SN
SCIENCE NEWS MAG
SOCIETY FOR SCIENCE &
JANUARY 20, 2018

Mosaic Mollusk Eyes

Frozen Soap Bubbles

Revisiting Menopause Relief

Climate Change Blame Game

Rocket to MARS

The race to put humans on the Red Planet may curtail the search for life

Caribbean Couples Retreat: $79

The striking beauty of the 340 total-carat Jasper Treasure Necklace transports you to a tropical paradise for **only $79**.

Limited to the first 1500 responders to this ad only!

You could fork over 6 months of mortgage payments for a Caribbean vacation— but that doesn't guarantee you a romantic grand slam. We have a better option.

Give her 340 total carats of island paradise that will score big in the romance department for a price that leaves plenty left over for plane tickets should you decide to go that route.

The perfect color. We've captured the magical tropical blue-green shade that appears when sunlight is absorbed by the ocean in exotic cuts of jasper gemstones— whose name literally translates to "king of the treasure."

The perfect romantic gift. The *Jasper Treasure Necklace* rises to the top with two strands of blue jasper. Showcasing the elegant oceanic enhanced blue-green, each of the 130 stones in this necklace features a marbleized pattern, which makes every stone unique. She'll feel special every time she wears it. And, most importantly treasured by you.

The perfect price. While big name designers are selling jasper necklaces for $775 or more, we've gone deep on value, pricing the *Jasper Treasure Necklace* **at $79**.

"The demand in Jasper, gradually transforming over centuries, has not decreased in over five millennia!"
— EXPENSIVE PLEASURE

Satisfaction guaranteed or your money back. Go ahead and test the waters for 30 days. If she isn't completely enchanted with the *Jasper Treasure Necklace*, send it back for a full refund of the item price. At Stauer, romance is guaranteed.

Limited Reserve. Now that the secret is out, we cannot guarantee this amazing find will be around for long. Don't miss this opportunity to treat her to a piece of island paradise without going overboard on price. Call today!

- **Jasper with yellow-gold finished spacers & setting**
- **Necklace: 18" plus 2" extender; lobster clasp**
- **Bracelet: 7 ½" plus 2" extender; lobster clasp**
- **Earrings: 1 ¾" drop; French hooks**

Jasper Treasure Collection non-offer code price ~~$597~~†

Necklace (340 ctw)	~~$299~~	$79†	Save $220
Earrings (40 ctw)	~~$99~~	$49†	Save $50
Bracelet (90 ctw)	~~$199~~	$59†	Save $140
Complete set above	~~$597~~	**$149†**	**Save $448!**

You must use the insider offer code to get our special sale price.

1-800-333-2045

Your Insider Offer Code: JTC133-01
Please use this code when you order to receive your discount.

Stauer® 14101 Southcross Drive W., Dept. JTC133-01
Burnsville, Minnesota 55337 **www.stauer.com**

† Special price only for customers using the offer code versus the price on Stauer.com without your offer code.

