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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ AUGUST 3, 2019

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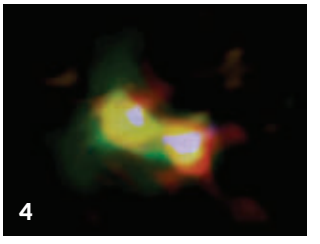

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Departments

COVER Gears are one of the many machine components that experience wear and tear because of friction. *Laszlo Podor/Getty*

FROM TOP: COSMAA/ISTOCK/GETTY IMAGES PLUS; T. HASHIMOTO *ET AL.*, HUBBLE SPACE TELESCOPE/NASA AND ESA, ALMA/ESO, NAOJ, NRAO; BRIAN LAPOINTE/HARBOR BRANCH OCEANOGRAPHIC INST./FLORIDA ATLANTIC UNIV.

You're only as old as you perceive yourself to be

Aging is inevitable, but the health declines that appear to be part of the package may not be, according to provocative research about how our attitudes about aging influence our physical health (see Page 22).

It's no surprise that the negative stereotypes about growing older that are pervasive in many societies could make people feel worse about themselves; the pioneering gerontologist Robert N. Butler coined the term "ageism" way back in the 1960s. And we know that being called a decrepit geezer can't be good for anybody's sense of self. Surely I'm not the only person who cringes when I see the word "elderly" applied to people in their 60s. A little Googling reveals that Oprah Winfrey is 65, Richard Gere turns 70 this month and Helen Mirren is 74. If this is what elderly looks like, it's time to rewrite the definition.

A growing body of research suggests that a psychological technique called subliminal priming might actually improve the physical health and mental performance of older people, perhaps by overriding negative perceptions of aging. Those are the kind of findings that make us congenital skeptics here at *Science News* think, hmm, interesting if true. Fortunately, we knew just the science journalist to tell us what's going on here: Robin Marantz Henig, an award-winning science writer and contributing writer for the *New York Times Magazine*. She's been fascinated by aging and social attitudes since she was young; her first book, written when she was 27, is titled *The Myth of Senility*.

Henig now has two young granddaughters, which has her thinking about how older women are perceived from a different perspective. "Inside we're the same as we always were," she told me. But on the outside, "you become the character that you've resisted for such a long time ... this terrible negative image."

If you met Henig, I think you'd agree with me that she's about as hip and youthful as a grandmother can be. So it's surprising to hear that she struggles against those stereotypes, too. She does think that ageism isn't quite as bad as it was in past generations, partly the result of baby boomers' insistence on redefining whatever stage they're in. "But I don't want to be too glib about it; it's complicated," she says. And the impact goes far beyond self-perception. *ProPublica* and the Urban Institute reported late last year that more than half of workers over 50 are pushed out of jobs before they would have chosen to retire. The financial consequences can be devastating, but it happens, more than 50 years after age-related job discrimination was made illegal in the United States.

The subliminal technique that the researchers used to change people's perception of aging remains controversial (*SN: 5/19/12, p. 26*), and the benefits the studies found are modest. But Henig says that knowing that it may be possible to counter what often feels inevitable helps motivate her to better manage her own aging. She's now following the lead of Lauren Carstensen at the Stanford Center for Longevity: "When my knees ache," Henig says, "I'm trying really hard to focus on fixing it rather than just living with it."

—Nancy Shute, Editor in Chief

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Excerpt from the July 19, 1969 issue of *Science News*

50 YEARS AGO

Thalidomide helps severe cases

The drug that was banned because of its crippling effect on babies when taken as a tranquilizer and sleeping pill by pregnant women is being studied for its use in Hansen's disease, or leprosy. Thalidomide has been tried on 22 leprosy patients ... on an experimental basis with the permission of the U.S. Food and Drug Administration.... The primary action is to halt or prevent acute reactions such as fever and skin lesions.

UPDATE: The FDA approved thalidomide for leprous skin lesions in limited cases in 1975. Related drugs were approved after 2005 also to help control the immune system and calm inflammation. These drugs also treat psoriasis, arthritis and the blood cancer multiple myeloma. Birth defects remain a risk, so use of thalidomide and its analogs is controlled in the United States. But lax oversight elsewhere means thalidomide is still misused. In Brazil, nearly 200 children born from 2005 to 2010 may have been disabled by the drug, a 2015 study found. The World Health Organization discourages thalidomide use for leprosy.

Adolescents caught in the U.S. justice system can be subject to conditions that interfere with brain development.

ZODEBALA/ISTOCK/GETTY IMAGES PLUS

SOAPBOX

U.S. justice system may damage teenagers' brains

A teenager's brain does not magically mature into its reasoned, adult form on his or her 18th birthday. Aspects of brain development stretch into a person's 20s, a protracted fine-tuning with serious implications for youths caught in the U.S. justice system, argues cognitive neuroscientist B.J. Casey of Yale University.

In the May 22 *Neuron*, Casey describes the case of Kalief Browder, sent at age 16 to Rikers Island correctional facility in New York City after being accused of stealing a backpack. Unable to come up with the $3,000 bail, Browder spent three years behind bars before his case was dropped. About two-thirds of that time was spent in solitary confinement — "a terrible place for a child to have to grow up," Casey says.

Two years after his 2013 release, Browder died from suicide.

For Casey, the case highlights how the criminal justice system — with the violence, stress and isolation (*SN: 12/8/18, p. 11*) that come with being incarcerated — can interfere with adolescent brain development. Recent stories of immigrant children separated from their families and held in detention centers have raised similar concerns (*SN Online: 6/20/18*).

Human brain-imaging studies and experiments with lab animals show that chronic stress and other assaults "impact the very brain circuitry that is changing so radically during adolescence," Casey says. An abundance of science says the way the justice system is "treating our young people is not the way to a healthy development."

The United States holds about 53,000 youths under age 18 in jails, prisons or other facilities. Some states allow children to be tried as adults for some crimes, so many young people are judged by laws designed for the more mature.

In brain development, the boundary between childhood and adulthood is fuzzy. Some abilities, such as being able to remember a string of numbers or think of words starting with a certain letter, are developed by age 18. Other skills, such as resisting peer pressure, avoiding risks and making good decisions under stress, are still developing in people's 20s.

> Skills such as resisting peer pressure and avoiding risks are still developing in people's 20s.

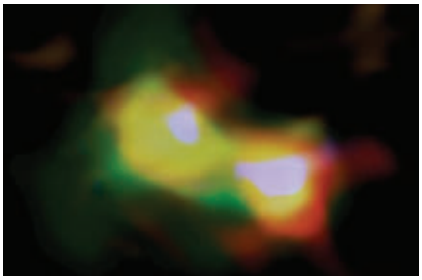
This ongoing brain development can become obvious in interactions with law enforcement. Youths don't always understand their rights, Casey says. Some will run away or say the wrong thing when cornered. "Kids are reactive under threat," she says.

Young people should face "a diminished accountability" for their actions, Casey suggests. States such as California and Nebraska, for example, have created young-adult courts that focus on rehabilitation. "Working together, we may be able to save young people like Kalief from the injustices that too often occur within the confines of our justice system," Casey writes. — *Laura Sanders*

THE –EST

Galaxies were merging soon after the Big Bang

Galaxy mergers helped make clumps of stars into the elegant spirals seen in the modern universe. Our own Milky Way has eaten some of its smaller neighbors (*SN: 11/24/18, p. 8*) and is expected to collide with the Andromeda galaxy in some 4 billion years (*SN: 7/14/12, p. 10*).



Galaxy B14-65666 is actually two galaxies merging, combining dust (red), oxygen (green), carbon (blue) and stars (white).

It's not clear when such mergers began, but scientists now confirm that the earliest to be detected happened when the universe was just 760 million years old. Hubble telescope images of galaxy B14-65666 suggested in 2016 that the butterfly-shaped object nearly 13 billion light-years from Earth is really two galaxies mid-merge.

That's now supported by observations showing the object's gas also split into two blobs that overlap with the galaxies' star clumps. The blobs are each moving at different speeds, another hint pointing to a galaxy merger, researchers report online June 17 in *Publications of the Astronomical Society of Japan*.

The merger triggered a burst of star formation, with the galaxies' combined gas making the equivalent of about 200 solar-mass stars per year, more than 100 times as many stars as the Milky Way makes. — *Lisa Grossman*

RETHINK

Calluses don't make feet any less sensitive

The tender feet of the shoe-clad are no better at sensing the ground than the callused soles of the barefoot.

Calluses, skin thickened by rubbing against other surfaces, would seem to offer protection at the expense of sensitivity. But that isn't what Harvard University human evolutionary biologist Daniel Lieberman has experienced when he runs barefoot in summer.

As Lieberman's calluses got thicker, "it [didn't] hurt as much to run — I could step on acorns and other things," he says. "But I never felt like I lost sensory perception."

To explore this, Lieberman's research group and colleagues in Germany and Africa measured the thickness of calluses on the feet of 81 adults in western Kenya. The participants, a mix of city and country dwellers, ranged from full-time shoe wearers to those who were usually or always barefoot.

The researchers measured how sensitive participants' soles were with a small device that applied pressure to the skin. When participants felt a poke from the device, they pressed a button. The results of the experiment failed to find a relationship between increased callus thickness and reduced foot sensitivity, the researchers report online June 26 in *Nature*.

"People who had thicker calluses had no loss of sensitivity," Lieberman says. Given that early humans were always barefoot, it makes sense that "calluses didn't exert a cost in terms of our ability to sense the ground underneath us." — *Aimee Cunningham*

Calluses (right) protect skin, but the foot stays as sensitive as an uncallused foot (left).

HOW BIZARRE

Cicadas are drugged by fungi to mate nonstop

SAN FRANCISCO — A cicada-infecting fungus produces drugs that make the insects literally mate their butts off.

Massospora fungi make one of the two drugs: either a psychedelic compound found in hallucinogenic mushrooms, or an amphetamine found in khat leaves, plant pathologist Matthew Kasson of West Virginia University in Morgantown reported June 22 at the ASM Microbe 2019 meeting.

The fungi may use psilocybin, which causes people to hallucinate, or the amphetamine cathinone to suppress cicadas' appetites and keep the insects mating even after they lose big chunks of their bodies. *Massospora* fungi are transmitted sexually from cicada to cicada. Huge plugs of fungi form on the insects' abdomens (white in photo above), and during mating, parts of the abdomens may break away, Kasson says. Losing body parts would surely slow most organisms down, and yet for the fungus-infected cicadas, "two-thirds of their body might be missing, and they would be whistling as they walk down the street," he says. Infected insects mate nearly nonstop, spreading the fungi to partners, he and colleagues report in the October *Fungal Ecology*.

The team found the two psychoactive compounds among 1,176 molecules identified in infected cicadas. The researchers aren't sure how the fungi produce the drugs, which in other organisms require enzymes that seem to be missing in *Massospora*. The team is also trying to determine how the other molecules might influence cicada behavior. — *Tina Hesman Saey*

CLOCKWISE FROM TOP LEFT: T. HASHIMOTO *ET AL*, HUBBLE SPACE TELESCOPE/NASA AND ESA, ALMA/ESO, NAOJ, NRAO; M. KASSON; D. LIEBERMAN

HUMANS & SOCIETY

Skull hints at early foray out of Africa

Greek find may be the oldest known human fossil in Eurasia

BY BRUCE BOWER

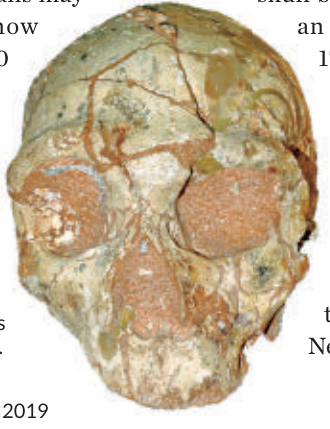
A skull found in a cliffside cave on Greece's southern coast in 1978 represents the oldest *Homo sapiens* fossil outside of Africa, scientists say.

That skull, from someone who lived at least 210,000 years ago, was encased in rock that also held a Neandertal skull dating to at least 170,000 years ago, paleoanthropologist Katerina Harvati of the University of Tübingen in Germany and colleagues contend.

If these findings, reported online July 10 in *Nature*, hold up, the ancient Greek *H. sapiens* skull is more than 160,000 years older than the next oldest European *H. sapiens* fossils (*SN Online: 11/2/11*). It's also older than a proposed *H. sapiens* jaw that was found at Israel's Misliya Cave. That jaw dates to between about 194,000 and 177,000 years ago (*SN: 2/17/18, p. 6*).

"Multiple *Homo sapiens* populations dispersed out of Africa starting much earlier, and reaching much farther into Europe, than previously thought," Harvati said at a July 8 news conference. African *H. sapiens* originated roughly 300,000 years ago (*SN: 7/8/17, p. 6*).

A small group of humans may have reached what's now Greece more than 200,000 years ago, she suggested. Neandertals who settled in southeastern Europe not long after that may have replaced that first *H. sapiens* group. Humans arriving in Mediterranean Europe tens of thousands of years later would eventually have replaced resident Neandertals, who died out about 40,000 years ago.



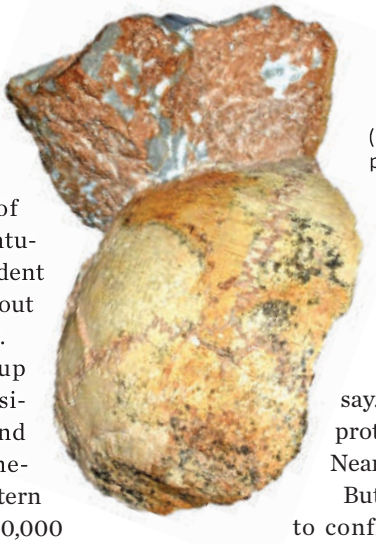
Another skull found in the Greek cave sported a heavy brow ridge and other features characteristic of Neandertals.

But Harvati's group can't exclude the possibility that humans and Neandertals simultaneously lived in southeastern Europe more than 200,000 years ago and sometimes interbred. A 2017 analysis of ancient and modern DNA concluded that humans probably mated with European Neandertals at that time.

The two skulls were held in a small section of cave wall that had washed into Greece's Apidima Cave from higher cliff sediment and then solidified roughly 150,000 years ago. Since one skull is older than the other, each must originally have been deposited in different sediment layers before ending up about 30 centimeters apart on the cave wall, the researchers say.

Earlier studies indicated that one skull, which retains the face and much of the braincase, was a Neandertal that lived at least 160,000 years ago. But fossilization and sediment pressures had distorted the skull's shape. Based on four 3-D digital reconstructions of the specimen, Harvati's team concluded that its heavy brow ridges, sloping face and other features resembled Neandertal skulls more than ancient and modern human skulls. An analysis of the decay rate of radioactive forms of uranium in skull bone fragments produced an age estimate of at least 170,000 years.

A second Apidima fossil, also dated using uranium analyses, consists of the back of a slightly distorted braincase. Digital reconstruction revealed a rounded shape characteristic of *H. sapiens*, not Neandertals, the researchers say. A bunlike bulge often protrudes from the back of Neandertal skulls.



The rounded braincase (bottom section) seen in this partial skull found in Greece pegs the fossil as a *Homo sapiens*, researchers claim. Dating of the fossil suggests that humans were present in southeastern Europe more than 200,000 years ago.

But without facial remains to confirm the species identity of the partial braincase, "it is still possible that both Apidima skulls are Neandertals," says paleoanthropologist Israel Hershkovitz of Tel Aviv University. He led the team that discovered the Misliya jaw and assigned it to *H. sapiens*.

