.

Other studies of managed forests have found less worrying carbon losses, or little evidence of long-term declines. Still, if Noormets's findings are upheld by further research, they might force a rethink of wood-fuel accounting, which often assumes no soil carbon loss, Abt says. "Then just modeling the aboveground carbon is going to give you a wrong answer."

The pellet trade could also have more immediate ecological impacts. In the Roanoke River National Wildlife Refuge near Williamston, North Carolina, Adam Macon strolls down a dirt path past oak trees so thick he couldn't encircle one with his arms. Towering cypress trees splay their roots into the boggy soil. It's a textbook example of a bottomland hardwood forest, says Macon, who works for the Dogwood Alliance, an environmental group based in Asheville, North Carolina. It hosts dozens of plant species, more than 200 kinds of birds, and mammals including muskrats and black bears.

As a wildlife refuge, these trees are beyond the reach of the saw. But just a few kilometers away it's a different story. Unlike forests in the western United States, which are mostly owned by the U.S. government, more than 80% of southeastern forests are in private hands. Macon fears that if demand for wood pellets keeps growing, it will create yet another incentive for landowners to log relatively diverse hardwood forests—which already account for approximately a quarter of the pellets coming from the South—and convert them into less diverse but faster growing pine plantations.

A recent study in the journal Global Change Biology Bioenergy concluded that increased demand for wood fuel could cause some North Carolina hardwood ecosystems to shrink by about 10% by 2050. A companion study found that some species living in those forests could decline as well, including the cerulean warbler, a little blue songbird whose populations have fallen by nearly 75% since the mid-1960s. "We see this biomass industry as one of the biggest threats, if not the biggest threat, to these forests," Macon says.

Officials in the wood products industry say the fears of sweeping habitat destruction are unfounded. So far, predictions of a huge surge in European demand for wood pellets haven't been borne out, says Seth Ginther, executive director for the U.S. Industrial Pellet Association in Richmond, Virginia. Only a handful of European countries are subsidizing wood pellets, he says, and a number of proposed U.S. pellet plants have never materialized. "The way the market has shaken out, there's just not that much demand," Ginther says.

Overall, pellets consumed 3% of the wood cut in the southeast in 2013, far less than what goes to pulp or lumber. Still, at least seven new pellet plants are expected to start operating in the region over the next 5 years, according to Forisk Consulting.

Both boosters and critics of labeling pellets as carbon-neutral now wonder how the incoming administration of President-elect Donald Trump might view wood fuels. With the Republican Party soon to be in control of both Congress and the White House, NRDC's Yassa predicts that industry groups and politicians from timber-rich states will again press their case that a carbon-neutral designation for wood would be good for the economy. But with Trump and his appointees vowing to dismantle domestic climate rules and withdraw from international agreements designed to promote the use of climate-friendlier fuels, it's not clear just how much cachet a carbon-neutral label will carry in the United States.

Elsewhere in the world, however, wood appears to be winning support. Demand for pellets is increasing in Japan and South Korea as those nations seek to meet renewable energy quotas. And at the end of November 2016, the European Commission recommended extending the European Union's existing wood-fuel policies until 2030, with some minor changes. Such policy decisions suggest the debate over wood and climate is far from over.

Posted in: Science and Policy

Our 10 favorite science news stories of 2016

By David Grimm

Dec. 23, 2016 , 5:00 AM

Plants that gamble. Floating creatures in the clouds of alien worlds. An ice-encased military base uncovered by climate change. Our favorite stories of 2016 didn't necessarily employ the most cutting-edge science—for that, see our breakthroughs of the year—but they were fun, compelling reads that resonated widely with our audience here and on social media. Some of these were our personal favorites; some were our most popular stories of the year. Either way, we hope you'll enjoy reading them again.

V.Rachai/iStockphoto

10. 'Undead' genes come alive days after life ends

Is death really the end? Not for some genes. This spooky story revealed that hundreds of genes turn on after an animal dies—and many are still active days after death. Even more disturbing, some of these genes are involved in sculpting a developing embryo.

Warwick Goble

9. Some fairy tales may be 6000 years old

Fairy tales existed long before the Brothers Grimm came around, but even literary scholars may be shocked by just how old some of our favorite stories are. Using methods typically employed by biologists to trace the evolutionary history of species, researchers found that some of the first fairy tales may have originated between 2500 and 6000 years ago. The key to a yarn's longevity? A story that's strange enough to be remembered, but not so strange as to defy comprehension.

WaterFrame/Alamy Stock Photo

8. Greenland shark may live 400 years, smashing longevity record

"Astonishing." That's what scientists are saying about the life span of the Greenland shark, which new research reveals can live more than 400 years. The downside? Females aren't ready to reproduce until they hit the ripe age of 156.

J. Seita/Flickr

7. Plants can gamble, according to study

People do it. So do the birds and the bees. And now it appears that plants do it, too. Get your mind out of the gutter—we mean gambling. Our leafy friends, it turns out, roll the dice when it comes to making a tough decision such as where to find nutrients in uncertain circumstances. The findings need more testing, however, so don't bring your favorite shrub to Las Vegas, Nevada, just yet.

Tinieder/iStockphoto

6. Alien life could feed on cosmic rays

Most life on Earth gets its energy either from the sun or by consuming organisms that do so. But would alien life do the same? A bizarre microbe found deep in a South African gold mine that gets energy from radioactive uranium suggests that life on other planets could feed off of this source as well, especially cosmic radiation raining down from space. In a somewhat related story—and one of our other favorites of the year—scientists found that alien life could thrive in the clouds of failed stars.

George Clerk/iStockphoto

5. Humans are still evolving—and we can watch it happen

Evolution doesn't just happen over millions of years—it can occur right before our eyes. Such is the case in humans, where genes for height and eye color have evolved relatively rapidly—and a gene that favors cigarette smoking has dwindled in just a single generation.

Jessica Smith

4. You could probably have outrun a T. rex

The Jurassic Park movies have made us fear dinosaurs all over again, but just how threatening was the infamous Tyrannosaurus rex? This story, concerning 66-million-year-old tracks found along an ancient shoreline in Wyoming, reveals that the beast may not have been able to run faster than 8 kilometers (or 5 miles) per hour. That's slower than a middle-aged power walker, so with a bit of spring in your step, you probably could have avoided becoming a dino's dinner.

John Durban/NOAA

3. Why did a humpback whale just save this seal's life?

Nature may be red in tooth and claw, but sometimes species show a softer side toward each other. Our favorite example from this year was the remarkable story of a humpback whale that saved a seal from a pack of killer whales. Scientists aren't sure why it happened, but at the very least they say it should make killer whales think twice about hunting when a humpback is nearby.

Pictorial Parade/Archive Photos/Getty Images

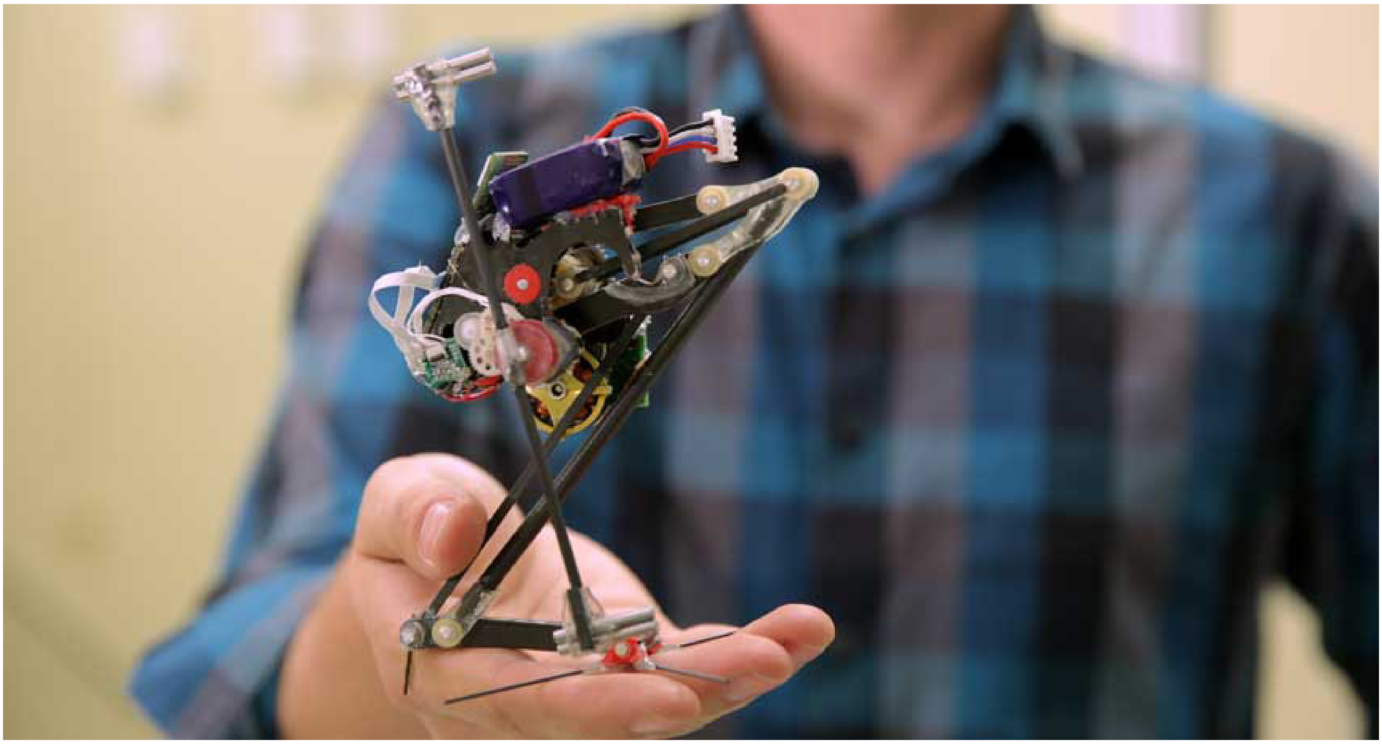
2. Mysterious, ice-buried Cold War military base may be unearthed by climate change