BBB ACCREDITED BUSINESS **Rating of A+**

CONSUMER AFFAIRS ACCREDITED

Stauer…Afford the Extraordinary.™

VOL. 193 | NO. 1

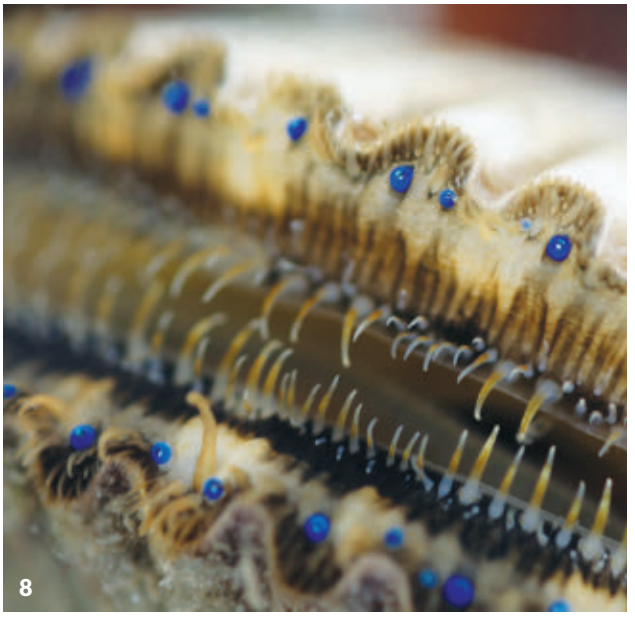
ScienceNews


18

Features


5

News


8

Departments

COVER Space agencies and private companies have set their sights on Mars. One company hopes to get humans to the planet by 2024. *JPL-Caltech/NASA*

FROM TOP: JOAN ALTURO; LUKAS PANZARIN; SHANEKATO/ISTOCKPHOTO

We'll be watching the skies, plus a lot more, this year

If this issue is any clue, 2018 may be the Year of Space. Our pages are packed with a surprising wealth of content for astronomy lovers, and anyone who dreams of otherworldly encounters.

In our cover story (Page 22), astronomy writer Lisa Grossman reports on the race to Mars. SpaceX announced last year that it plans to get people to the Red Planet by 2024, but the battle over what humans' arrival would mean for the search for life on Mars will probably reach a fever pitch this year. Researchers are already exploring the dangers that hitchhiking microbes from Earth would pose to potential alien life, as well as the risk of alien microbes to the health of human astronauts. Expect more experiments that try to fill in the knowledge gaps after a meeting of the international Committee on Space Research, or COSPAR, in February. Debate over mission objectives might also erupt when the COSPAR Scientific Assembly convenes in July. All the back-and-forth will set the stage for a maiden Martian voyage.

Regardless of the timing of that voyage, solid steps are under way this year. Both SpaceX and aerospace company Boeing could launch crewed missions to the International Space Station before 2018 is out. If successful, one or both may soon be taxiing astronauts to and from space.

Also packed in this issue are new clues to the origins of Saturn's rings, a recent measurement of the depth of Jupiter's Great Red Spot (both on Page 7) and a report of the most distant quasar yet detected (Page 5). Emily Conover reports on a study that re-creates in space Galileo's most famous experiment, confirming once again that objects in a vacuum fall at the same rate no matter their composition (Page 9).

Artificial intelligence will probably prove increasingly useful to space scientists in 2018. On Page 12, Maria Temming describes a neural network designed to spot overlooked planets circling other stars. The researchers behind the algorithm plan to apply it to more than 150,000 stars.

On top of all that, NASA's InSight mission is expected to reach Mars this year to study how rocky planets form. Hayabusa2 and OSIRIS-REx are set to convene with their target asteroids. If all goes well, the Transiting Exoplanet Survey Satellite will launch, and the Parker Solar Probe will make its first swing by the sun. We might get the first direct image of a black hole, courtesy of the Event Horizon Telescope team (though we made that same prediction for 2017).

But landlubbers needn't worry. *Science News* readers more interested in the science of Mother Earth will always find content to keep them grounded. On Page 6, Carolyn Gramling writes about studies that, for the first time, blame specific extreme weather events on human-caused climate change — certain to be a hot topic in 2018. Tina Hesman Saey covers the ethics of gene editing (Page 4), and Aimee Cunningham revisits hormone replacement therapy (Page 18). Laurel Hamers offers the latest on a deadly snake fungus (Page 16).

Whether you're looking to the stars or more interested in goings-on in your own backyard, you'll find it in the pages of *Science News*, in 2018 and beyond.