Harvati's team will try to extract DNA and species-distinguishing proteins from the Greek skulls to determine their evolutionary identities and to look for signs of interbreeding between humans and Neandertals.

The find does little to resolve competing explanations of how ancient humans made their way out of Africa. Harvati's suggestion that humans trekked from Africa to Eurasia several times starting more than 200,000 years ago is plausible, paleoanthropologist Eric Delson of City University of New York's Lehman College writes in a related commentary in *Nature*. And the idea that some *H. sapiens* newcomers gave way to Neandertals probably also applied to humans who reached Misliya Cave and nearby Middle Eastern sites as late as around 90,000 years ago, before Neandertals occupied the area by 60,000 years ago, Delson says.

Hershkovitz disagrees. He contends that ancient humans and Neandertals lived side by side in the Middle East for 100,000 years or more and occasionally interbred. Misliya Cave sediment bearing stone tools dates to as early as 274,000 years ago, Hershkovitz says. Since only *H. sapiens* remains have been found in the Israeli cave, ancient humans probably made those stone artifacts and could have been forerunners of the Greek *H. sapiens*. ■

BOTH: K. HARVATI/EBERHARD KARLS UNIV. OF TÜBINGEN

EARTH & ENVIRONMENT

World is on track to miss warming goal

Emissions from current infrastructure threaten 1.5 degree target

BY CAROLYN WILKE

A study shows just how hard it may be to limit global warming to 1.5 degrees Celsius over preindustrial times.

The world's existing power plants, industrial equipment, vehicles and other carbon dioxide emitters could pump out enough CO_2 by midcentury to blow past that target, researchers report online July 1 in *Nature*. Add in the fossil fuel power plants that are planned, permitted or under construction for the future, and the threshold for raising average global atmospheric temperatures by 1.5 degrees could be reached by 2033.

To limit warming to 1.5 degrees, "we cannot invest more in fossil fuel power or infrastructure," says Thorsten Mauritsen, a physical climate scientist at Stockholm University who was not involved in the study. "Everything we do from now has to change direction and not use fossil fuels."

In the 2015 Paris climate agreement, nearly all the world's nations agreed to try to reduce greenhouse gas emissions to limit warming to "well below" 2 degrees by 2100. (The United States has said it would pull out of the agreement, though the exit wouldn't be complete until 2020.) Since the Paris agreement, calls have increased for the more ambitious goal of keeping warming to 1.5 degrees. That would mean fewer heat waves, spells of extreme weather and species extinctions (*SN: 10/27/18, p. 7*).

Human activity already has increased global temperatures by 1 degree. The Intergovernmental Panel on Climate Change has also warned that adding another 420 to 580 gigatons of CO_2 to the atmosphere could be enough to blow past 1.5 degrees of warming. Current infrastructure could emit that much CO_2 by 2046, if not earlier, the researchers found.

Existing infrastructure, over its expected lifetime, would emit about 658 gigatons of CO_2, say Steven Davis, an earth systems scientist at the University of California, Irvine, and his colleagues. About 41 percent of those emissions would come from China, 9 percent from the United States and 7 percent from the European Union.

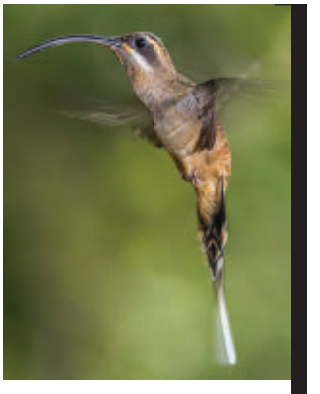
Expected global emissions rise to about 850 gigatons when future power plants are included. That's enough to hit the 1.5 degree budget by 2033, and makes up roughly two-thirds of the CO_2 needed to reach 2 degrees.

"This analysis ... lends some concrete context to what a 1.5 degree target would mean," Davis says. "These targets that get bandied about are very ambitious," and will require more than incremental emissions reductions, he says.

The study updates a 2010 census of CO_2-emitting infrastructure to include known CO_2 sources at the end of 2018, including power plants and industrial emitters, such as cement kilns, as well as transportation sources such as airplanes and vehicles. The update accounts for shifts in greenhouse gas emissions caused by things such as the U.S. natural gas boom and China's burgeoning economy. The resulting calculation is how much CO_2 is "committed" to be created, unless policy or technology triggers change.

The work does not consider other sectors, for instance agriculture, which contributes methane, a potent greenhouse gas, says climate scientist Joeri Rogelj of Imperial College London. Still, he says, the results are a wake-up call.

"This should not be seen as a fatalistic prediction of what will happen," Rogelj says. It's a "call to ensure that we make choices that reduce the carbon impact of what is currently in the pipeline." ■



FROM LEFT: M. EDA; MATS LINDBERG/ALAMY STOCK PHOTO

HUMANS & SOCIETY

Nazca lines record exotic creatures

Massive drawings of birds etched on southern Peru's Nazca desert plateau include exotic surprises. Several images depict species that live far outside the region where the drawings were created some 2,400 to 1,300 years ago, zooarchaeologist Masaki Eda of Hokkaido University Museum in Japan and colleagues conclude. A drawing (above left) previously classified as a hummingbird actually represents a related species, a long-tailed hermit (above right), Eda's group reports online June 20 in the *Journal of Archaeological Science: Reports*. These hermits, which live in rainforests, have long, pointed tails, as in the drawing; the desert region's hummingbirds have forked or fan-shaped tails. Another drawing previously classified as a duckling instead portrays a baby parrot, the scientists suspect. Like hermits, most parrots in Peru inhabit rainforests. Two other drawings depict pelicans that live along Peru's Pacific coast, the scientists say. It's unclear why birds from distant locales were portrayed on the dry plateau. — *Bruce Bower*

LIFE & EVOLUTION

Diversity of insect eggs explained

Where laying occurs appears to influence size and shape

BY YAO-HUA LAW

Look at the nail of your pinky finger. That's about the width of the biggest known insect egg, belonging to an earth-borer beetle. The smallest known egg, from a parasitoid wasp, is half the width of the thinnest recorded human hair.

Insect eggs range across eight orders of magnitude in size and come in a variety of shapes, a new database of almost 10,500 descriptions of eggs from about 6,700 species shows. The team behind the database, described online July 3 in *Scientific Data*, thinks it has figured out one reason why. Where insects lay their eggs — for example, in water or in the bodies of other critters — helps to explain some of the diversity that has evolved, the team reports in the July 4 *Nature*.

To compile the database, the team developed computer programs that extracted egg measurements from text and photos in 1,756 digitized publications and then used the measurements to estimate egg sizes and shapes. Representatives of more than 500 families from all insect orders were included.

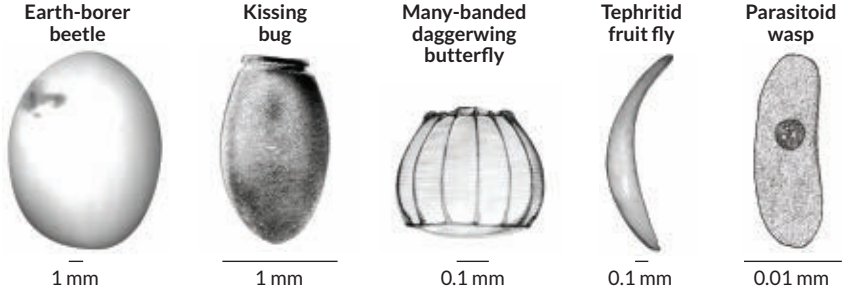
Analyzing the egg data revealed astounding diversity. Still, within that variety, many insect groups have converged upon similar egg shapes, such as spherical or elongated, says evolutionary biologist Samuel Church of Harvard University.

Scientists previously had proposed reasons for those similarities; larger eggs, for example, might be more elongated because it's easier for females to lay them. But using statistical and evolutionary tree analyses, Church and colleagues found no support for that idea. Even the seemingly straightforward hypothesis that larger eggs would go along with larger adult body sizes was rejected for many species.

Instead, an egg's size and form are best explained by where it is laid, the team says. Eggs laid in or on water tend to be smaller and rounder; those laid inside another animal tend to be smaller and asymmetrical, with one end coming to more of a point than the other. Eggs laid in soil or leaf litter tend to be larger. The researchers have yet to determine exactly how such environments might have influenced the evolution of size and shape.

"The level of technical rigor [in these publications] is extremely high, and they did everything carefully and thoughtfully" to construct the database, says entomologist Jay Rosenheim of the University of California, Davis. The team might have applied "unduly stringent criterion" for rejecting some hypotheses, he says. Rosenheim sees in the data "a general pattern that egg size increases with body size in all of the taxa," though the correlation isn't always statistically significant.

Church says that he is "convinced that the patterns we have described are broad patterns," but he emphasizes that an egg's form is probably explained by more than just its immediate environment. ■



All shapes and sizes These drawings represent the size range of insect eggs. The largest egg (left) is about 700 million times as big as the smallest egg (right).

EARTH & ENVIRONMENT

Seaweed bloom sets new record

Satellite data reveal uptick in *Sargassum* algae since 2011

BY CAROLYN GRAMLING

Every year, vast, floating islands of *Sargassum* seaweed can blanket entire parts of the tropical Atlantic Ocean. The seaweed reached its largest extent on record in June 2018, forming a brown belt that extended from Africa's west coast into the Gulf of Mexico. At least 20 million metric tons of *Sargassum* made up the belt, the largest seaweed bloom ever detected, researchers say.

Satellite data over the last 19 years reveal a sudden, dramatic increase in the mats' extent in summer 2011, which has recurred almost every year since, the scientists report in the July 5 *Science*.

These annual massive mats, which the researchers dub the great Atlantic *Sargassum* belt, have been fueled in part by increasing nutrients pouring into the ocean from the Amazon River, the study suggests. Forests can filter and regulate the flow of water from land to ocean. But with increasing fertilizer use and deforestation anticipated in the future along the Amazon's tributaries, such colossal blooms may become the new norm.

The floating algae islands can provide shelter for turtles, fish, crabs, eels and other marine species. But there can be too much of a good thing. *Sargassum* mats can smother corals and seagrass and wreak havoc on coastlines when heavy, meters-thick layers wash up on beaches and rot.

To track the waxing and waning of the *Sargassum*, researchers led by optical oceanographer Mengqiu Wang of the University of South Florida in Tampa used data from satellite instruments that scan the ocean in visible and infrared light. *Sargassum* seaweed, like photosynthesizing plants, contains abundant chlorophyll-a. That pigment pings brightly at infrared wavelengths, creating a sharp and easily detectable

contrast to the darker water beneath.

From 2000 to 2010, there was little of the seaweed in the central Atlantic, with the occasional patch near the mouth of the Amazon River in summer and fall. But a tipping point occurred in 2011, when the line of seaweed suddenly and dramatically extended all the way across the ocean.

That change "was really surprising," says James Gower, an optical oceanographer at Fisheries and Oceans Canada in North Saanich, who coauthored a commentary in the same issue of *Science*.

Each year since, except 2013, the seaweed formed a similar vast belt. In 2018, that belt was the largest and densest yet, weighing in at about four times the heft of the Great Pyramid of Giza.

Two sources of nutrients appear to feed the blooms: discharge from the Amazon River and upwelling along western Africa. Upwelling — in which strong prevailing winds push surface waters aside, allowing nutrient-rich deeper waters to rise — occurs there naturally due to the interaction of winds, ocean and Earth's rotation.

Sargassum seaweed (shown off Florida) can form vast mats in the Atlantic Ocean.

How those nutrients will change in the future is uncertain. There's a lot that scientists still don't know about the sources of those nutrients, as well as how climate change will affect the seaweed's life cycle. Nutrients carried on dust blown into the ocean from the Sahara, as well as inputs from Africa's Congo River, may also have a role. Particularly warm sea-surface temperatures, such as occurred in 2013, appear to suppress the algae's growth, the team notes. That casts some doubt on the fate of the blooms in a warming world.

Having a global eye on the seaweed has been key to assessing the sudden growth. Even higher-resolution satellite data could help researchers better track the movement of the algae and suss out what's really causing the blooms, Gower says. ■

LIFE & EVOLUTION

Zebrafish offer clues to sleep's origins

Basic features of slumber may go back 450 million years

BY TINA HESMAN SAEY

No one should have to sleep *with* the fishes, but new research on zebrafish suggests that we sleep *like* them.

Sleeping zebrafish have brain activity similar to mammals' deep slow-wave sleep and rapid eye movement, or REM, sleep, researchers report in the July 11 *Nature*.

The findings suggest the basics of sleep evolved at least 450 million years ago in zebrafish ancestors, before the origin of animals that give birth to live young. That's 150 million years earlier than previously thought (*SN: 5/28/16, p. 9*).

"These signatures [of sleep] really have important functions — even though we may not know what they are — that have survived hundreds of millions of years of evolution," says Louis C. Leung, a neuroscientist at Stanford University School of Medicine.

In mammals, birds and lizards, sleep has stages characterized by specific electrical signals. During slow-wave sleep, the brain is mostly quiet except for synchronized waves of electrical activity. The heart rate decreases and muscles relax. During REM sleep, the brain lights up with activity, but the muscles are paralyzed (except for rapid eye twitching), and the heart beats erratically.

Scientists had known that fruit flies, nematodes, octopuses and other creatures have rest periods reminiscent of sleep. But no one could measure the electrical brain activity of those animals to see if that rest follows the familiar snoozing pattern.

Leung's group developed a system to do just that by genetically engineering zebrafish to make a fluorescent molecule that lights up when it encounters calcium, which is released when nerve cells and muscles are active. By following the flashes using a microscope, the team tracked brain and muscle activity in naturally transparent zebrafish larvae.

Sleeping fish had two types of brain activity. One similar to slow-wave sleep was characterized by short bursts of activity in some nerve cells in the brain. The researchers call this slow-bursting sleep. REM-like sleep, which the team dubbed propagating-wave sleep, was marked by frenzied brain activity that spread like a wave through the brain.

A group of cells that line hollow spaces called ventricles deep in the brain seems to trigger the REM-like activity. These ependymal cells dip fingerlike cilia into the cerebral spinal fluid that bathes the central nervous system. Cilia seem to beat faster as amounts of a sleep-promoting hormone in the fluid increases.

It's unclear how the ependymal cells communicate with the rest of the brain to set off REM-like activity. Mammals have these cells, but it's unknown whether they play a role in mammalian sleep.

Just as in mammals, zebrafish's whole bodies are affected by sleep. Muscles relax and the heart slows during the slow-wave–like sleep. During the REM-like sleep, the heart slows even more and loses its regular rhythm. And the fish's muscles go slack. That whole-body involvement solidifies the argument that the sleep of fish is similar to that of mammals, says neuroscientist Paul Shaw of Washington University School of Medicine in St. Louis. "Sleep is manifest everywhere" in the body. ■

BRIAN LAPOINTE/HARBOR BRANCH OCEANOGRAPHIC INST./FLORIDA ATLANTIC UNIV.

ATOM & COSMOS

Homes of lone fast radio bursts found

Massive galaxies suggest that FRBs have more than one source

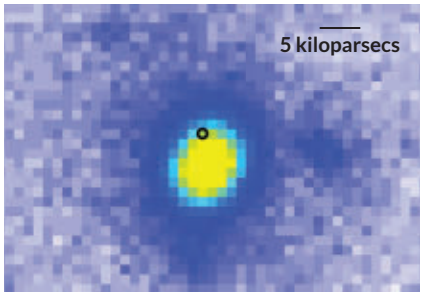
BY MARIA TEMMING

Astronomers have long wondered what triggers brief, brilliant blasts of radio waves from other galaxies. Now, observations suggest these events, fast radio bursts, or FRBs for short, may emanate from two completely different sources.