A military operation hidden beneath the Greenland Ice Sheet. A covert plan known as Project Iceworm. Rising international tensions. These may sound like the ingredients for a James Bond movie, but they're the real-life details of a Cold War base known as Camp Century. And now a warming world may be bringing them all to light.

Carol and Mike Werner/Visuals Unlimited, Inc.

1. Why do our cell's power plants have their own DNA?

Our most popular story of the year addresses one of the biggest mysteries of cell biology: Why do mitochondria—the oval-shaped structures that power our cells—have their own DNA, especially when the rest of the cell contains plenty of its own? A new study may hold the answers—and the clues to several rare and crippling diseases.



ROBOTICS TECHNOLOGY

Speedy, springy robot 'Salto' catches some serious air

One day, lightweight robots like Salto could help search rubble at disaster sites

MEGHAN ROSEN

Salto robot

This lightweight robot, nicknamed Salto, uses a twisted spring to quickly jump a meter (more than 3 feet) from floor to wall. Someday, researchers say, robots like it could help search through rubble at disaster sites.

Salto is a lightweight bot that stands on one skinny leg like a flamingo. But unlike a flamingo, it can leap from floor to wall, then off again. Its antics are like those of parkour athletes — people who bounce between buildings, vault and flip over railings and scramble up walls. Researchers at the University of California, Berkeley, described their agile robot December 6 in Science Robotics.

The palm-sized machine weighs just 100 grams (3.5 ounces) — or about as much as two large eggs. It's not the highest jumping robot, but it's got something others lack: speed. The new bot can spring a meter (39 inches) off the ground in just 0.58 seconds. That's about what a bullfrog can do, noted coauthor Duncan Haldane in a December 5 news conference.

The robot's mix of air and speed might one day aid search-and-rescue teams, he said. Ideally, a rescue robot would be able to move quickly and nimbly over rubble. To do that, Haldane explains, "It has to be able to jump."

Salto isn't able to help out in situations like that yet, though. For now, it is just "great eye candy," says roboticist Jeff Duperret. He works at the University of Pennsylvania in Philadelphia and wasn't involved with the study. Its authors, he says, "came up with a new idea and showed it really clearly."

Bush baby

Salto was inspired by a primate called the lesser galago, or bush baby. Before jumping, galagos hunker down in a "supercrouch" that lets them access more energy for jumping.

Haldane's bot was inspired by a tiny, saucer-eyed primate called the lesser galago. (It's also known as a bush baby.) "Animals can outclass any robot when it comes to jumping," Haldane said. Galagos, in particular, stand out. They've got the highest known vertical jumping agility. That's the ratio of maximum jumping height to the time it takes to complete a jump.

Before jumping, galagos hunker down in a kind of "supercrouch." This stance lets them access more energy before they spring into a jump, Haldane said. That allows them "to jump high and do it quickly."

His team built this capability into Salto's single leg. That leg is a spindly series of eight bars. Made with carbon fibers, they're super-strong but lightweight. Aluminum pins connect the bars. The team also attached a kind of spring that's like a twisted rubber band. In sits in the robot's body between the leg and the motor that powers the bot. When the team turns its motor on, the bot's spring twists, storing energy.

As the device settles into a deeper and deeper crouch, Haldane explains, the motor has more time to twist the spring. And that gives Salto extra oomph when it finally jumps and the spring untwists.

It's like the robot is getting a mega boost, Duperret says. The robot crouches again as it lands and can then immediately jump off again.

That's an added bonus, said study coauthor Justin Yim. "The spring can store some of the energy of landing for use in the next jump." It's like a bouncing ball, he said.

Salto joins a growing list of robots that hop off walls, spring off water or even launch themselves into the air with an explosion.

Salto, a lightweight, palm-sized robot, crouches low and then springs from floor to wall and down again — all in barely half a second.

Power Words

aluminum A metallic element, the third most abundant in Earth's crust. It is light and soft, and used in many items from bicycles to spacecraft.

carbon The chemical element having the atomic number 6. It is the physical basis of all life on Earth. Carbon exists freely as graphite and diamond. It is an important part of coal, limestone and petroleum, and is capable of self-bonding, chemically, to form an enormous number of chemically, biologically and commercially important molecules.

coauthor One of a group (two or more people) who together had prepared a written work, such as a book, report or research paper. Not all coauthors may have contributed equally.

fiber Something whose shape resembles a thread or filament of some kind. (in nutrition) Components of many fibrous plant-based foods. These so-called non-digestible fiber tends to come from cellulose, lignin, and pectin — all plant constituents that resist breakdown by the body's digestive enzymes.

galagos Also known as bush babies, these are small, large-eyed, nocturnal, tree-dwelling African primates. They get their name for their baby-like cries. Known as vertical clingers and leapers, they can spring off the trunk of one tree and turn around in mid-air to face the next tree it will latch onto.

mega A prefix for units of measurement meaning million in the international metric system.

motor A device that converts electricity into mechanical motion.

parkour A term, from the French, for a type of gymnastics-like activity where people soar through an environment by jumping, leaping and scrambling up, around and between walls and other obstacles. Movements tend to be very rapid and fluid. Some may involve vaulting or flipping over railings, stairs or other structures. People may even climb up walls or leap from one wall or fence to some other structure.

primate The order of mammals that includes humans, apes, monkeys and related animals (such as tarsiers, the Daubentonia and other lemurs).

ratio The relationship between two numbers or amounts. When written out, the numbers usually are separated by a colon, such as a 50:50. That would mean that for every 50 units of one thing (on the left) there would also be 50 units of another thing (represented by the number on the right).

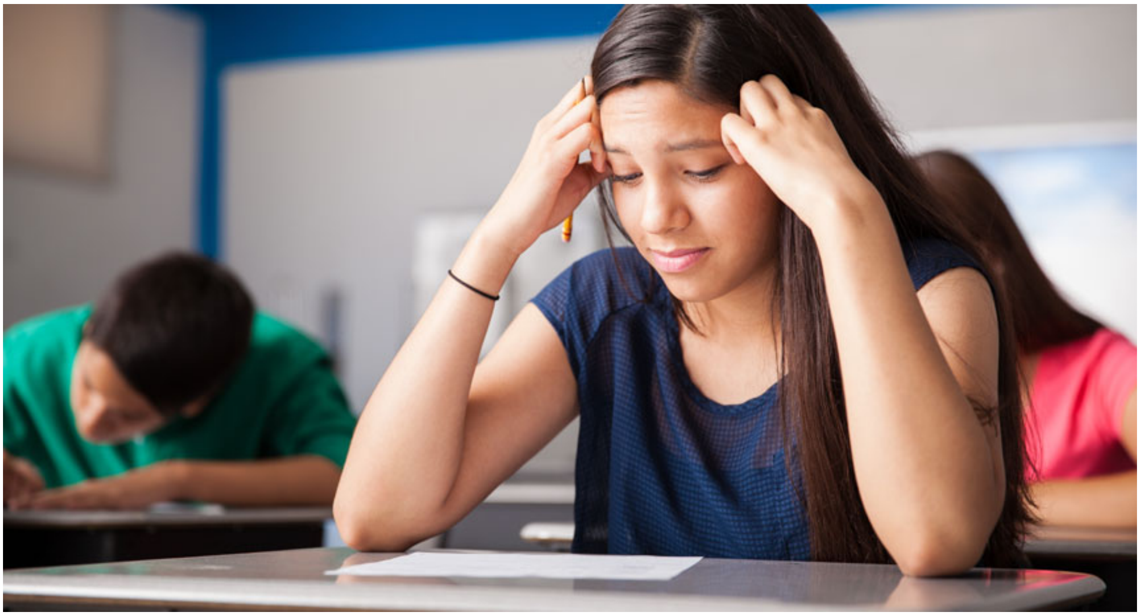
robot A machine that can sense its environment, process information and respond with specific actions. Some robots can act without any human input, while others are guided by a human.

vertical A term for the direction of a line or plane that runs up and down, as the vertical post for a streetlight does. It's the opposite of horizontal, which would run parallel to the ground.