— Elizabeth Quill, Acting Editor in Chief

Science News
1719 N Street NW, Washington, DC 20036
(202) 785-2255

Subscriber services:
E-mail subs@sciencenewssubscriberservice.com
Phone (800) 552-4412 in the U.S. or
(570) 567-1191 outside of the U.S.
Web www.sciencenews.org/join
For renewals, www.sciencenews.org/renew
Mail *Science News*, PO Box 1205, Williamsport, PA 17703-1205

Editorial/Letters: editors@sciencenews.org
***Science News* in High Schools:** snhs@societyforscience.org
Advertising/Sponsor content: ads@societyforscience.org
Science News (ISSN 0036-8423) is published biweekly by Society for Science & the Public, 1719 N Street, NW, Washington, DC 20036.
Online and tablet access: Activate your subscribing member account, including digital access and the ability to opt out of print, at www.sciencenews.org/activate
Subscribing memberships include 24 issues of *Science News* and are available for $50 for one year, published biweekly except monthly in January and July (international rate of $68 includes extra shipping charge). Single copies are $3.99 (plus $1.01 shipping and handling). Preferred periodicals postage paid at Washington, D.C., and an additional mailing office.
Postmaster: Send address changes to *Science News*, PO Box 1205, Williamsport, PA 17703-1205. Two to four weeks' notice is required. Old and new addresses, including zip codes, must be provided.

Alliance for Audited Media

SSP

Actual size is 38 mm

30 Years of Purity:

2018 Silver Maple Leafs Now Available

First issued 30 years ago, the Canadian Silver Maple Leaf has become one of the world's premier silver bullion coins. Millions are struck each year and quickly secured by collectors and silver stackers alike. They are second only to the U.S. Silver Eagle in terms of unit sales, but are superior in terms of purity, legal-tender value and security. Best of all, excitement is white-hot for 2018's 30th anniversary issue.

Special 30th Anniversary Issue

2017 marked Canada's 150th anniversary, and with it came a number of special issues. Collectors around the world discovered the benefits of Canada's precious metal coins. Combine that discovery with this coin's 30th anniversary, and you've got a release that even casual stackers can't afford to miss!

One of the World's Purest Silver Coins — Guaranteed

The Canadian Silver Maple Leaf is one of the world's purest silver coins, struck in a full ounce of 99.99% ("four nines") pure silver, its content, purity and $5 Canadian legal-tender value guaranteed by the Canadian government. By contrast, the U.S. Silver Eagle is only struck in 99.9% purity and carries only a $1 U.S. legal-tender value.

Advanced Security Features

While the Silver Maple Leaf still displays the same immortal symbol of Canada that it did 30 years ago, a few changes have been made along the way. Radial lines were added to the design's background, and laser technology was used to add a micro-engraved, textured maple leaf, complete with a tiny number "18" visible under magnification.

These updated security features make the Silver Maple Leaf nearly impossible to forge, turning one of the world's purest silver coins into one of its most secure. For both stackers and collectors, this is an incredibly important benefit of owning Canadian Silver.

Reputation Matters

Why are we releasing one of the most pure, secure coins ever at such a remarkable price? We want you to know what hundreds of thousands of satisfied collectors and stackers have known since 1984 — GovMint.com is *the best source for coins worldwide.*

Call Now And Beat the Crowd!

This is a strictly limited release of one of the purest silver coins in the world—and a great opportunity to secure one or more hefty 2018 One-Ounce Silver Maple Leafs in Brilliant Uncirculated (BU) condition. These freshly struck coins will quickly be secured by collectors and stackers around the world, so don't wait—call immediately and order your very own Canadian Silver Maple Leafs today!

2018 Canada Silver Maple Leaf BU

1-4 Coins -	$21.60 each + *s/h*
5-9 Coins -	$19.30 each + *s/h*
10-19 Coins -	$19.25 each + *FREE SHIPPING*
20+ Coins -	$19.20 each + *FREE SHIPPING*

FREE SHIPPING on 7 or More!

Limited time only. Product total over $149 before taxes (if any). Standard domestic shipping only. Not valid on previous purchases.

Call today toll-free for fastest service

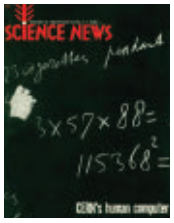
1-800-969-0686

Offer Code SML130-01
Please mention this code when you call.