Scientists have now identified the home galaxies of two one-off FRBs. Until now, only the repeating FRB 121102 had been pegged to a galaxy — an active dwarf galaxy about 2.5 billion light-years away (*SN: 2/4/17, p. 10*). The lone FRBs hailed from more massive, tranquil hosts, two different research teams report.

"You have to be somewhat wary" about drawing broad conclusions from just two examples, says astrophysicist Duncan Lorimer of West Virginia University in Morgantown, who in 2007 helped find the first known FRB. He says the new findings offer compelling evidence that a one-and-done FRB is a different animal than an FRB that flickers on and off.

Astronomers spotted one of the new FRBs using the Australian Square Kilometer Array Pathfinder, 36 radio dishes in the Australian outback. By combining data using a technique called interferometry, the team pinpointed the FRB's location with much higher accuracy than possible with a single telescope.



A fast radio burst dubbed Tony (black circle) originated not from the active center of a galaxy (yellow) but from the outskirts.

The discovery was serendipitous. Scientists had spent two weeks scouting for FRBs, with no luck. "We were just about to give the telescope back," but the next person scheduled for telescope time called in sick, says astronomer Keith Bannister, an astronomer at Australia's Commonwealth Scientific and Industrial Research Organization in Sydney. So the team got an extra day and caught the 1.3-millisecond burst of radio waves. "In his honor, for being sick that day ... we called the FRB 'Tony,' " Bannister says.

Tony — officially FRB 18092 — hailed from the galaxy DES J214425.25–405400.81, about 4 billion light-years away in the constellation Grus, the team reports online June 27 in *Science*.

Compared with the repeating FRB's origin, "you couldn't think of two galaxies that are more different," Bannister says. FRB 121102, which flickers on and off at seemingly erratic intervals, is nestled in a dense, highly magnetized region near the center of a faint dwarf galaxy that is furiously forging new stars. Tony's home, however, sits on the edge of a galaxy about the size of the Milky Way that is undergoing little star formation.

At about 13,000 light-years from the galactic center, the position was surprising. Galaxy centers usually have a lot of energetic sources that could power an FRB, Bannister says. Tony "seems to come from the suburbs. Not a lot is happening out there, that we know of."

FRB 121102's rapid blinks have led to speculation that it's generated by a

MATTER & ENERGY

Claim made for metallic hydrogen

New result raises hopes for long-sought material

BY EMILY CONOVER

Physicists are crushing it — hydrogen, that is. Squeezing the chemical element to extremely high pressure transforms it into a metal, a trio of researchers claims.

The purported metallic hydrogen appeared at a pressure over 4 million times that of Earth's atmosphere, the team reports online June 13 at arXiv.org. If confirmed, the achievement would fulfill a long-standing quest to produce the elusive metal that scientists have speculated about since the 1930s.

The work has yet to undergo peer review. But it's "a very substantial step ahead" of previous work, says physicist Alexander Goncharov of the Carnegie Institution for Science in Washington, D.C., who was not involved with the study. "I think it's quite conclusive it is metallic."

Others are more skeptical. Physicist Eugene Gregoryanz of the University of Edinburgh says that he does not find the experiment convincing and notes that many previous claims of metallic hydrogen were proven wrong in the end.

Some aspects of the result disagree with previous measurements of hydrogen at high pressure, says Harvard University physicist Isaac Silvera. In 2017, he and colleagues reported spotting hydrogen turning into a metal, a claim Gregoryanz and others criticized (*SN: 2/18/17, p. 14*).

Physicist Paul Loubeyre of the French Alternative Energies and Atomic Energy Commission in Arpajon, a coauthor of the new study, did not respond to requests for comment.

Metallic hydrogen is particularly enticing to physicists because of predictions that it may be a superconductor, a material that allows electricity to flow without resistance. Unlike other known superconductors, which must be chilled to very low temperatures, metallic hydrogen might be a superconductor at room temperature. Scientists' eventual goal is to find a superconductor that requires neither cooling nor high pressure. If such materials are found, they could be integrated into electronics and save vast amounts of energy (*SN: 8/20/16, p. 18*).

Loubeyre and colleagues squeezed hydrogen gas between two diamonds. An improved setup, with diamonds etched

K.W. BANNISTER *ET AL*/*SCIENCE* 2019

rapidly rotating neutron star called a pulsar (*SN: 2/3/18, p. 6*). Given its intense environs, that neutron star could either be interacting with a black hole, or be an unusually magnetic form called a magnetar, says Sarah Burke-Spolaor, a West Virginia astrophysicist who helped track FRB 121102's origins. Tony's quiet home isn't a galaxy where you'd expect to find such energetic objects, she says.

That leaves scientists to wonder what could trigger a single-flash FRB. Lorimer thinks these FRBs might originate from neutron star mergers. But Burke-Spolaor says such mergers don't occur often enough to explain the dozens of radio bursts observed over the last decade.

Over the next few years, telescopes around the world are expected to provide a more comprehensive FRB census (*SN: 2/2/19, p. 12*). Already on the heels of Tony's discovery, another group reported finding a second lone FRB's home galaxy, using a telescope array in California. Like Tony, this FRB, reported online July 2 in *Nature*, emanated from a galaxy much more massive and much less active than FRB 121102's. Building up a rolodex of FRBs with known home addresses should "paint a clearer picture about what's going on," Burke-Spolaor says. ■

with a doughnut shape, allowed the researchers to reach higher pressures than previous experiments.

Using a powerful source of light called a synchrotron, the team sent infrared light through the diamonds and the squeezed hydrogen. As the physicists ratcheted up the pressure, the hydrogen suddenly became opaque to the light, a sign of a transition to a metal.

"It's the best experimental data to date on hydrogen in this pressure range," says physicist Russell Hemley of the University of Illinois at Chicago. It's unclear what the properties of the claimed metal are, such as whether it is superconducting. But the result adds to the complexities of hydrogen that scientists have already uncovered, Hemley says. "It's part of this developing story about the nature of hydrogen at high pressure." ■

ATOM & COSMOS

Highest-energy light detected

Nebula shoots photons at over 100 trillion electron volts

BY EMILY CONOVER

Physicists have spotted the highest-energy light ever seen. The light — gamma rays — came from the Crab Nebula, a remnant of a star explosion, about 6,500 light-years away in the Milky Way. The Tibet AS-gamma experiment caught particles of the light, or photons, with energies higher than 100 trillion electron volts, researchers report in an upcoming *Physical Review Letters*. (Visible light has just a few electron volts of energy.)

Although scientists have searched for photons at these energies before, they hadn't succeeded, says astrophysicist Petra Huentemeyer of Michigan Technological University in Houghton. "It's an exciting time," she says.

Supernova remnants and other cosmic accelerators can boost subatomic particles to energies much higher than those achieved in earthly particle accelerators. Protons in the Large Hadron Collider, for example, reach 6.5 trillion electron volts, or TeV. Somehow, cosmic accelerators outperform humans' most advanced machines.

In the Crab Nebula, the initial explosion set up conditions for acceleration, with magnetic fields and shock waves plowing through space, giving an energy boost to charged particles such as electrons. Low-energy photons in the vicinity got kicked to high energies in collisions with speedy electrons.

When a high-energy photon reaches Earth's atmosphere, it creates a shower of other subatomic particles. To capture that deluge, Tibet AS-gamma uses nearly 600 particle detectors spread across an area of more than 65,000 square meters in Tibet. From the data recorded by the detectors, researchers can calculate the energy of the initial photon.

Spacefaring particles called cosmic rays, mainly made of protons and atomic nuclei, also create particle showers. To weed out those showers, the team used detectors that look for muons, heavier relatives of electrons that form in cosmic ray showers but not photon-initiated ones.

Previous experiments glimpsed photons with nearly 100 TeV. The team found 24 potential photon-initiated showers above 100 TeV, some as high as 450 TeV. Because the weeding out process isn't perfect, the researchers estimate that maybe six of those showers could be from cosmic rays.

Researchers with Tibet AS-gamma declined to comment.

Looking for high-energy photons could help reveal how the particles are accelerated. "There has to be a limit to how high the energy of the photons can go," says David Hanna, a physicist at McGill University in Montreal. Finding that limit could help distinguish between ideas of how the particles get their oomph. ■

Scientists hunting for high-energy photons raining down on Earth from space have found the most energetic light yet detected. It's from the Crab Nebula, a remnant of an exploded star (shown in an image combining light seen by multiple telescopes).

NASA, ESA, NRAO, AUI, NSF AND G. DUBNER/UNIV. OF BUENOS AIRES

BODY & BRAIN

Why some robots are so unsettling

Researchers link brain region to the 'uncanny valley' effect

BY MARIA TEMMING

A brain-scan analysis may explain why hyperrealistic androids can seem creepy.

By measuring neural activity as people viewed pictures of humans and robots, researchers identified a brain region that seems to underlie the "uncanny valley" effect — the unsettling sensation caused by robots that look almost, but not quite, human. Understanding the neural circuitry that causes this feeling may help designers create less unnerving androids.

In research described online July 1 in the *Journal of Neuroscience*, neuroscientist Fabian Grabenhorst of the University of Cambridge and colleagues took functional MRI scans of 21 people during two activities. In each, participants viewed pictures of humans, humanoid robots of varying degrees of realism and — to simulate the appearance of hyperrealistic robots — "artificial humans," people whose features were distorted via plastic surgery and photo editing.

First, participants rated each picture on likability and how humanlike the figures were. Second, people chose between pairs of pictures, based on which subject they would rather get a gift from. In line with the uncanny valley effect, people generally rated more humanlike candidates as more likable, but this trend broke down for artificial humans — the most humanlike of the nonhuman options. A similar trend emerged in judgments about which figures were more trustworthy gift-givers.

By studying reactions to images of various robots, scientists say they found the source of the "uncanny valley" sensation in the brain.

Brain scans revealed that activity in the ventromedial prefrontal cortex, involved in making value judgments, mirrored participants' reactions. VMPFC activity was typically higher in response to more humanlike pictures but dipped in response to artificial humans. That drop was most pronounced in people with the strongest dislike for artificial humans.

The scientists suggest that the VMPFC underpins the uncanny valley sensation. But this analysis may not directly map uncanny valley chills to neural activity, says human-computer interaction researcher Karl MacDorman. A lack of likability and gift-giving reliability don't necessarily make something eerie. Disney villains, for example, may not look likable or trustworthy, but they don't fall into the uncanny valley, says MacDorman, of Indiana University in Indianapolis. A future study could investigate the relationship between brain activity and how weirded out people feel when they see different humanoids, rather than how much they like or dislike the figures. ■

BODY & BRAIN

High-fat diet cuts brain's food brake

Mouse study hints at neural changes related to overeating

BY LAURA SANDERS

A gut-busting diet may set the brain up for more of the same. After mice ate fatty food for just two weeks, cells in their brains that send a "stop eating" signal were quieter than those in mice that didn't eat high-fat chow, researchers report in the June 28 *Science*.

Food is key to survival, which may be why the brain has built-in redundancy — a multitude of overlapping systems to make sure animals eat enough. Neuroscientist Garret Stuber of the University of Washington in Seattle investigated one area known to be involved in eating.

Called the lateral hypothalamus, this brain structure contains a large number of diverse nerve cells. Stuber and colleagues looked at gene behavior in single cells there and found that one group, called glutamatergic nerve cells, showed particularly big changes in which genes were active when the team compared lean mice with obese mice.

Earlier work suggested that glutamatergic cells act like a brake on feeding: When the cells were artificially blocked from firing signals, mice ate more food and gained more weight. But it wasn't clear how these cells behave over a more natural shift from leanness to obesity.

"Obesity doesn't just happen overnight," says Stuber, who conducted some of the work while at the University of North Carolina at Chapel Hill. To study that transition, the researchers fed mice high-fat mouse chow and periodically checked the glutamatergic cells' ability to fire signals.

Two weeks into the binge, even before mice plumped up, the nerve cells showed more sluggish activity, both in their spontaneous behavior and when an animal was given a sip of sweet liquid. That reduction continued as the mice grew larger, for up to 12 weeks in some cases.

The results imply that "these cells' decreased activity is removing the brake on feeding and obesity," says neuroscientist Stephanie Borgland of the University of Calgary in Canada, who wrote a related commentary in the same issue of *Science*.

The researchers don't know whether these cells would regain their normal behavior if the mice stopped eating high-fat food and shed weight. And it's hard to say whether similar appetite-suppressing nerve cells are at work in people. ■

A.M. ROSENTHAL-VON DER PÜTTEN *ET AL/J. NEUROSCIENCE 2019*

LIFE & EVOLUTION

Monkeys' tools changed with diet

Artifacts reveal capuchins' long use of pounding devices

BY BRUCE BOWER

Capuchin monkeys use stones as pounding tools (left). Artifacts excavated in Brazil (one above, shown from different angles) indicate the monkeys have changed tool styles over the last 3,000 years.

Excavations in Brazil have pounded out new insights into the handiness of ancient monkeys.

South American capuchin monkeys have hammered and dug with carefully chosen stones for the last 3,000 years, and they have selected pounding tools of varying sizes and weights along the way.

Capuchin stone implements recovered at a site in northeastern Brazil display signs of shifts during the last three millennia between a focus on dealing with either relatively small, soft foods or larger, hard-shelled edibles, researchers report. These discoveries, described June 24 in *Nature Ecology & Evolution*, are the first evidence of changing patterns of stone-tool use in a nonhuman primate.

"It's likely that local vegetation changes after 3,000 years ago led to changes in capuchin stone tools," says Tomos Proffitt, an archaeologist at University College London. The new findings raise the possibility that chimpanzees and macaque monkeys, which also use stones to pound and dig, have shifted their tool-use styles over the long haul, perhaps in response to climate and habitat changes, Proffitt says.

Archaeological sites linked to apes and monkeys are rare, though. Previous excavations in West Africa unearthed nut-cracking stones wielded by chimps about 4,300 years ago (*SN: 11/21/09, p. 24*). Present-day chimps inhabiting the same part of Africa crack nuts with similar-looking rocks.

Evidence of long-term changes in tools used by wild black-striped capuchins (*Sapajus libidinosus*) comes from a site in Brazil's Serra da Capivara National Park. Excavations there have also yielded ancient human stone tools (*SN: 10/18/14, p. 14*). But the newly unearthed artifacts more closely resemble stone tools used by modern capuchins at the same site (*SN: 11/26/16, p. 16*), rather than Stone Age human implements, the researchers say.

Primatologist Tiago Falótico of the University of São Paulo, Proffitt and colleagues recovered 122 capuchin stone artifacts from four sediment layers. Radiocarbon dating of charred wood in each layer provided age estimates for the finds. Excavated tools consisted of partial and complete pounding stones, rocks used as platforms on which to pound objects and pieces of rock that detached from pounding stones and platforms during use.

Relatively small, heavily damaged pounding implements from between around 3,000 and 2,500 years ago were probably used to smash open tiny foods such as seeds or fruits with soft rinds, the researchers say. Similar tools uncovered at the site date to about 600 years ago. Larger pounding stones from overlying sediment appeared about 300 years ago. The appearance of bigger capuchin tools by around that time denoted a shift to eating hard-shelled fruits and nuts that required high-impact pounding to open, the team argues.

Then about 100 years ago, capuchins downsized pounding stones slightly to crack cashews efficiently, the researchers suspect. Capuchins living near the site today eat cashews that the animals crack with similar pounding stones.