Don't let math stress you out

Research shows how to overcome math anxiety

EVELYN LAMB



Plenty of people get nervous taking a test, but some suffer from math anxiety. The good news is that there are ways to overcome it.

As your teacher passes out the math test, your palms turn sweaty. You notice that your heart has begun to race. Glancing down at the page, you suddenly forget those operations on which you had drilled only a few days earlier. Do you perform all additions first in a complex calculation, or all multiplications? What's the multiplication table again for 9's? Oh, you know it — well you're pretty sure, right? Suddenly, you start to doubt a lot of things that you "know."

If that sounds familiar, you might suffer from math anxiety.

Or maybe not. Even researchers who study this condition note that it can be surprisingly hard to define math anxiety. It's also hard to identify precisely how many people suffer from it. After all, it's not an officially recognized mental disorder in the way that depression or schizophrenia is.

To diagnose math anxiety, researchers administer a questionnaire. It asks things like: "How anxious would you feel about being given a set of division problems to solve on paper?" Some people will rate their reactions as being very panicky. Others have no stress — even if they know they aren't numerical wizards. So how anxious someone feels tends to fall along a spectrum.

Those who score high on these surveys about stress over making numerical calculations will be labeled math anxious. The exact share who get this diagnosis, however, will vary, depending on where researchers choose to draw the line at what counts as high.

In general, people who panic over their math skills tend to do worse in math classes than do people who don't mind numbers. But that's not always true. "Just because you're math anxious, that doesn't always mean you're bad at math," notes Rose Vukovic. She's an educational psychologist at the University of Minnesota in Minneapolis.

Math anxiety affects people of all ages. It can lead to poor performance in math classes. And its impacts don't end at graduation. Throughout life, this type of stress can stand in the way of mastering skills or projects in a host of areas that rely on computations.

But the good news is that the problem is manageable. Researchers are finding ways people can cope with this stress — maybe even to the point of making numbers their friends.

What is math anxiety?

People often think of math anxiety as a problem in middle- and high-school students. But by age 12, kids already will have had many opportunities for bad experiences with math. So panicking over working with numbers may start much earlier. Math anxiety has emerged in some as early as first grade, Vukovic points out.

Understanding the issue can be a kind of chicken-and-egg problem, however. Does math anxiety cause low performance, or do skill problems trigger the stress? The two probably feed on each other, Vukovic says. Indeed, she argues, if low math knowledge were the only issue, building up those skills should erase the problem. Instead, research shows, simply dealing with the anxiety can improve math performance. That suggests that anxiety alone can sabotage math performance, regardless of someone's skills.

Explainer: What is anxiety?

Anxiety, it turns out, can interfere with the brain's "working memory." This type of memory allows the mind to hold onto several different pieces of information at once. Mark Ashcraft is a psychologist at the University of Nevada, Las Vegas. There, he studies the role of anxiety in math cognition — how people mentally learn and do math. "When you are math anxious," he finds, "anxiety steals away working-memory resources."

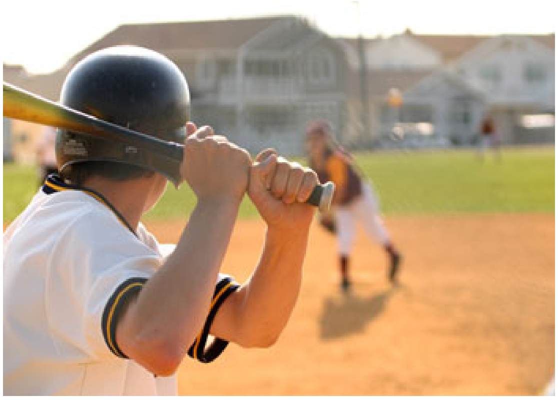
As if theft of working memory isn't bad enough, math anxiety also can hurt, literally. Ian Lyons is a psychologist at Georgetown University in Washington, D.C. Sian Beilock is a psychologist at the University of Chicago in Illinois. Four years ago, when Lyons was Beilock's student at the University of Chicago, the two conducted a study that looked at people's brains when they thought about doing a math problem.

In people with high math anxiety, just anticipating doing math turned on areas in the brain associated with pain. In other words, math anxiety can hurt! Interestingly, they did not find the same response when people were actually doing the math. It was the worrying about doing math that was the problem.

Why is math different?

Many issues can trigger anxiety. It might be the anticipation of moving to a new city, of confronting some bully or of remembering your lines on stage during the performance of a play in front of an auditorium full of strangers. But even among academic subjects, researchers note, when it comes to anxiety, math seems special.

You don't hear people saying they have "chemistry anxiety" or "social studies anxiety." Likewise, people sometimes say they're bad at math almost as a badge of honor. In contrast, no one would be proud of the fact that they were bad at reading!



Math is like baseball — you can't master either overnight.

One difference may be mindset. Many people believe mathematical abilities are fixed. You're either a "math person" or you aren't. People who think this way take difficulty in math as a sign that they are just not cut out for it. Closely related to this "fixed mindset" is the genius myth. That belief holds that someone must be extremely gifted to do well at math. Together, these attitudes make people think that if math makes them struggle, it must be because they're just not a math person. So they might as well give up.

Many education researchers instead argue that a "growth mindset" is better. This idea holds that with enough effort, skill in any area can be learned. Someone with a growth mindset sees failure as an opportunity for learning. Someone with a fixed mindset sees it as a setback.

Research suggests that students with a growth mindset learn more and get higher grades than those with a fixed mindset.

One way to think about it is to compare math to music or sports. You don't expect to sit down at a piano and immediately be able to play a Beethoven sonata. Similarly, no one would expect to make a three-point shot in basketball the first time they stepped onto a court. Sure, some people learn these things more easily than others. Still, with practice, anyone can keep getting better at piano or basketball. And even if you never become a famous musician or athlete, you can still enjoy playing music and sports throughout life. This holds true for math, as well.

How to manage the stress

Math computations are an important element in many careers in science, technology, engineering and math, also known as STEM. So stress over math can serve as a barrier to students who want to become scientists or engineers. Beyond that, math is used in many everyday activities, from cooking to shopping. And math anxiety is just plain unpleasant. (Remember that pain-area activation in the brain?)

So if you stress out over math, what should you do?

The main thing seems to be to separate that stress from your thoughts about math. Ashcraft at the University of Nevada recommends compartmentalizing it. “I try to encourage people to think about setting the anxiety aside,” he says. “Engage in the worry later.”

Scientists have found that when students write about their math anxiety, they perform better on math tests.

And a little math anxiety doesn’t have to be a bad thing, says Lyons at Georgetown. He compares it to public speaking. Many people get anxious before giving a speech or performing. It's called stage fright. “You can respond to that positively and use that,” he says, “or you can go the other way.” In other words, you can either “psych yourself up” or “freak yourself out.” At issue is whether you can see that stress as a positive challenge to overcome — and then devise a game plan to succeed.