GovMint.com • 14101 Southcross Dr. W., Suite 175, Dept. SML130-01 • Burnsville, MN 55337

GovMint.com®

THE BEST SOURCE FOR COINS WORLDWIDE™



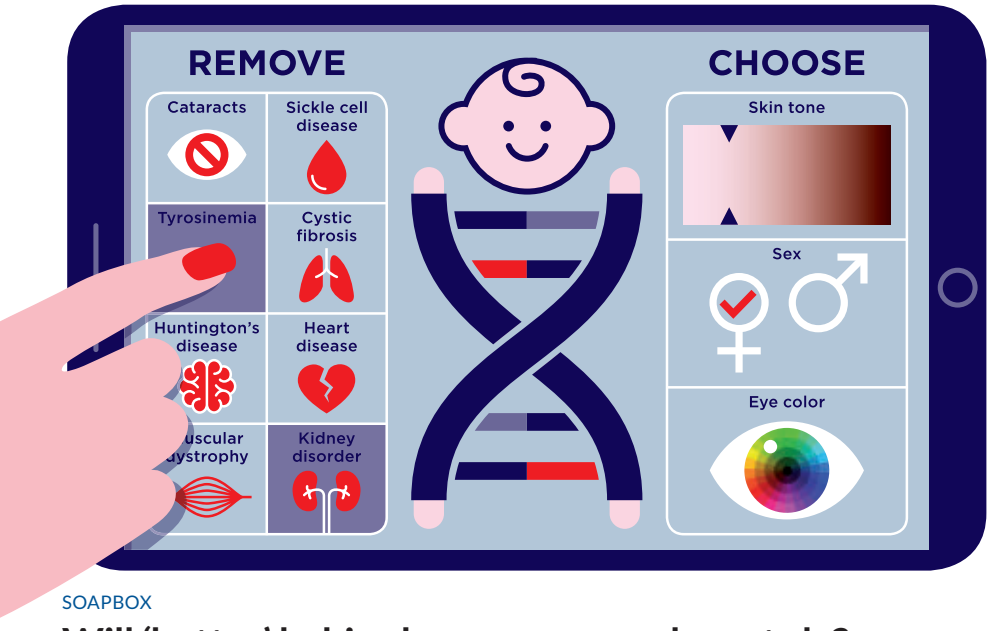
Excerpt from the January 20, 1968 issue of *Science News*

50 YEARS AGO

Dead Sea Scrolls safe

The famous Dead Sea Scrolls, rumored lost or damaged during the June war between Israel and Egypt, are safe, according to *Antiquity*.... On the eve of the war they were packed up and put safely in a strong room in the basement of the Palestine Archaeological Museum (Rockefeller Museum), according to a reliable authority.

UPDATE: The Dead Sea Scrolls made news again in 2017 when archaeologists announced the discovery of a cave with new evidence of scrolls. The cave, close to the original 11 caves that housed scrolls near Qumran in the West Bank, held several broken jars and linen like that used to wrap the scrolls. The pottery dates to roughly 2,200 years ago and is typical of the kind used to store scrolls. One large jar still held a blank fragment of hide, possibly intended to be written on. Two rusty pickaxes located near that jar suggest looters took scrolls from the cave several decades ago.



SOAPBOX

Will 'better' babies become a moral must-do?

Until recently, fiddling with human DNA to give a child the best possible start was only science fiction. Films like 1997's *Gattaca* warned against a new kind of eugenics that could pit the genetic haves against the have-nots. At an October symposium in San Francisco at the World Conference of Science Journalists, ethicists and journalists explored the flip side of that discussion: Do parents have a moral obligation to make "better" babies through genetic engineering?

Gene-editing technology that can precisely change a baby's genes is quickly approaching reality. Last year, scientists reported using CRISPR/Cas9 in viable human embryos to fix mutations that cause heart and blood disorders (*SN: 12/23/17 & 1/6/18, p. 21*). CRISPR/Cas9 acts as a molecular scissors that manipulates DNA (see Page 10). Its use in human embryos has been hotly debated. Should we or shouldn't we?