Either of two scenarios accounts for the variety of stone artifacts found at the Brazilian site, Proffitt says. Different capuchin populations may have visited the location at various times, each using particular types of stones to crack or open preferred seeds, nuts or fruits. Or a single capuchin population may have regularly returned to the site and changed its tool use over time to exploit different types of foods.

Stone-tool modifications that occurred over the last 3,000 years among Brazilian capuchins are comparable to those observed among West African chimp communities today, says primatologist and archaeologist Susana Carvalho of the University of Oxford. These chimps use large, heavy stones to crack hard *Panda* nuts as well as small stones to break open softer palm oil nuts. "What's novel is that a stone-tool pattern we had already seen in chimps today is now recognizable from the archaeological evidence for capuchins."

Still, differences between large and small tools used by capuchins and chimps are modest relative to contrasts among ancient hominid tools, such as simple chopping implements and oval hand axes, Carvalho says. Hominids began making and using stone tools at least 2.6 million years ago. ■

FROM LEFT: MIKELANE45/ISTOCK/GETTY IMAGES PLUS; T. FALÓTICO *ET AL*/*NATURE ECOLOGY & EVOLUTION* 2019

EARTH & ENVIRONMENT

Mystery disease is ravaging coral reefs

Scientists race to identify a killer spreading across the Caribbean

BY CASSIE MARTIN

Divers monitoring coral reefs off St. Thomas in the U.S. Virgin Islands in January noticed something alarming: Lesions were eating into the colorful tissues of hundreds of stony corals on one reef. Some corals were dead by the next day — only stark white skeletons remained. Others languished for up to two weeks before dying. Within four months, more than half of the reef suffered the same demise.

What's killing the corals is far from clear, but it's been pegged as stony coral tissue loss disease, sometimes referred to by its initials SCTLD or by the nickname "skittle-D." The infection, discovered off Florida in 2014, is responsible for what some scientists consider one of the deadliest coral disease outbreaks on record.

The disease is ravaging about a third of the Caribbean's 65 reef-building species, scientists estimate. Yet researchers aren't even sure if the disease is viral, bacterial or some other microbial mix. Whatever the cause, "it's annihilating whole species," says coral ecologist Marilyn Brandt, who is leading a team tackling the outbreak from multiple research angles.

Other coral diseases near St. Thomas have cut coral cover by as much as 50 percent over a year, says Brandt, of the University of the Virgin Islands. But this disease has done that amount of damage in half the time — spreading faster and killing more corals than any past outbreaks in the area. "It marches along the reef and rarely leaves corals behind," Brandt says. "We're pretty scared."

A disease hot spot

Coral reefs occupy less than 2 percent of the seafloor, but they play a crucial role, sustaining about a quarter of marine species. Sometimes mistaken for rocks or plants, corals are collectives of coral polyps, tiny invertebrates that get sick just like any other animal. Corals sometimes succumb to plagues but can shake off milder maladies akin to a common cold.

Since the first coral disease was documented in the 1970s, in the Caribbean, researchers have identified dozens more around the world, with the Caribbean now considered a coral disease hot spot. But scientists still know little about these illnesses. Many marine microbes don't grow well in the lab, so studying coral diseases is tough, Brandt says.

Even the names given to the diseases are vague, based on the visual cues of an infection, such as yellow-band disease, dark-spot syndrome and white plague. Many diseases look similar. SCTLD, which first attacks brain corals before moving on to other stony corals, was initially mistaken for white plague.

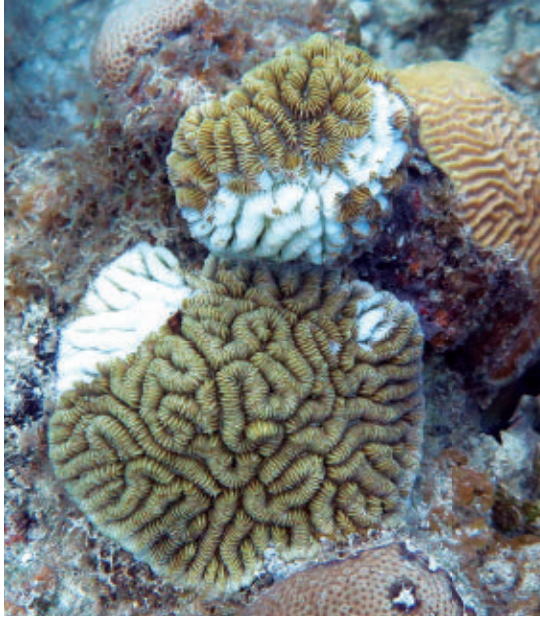
Performing reef triage

Off southeast Florida, the outbreak has persisted for five years. It has now affected almost all of a 580-kilometer stretch of reef, including along the Florida Keys, says Karen Neely, a marine biologist at Nova Southeastern University in Fort Lauderdale, Fla. Such a prolonged assault surprised scientists. Coral disease outbreaks typically burn out after a few months.

Neely and others are trying to save Florida's reef-building corals by moving hundreds of healthy colonies to tanks, where they can be studied, bred and protected. Meanwhile, divers are slathering sick corals left behind with a disinfectant and a paste made with the antibiotic amoxicillin, which seems to heal lesions. Neely estimates that nearly 1,200 colonies have been treated since January.

"We are seeing about 85 percent success," Neely says. But the antibiotic doesn't prevent new lesions. "One of the big priorities is to develop colony-level treatments," she says.

Amoxicillin's effectiveness suggests that the disease could be bacterial, Brandt says. But SCTLD could have viral origins, in which case the paste would be treating a symptom, not the cause.



Lesions that destroy the tissue of maze corals on a reef near St. Thomas in the U.S. Virgin Islands, exposing the underlying skeleton, are a sign of stony coral tissue loss disease.

M. BRANDT

Because the St. Thomas outbreak is just getting started, Brandt's team is trying a different approach: removing sick corals and leaving the healthy ones. That should reduce the water's pathogen load, which in theory would make disease spread more difficult, she says. But it will take about six months before the effectiveness of this strategy is clear.

Hunting a coral killer

To find out what might be causing the disease, members of Brandt's team are looking at coral microbiomes — the microbes that live in and around corals. Building the list of suspects requires first sorting out what normally belongs on healthy corals, and what doesn't.

At Woods Hole Oceanographic Institution in Massachusetts, marine ecologist Amy Apprill and colleagues are scrutinizing the microbiomes of sick corals, as well as sediments and water circulating around the reefs off St. Thomas. Comparing that data with data from Florida corals may uncover similarities between the two outbreaks that can help narrow the list of culprits, Apprill says.

The team is also focusing microscopes on samples of brain and star corals taken just as lesions popped up. Originally from a healthy reef in St. Thomas, the corals caught the disease during an experiment in which they were placed

near infected corals in an aquarium. "We might be getting a look at what 'early' disease looks like," Apprill says.

She doesn't expect to find a singular pathogen. "Many scientists are moving toward this idea that it may be a consortium" of microbes that causes a disease, she says. That consortium might look different for different coral species and in different environments. But a disease might trigger similar shifts in microbial diversity, so those patterns are something to watch for, Apprill says.

New clues about SCTLD are coming from researchers led by marine microbial ecologist Julie Meyer of the University of Florida in Gainesville. The team found that diseased corals have microbiomes that are more prone to change and become more diverse than their healthy counterparts. Genetic analyses of these microbiomes identified five types of bacteria abundant in corals infected with the disease, the researchers reported online May 3 at bioRxiv.org. At least one type thrives in the low-oxygen conditions that accompany decaying tissue, and all have been linked to other coral disease outbreaks around the world.

But more work is needed to determine if the microbes identified cause the disease, or simply take advantage of an opportunity to populate weakened coral.

Profiling the victims

Coral immunologist Laura Mydlarz, a member of Brandt's team, and others are investigating what happens to sick corals at the cellular level to figure out why some hard coral species are more vulnerable than others.

Mydlarz's lab, at the University of Texas at Arlington, showed that the immune systems of some susceptible coral species get stuck in cell-death mode, or apoptosis, when the team tricked them into thinking pathogenic bacteria are invading. These corals slough off their tissue. Species that are more disease-tolerant have immune systems that go into cell-recycling mode and fight off infection, Mydlarz's team reported in 2017 in the *Proceedings of the Royal Society B*.

Mydlarz suspects something similar might happen in corals vulnerable to SCTLD; the species in her study that favored cell-death mode are among those hit hardest by the outbreak.

Warming waters

The race to learn more about coral diseases is becoming urgent due to climate change. Global warming is a one-two punch for corals: Heat stress and bleaching may weaken coral defenses, while warming waters can send pathogens into overdrive. Pollution, overfishing and other environmental factors also stress corals, giving intruders an in.

Oceans are warming 40 percent faster than what had been predicted in the 2014 Intergovernmental Panel on Climate Change report, according to an analysis published in January in *Science*. As oceans continue to warm, outbreaks are expected to become more frequent and severe, researchers reported in 2015 in *Nature Climate Change*. And coral disease will probably rival bleaching as a driver of coral decline.

Flat Cay reef off St. Thomas had been considered resilient, having rebounded from major bleaching in 2005 and back-to-back hurricanes in 2017. But the current outbreak has killed the reef's maze corals, a type of brain coral. Pillar corals could be next, Brandt says. SCTLD "seems to be capable of changing the face of coral reefs as we know it."

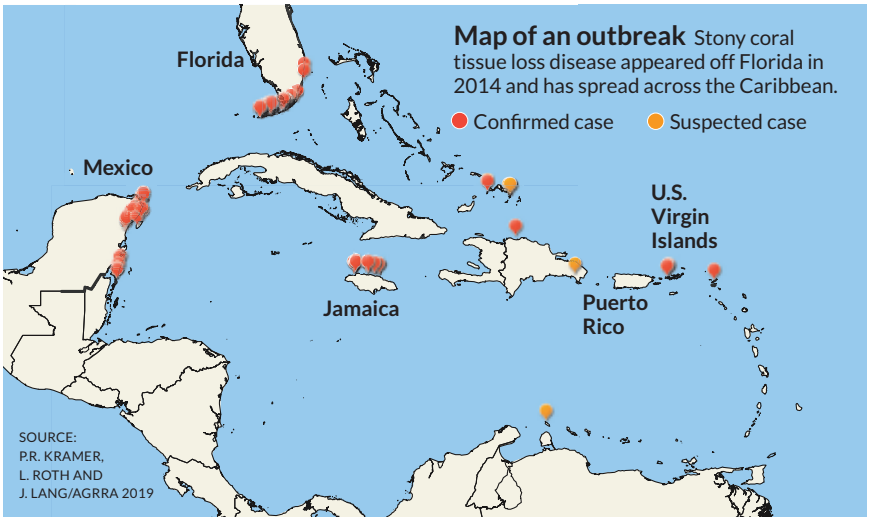
A disease on the move

Researchers are trying to keep up with SCTLD's spread. Pathogens may have traveled from Florida to St. Thomas in the ballast water of ships, says coral reef ecologist Dan Holstein of Louisiana State University in Baton Rouge. The disease has also been reported off Mexico, the Dominican Republic, Jamaica and other Caribbean islands.

Holstein uses ocean current data and other factors to forecast where the disease might spread. Early results suggest Puerto Rico could be next. Divers in May confirmed that the outbreak is inching toward the Puerto Rican island of Vieques. Star corals about 17 kilometers offshore and 40 meters deep are pocked with lesions, says Tyler Smith, who oversees the reef-monitoring program at the University of the Virgin Islands.

The discovery was disheartening, Smith says. Scientists knew star corals in shallower waters are susceptible, but hoped those living in deeper waters might be spared. He likens the deep reefs to a powder keg since they are made up of hundreds of millions of densely packed colonies where disease can jump easily from coral to coral.

Brandt's group continues to monitor reefs in the U.S. Virgin Islands. A June survey of 270 sites around St. Croix spotted infections. "It was a moment of panic," Brandt says. It turns out some of the corals had the less-severe white plague, but none had SCTLD, giving a glimmer of hope — for now. ■



E. OTWELL

HUMANS & SOCIETY

Ancient DNA reveals origins of the mysterious Philistines

Hard-won genetic clues from the bones of Philistines, a people known from the Old Testament for their battles with Israelites, have taken some of the mystery out of the Philistines' hazy origins.

DNA taken from the remains of 10 individuals buried at Ashkelon, an ancient Philistine port in Israel, displays molecular links to ancient and modern populations in the eastern Mediterranean, archaeogeneticist Michal Feldman and her colleagues report. Ashkelon residents carried that southern European genetic signature between about 3,400 and 3,150 years ago, but it disappeared rapidly as mating increased with locals, the researchers conclude online July 3 in *Science Advances*.

This genetic evidence fits a scenario in which seafaring populations from southern Europe fled collapsing Bronze Age societies more than 3,000 years ago and settled along the eastern Mediterranean coast and were dubbed Philistines. Larger ancient DNA studies may help identify the Philistines' origins more precisely, say Feldman, of the Max Planck Institute for the Science of Human History in Jena, Germany, and colleagues.

DNA from remains of people, including this child, from an ancient city on Israel's coast suggest that the Philistines described in the Bible descended from seafaring Europeans.

DNA preserves poorly in hot, dry regions such as the Middle East. The researchers managed to retrieve nuclear DNA, which is inherited from both parents, from 10 skeletons: three Late Bronze Age individuals buried at Ashkelon about 3,600 years ago; four early Iron Age infants interred beneath Ashkelon houses between about 3,400 and 3,150 years ago; and three later Iron Age individuals buried in a large cemetery next to Ashkelon's city wall roughly 3,100 years ago. Southern European DNA first appeared in the early Iron Age youngsters around the time archaeological finds indicate that Philistines inhabited Ashkelon, but had largely disappeared by the later Iron Age (*SN: 12/24/16 & 1/7/17, p. 8*). *— Bruce Bower*

BODY & BRAIN

Immune cells go rogue in old brains

Immune cells can storm into the brains of older mice, where these normally helpful cells seem to be up to no good. Described in the July 11 *Nature*, the finding raises the possibility that immune cells may play a role in aging.

Anne Brunet, a biologist who studies aging at Stanford University School of Medicine, and colleagues studied gene activity to identify all sorts of cells in the subventricular zone, where new nerve cells are born. Compared with young mice, old mice had many more killer T cells in that area. These immune system fighters take out damaged or infected cells in the rest of the body, but weren't thought to show up in the brain.

Experiments on postmortem human brain tissue suggest that a similar thing happens in old people. T cells were more abundant in tissue that came from people ages 79 to 93 than in tissue from people ages 20 to 44, the researchers found.

In the brains of mice, killer T cells churn out a compound called interferon-gamma. This molecule might be responsible for the falling birthrate of new nerve cells that comes with old age, experiments on mouse stem cells in dishes suggest.

The study adds to the debate over whether adult human brains continue to make new nerve cells (*SN Online: 3/8/18*). If so, then therapies that shut T cells out of the brain might help keep nerve cell production rates high, even into older age — a renewal that might stave off some of the mental decline that comes with aging. *— Laura Sanders*

BODY & BRAIN

Rotavirus vaccines may lower kids' chances of getting type 1 diabetes

Rotavirus vaccines may have an unexpected benefit: a reduced likelihood of developing type 1 diabetes.

Past work in mice prone to diabetes suggests that infection with rotavirus can hasten damage to beta cells in the pancreas, the same cells destroyed in a person with type 1 diabetes. Rotavirus vaccines are effective at protecting against intestinal infections caused by the virus (*SN: 8/8/15, p. 5*).