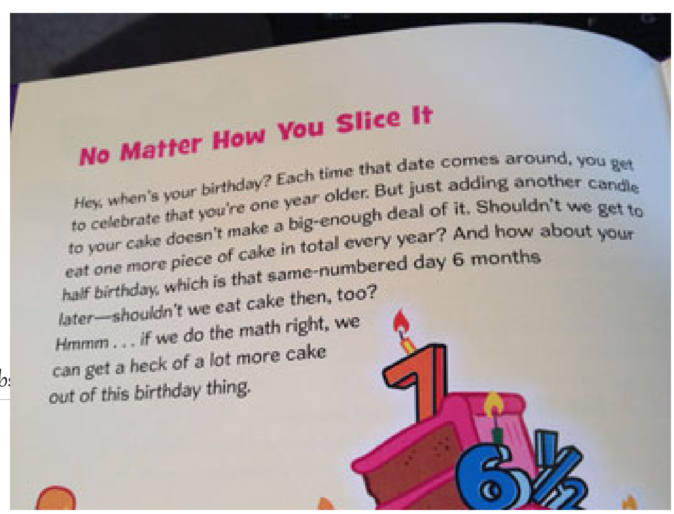
Because of the effect stress has on working memory, taking a test is more difficult if you have math anxiety. So, Lyons says, “There are two tasks you have to do: the math and working through the anxiety.” Tackling each task separately could help, science suggests.

Researchers did an experiment to see if separating them helped students with math anxiety. They split the students into two groups. One group did expressive writing about their math anxiety for seven minutes. They would write down their thoughts and feelings related to the looming test. The other group just sat quietly. Then each student took the math test. Those with high math anxiety scored significantly better on the test if they had been in the expressive writing group than if they had just sat quietly.

Expressive writing allows people to work through their anxiety, researchers now think. It allows people to deal with their emotions before an exam so that they can gain that working memory back. Now they could better focus on the math while taking a test.

What can parents and teachers do?

Adults sometimes have a tough time defusing kids’ stress over math. One reason: The older generation itself may suffer from math anxiety — and pass its stress along to those students. But there is some encouraging research that points out ways to help kids grow up thinking of math as fun.



No Matter How You Slice It

Hey, when's your birthday? Each time that date comes around, you get to celebrate that you're one year older. But just adding another candle to your cake doesn't make a big-enough deal of it. Shouldn't we get to eat one more piece of cake in total every year? And how about your half birthday, which is that same-numbered day 6 months later—shouldn't we eat cake then, too? Hmmm . . . if we do the math right, we can get a heck of a lot more cake out of this birthday thing.

The Bedtime Math series presents word problems that families can work out together.

One study focused on an app. Many families make a routine of reading or telling bedtime stories at night. Why not instead play Bedtime Math?

"This is a free app that allows kids and parents to work through math in a structured and fun way," says Beilock. She was one of the researchers who studied the effect of this app on a diverse group of first graders.

The idea of this app is to get parents and kids talking about math outside of homework time. Instead of focusing on problems that have a right or wrong answer, families can talk about math in a lower-pressure fashion. For example, one prompt goes like this:

Whipped cream was invented about 500 years ago and is credited to a bunch of guys with long, unpronounceable Italian and French names. But what made them think to whip up cream in the first place? Did they know what would happen? Never mind that there was no electricity back then — they had to whip it by hand. Luckily, it was worth the effort.

Whipping air bubbles into cream makes it take up a lot more "volume," or space.

In the Bedtime Learning Together test kitchen, 1 cup of heavy cream generated 3 cups of whipped cream. With something as important as dessert, that's a key fact.

The prompt then asks questions for children of different ages:

"If you can whip 2 cups of heavy cream into 6 cups of whipped cream, how many cups of air did you whip into it?"

Or

"If when no one's looking you slurp up 9 cups of the whipped cream, how much heavy cream did it take to make that?"

Youngsters whose families used the app had bigger gains in math achievement over the course of a school year than did the kids whose families didn't. This was especially true, the researchers found, for kids whose parents themselves were stressed by math. (The study was funded by the foundation that created the app.)

Parents and teachers need to be especially careful when working with girls. A recent study found that in developed countries such as the United States, girls tend to have more math anxiety than do boys. In lesser-developed countries, the gap between genders is lower. That suggests gender differences in math anxiety may stem from cultural messages, not biology. Another, earlier study suggested that female teachers with math anxiety can unintentionally pass that anxiety on to girls in their classes.

Just being aware of these potential problems can help parents and teachers make sure they do not send unintended messages to children.

It's never too late

One common problem with math anxiety is that affected students take fewer math courses and avoid majors and careers that use math. But that's not true for everyone. Virginie Charette changed schools in the middle of ninth grade. And the first math test she took at the new school didn't go well. She just bombed. "It wiped out every thought I had that I was good at math," she recalls. Her confidence in math plummeted. For a while she even hated the subject.

Even if you have math anxiety when you're young, you can still overcome it and become a math whiz.

Later, in college, she became friends with a math major. He started sharing math puzzles with her. And they proved fun. In fact, they actually kindled "a very emotional attachment," she says. What's more, she soon realized: "I had the calling."

She is now a mathematician at the University of Sherbrooke in Quebec, Canada. As someone who has dealt with her own math anxiety, she proves that it's never too late to make friends with math.

Power Words

(for more about Power Words, click here)

academic Relating to school, classes or things taught by teachers in formal institutes of learning (such as a college).

anxiety (adj. anxious) A nervous or almost fearful reaction to events causing excessive uneasiness and apprehension. People with anxiety may even develop panic attacks.

app Short for application , or a computer program designed for a specific task.

biology The study of living things. The scientists who study them are known as biologists.

chemistry The field of science that deals with the composition, structure and properties of substances and how they interact with one another. Chemists use this knowledge to study unfamiliar substances, to reproduce large quantities of useful substances or to design and create new and useful substances. (about compounds) The term is used to refer to the recipe of a compound, the way it's produced or some of its properties. People who work in this field are known as chemists.

cognition The mental processes of thought, remembering, learning information and interpreting those data that the senses send to the brain.

depression A mental illness characterized by persistent sadness and apathy. Although these feelings can be triggered by events, such as the death of a loved one or the move to a new city, that isn't typically considered an "illness" — unless the symptoms are prolonged and harm an individual's ability to perform normal daily tasks (such as working, sleeping or interacting with others). People suffering from depression often feel they lack the energy needed to get anything done. They may have difficulty concentrating on things or showing an interest in normal events. Many times, these feelings seem to be triggered by nothing; they can appear out of nowhere.

developed country Sometimes called an industrialized country, this is a nation that tends to be relatively wealthy on the basis of having substantial commercial and industrial activity. Today, developed countries also tend to be among the more technologically advanced nations.

diagnose To analyze clues or symptoms in the search for their cause. The conclusion usually results in a diagnosis — identification of the causal problem or disease.

disorder (in medicine) A condition where the body does not work appropriately, leading to what might be viewed as an illness. This term can sometimes be used interchangeably with disease.

electricity A flow of charge, usually from the movement of negatively charged particles, called electrons.

element (in chemistry) Each of more than one hundred substances for which the smallest unit of each is a single atom. Examples include hydrogen, oxygen, carbon, lithium and uranium.

engineer A person who uses science to solve problems. As a verb, to engineer means to design a device, material or process that will solve some problem or unmet need.

engineering The field of research that uses math and science to solve practical problems.

field An area of study, as in: Her field of research was biology. Also a term to describe a real-world environment in which some research is conducted, such as at sea, in a forest, on a mountaintop or on a city street. It is the opposite of an artificial setting, such as a research laboratory.

gender The attitudes, feelings, and behaviors that a given culture associates with a person's biological sex. Behavior that is compatible with cultural expectations is referred to as being the norm. Behaviors that are incompatible with these expectations are described as non-conforming.

generation A group of individuals born about the same time or that are regarded as a single group. Your parents belong to one generation of your family, for example, and your grandparents to another. Similarly, you and everyone within a few years of your age across the planet are referred to as belonging to a particular generation of humans. The term also is sometimes extended to year classes or types of inanimate objects, such as electronics or automobiles.

major (in education) A subject that a student chooses as his or her area of focus in college, such as: chemistry, English literature, German, journalism, pre-medicine, electrical engineering or elementary education.

mindset In psychology, the belief about and attitude toward a situation that influences behavior. For instance, holding a mindset that stress may be beneficial can help improve performance under pressure.

numerical Having to do with numbers.

psychologist A scientist or mental-health professional who studies the human mind, especially in relation to actions and behavior.

questionnaire A list of identical questions administered to a group of people to collect related information on each of them. The questions may be delivered by voice, online or in writing. Questionnaires may elicit opinions, health information (like sleep times, weight or items in the last day's meals), descriptions of daily habits (how much exercise you get or how much TV do you watch) and demographic data (such as age, ethnic background, income and political affiliation).

schizophrenia A serious brain disorder that can lead to hallucinations, delusions and other uncontrolled behaviors.

social (adj.) Relating to gatherings of people; a term for animals (or people) that prefer to exist in groups. (noun) A gathering of people, for instance those who belong to a club or other organization, for the purpose of enjoying each other's company.

spectrum (plural: spectra) A range of related things that appear in some order. (in light and energy) The range of electromagnetic radiation types; they span from gamma rays to X rays, ultraviolet light, visible light, infrared energy, microwaves and radio waves.