Researchers analyzed private insurance data covering 2001 to 2017 for close to 1.5 million U.S. children who were infants at the time of enrollment. Among children fully vaccinated against rotavirus, there were 41 percent fewer new cases of type 1 diabetes than among unvaccinated children, the team reports June 13 in *Scientific Reports*.

The results apply to both rotavirus vaccines that are available in the United States. In fully vaccinated children, the incidence of type 1 diabetes was 12.2 cases per 100,000 people per year; in the unvaccinated group, it was 20.6 per 100,000. There was not a benefit for partially vaccinated kids, those who did not complete the full number of doses (either two or three depending on the vaccine).

In the United States, about 1.25 million people have type 1 diabetes, which occurs when the immune system mistakenly attacks insulin-secreting beta cells.

The research, which builds on a recent study in Australian children, suggests that rotavirus vaccination may be a tool to help prevent type 1 diabetes, but more work is needed, says epidemiologist Mary Rogers of the University of Michigan in Ann Arbor.

Type 1 diabetes "has no cure," so preventing even some cases could transform lives, she says. *— Aimee Cunningham*

ROBERT WALCH/LEON LEVY EXPEDITION TO ASHKELON

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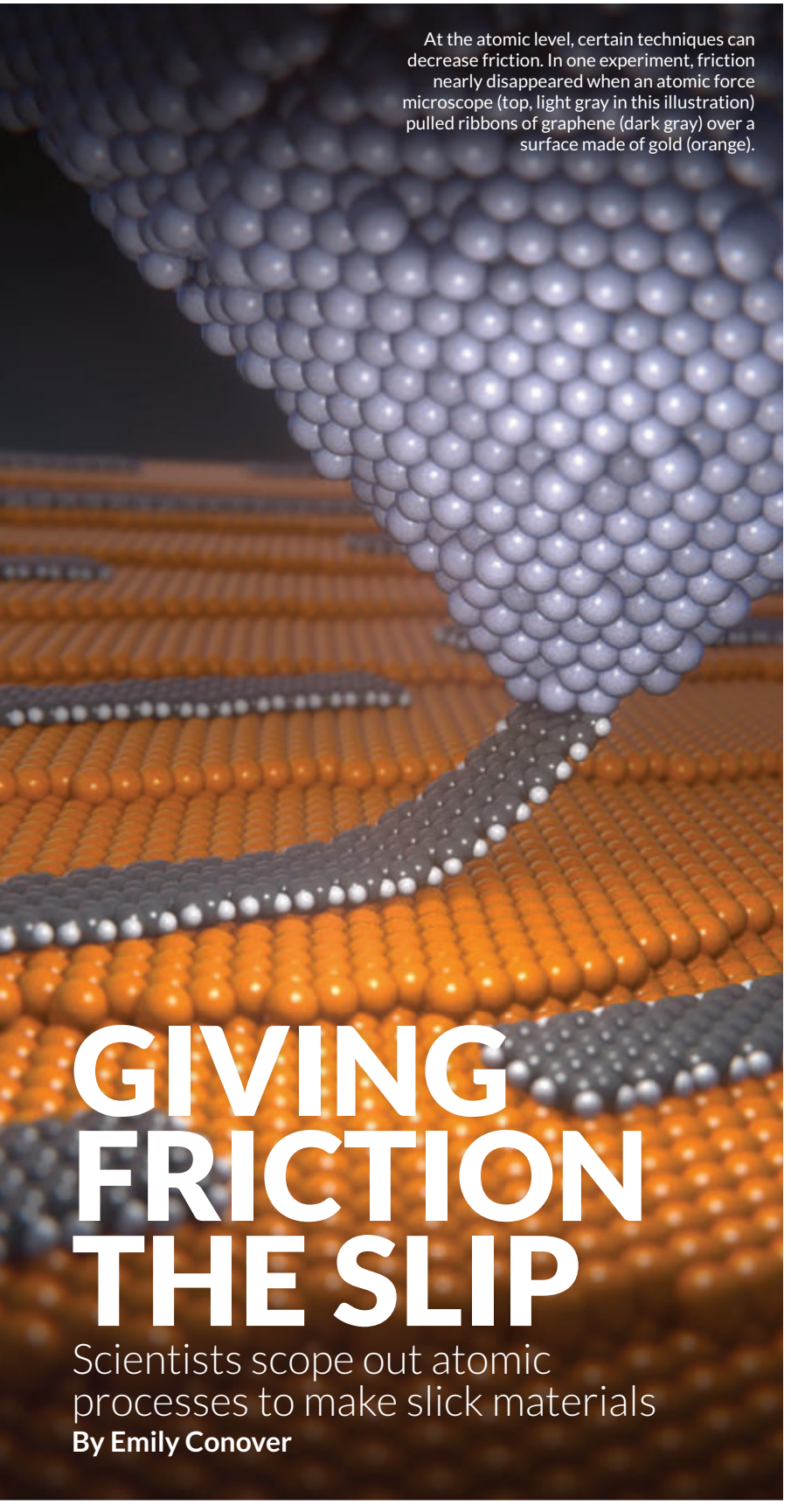


At the atomic level, certain techniques can decrease friction. In one experiment, friction nearly disappeared when an atomic force microscope (top, light gray in this illustration) pulled ribbons of graphene (dark gray) over a surface made of gold (orange).

GIVING FRICTION THE SLIP

Scientists scope out atomic processes to make slick materials

By Emily Conover

It's a moonless night. The wind howls outside. A door opens slowly, as if pushed by an invisible hand.

"Cre-e-e-a-k."

That sound — a horror movie cliché — is the result of friction. A stealthier entrance calls for oiling the door's hinges.

Friction is everywhere — from a violinist bowing a string to children skidding down a slide. In the right situation, the ubiquitous force can have big effects: Interleave the pages of two phone books, and the friction between the pages will hold the books together so tightly that they become strong enough to suspend a car above the ground.

But scientists can't fully explain, at the scale of atoms and molecules, why one pair of materials sticks while another moves with ease. The extreme slipperiness of ice, for example, has been a puzzle for more than 160 years. The multitude of water molecules on an icy surface creates a sheen that can send a car spinning or a penguin tobogganing. But getting a handle on the details of how this slippery surface arises from the water molecules is surprisingly tricky (see Page 20).

Despite its everyday nature, "we still don't really understand a lot of things about friction," says mechanical engineer Ali Erdemir of Argonne National Laboratory in Lemont, Ill. On its most basic level, friction results from the interactions between atoms in two materials that are butted up against one another. But, Erdemir says, "there is a disconnect" between the large-scale processes of friction that we can see, feel or hear and the smaller, atomic properties of materials that produce those well-known behaviors.

Now, by scrutinizing atoms' wily ways, scientists are devising new techniques to cut down on friction, going beyond known slippery surfaces like ice, Teflon and the banana peel of countless comedy gags. Some scientists have found ways to bring friction down to near-zero levels, a property known as superlubricity. Others are studying quantum effects that reduce friction.

Atomic acrobatics might help turn friction up and down at will, a useful ability since there are times when friction, a force working against the motion of a sliding or rolling object, is helpful. The frictional force of tires on asphalt, for example, lets a car turn without spinning out. But friction also saps the car's speed, so that more energy is needed to keep the vehicle moving.

Gaining the ability to wrangle friction could have real-world consequences. It's estimated that a third of the energy that goes into powering fossil fuel–

UNIV. OF BASEL

guzzling cars is lost to friction, converted into other forms of energy like heat and sound. The same hindrance affects just about every other machine imaginable, so that an estimated one-fifth of the world's annual energy consumption goes to fighting friction. Reducing those losses would mean "huge savings," Erdemir says.

A real drag

Humans have been fiddling with friction for ages. Ancient Egyptians appeared to know that pouring a little bit of water on sand made sliding heavy stones across the sand easier — a necessity for building the pyramids, researchers reported in 2014 in *Physical Review Letters*.

Leonardo da Vinci took an interest in friction and systematically analyzed the force. More recently, scientists have invented new materials with important frictional properties, such as Teflon, created in 1938, which lets eggs slip easily from a frying pan onto a plate.

When surfaces rub together, the atoms in the two materials jostle, sending tiny vibrational waves called phonons rippling through the materials. Meanwhile, chemical bonds between the surfaces form and break as one material slides along the other. Atoms can get wrenched entirely out of place, scraping off material. This process, known as wear, explains why the tread in your sneakers rubs off over time, leaving you with soles too slick to grip the pavement.

Friction can set off sound waves that we can hear, like the scratch of rough sandpaper, the squeak of a sticky bike chain or yes, horror fans, a creaky door. Friction sometimes causes a buildup of electric charge, making static electricity that can produce quite a zap, as anyone who's taken off a sweater and then touched a metal doorknob knows.

Different types of motion have different amounts of friction. A stationary object requires more force to overcome friction than one that's already moving. And rolling objects have less friction than sliding ones — locking a stroller's wheels makes it stay put unless you push with enough force to drag the stationary wheels across the floor.

Superpowered slipperiness

Friction's strength is defined by a number known as the coefficient of friction, which describes how much force must be exerted to move an object relative to its weight for a given pair of materials (*SN: 7/16/11, p. 14*). A coefficient of friction of 0 means smooth sailing, or no friction at all. Depending on the conditions, a steel skate sliding over ice can have a coefficient of 0.01, while steel on steel is more than 10 times greater, around 0.6. Banana peels' reputation for slipperiness is well-deserved: On a linoleum floor, the slick skins have a coefficient of friction of about 0.07 (*SN Online: 9/19/14*). Tires on a dry road can have a coefficient as large as 1, a value that drops to around 0.6 when the road is wet (*SN: 11/13/04, p. 308*).

Scientists are now harnessing superlubricity, which makes materials more slick than ice and banana peels. Material pairs with a coefficient below 0.01 are considered superlubric. One method of achieving superlubricity relies on carefully selecting the structure and orientation of the rubbing materials. The aim is to dramatically reduce friction of a type known as stick-slip motion, in which sliding surfaces switch between moving and stuck states. This type of friction is common — it's what accounts for that eerie creaking door sound, says physicist Oded Hod of Tel Aviv University.

If you could shrink down to the size of an atom, you'd see that the surface of a sheet of smooth, crystalline material is a series of hills and valleys in a regular pattern, the structure of atoms arranged in a grid. When surfaces slide by one another, the atoms in one layer don't want their electrons to overlap with those in the other layer. "The electrons say, 'Hey, stay away from my territory,'" says theoretical condensed matter physicist Erio Tosatti of the International School for Advanced Studies, or SISSA, in Trieste, Italy. That means the materials can get temporarily locked into place; when the atoms are arranged as they prefer, they don't want to move from their comfortable spots. This dispute leads to intermittent sliding and stopping instead of smooth movement.

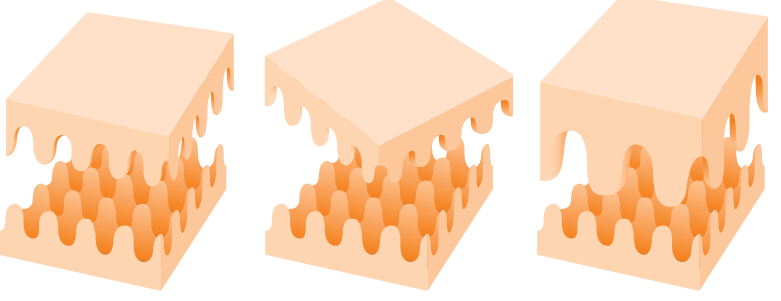
The hills and valleys created by the atoms are reminiscent of an egg carton, with a regular series of dips where each egg sits. Imagine trying to slide two empty egg cartons past each other, one on top

Friction's range

Some materials slide easily over one another, while others require extra oomph to move. That movability is described by a number called the coefficient of friction. The more slippery the pair, the lower the coefficient. The numbers below are estimates; exact values depend on conditions.

Sliding materials	Coefficient of friction
Index finger on sandpaper	1
Tires on dry pavement	1
Tires on wet pavement	0.6
Steel on steel	0.6
Tires on icy pavement	0.2
Banana peel on linoleum	0.07
Steel on Teflon	0.04
Steel on ice	0.01

SOURCES: D.R. LIDE/*CRC HANDBOOK OF CHEMISTRY AND PHYSICS* 2005; S. MÜLLER *ET AL/ J. DYNAMIC SYST., MEAS. AND CONTROL* 2003; M. SCHERGE *ET AL/ LUBRICANTS* 2018; A.V. SAVESCU *ET AL/J. APPL. BIOMECH.* 2008; K. MABUCHI *ET AL/TRIBOLOGY ONLINE* 2012



Stick-slip solution Slide two identical egg cartons (left) over one another and the ridges and valleys get stuck together, making them harder to push. But for egg cartons of different orientations (middle) or sizes (right), the peaks won't interlock and will slide more easily. When this principle is applied at the scale of atoms, this effect can drastically reduce friction.

C. CHANG

Ice dancing

To crack the enduring problem of why ice is slippery, a group of researchers connected the jiggling dance of water molecules to that slip-sliding samba of a pedestrian encountering an icy sidewalk.

Scientific folklore has held that the pressure from a shoe sole melts the ice and produces a lubricating layer of water, reducing the friction and sending the person wearing the shoe on a ride. Not so, says Mischa Bonn, a physical chemist at the Max Planck Institute for Polymer Research in Mainz, Germany: At temperatures well below ice's melting point, "even an elephant … stacked on one high heel still would not exert enough pressure to melt ice substantially." The idea that heat from the friction of a sliding object melts the ice doesn't hold up either. The heat produced is too feeble, experiments have shown. "You need a lot of heat to melt ice," Bonn says.

Another theory turns out to be closer to the truth. A film of mobile water molecules covers the surface of ice, reducing the friction, Bonn and colleagues determined based on simulations and experiments reported May 2018 in the *Journal of Physical Chemistry Letters*.

Perhaps, the researchers suggest, those loose molecules even roll around. Stepping on a slippery patch is like trying to dance on marbles; there's no getting a foothold.

The explanation also accounts for another feature of frozen water: When ice gets too cold, it loses its slipperiness. That happens, Bonn and colleagues say, because the loose molecules get pinned down to the surface. That means there's an optimal temperature for ice skating that's not too cold and not too warm. By the team's calculations, this Goldilocks temperature should be –7° Celsius (19° Fahrenheit). That's about the same temperature that ice skating rinks try to maintain for the fastest skating speeds. — *Emily Conover*

of the other. Once the cartons reach the spot where their cups and ridges line up perfectly, they'll get stuck. With a push, they'll slide until the cups interlock again, and so on, sticking and slipping repeatedly. In arrays of atoms, that stick-slip process results in energy being converted, not into motion, but into other, unhelpful forms, like sound or heat.

Now picture rotating the cartons so that the cups and ridges no longer line up. One carton will glide along the top of the other, making for smoother motion. This idea works for atoms, too, and it's called structural superlubricity. Two materials that stick mightily when aligned can slide with nearly frictionless ease when they rub at an angle. Likewise, consider two cartons that are made to fit different types of eggs — like chicken eggs and duck eggs. The cups in the two cartons will be spaced at different distances, since the larger duck eggs need more space. That means that the cups won't line up exactly, and they won't lock together, no matter how they are oriented. The same goes for two materials with differently spaced atoms.

Predicted in the 1980s and 1990s, structural superlubricity was first conclusively spotted and reported in 2004, when researchers showed that the ease with which a graphite flake slides over another graphite surface depended strongly on its orientation: At certain rotation angles, friction dropped to next to nothing, the team noted in *Physical Review Letters*.

More recently, structural superlubricity showed up in graphene — a sheet of graphite a single atom thick. A ribbon of graphene slides with ease across a gold surface, scientists reported in 2016 in *Science*. The ribbons can be hundreds of nanometers long, made up of thousands of atoms, but "they move with forces which are sometimes smaller than [those needed] to move a single atom," says study coauthor Ernst Meyer, a physicist at the University of Basel in Switzerland. "This is really quite amazing, if you tune everything quite the right way."

But structural superlubricity tends to require pristine conditions; dirt or blemishes on the materials will muck it up. So the effect is usually demonstrated only in a vacuum, with carefully controlled conditions and specially prepared surfaces. For those reasons, structural superlubricity was initially confined to objects that are best measured in nanometers, or billionths of a meter, a scale on which such imperfections can be avoided. But recently, scientists have enhanced their superlubricity superpowers.

Researchers from China and Israel found superlubricity with surfaces a million times larger in area — micrometer scales. When graphite slid over a compound of boron and nitrogen, the combination boasted an ultralow coefficient of friction, less than 0.00014, the group reported in July 2018 in *Nature Materials*. Atoms within the compound, known as hexagonal boron nitride, are arranged into hexagons, the same shape as carbon atoms in graphite. But the hexagons in the two materials are different sizes, like egg cartons made for duck eggs compared with chicken eggs. And the friction remained low even when the tests weren't performed under vacuum conditions, says Tel Aviv's Hod, a coauthor of the study with Tsinghua University's Ming Ma, Quanshui Zheng and others.

The next goal, Hod says, is to bring structural superlubricity to millimeter scales, to objects we can see and hold, even if tiny. Small moving parts of that size are common, and such reductions in friction could be useful in a variety of devices, from tiny computer components to miniature engines. "It can be in the medical industry, data storage, watches, satellites, you name it," he says.

VANVEENJF/UNSPLASH

Scaling up to that next size will be a challenge, but Hod is working on ideas to get there.

Putting it together

Throwing nanoparticles into the mix is one way of leaping to larger scales. Argonne materials scientist Anirudha Sumant and colleagues have created lubricants based on pieces of graphene that roll up around minuscule balls of diamond, forming scrolls.

The researchers paired the graphene with a material called diamond-like carbon, which is made of carbon atoms arranged in an irregular pattern. The two materials have a structure mismatch suggesting that they might exhibit structural superlubricity. But simply sliding the diamond-like carbon against a graphene surface results in a coefficient of friction of 0.04, which is low, but not quite superlubric.

The addition of the graphene nanoscrolls makes the difference, forming an army of small, slippery surfaces that work collectively to keep things moving smoothly. With that combination, the coefficient of friction dropped precipitously, to 0.004, Sumant, Erdemir and colleagues reported in 2015 in *Science*. Sumant says he's working on similar lubricants for industry that could help devices like wind turbines move freely and more efficiently.

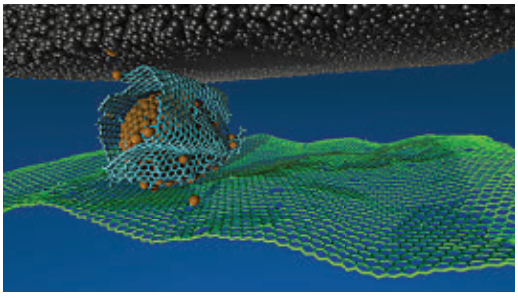
Wrangling friction

Some scientists are using their atomic-scale studies to control friction, tuning it up and down as needed. This power over friction, making a surface slippery or rough as desired, could be useful as more than a laboratory trick. Imagine car tires that are grippy when you brake or accelerate, but smooth when you're cruising along.

Physicist Jacqueline Krim and colleagues studied the friction between a thin layer of oxygen molecules and a nickel surface that the oxygen molecules were stuck to. By vibrating the nickel surface and measuring how easily the oxygen slid over it, the researchers measured the friction. The experiment is a bit like pulling a tablecloth (the nickel) out from under some dishes (the oxygen). If friction is too high, you smash some plates.

Then, using magnetic fields, the researchers reoriented the egg-shaped oxygen molecules to stand on their ends. That reorientation decreased the friction by half, the team reported in December 2018 in *Condensed Matter*.

Scientists also hope to explore even more exotic effects to bolster slipperiness. Theoretical calculations say that quantum mechanical weirdness can



Tiny scrolls of graphene (one shown, blue, in this illustration) wrap around a small bit of diamond (brown) to lubricate the movement of a material called diamond-like carbon (black) across a sheet of graphene (green).

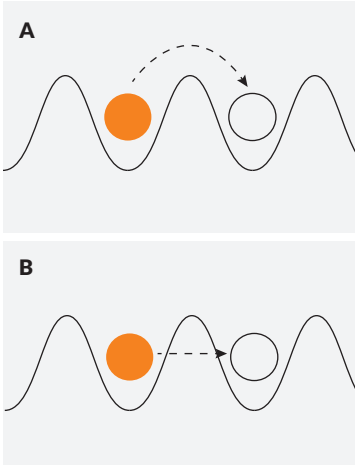
reduce friction, Tosatti and colleagues reported in April 2018 in the *Proceedings of the National Academy of Sciences*. A single electrically charged atom, an ion, dragged across the surface of a material can tunnel through an otherwise impassable barrier, a process known as quantum tunneling.

Imagine a single particle traversing an egg carton. Normally, the particle would have to climb up and down each cup, requiring enough energy to navigate that landscape. But quantum mechanics indicates that a particle can occasionally skip the up and down and pass straight through one cup to another, as if burrowing through the carton. That ability reduces friction.

Although this quantum lubricity, as it is called, has yet to be harnessed in the lab, Tosatti and colleagues predict that it should be possible to demonstrate via an established technique. Scientists have used lasers to create a simulated surface that mimics the dips and bumps of a material. Dragging cold ions across the mock material can re-create friction, and possibly its quantum effects.

In the quest to tweak materials to adjust friction, scientists have been making steady progress, but it's not so easy to draw direct connections between the physics of big and small. In her lab at North Carolina State University in Raleigh, Krim says she can adjust atomic properties of materials and study what happens. But in general, the two worlds are separated by a tough-to-penetrate forest. "There are some foot trails that have connected up," she says. But "there is still some bushwhacking" to do.

That trailblazing could be worthwhile. Harnessing the power of materials made nearly friction free based on the atoms within would be a game changer, Erdemir says. With that capability, he says, "we can solve the world's friction problems." ■



Quantum tunnel
An atom sliding over a bumpy surface loses energy to friction as it traverses the ridges (A). But thanks to quantum mechanics, an atom might be able to tunnel through barriers and cut down on friction (B).
SOURCE: T. ZANCA *ET AL*/*PNAS* 2018

Explore more

- Anirudha Sumant. "Superlubricity — near zero friction from nanodiamonds." TEDx. November 30, 2018. bit.ly/superlubricity

FROM TOP: CENTER FOR NANOSCALE MATERIALS/ARGONNE NATIONAL LAB; C. CHANG

Positive Spin

Aging well may come down to attitude

By Robin Marantz Henig

The first time someone offered me a seat on the subway, I reflexively declined, and then stewed about it all the way home. Sheesh, I thought, do I really look like an old lady in need of assistance? When I got off the train, I swear my knees felt a bit creaky as I clomped up the subway steps.

When we're busy doing things we love — which for me these days means playing with my two young granddaughters — we don't think about how old we are or the state of our knees. But then something pulls us up short, like a polite young man offering his seat, or catching a view of a selfie from an unflattering angle, and suddenly we're walking more slowly, feeling just a little worse about life in general.

The way these internalized attitudes about aging affect us physically is a focus within a growing field in social psychology known as mind-body studies. In the next few months, the World Health Organization is expected to publish the results of a global investigation of ageism — discrimination toward

COSMAA/ISTOCK/GETTY IMAGES PLUS, ADAPTED BY E. OTWELL

the aged, akin to racism and sexism — that will address how to fight the prejudice. The report will also outline the myriad ways that ageist attitudes can affect the health and well-being of older people.

Psychologist Becca Levy is a contributor to the forthcoming WHO report and has spent her career linking negative aging attitudes to such measures as walking speed in older people, a greater likelihood of developing the brain changes of Alzheimer's disease and even a reduction in life span.

But it's not all grim; Levy, at the Yale School of Public Health, has also shown that something as simple as subliminal exposure to age-positive words can lead to physical improvements in older people of the sort that typically come about only after a program of regular exercise. If Levy and other scientists are correct, putting a more positive spin on our general view of aging might make a profound difference in the health of people over 65, the fastest-growing age group in America today.

It seems almost too good to be true to think that a simple shift in mind-set could make a serious dent in the $702 billion spent annually on Medicare, 90 percent of which is for older people with multiple chronic diseases. But that's what some of the most surprising mind-body findings suggest: A more positive attitude toward aging leads to improvements in older people's memory, gait, balance, speed and a quality that Levy refers to as "will to live."

Words matter

Levy began research in this field during graduate school in the 1990s, when she first assessed the physical impact of ageism using a technique she called "age-stereotype activation." She wanted to test the hypothesis that holding ageist attitudes might be a literal health hazard for older people.

First she recruited a couple dozen people of all ages living near Harvard University, where she was studying social psychology, to brainstorm words that represented positive and negative stereotypes of old age. "Decrepit," "incompetent" and "decline" were among the 12 they settled on as both relevant to aging and negative; "accomplished" and "sage" were among the 12 deemed both relevant to aging and positive.

Then she brought into her lab 90 adults ages 60 to 90 — three-quarters from the Boston metro area, one-quarter from rural Vermont — and randomly assigned them to be exposed to either the negative or positive terms, interspersed with a few neutral words like "between."

"We put them in front of a computer and flashed the words at the level of perception without awareness," Levy says, describing the technique she also used 20 years later for her study using age-positive words as therapy. The words flashed so quickly on the screen that they appeared only as a blur. This well-tested "semantic priming" technique operated below the level of consciousness to get the subject thinking of aging in a particular way, as either a benefit or burden. "I designed that method after reading about research that was done activating race stereotypes," she says. In race relations, the technique, which has been the subject of some controversy (*SN: 4/22/06, p. 250*), has been used to identify an underlying prejudice known as "implicit bias."

When applied to older people, implicit bias has a particularly cruel twist: If you live long enough, it becomes prejudice against a group you now belong to. Levy was interested in whether this prejudice, which pervades so much of Western culture, would eventually have physical effects on an older person's aging body.

Subjects exposed subliminally to negative age stereotypes showed a decline in performance compared with their results on earlier memory tests (taken right before exposure to the loaded words), Levy found. Those exposed subliminally to positive age stereotypes showed an improvement. The biggest negative effects of the downer words were in tests of immediate recall (an average drop of 1.77 points, on a 7-point scale) and delayed recall (down 1.11 points on a 7-point scale). The biggest improvements in the positive-bias group were in tests of immediate recall (an average increase of 0.98 points on a 7-point scale) and photo recall (up 1.4 points on an 8-point scale).

When she wrote up her findings in 1996 in the *Journal of Personality and Social Psychology*, Levy offered two ways of

Aging attributes

The terms below were used to test the impact of positive and negative stereotypes on memory in older people.

Negative age-related words

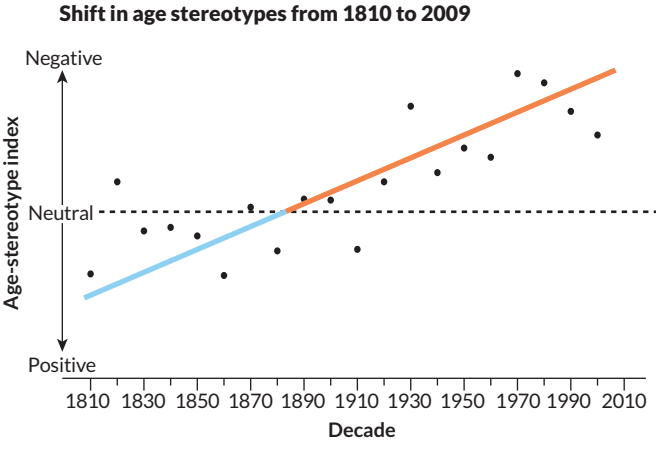
Alzheimer's	Dying
Decline	Forgets
Dependent	Confused
Senile	Decrepit
Misplaces	Incompetent
Dementia	Diseased

Positive age-related words

Guidance	Improving
Wise	Advise
Alert	Creative
Sage	Enlightened
Accomplished	Insightful
Learned	Astute

SOURCE: B. LEVY/*J. OF PERSONALITY AND SOCIAL PSYCHOL.* 1996

Systemic bias Words used to describe older people, found in a database of historical American English, have become increasingly negative in the past 200 years, possibly because aging has come to be seen as a medical condition. SOURCE: R. NG *ET AL/PLOS ONE* 2015



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looking at these results. The pessimistic view was that "the stereotype that memory decline is inevitable can become a self-fulfilling prophecy." But the optimistic reading was that memory decline is not inevitable. "In fact," she wrote, "the studies show that memory performance can be enhanced in old age ... as the consequence of a brief priming intervention."

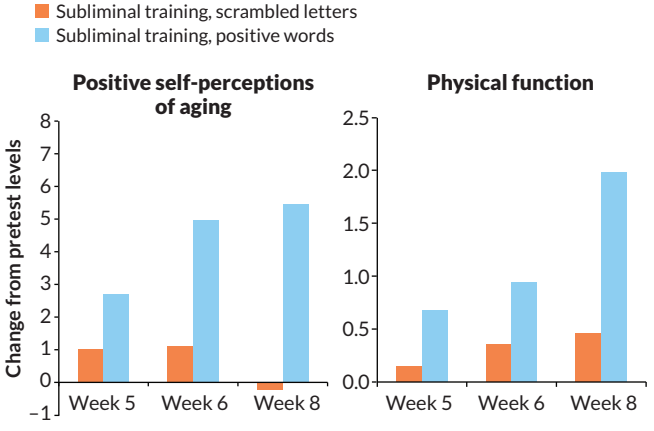
Pernicious predictors

In Western culture, the most deeply held aging stereotypes tend to be the negative ones. Levy and a grad student in computational linguistics, Reuben Ng, now at the National University of Singapore, did a linguistic analysis of 400 million words in written material collected from the past 200 years. The words describing older people grew progressively more negative over time, the two reported with colleagues in 2015 in *PLOS ONE*. As aging became seen as a medical problem and the proportion of the population over age 65 grew, both changes were "significantly associated with the increase in negative age stereotypes," the researchers wrote. "The upward trajectory of age-stereotype negativity makes a case for remedial action on a societal level."

These negative views of aging can have pernicious physical effects. In 2002 in the *Journal of Personality and Social Psychology*, Levy and colleagues published an analysis of data from the Ohio Longitudinal Study of Aging and Retirement. Of 660 subjects over age 50 who had been followed for more than 20 years, those with the most negative attitude toward aging when the study began died at an average age that was 7.5 years younger than those with the most positive attitudes.

A German study attempting to suss out the true direction of this relationship concluded that belief in age stereotypes was a more accurate predictor of health than the other way around. The researchers reported in 2007 in the *Journals of Gerontology, Series B* that it wasn't that people had positive views of aging because they were healthy; they were healthy because they had positive views of aging.

Flash forward Flashing positive words about aging on a screen — too fast to read — in four weekly sessions improved perceptions of aging and physical function in people 61 and older. People who got scrambled letters saw little change. SOURCE: B. LEVY *ET AL/PSYCHOL. SCIENCE* 2014



The preponderance of research evidence, collected over a decade and a half, is what gave Levy the more recent idea to turn age-stereotype activation into an actual treatment.