STEM An acronym (abbreviation made using the first letters of a term) for science, technology, engineering and math.

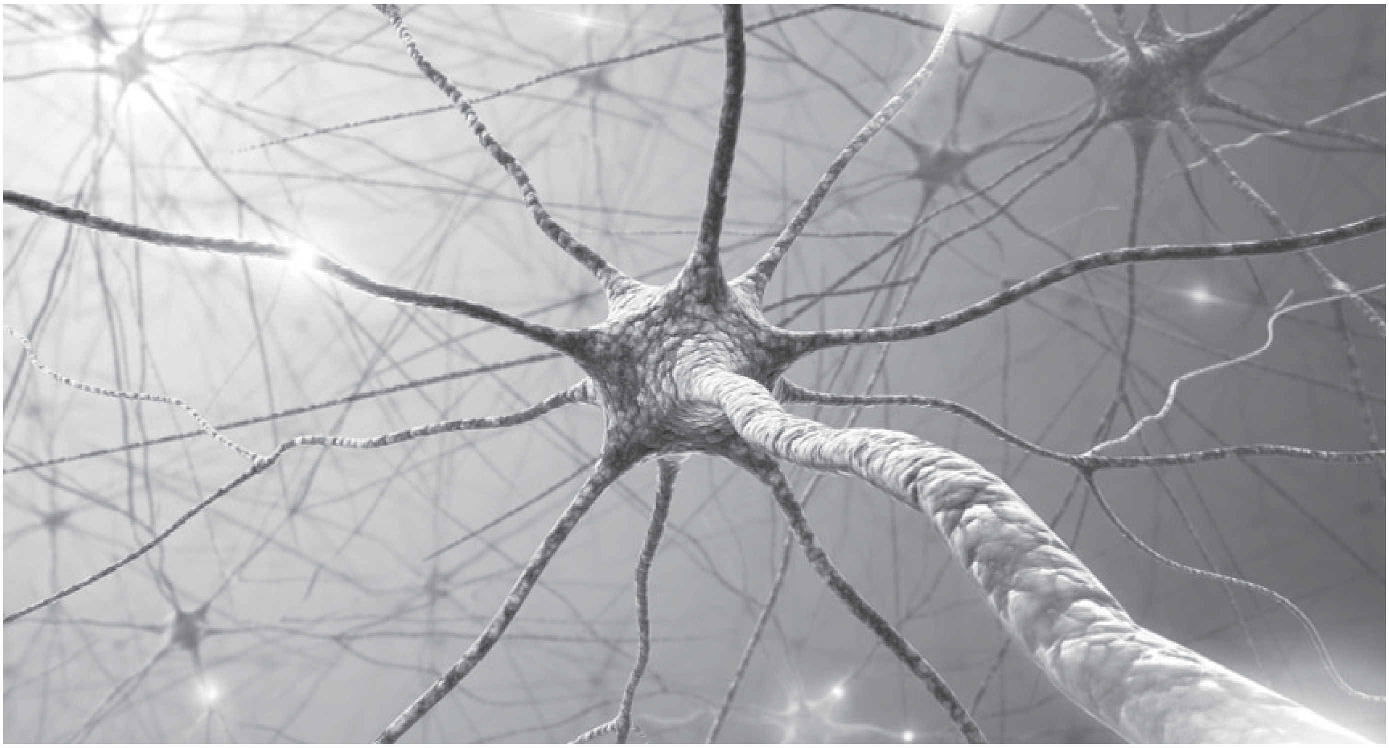
stress (in biology) A factor, such as unusual temperatures, moisture or pollution, that affects the health of a species or ecosystem. (in psychology) A mental, physical, emotional, or behavioral reaction to an event or circumstance, or stressor, that disturbs a person or animal's usual state of being or places increased demands on a person or animal; psychological stress can be either positive or negative.

subjects (in research) The participants in a trial. The term usually refers to people who volunteered to take part. Some may receive money or other compensation for their participation, particularly if they entered the trial healthy.

survey (v.) To ask questions that glean data on the opinions, practices (such as dining or sleeping habits), knowledge or skills of a broad range of people. Researchers select the number and types of people questioned in hopes that the answers these individuals give will be representative of others who are their age, belong to the same ethnic group or live in the same region. (n.) The list of questions that will be offered to glean those data.

technology The application of scientific knowledge for practical purposes, especially in industry — or the devices, processes and systems that result from those efforts.

working memory The ability to hold something in the mind for a short period of time, such as a mental grocery list or a phone number.



BODY FUNCTIONSCELLS

Learning rewires the brain

In the process, some of the brain's nerve cells change shape or even fire backwards

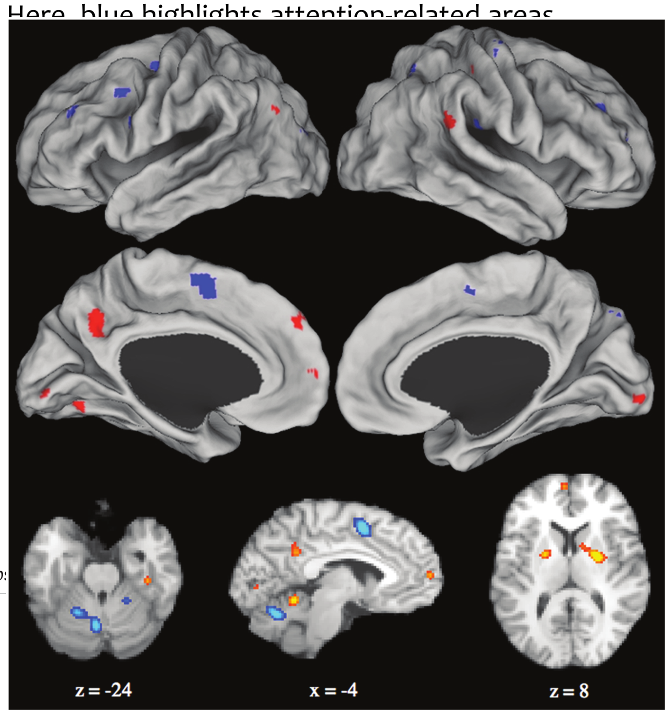
ALISON PEARCE STEVENS

An artist's depiction of an electrical signal (yellow-orange regions) shooting down a nerve cell and then off to others in the brain. Learning strengthens the paths that these signals take, essentially "wiring" certain common paths through the brain.

Musicians, athletes and quiz bowl champions all have one thing in common: training. Learning to play an instrument or a sport requires time and patience. It is all about steadily mastering new skills. The same is true when it comes to learning information — preparing for that quiz bowl, say, or studying for a big test.

As teachers, coaches and parents everywhere like to say: Practice makes perfect.

Blood flow reveals activity in the brain. Here, blue highlights attention-related areas



that had greater blood flow when people first learned a task. Blood flow decreased in those areas as they became more familiar with the task. Red shows mind-wandering areas that became more active as the task was mastered.

Doing something over and over again doesn't just make it easier. It actually changes the brain. That may not come as a surprise. But exactly how that process happens has long been a mystery. Scientists have known that the brain continues to develop through our teenage years. But these experts used to think that those changes stopped once the brain matured.

No more.

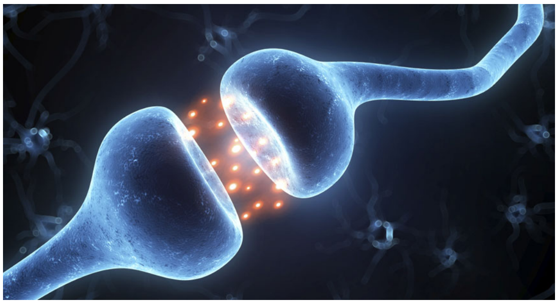
Recent data have been showing that the brain continues to change over the course of our lives. Cells grow. They form connections with new cells. Some stop talking to others. And it's not just nerve cells that shift and change as we learn. Other brain cells also get into the act.