A dose of positivity

Levy suspected the treatment — exposing older people to positive age-related words — would work best when done on a subliminal level, rather than via cheery self-talk or other explicit reinforcement. When presented beneath the level of consciousness, she believed, positive age stereotypes could overturn long-held ageist beliefs that the mind tries to hold on to.

She and colleagues recruited 100 individuals, ages 61 to 99, who received one of four "treatments" once a week for four weeks. The "implicit stereotype" treatment involved sitting at computers and being exposed subliminally to positive aging stereotypes using the same priming technique Levy had used in her grad school experiment; the "implicit control" treatment involved subliminal exposure to random strings of letters. The "explicit stereotype" treatment asked participants to imagine and then write about "a senior citizen who is mentally and physically healthy"; the "explicit control" condition had them write about a neutral topic, like the uniforms people wear to work.

Three weeks after the treatments ended, the subjects came back. As Levy reported in 2014 in *Psychological Science*, exposure to positive stereotypes had a lasting positive impact, and implicit exposure worked better than explicit exposure. The investigators measured balance, walking speed and the ability to get into and out of a chair. Low scores on these measures, Levy and colleagues wrote, mean a higher risk for disability, nursing home placement and earlier death. The subjects in both the "implicit stereotype" and "implicit control" group had scores close to 7 out of 12 on the physical function test the week before the intervention started. In the three weeks following the intervention, the implicit exposure group saw statistically significant improvements. In contrast, the implicit control group made almost no change from the first measurement to the last.

Not only did the effects seem to last, but they were more robust than those seen in a comparable group of older people who were given an in-home exercise program for six months. Levy and colleagues wrote that they seemed to have created "an implicit fitness center" for older people.

Time warp

Levy's work builds on the work of her mentor, Harvard psychologist Ellen Langer, who has been examining the theory of mind-body unity since the late 1970s, when she conducted the audacious "counterclockwise study."

In 1979, Langer housed 17 men in their early 70s in a former monastery in New Hampshire for five days. She told the men they would spend that time thinking about what their lives had been like in 1959, when they were in their 50s; she also told them she expected those recollections to have a salutary effect.

"It was all about the mind-body connection," Langer told

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me recently by phone. Her hypothesis was that "if you take the mind and put it back in time, the body follows suit."

What Langer didn't tell the participants was that there would be two groups operating under slightly different conditions. For half of the men, the experience would consist solely of remembrance — talking about what things were like in 1959, but from the perspective of the current date, 1979. For the other half, the men were told not only to remember 1959, but to pretend it was 1959.

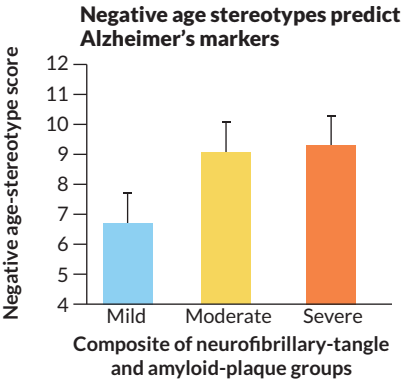
For both groups, the living quarters were outfitted with historical cues — furniture, home appliances, newspaper headlines, reports on the radio — to evoke the world of 20 years earlier. (Significantly, all mirrors were removed.) The only difference was that for the time capsule group, when they talked about that time period, they were urged to use the present tense.

The men in the time capsule group had daily sessions talking about news events — Castro attacking Cuba, a Soviet rocketship reaching the moon, the Colts winning the NFL championship — as if they were happening right then. (The control group discussed the same events, but in the past tense.) Like the control group men, the time capsule group watched *The Ed Sullivan Show* on a black-and-white television and listened to Nat King Cole and Perry Como on a vintage radio — but this group discussed those shows as though they had just been aired.

At the end of five days, the men in the time capsule group had lower blood pressure, stronger hand grip, better hearing and vision and fewer aches and pains than they had at the outset. It wasn't just the result of being at a nice retreat for five days, since the men in the control group improved, too, but not to nearly the same extent. In the time capsule group, finger length — an indication of joint flexibility — increased in three of the eight men. In the control group, one in three men had a decrease in finger length. Langer never submitted her study to a professional journal; she thought it was too small, not to mention too radical. But she did write it up in *Higher Stages of Human Development*, a peer-reviewed volume she coedited for Oxford University Press in 1990.

"The mind and body are one," Langer says. "We all have far more control over our health and well-being than we realize."

In the years since, Langer has conducted dozens more studies that demonstrate the mind-body connection. In one, known as the "chambermaid study," Langer and coauthor Alia Crum asked 84 hotel maids whether they exercised. Every one said not really. Langer and Crum then told half the volunteers that their jobs actually were exercise, and that making beds, for instance, was no different from working out at the gym. For the other half, the scientists made no attempt to reframe how the maids viewed their daily activity levels. (For unexplained reasons, the maids in the experimental group turned out to be younger than the controls, with average ages of 34 and 42, respectively.)



Brain changes
The number of Alzheimer's disease markers (tangles and plaques) were greater in autopsied brains of people who had held more negative stereotypes about aging.
SOURCE: B. LEVY *ET AL/ PSYCHOL. AGING* 2016

As Langer and Crum, now at Stanford University, reported in 2007 in *Psychological Science*, that single change — encouraging the chambermaids to think of their jobs as exercise — made a big difference. With no change in anyone's actual activity levels or food intake, the maids in the control group were virtually the same at the four-week follow-up, while those in the experimental group had lost weight (1.78 pounds on average), showed a decrease in waist-to-hip ratio, had a lower body mass index (a drop from an average of 26.05 to 25.70) and had a drop in blood pressure from an average of 130/80 to 120/75. The only difference between the two groups — other than the age difference, which the authors said they controlled for in their analysis — was a change of mind-set.

> "We all have far more control over our health and well-being than we realize."
> ELLEN LANGER

When it comes to aging, even the changes that seem most harshly and immutably physiological, like the plaques of Alzheimer's disease, have been linked to attitude. In the long-running Baltimore Longitudinal Study on Aging, for instance, attitudes toward aging appeared to make a difference in what happened to the brains of the participants, who were all dementia-free when the study began. People who had more negative views of aging at the outset had a significantly greater buildup, measured postmortem, of the amyloid plaques and neurofibrillary tangles that are the markers of Alzheimer's, compared with those who had more positive attitudes at the outset. Those with negative views also had more shrinkage in the hippocampus, the brain's memory center.

Living the stereotype

Some scientists worry about the true direction of the relationship between negative attitudes toward aging and health. "It's hard to tease things out," says Laura L. Carstensen, director of the Stanford Center on Longevity. "It's hard to be sure that it's not some third variable" that accounts for the link between better attitudes and better outcomes. For instance, she says, "it's a highly replicated finding that positive emotional experience is related to longer life expectancy." But might some other

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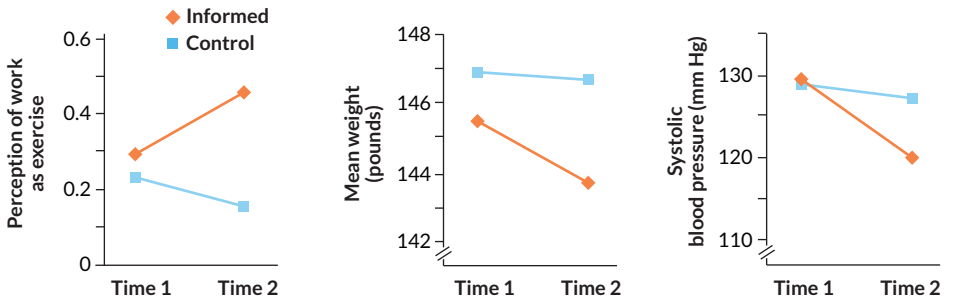

Mind-set matters When one group of hotel maids was told their work counts as exercise and a control group was not, the "informed" group experienced a change in perception, along with a drop in body weight and blood pressure after four weeks, even though their behaviors didn't change.
SOURCE: A.J. CRUM AND E. LANGER/*PSYCHOL. SCIENCE* 2007

factor be causing the negative attitude — maybe an underlying illness that researchers are missing — that confuses the direction of cause and effect?

"When you're in good physical health, you tend to be happier," Carstensen says. So maybe the healthiest older people, who will live longest precisely because they're healthiest, also happen to have the best attitude toward aging, rather than the other way around. "It always gnaws away at me that there might be some relatively subtle physical vulnerability under way that we're not picking up," she says.

Many carefully designed studies, including her own, have found a connection between positive attitude and longevity even after correcting for confounding factors such as health. In fact, as she wrote in a 2019 review article in *Cognition and Emotion*, recent work has uncovered what she calls a "positivity effect" — the preference, as we age, to accentuate the positive, as revealed in age-related shifts in the emotional content of what people remember, what images catch their attention and how they interpret ambiguous social situations. Still, she frets that even the best-intentioned investigators might be missing something in their older subjects.

"I'd put my money less on attitude and more on problem-solving," she says — even though problem-solving and attitude are in many ways intertwined. If an older person's knee starts hurting, someone with a negative view of aging is likely to think she just has to learn to live with it. The problem-solving kicks in only for people who don't see age as one unremitting, inevitable decline — age-positive people like Carstensen herself. "If my knee isn't doing well," she says, "I call my trainer and he has me start doing different stretches."

Another concern is the one attached recently to the research methodology at the heart of some of these studies: psychological priming (*SN: 5/19/12, p. 26*). While Levy's studies involve subliminal exposure to priming cues, some of the limitations of studies involving more explicit forms of psychological priming — having subjects hold a hot coffee mug to elicit warm and fuzzy feelings, for instance — might also apply to some of her findings about ageism.

One salient point, according to Levy, is that stereotypes about aging are so pervasive. They can easily be assimilated "from the surrounding culture," become part of an individual's self-definition, and ultimately affect how that person's body operates — a process she describes as "stereotype embodiment."

The process has four components, she explained in 2009 in *Current Directions in Psychological Science*: The stereotypes become internalized across one's life span, can operate without us realizing, gain salience as they become relevant to our own situation and use multiple cognitive pathways to gain a hold. Her bottom line: Aging itself is, in part, a social construct.

Aging itself is, in part, a social construct.

A few months ago, I had another subway encounter that made me feel a lot better about what it means to be older. I was coming home from dinner with a friend, wearing my vintage patterned winter coat, black cowboy boots and a funky herringbone pocketbook with bright coral straps. As I stepped off the train and started to pull on my periwinkle gloves, a college-aged woman approached. "You look great," she said. "I love your style. It's just what I aspire to when ..." Her voice trailed off. She seemed embarrassed that she'd planned to end that sentence with "when I'm your age."

But the fact that she had seen me as old was actually the point; the view of aging she invoked was a positive one. I told her she had made my night, and I found myself sprinting up the stairs and walking home briskly, happy to be some young stranger's inspiration for a cool and lively old age. It suddenly felt possible that I could stay nimble, both mentally and physically, no matter how old I got. ■

Explore more

- Laura L. Carstensen. "Integrating cognitive and emotion paradigms to address the paradox of aging." *Cognition and Emotion*. February 2019.

Robin Marantz Henig is a freelance science writer based in New York City. She is writing a book of essays about what it means to be a grandmother.

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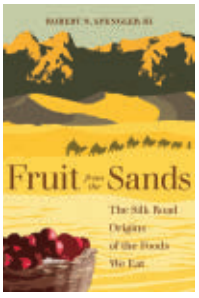

Fruit from the Sands
Robert N. Spengler III
UNIV. OF CALIFORNIA, $34.95

BOOKSHELF

Seeds of the Silk Road

Many popular foods can be traced back to trade caravans and herding groups that turned Central Asia into a hub of globalization several thousand years ago. In *Fruit from the Sands*, archaeobotanist Robert Spengler, who studies how people used plants in the past, surveys evidence suggesting that the ancient Silk Road was the conduit for dispersing much of what is now munched and sipped. Edibles with a Silk Road pedigree include almonds, apples, grapes, peaches, rice and wheat.

To understand how this food distribution process worked, readers must first discard romantic notions about the Silk Road, Spengler explains. The name is misleading: The Silk Road wasn't a road and didn't primarily transport silk. Instead, archaeological evidence indicates that the Silk Road encompassed a network of trade routes radiating out from Central Asia that connected China to the Mediterranean. Silk Road exchanges of commodities and cultural practices, such as metalworking and horseback riding, began about 5,000 years ago.

Grains were among the most important products to travel those ancient routes. Excavations led by Spengler of two herders' camps in Kazakhstan indicate that grain movements began more than 4,000 years ago. Graves at those sites contain seeds of both wheat and broomcorn millet (*SN: 5/3/14, p. 15*). Grain crops carried back and forth on the Silk Road transformed societies, Spengler argues. Wheat from the Fertile Crescent in Southwest Asia spread into China along the foothills of Central Asian mountains, plant remains from an increasing number of sites suggest. The grain put a new spin on rice-based East Asian cuisine, adding noodles, dumplings and steamed buns made from wheat flour to the menu. Wheat became the winter crop of Chinese dynasties starting about 2,000 years ago.

Traders and travelers carried broomcorn millet out of China via the same route. This hardy, easy-to-cultivate crop fed farmers, herders and laborers who built states across Europe and parts of Asia. With the introduction of irrigation systems about 2,500 years ago, millet could be farmed year-round. It was the crop, Spengler writes, "that turned the chariot wheels of the Roman Empire and fed Eastern Europe." Today, broomcorn millet serves mainly as bird food in Western Europe and the United States.

Rice has fared much better on the world stage despite being a late bloomer. This crop's Silk Road journeys were a long time coming after its domestication in East Asia 6,000 or so years ago (*SN: 7/8/17, p. 20*). Spengler cites genetic and archaeological data suggesting that rice became an important crop west of the Indus Valley only after Islamic conquests about 1,500 years ago.

Apples also got their big break on the Silk Road. Genetic studies have traced the domesticated version of this fruit back several thousand years to a few Central Asian river valleys in what is now Kazakhstan. Silk Road traders rapidly transported domesticated apples westward. Hybridization of the fruit with wild crabapples occurred along the way, and now apples are grown on every continent except Antarctica. Tea's worldwide popularity also flowed from a humble start. Chinese merchants supplied high-altitude Silk Road trading towns with tea and other items by about 1,800 years ago; a few hundred years later, the Chinese traded dried bricks of tea in exchange for Tibetan horses.

Overall, Spengler tells a fascinating tale of a culinary past that is just beginning to come into focus. Perhaps a follow-up volume could delve into what life was like for traders and herders on the Silk Road. For now, though, Spengler's book provides lots of food for thought. — *Bruce Bower*

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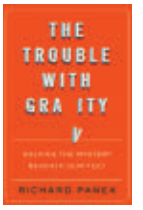

The Trouble with Gravity
Richard Panek
A science writer journeys through history and metaphysics after learning there's no answer to a deceptively simple question: What is gravity? *Houghton Mifflin Harcourt, $28*

10 Women Who Changed Science and the World
Catherine Whitlock and Rhodri Evans
Most of the female scientists profiled in this book aren't household names, but they should be, the authors argue. *Diversion Books, $26.99*

Lithium
Walter A. Brown
A psychiatrist pieces together the discovery and acceptance of one of medicine's most revolutionary treatments. *Liveright, $27.95*

More Things in the Heavens
Michael Werner and Peter Eisenhardt
For serious space fans, this ode to NASA's Spitzer Space Telescope reveals what we've learned by looking at the universe through an infrared lens. *Princeton Univ., $35*

Giants of the Monsoon Forest
Jacob Shell
A geographer travels through South Asia to explore the enduring alliance forged between humans and elephants. *W.W. Norton & Co., $26.95*

Science News in High Schools inspires teachers and students

Launched in 2015, the *Science News* in High Schools, *SNHS*, program brings *Science News* magazine to high schools across the United States and around the world. As part of a larger commitment to creating a more scientifically literate society, the program offers teachers and students access to the latest in-depth reporting on science, technology and health topics, transforming how students and educators interact with science in the classroom.