Scientists have begun unlocking these secrets of how we learn, not only in huge blocks of tissue, but even within individual cells.

Rewiring

The brain is not one big blob of tissue. Just six to seven weeks into the development of a human embryo, the brain starts to form into different parts. Later, these areas will each take on different roles. Consider the prefrontal cortex. It's the region right behind your forehead. That's where you solve problems. Other parts of the cortex (the outer layer of the brain) help process sights and sounds. Deep in the brain, the hippocampus helps store memories. It also helps you figure out where things are located around you.

Scientists can see what part of the brain is active by using functional magnetic resonance imaging, or fMRI. At the heart of every fMRI device is a strong magnet. It allows the device to detect changes in blood flow. Now, when a scientist asks a volunteer to perform a particular task — such as playing a game or learning something new — the machine reveals where blood flow within the brain is highest. That boost in blood flow highlights which cells are busy working.



Chemical messengers — called neurotransmitters — leave the end of one nerve cell and jump across a gap to stimulate the next nerve cell.

Many brain scientists use fMRI to map brain activity. Others use another type of brain scan, known as positron emission tomography, or PET. Experts have performed dozens of such studies. Each looked at how specific areas of the brain responded to specific tasks.

Nathan Spreng did something a little different: He decided to study the studies. Spreng is a neuroscientist at Cornell University in Ithaca, N.Y. A neuroscientist studies the brain and nervous system. Spreng wanted to know how the brain changes — how it morphs a little bit — as we learn.

He teamed up with two other researchers. Together, they analyzed 38 of those earlier studies. Each study had used an fMRI or PET scan to probe which regions of the brain turn on when people learn new tasks.

Areas that allow people to pay attention became most active as someone began a new task. But those attention areas became less active over time. Meanwhile, areas of the brain linked with daydreaming and mind-wandering became more active as people became more familiar with a task.

“At the beginning, you require a lot of focused attention,” Spreng says. Learning to swing a bat requires a great deal of focus when you first try to hit a ball. But the more you practice, Spreng says, the less you have to think about what you’re doing.

Extensive practice can even allow a person to perform a task while thinking about other things — or about nothing at all. A professional pianist, for example, can play a complex piece of music without thinking about which notes to play next. In fact, stopping to think about the task can actually interfere with a flawless performance. This is what musicians, athletes and others often refer to as being “in the zone.”

This neuron from a mouse brain shows the bulbous cell body with a single axon projecting from it. As the brain learns, neurons relay information faster and more efficiently. The mouse was genetically modified to make a fluorescent protein that glows green.

Cells that fire together, wire together

Spreng’s findings involve the whole brain. However, those changes actually reflect what’s happening at the level of individual cells.

The brain is made up of billions of nerve cells, called neurons. These cells are chatty. They “talk” to each other, mostly using chemical messengers. Incoming signals cause a listening neuron to fire or send signals of its own. A cell fires when an electrical signal travels through it. The signal moves away from what is called the cell body, down through a long structure called an axon. When the signal reaches the end of the axon, it triggers the release of those chemical messengers. The chemicals then leap across a tiny gap. This triggers the next cell to fire. And on it goes.

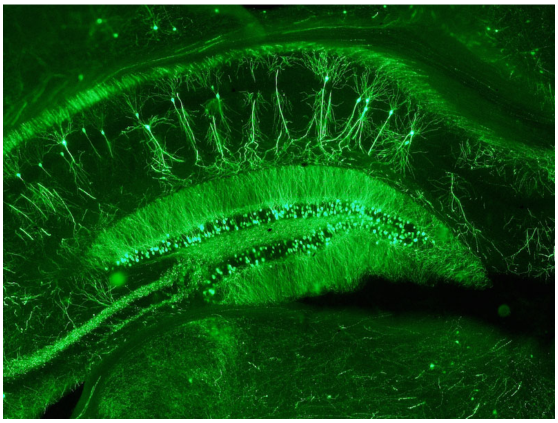
As we learn something new, cells that send and receive information about the task become more and more efficient. It takes less effort for them to signal the next cell about what’s going on. In a sense, the neurons become wired together.

Spreng detected that wiring. As cells in a brain area related to some task became more efficient, they used less energy to chat. This allowed more neurons in the “daydreaming” region of the brain to rev up their activity.

Neurons can signal to several neighbors at once. For example, one neuron might transmit information about the location of a baseball pitch that’s flying toward you. Meanwhile, other neurons alert your muscles to get ready to swing the bat. When those neurons fire at the same time, connections between them strengthen. That improves your ability to connect with the ball.

Learning while you slumber

The brain doesn't shut down overnight. In fact, catching some zzz's can dramatically improve learning. That's because as we sleep, our brains store memories and new information from the previous day. So a poor night's sleep can hurt our ability to remember new things. Until recently, however, researchers didn't know why.



The hippocampus, shown here in a mouse, is a brain region involved in storing memories. The mouse was genetically modified with a gene that creates a green fluorescent protein that causes the neurons to glow green.

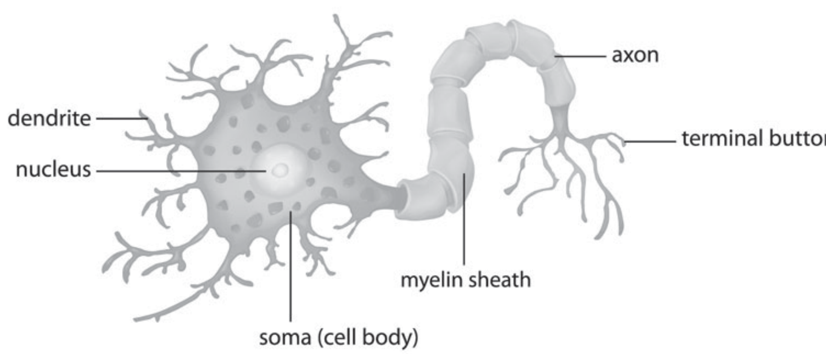
A group of scientists at the University of Heidelberg in Germany provided the first clues. Specific cells in the hippocampus — that region involved in storing memories — fired when mice slept, the scientists found. But the cells didn't fire normally. Instead, electrical signals spontaneously fired near the middle of an axon, then traveled back in the direction of the cell body. In other words, the cells fired in reverse.

This boosted learning. It did so by making connections between cells stronger. Again, the action sort of wired together the cells. Research by Olena Bukalo and Doug Fields showed how it happens. They are neuroscientists at the National Institutes of Child Health and Human Development in Bethesda, Md.

Working with tissue from rat brains, the scientists electrically stimulated nerve axons. Carefully, they stimulated them just in the middle. The electrical signals then traveled in reverse. That is just what the German scientists had seen.

This reverse signaling made the neuron less sensitive to signals from its neighbors, the experts found. This made it harder for the cell to fire, which gave the neuron a chance to recharge, Bukalo explains. When she then applied electric stimulation near the cell body, the neuron fired. And it did so even more strongly than it had before.

Cells involved in learning new information are most likely to fire in reverse during sleep, Bukalo says. The next day, they will be wired more tightly to each other. Although scientists don't know for certain, it is likely that repeated cycles of reverse firing create a strong network of neurons. The neurons relay information faster and



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more efficiently, just as Spreng found in his study. As a result, those networks reflect an improvement in understanding or physical skill.

Artist's depiction of a nerve cell in the brain. Glial cells wrap around the axon like a blanket, forming the myelin sheath. As people learn, brain cells change in ways that increase the speed and efficiency with which signals travel down the nerve cells.

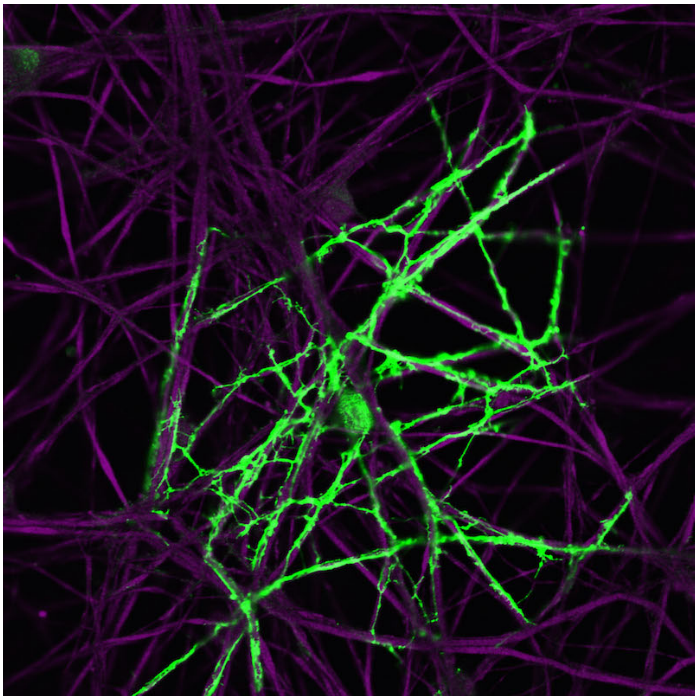
BLUERINGMEDIA/ISTOCKPHOTO

Firing faster

Neurons are the best-known cells in the brain. But they are far from the only ones. Another type, called glia, actually makes up a whopping 85 percent of brain cells. For a long time, scientists thought that glia simply held neurons together. (Indeed, "glia" take their name from the Greek word for glue.) But recent research by Fields, Bukalo's colleague at the National Institutes of Child Health and Human Development, reveals that glial cells also become active during learning.

One type of glial cell wraps around nerve axons. (Note: Not all axons have this wrapping.) These wrapping cells create what's known as a myelin sheath. Myelin is made of protein and fatty substances. It insulates the axons. Myelin is a bit like the plastic coating that jackets the copper wires in your home. That insulation prevents electrical signals from inappropriately leaking out of one wire (or axon) and into another.

In axons, the myelin sheath has a second role: It actually speeds the electrical signals along. That's because glial cells force a signal to jump from one spot on the axon to the next. As it hops between glial cells, the signal moves faster. It's kind of like flying from one spot to the next, instead of taking the train.



The green, octopus-like cell in the center is a type of glial cell that creates the myelin sheath. Here, the tips of the tentacles are in the early stages of wrapping around several different axons. As the brain learns, the glial cells grow, change and help increase the efficiency with which axons move signals.

DOUG FIELDS/NIH

Fields has found that when new skills are learned, the amount of myelin insulating an axon increases. This happens as the size of individual glial cells increases. New glial cells also may be added to bare axons. These changes improve the ability of a neuron to signal. And that leads to better learning.

A thicker myelin sheath helps improve all types of brainy tasks. These include reading, creating memories, playing a musical instrument and more. A thicker sheath is also linked with better decision-making.

Nerve cells continue to add myelin well into adulthood, as our brains continue to grow and develop. The prefrontal cortex, for example — that area where decisions are made — gains myelin well into a person's 20s. This may explain why teens don't always make the best decisions. They're not finished sheathing their nerve cells. But there is hope. And getting enough sleep certainly can help. Glial cells, like neurons, seem to change most during certain stages of sleep.

Exactly what causes the glial cells to change remains a mystery. Fields and his colleagues are hard at work to figure that out. It's exciting, he says, to launch into a whole new field of research.

Slow and steady

These changes in the brain allow for faster, stronger signaling between neurons as the brain gains new skills. But the best way to speed up those signals is to introduce new information to our noggins — slowly.

Many students instead try to memorize lots of information the night before a test. Cramming may get them through the test. But the students won't remember the information for very long, says Hadley Bergstrom. He is a neuroscientist at the National Institutes of Alcohol Abuse and Alcoholism in Rockville, Md.

These musicians with the Vancouver Youth Symphony may not know it, but learning to play an instrument will remodel the brain. With practice, anyone who has mastered a skill can perform it well — even without having to pay attention.

VANCOUVER FOUNDATION/WIKIMEDIA COMMONS

It's important to spread out learning over many days, his work shows. That means learning a little bit at a time. Doing so allows links between neurons to steadily strengthen. It also allows glial cells time to better insulate axons.

Even an "aha!" moment — when something suddenly becomes clear — doesn't come out of nowhere. Instead, it is the result of a steady accumulation of information. That's because adding new information opens up memories associated with the task. Once those memory neurons are active, they can form new connections, explains Bergstrom. They also can form stronger connections within an existing network. Over time, your level of understanding increases until you suddenly "get" it.

Like Fields and Bukalo, Bergstrom stresses the importance of sleep in forming the new memories needed to gain knowledge. So the next time you study for a test, start learning new information a few days ahead of time. The night before, give your brain a break and go to bed early. It will allow your brain a chance to cement that new information into its cells. And that should boost your chances of doing well.

Word Find (click here to enlarge for printing)

Power Words

axon The long, tail-like extension of a neuron that conducts electrical signals away from the cell.

cell body The compact section of a

LEARNING CHANGES THE BRAIN

C	S	Y	F	J	B	K	K	V	V	P	O	E	K	X	K	Y	A	W	R
T	L	O	J	D	R	U	Q	X	T	E	D	Z	M	P	X	J	Z	Q	Y
D	Y	G	V	K	K	F	R	E	G	N	O	R	T	S	S	Z	M	T	K
T	O	Y	V	Q	I	Y	M	T	K	O	Y	I	G	T	L	E	T	T	R
V	A	K	N	Y	R	W	D	R	J	I	N	O	I	P	M	A	H	C	C
D	F	T	D	E	C	Z	N	O	I	T	A	M	R	O	F	N	I	I	O
V	E	J	T	E	M	B	W	C	B	A	U	N	R	Z	H	R	A	L	X
A	F	S	N	E	C	R	R	L	H	L	H	Y	T	R	T	E	U	L	G
X	Y	P	J	S	N	O	X	A	A	U	L	D	E	C	I	S	I	O	N
M	E	V	Q	R	V	T	M	T	I	S	L	E	E	P	U	C	W	P	C
I	Y	J	V	E	I	O	I	N	T	N	Q	L	C	P	K	R	O	R	J
F	X	S	B	V	M	O	M	O	H	I	E	G	M	Q	U	A	G	E	K
M	E	S	S	E	N	G	E	R	N	G	V	A	U	J	S	M	S	W	I
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P	A	Q	M	K	U	L	E	R	P	N	D	I	V	F	H	N	F	W	D
F	R	U	M	G	N	I	P	P	A	R	W	I	R	I	N	G	J	F	U
Y	W	E	I	K	M	U	I	G	F	K	B	H	R	T	T	B	I	E	T
X	V	F	A	C	V	H	K	Q	X	K	A	H	X	O	R	C	M	N	N
B	J	X	Q	J	J	M	P	B	Y	D	S	M	I	U	L	I	A	Q	A

ACTIVE
AHA MOMENT
ATTENTION
AXON
BRAIN
CELL BODY
CHAMPION
CRAMMING
DECISION
ELECTRIC
FATTY
FIGURE
FMRI
GLIAL
GLUE
HIPPOCAMPUS
IN THE ZONE
INFORMATION
INSULATION
MEMORY
MESSENGER
MYSTERY
NEURON
NIGHT
NOGGIN
PREFRONTAL CORTEX
QUIZ
REVERSE
SLEEP
STIMULATION
STRONGER
WIRING
WRAPPING

neuron (nerve cell) where its nucleus is located.

cortex The outermost layer of neural tissue of the brain.

fMRI (short for functional magnetic resonance imaging) A special type of machine used to study brain activity. It uses a strong magnetic field to monitor blood flow in the brain. Tracking the movement of blood can tell researchers which brain regions are active.

glia Non-nerve cells, these make up 85 percent of the cells in the brain. Some glial cells wrap around axons. This speeds the rate of neural signaling and helps to prevent confusing "cross-talk" between neighboring nerve cells.

hippocampus A seahorse-shaped region of the brain. It is thought to be the center of emotion, memory and the involuntary nervous system.