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Students at Two Rivers Public Charter School in Washington, D.C., explore *Science News* magazine in their classroom.

JESSICA YURINKO/SSP

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JUNE 8, 2019

Poetry with a twist

The first gene-edited snails confirm that the protein Lsdia1 determines the direction a snail's shell spirals, **Tina Hesman Saey** reported in "Genetics of snail twists unraveled" (*SN: 6/8/19, p. 8*). Online reader **Trevor Zuroff** turned the story into a poem inspired by the Dr. Suess book *Sneetches on Beaches*:

"Now, the right twisting snails / Clockwise their shells were / The left twisting snails / Counter-clock they prefer / The direction was quite subtle, really quite small / You might think the twist wouldn't matter at all / But, for snails you see, the direction it quite mattered / It meant the difference between a mate who was bored or was flattered / With their snoots in the air, the right twists would move with such pride / But, only now do we know, what's on the inside / With CRISPR-Cas9 and more than one scientist / A protein was discovered that gives snails the twist / Lsdia1 is its name and it's quite a surprise / It controls a snail's clock- or counterclockwise!"

Join the conversation

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Tough choices

*Discussing shared health goals with vaccine-hesitant parents may help doctors get those parents on board, **Aimee Cunningham** reported in "Easing parents' fears"* (SN: 6/8/19, p. 16).

Reader **Dona Chilcoat** objected to a photo in the story that showed a crying baby getting a shot. She thought the image might help reinforce anti-vaccination sentiments. "This is an unhelpful, unsettling photo!" she wrote.

The *Science News* team had multiple discussions about how to best illustrate this story, says Editor in Chief **Nancy Shute**. Research on public health messages about vaccination suggests that images communicate powerfully. And parents' fear of needles and worry that children get too many shots contribute to vaccine hesitancy. "So should we avoid images that show a child in pain? We considered a wide variety of photos, and in the end decided that since the story focused on parents' concerns, this image best captured those fears," **Shute** says.

Not everyone on staff agreed with the choice. "Some staff members thought it could stoke opposition to vaccines. That's a valid point," she says. "But I thought the image was editorially appropriate. The pain of an immunization is momentary; the benefit is lifelong. Though as a parent, I cringed with every shot my baby got."

Memory loss

*The measles virus wipes clean the immune system's memories of past infections, which may leave victims susceptible to other illnesses for months or even years, **Laura Sanders** reported in "Measles erases immune memory"* (SN: 6/8/19, p. 20).

"Given that the immune system eventually recovers, perhaps measles temporarily represses the immune system rather than wipes it clean," reader **Annette Aiello** wrote. From where else would it recover memories, she wondered.

Certain memories of prior threats may persist among some of the many immune cells in the body after a measles infection, **Sanders** says. "But the specifics aren't yet known, and may vary from person to person." Experiments designed to look at large collections of single immune cells' memories will help answer questions of resilience and recovery, she says. Memories can be rebuilt from new exposures as well.

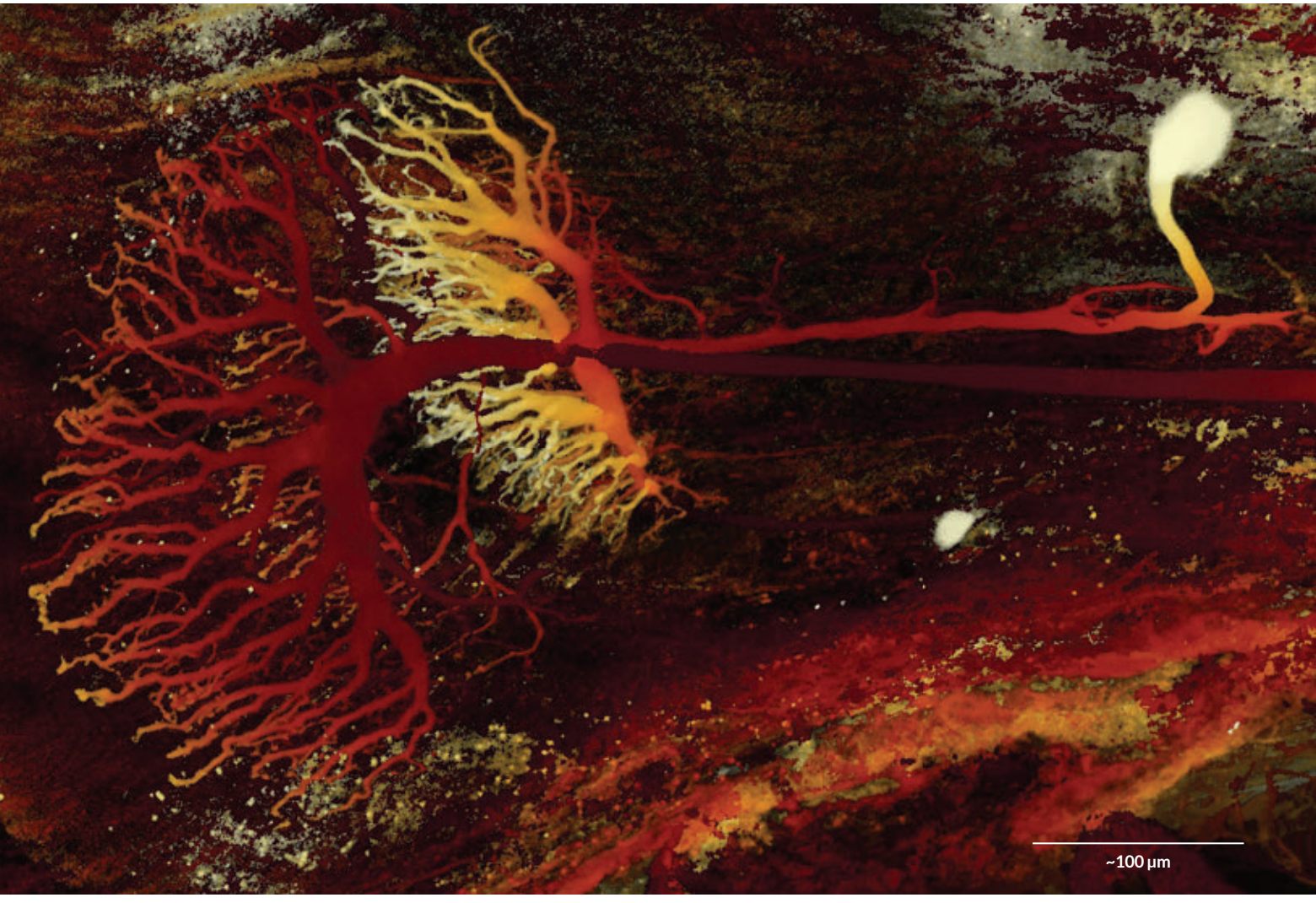
Protein puzzle

*An analysis of a partial jawbone found on the Tibetan Plateau suggests that Denisovans were the first hominids to reach such high altitudes 160,000 years or more ago, **Bruce Bower** reported in "Denisovans lived the high life"* (SN: 6/8/19, p. 6).

The story "made several references to identifying species using proteins rather than DNA," reader **Tim Cliffe** wrote. "Can geneticists read back from an amino acid sequence to infer the DNA sequence?" He suggested that fossil DNA could be reconstructed this way. "I suppose the problem is redundancy; different DNA codons can code for the same amino acid," he wrote.

Researchers can use proteins' amino acid sequences to infer the sequence of DNA letters, but it's difficult, says **Tina Hesman Saey**, who covers molecular biology for *Science News*. "As the reader points out, there are multiple three-DNA-letter combinations, or codons, for most of the amino acids," she says. For instance, while the amino acid methionine has just one codon, the amino acid leucine has six codons. "So it may be just easier to compare amino acid sequences directly" instead of trying to reconstruct DNA, **Saey** says.

But that method has its challenges. Because important proteins shared across the tree of life don't change much over evolutionary time, "it may be hard to tell which protein fragments belong to a fossil and which are from contaminating bacteria," **Saey** says. "DNA, especially the roughly 98 to 99 percent of the human genetic instruction book that doesn't contain protein-coding genes, is much more variable and can be used to tease out relationships between species."



How praying mantises can see in 3-D

A praying mantis depends on precision targeting to catch a moving insect meal. Now, scientists have identified nerve cells (one shown above with a colored stain) that help the predators see in 3-D, an ability required for their surgical strikes.

The mantises are the only insects known to be able to see in three dimensions. To understand what happens in the brain, neuroscientist Ronny Rosner of Newcastle University in England and colleagues used a tiny theater that played the insects' favorite films — moving disks that mimic bugs. The disks appeared in 3-D because the insects' eyes were covered with differently colored filters, creating minuscule 3-D glasses (shown at right). As a praying mantis watched the films, electrodes monitored the behavior of nerve cells in the optic lobe, a brain structure responsible for many aspects of vision.

There, researchers found four types of nerve cells that are active when each eye's view of an object is different, a mismatch that's needed for depth perception. The cells seem to help merge the two views into a complete 3-D picture, a skill that human vision cells use to sense depth, too. The finding suggests that these insects' vision is more sophisticated than some scientists had thought, and could inspire advances in robot vision or other automated systems, the team reports June 28 in *Nature Communications*. — *Laura Sanders*

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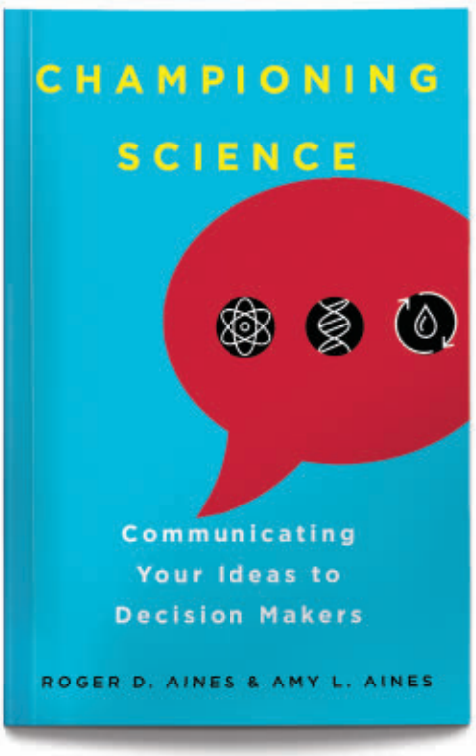

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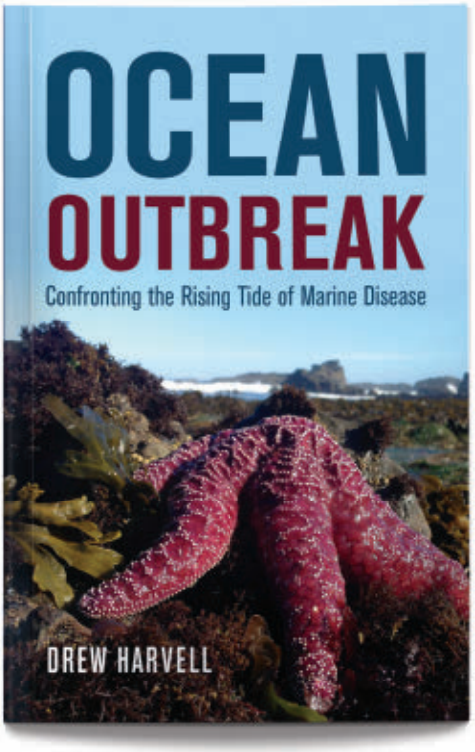

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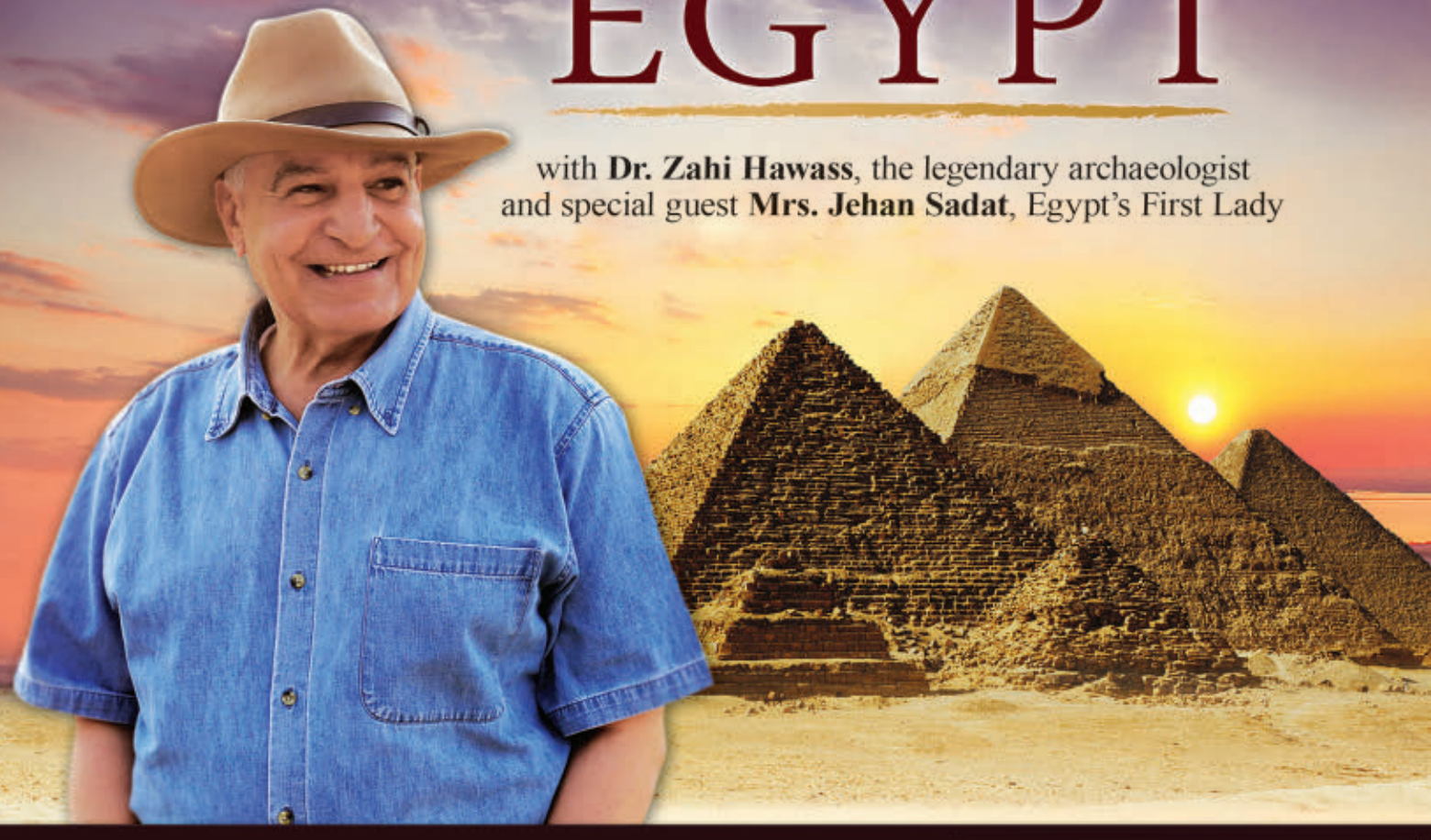

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