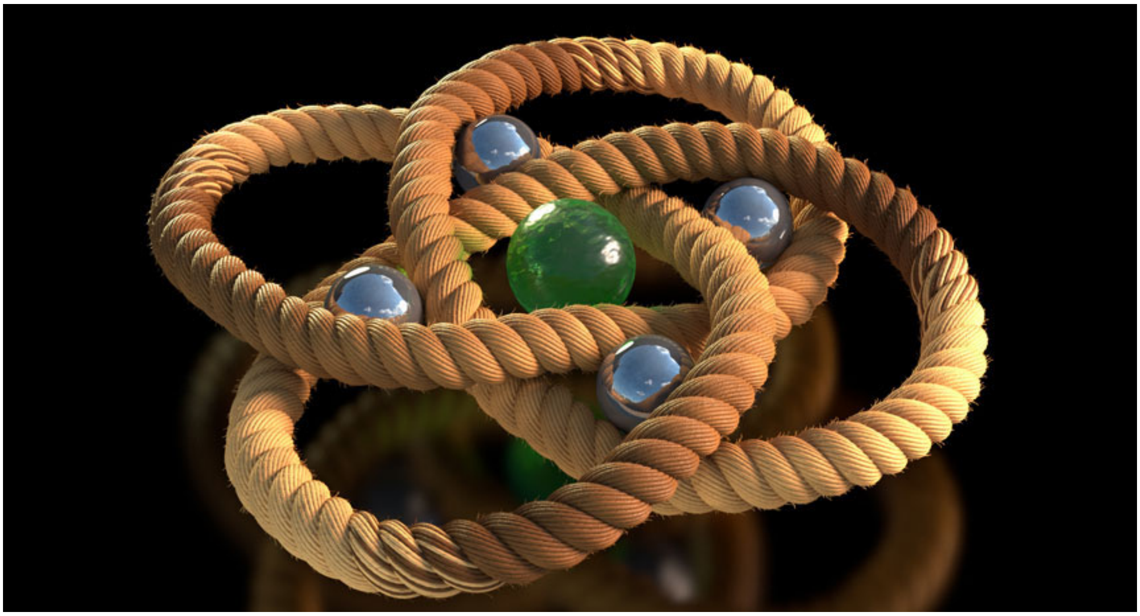
myelin (as inmyelin sheath) A layer of fatty cells, called glia, that wraps around nerve-cell axons. The myelin sheath insulates axons, speeding the rate at which signals speed down them. The addition of this sheath is a process known as myelination or myelinating.

neuron (or nerve cell) Any of the impulse-conducting cells that make up the brain, spinal column and nervous system. These specialized cells transmit information to other neurons in the form of electrical signals.

neuroscience Science that deals with the structure or function of the brain and other parts of the nervous system. Researchers in this field are known as neuroscientists.

PET (short for positron emission tomography) A technology that uses radiation to create three-dimensional images of the inside of the body. The individual receives a radioactive "tracer" chemical in the blood that shows up during the scan. As the tracer moves through the body, it will accumulate in certain organs. This allows researchers and doctors to see create X-ray-like details of those organs.

prefrontal cortex A region containing some of the brain's gray matter. Located behind the forehead, it plays a role in making decisions and other complex mental activities, in emotions and in behaviors



molecular knot

WOVEN TOGETHER A new molecular knot (representation shown) is the most complex one ever described. It forms a triple braid, with iron ions (silvery-blue) and a chloride ion (green) guiding the formation.

STUART JANTZEN/BIOCINEMATICS.COM

NEWS

CHEMISTRY,MATERIALS

New molecular knot is most complex yet

Crisscrossing braid of atoms has 'astonishing amount of symmetry'

BY MEGHAN ROSEN 2:00PM, JANUARY 12, 2017

One hundred and ninety-two atoms have tied the knot.

Chains of carbon, hydrogen, oxygen and nitrogen atoms, woven together in a triple braid, form the most complex molecular knot ever described, chemists from the University of Manchester in England report in the Jan. 13 Science.

Learning how to tie such knots could one day help researchers weave molecular fabrics with all sorts of snazzy properties. "We might get the strength of Kevlar with a lighter and more flexible material," says study coauthor David Leigh.

That's still a long way away, but molecular knot tying has an appeal that's purely intellectual, too, says University of Cambridge chemist Jeremy Sanders. "It's like the answer to why you climb Everest," he says. "It's a challenge."

Mathematicians know of more than six billion types of prime knots, which, like prime numbers, cannot be broken down into simpler components. "Prime knots can't be built up by sticking other knots together," Leigh explains. For years, chemists were able to synthesize just one type of prime knot out of small molecules. "We thought that was pretty ridiculous," says Leigh.

That molecular knot was a trefoil, like a three-leaf clover. Jean-Pierre Sauvage and colleagues wove it from chemical strands in 1989. Sauvage won a Nobel Prize in 2016 for earlier work that used the same principles explored in his knots (SN: 10/29/16, p. 6).

In the decades since Sauvage's trefoil, chemists have tried to synthesize other types of molecular knots, but "they've always found it incredibly difficult," says chemist Sophie Jackson, also at the University of Cambridge.

Persuading nanoscale strands to interlock together in an orderly fashion isn't simple. "You can't just grab the ends and tie them like you would a shoelace," Leigh says. Instead, scientists choose molecular ingredients that assemble themselves.

In 2012, Leigh and colleagues used the self-assembly technique to make a molecular pentafoil knot, a star-shaped structure made up of 160 atoms and with strands that cross five times (SN: 1/28/12, p. 12). This latest knot, with eight crossing points, is even more intricate.

Leigh's team mixed together building blocks containing carbon, hydrogen, oxygen and nitrogen atoms with iron ions and chloride ions. "You dump them all in, heat them all up and they self-assemble," he says. Sticky metal ions hold the building blocks in the correct position, and a single chloride ion sitting in the middle of the structure anchors it all together. Then, a chemical catalyst links the building blocks, forming the completed knot. The new knot is the tightest ever created, Leigh says, with just 24 atoms between each crossing point.

It's beautiful, Sanders says. "It's a string of atoms rolled up in a spherical shape, with an astonishing amount of symmetry." Sanders is reluctant to speculate how such a knot might be used, but it's round and very dense, he says. That could give it some interesting materials properties.

Leigh suspects that different molecular knots might behave differently, like the various knots used by fishermen and sailors. "We want to make specific knots, see what they do and then figure out how to best exploit that," he says.

ALL TIED UP The most complex molecular knot synthesized by chemists (X-ray crystal structure shown) is formed by linking atoms of carbon, hydrogen, oxygen and nitrogen. A single chloride ion (green sphere in center) and four iron ions (purple spheres) help the knot form, but can later be washed away.

WEATHER & CLIMATE EARTH

Massive ice shelf is poised to break off of Antarctica

Huge crack threatens to release an ice shelf as big as Delaware

THOMAS SUMNER

Antarctica ice

A 100-meter-wide, kilometers-long rift in Antarctica's Larsen C ice shelf could soon break off a 5,000-square-kilometer chunk of ice into the ocean, scientists warn.

JOHN SONNTAG/NASA

One of Antarctica's largest ice shelves is nearing its breaking point, scientists warn. A colossal crack in this ice shelf, known as Larsen C, abruptly grew by 18 kilometers (11 miles) during the second half of December 2016. (That was the height of the region's summer.) Members of Project MIDAS, an Antarctic research group, reported the crack's dramatic growth on January 5. This separating ice is now only about 20 kilometers from Larsen C's edge.

Explainer: Ice sheets and glaciers

Satellite images in 2014 revealed that a crack in Larsen C rapidly extended across the ice shelf. If the crack reaches the ice shelf's edge, it could snap off a Delaware-sized area of ice, researchers reported roughly 18 months ago in The Cryosphere. Such a loss would reduce Larsen C's size by about 10 percent. That's enough to shrink the shelf to its smallest size in recorded history. And it could potentially kick start the shelf's disintegration.

Daniela Jansen is a glaciologist at the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Germany. She led the 2015 study. At that time, she had expected the crack might chip apart Larsen C within five years. "We should keep a close eye on Larsen C," she had argued. "It might not be there for so much longer."

Larsen C covers about 55,000 square kilometers (21,000 square miles). That makes it the largest ice shelf along the Antarctic Peninsula. Since Larsen C's ice already floats in the ocean, the big break-off won't immediately raise global sea levels. But if the shelf collapses, then glacial ice could flow into the sea unabated and contribute to rising sea levels. This is what happened to Larsen B in 2002.

xplainer: How scientists know Earth is warming

The scientists can't say for certain when Larsen C will break off. But they think it could be soon.

Usually, researchers camp on the shelf during the Antarctic summer to conduct their science. But this year, the British Antarctic Survey announced it would halt this practice. Scientists will still be allowed access to the area. But they will be restricted to day trips only — with rescue aircraft waiting nearby.

Power Words

(for more about Power Words, click here)

Antarctica A continent mostly covered in ice, which sits in the southernmost part of the world.

marine Having to do with the ocean world or environment.

satellite A moon orbiting a planet or a vehicle or other manufactured object that orbits some celestial body in space.

sea An ocean (or region that is part of an ocean). Unlike lakes and streams, seawater — or ocean water — is salty.

sea level The overall level of the ocean over the entire globe when all tides and other short-term changes are averaged out.