For many people, the fear of a class of genetically enhanced people is reason enough not to tinker with the DNA of the human germ line — embryos, eggs, sperm and the cells that give rise to eggs and sperm. Yes, correct diseases, these folks say, but don't meddle with characteristics that don't have anything to do with health. A panel of ethicists convened by the National Academies of Sciences, Engineering and Medicine took that exact position last February (*SN: 3/18/17, p. 7*).

But the question of "should we?" may not matter much longer, predicted Josephine Johnston, director of research at the Hastings Center, a bioethics research institute that sponsored the session. As science advances and people become more comfortable with gene editing, laws that prohibit tinkering with embryos will fall, she said, and it will be up to prospective parents to decide for themselves. "Will editing a baby's genes be the kind of thing you're supposed to do?"

Asked after the meeting, Julian Savulescu, an ethicist at the University of Oxford, says yes. Parents are morally obligated to take steps to keep their children healthy, he says. That includes vaccinating them and giving them medicine when they're ill. Genetic technologies are no different, he argues. If these techniques could make children resistant to infections, cancer or diabetes, then parents have an obligation to use the techniques.

Editing genes to cure genetic diseases is something retired bioethicist Ronald Green of Dartmouth College can get behind. "I fully support the reproductive use of gene-editing technology for the prevention and elimination of serious genetic diseases," Green said at the symposium. "If we could use gene editing to remove the sequences in an embryo that cause sickle cell disease or cystic fibrosis, I would say not only that we may do so, but in the case of such severe diseases, we

PATRICK GEORGE

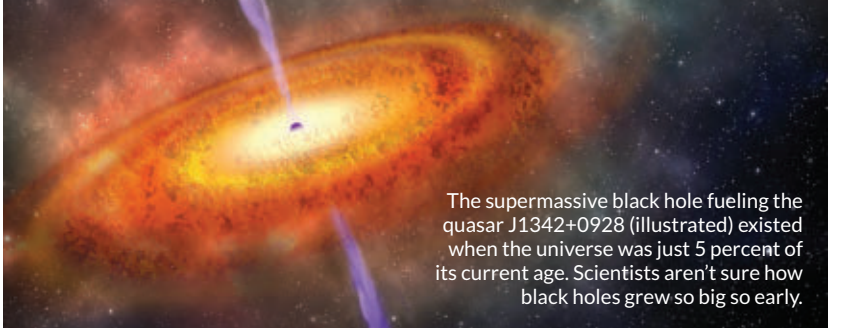
have a moral obligation to do so."

But that's where parental obligation stops, added Green, who votes against creating a class of "genobility," as he calls genetically enhanced people. Parents and medical professionals are not required to enhance health "to make people who are better than well," he said.

Savulescu would go further, extending the obligation to conditions that could prevent a kid from having a full set of opportunities in life. For instance, children with poor impulse control may have difficulty succeeding in school and life. The drug Ritalin is sometimes prescribed to such kids. "If CRISPR could do what Ritalin does and improve impulse control and give a child a greater range of opportunities," he says, "then I'd have to say we have the same moral obligation to use CRISPR as we do to provide education, to provide an adequate diet or to provide Ritalin."

Green, however, rejected the idea that parents should, or even could, secure a better life for their kids through genetic manipulation. Scientists haven't identified all the genes that contribute to good lives — and there are plenty of factors beyond genetics that go into making someone happy and successful. Already, Green said, "the healthy natural human genome has enough variety in it to let any child successfully navigate the world and fulfill his or her own vision of happiness."

Many traits that today help a person make more money or have an easier life are mixed up in social prejudices and discrimination, says Marcy Darnovsky, executive director of the Center for Genetics and Society in Berkeley, Calif. For instance, people who are taller and fair-skinned tend to make more money. If parents were to engineer their children to have such traits, "I think we would be inscribing those kinds of social prejudices in biology," she says. "We get to very troubled waters very quickly as a society once we start down that road." — *Tina Hesman Saey*



The supermassive black hole fueling the quasar J1342+0928 (illustrated) existed when the universe was just 5 percent of its current age. Scientists aren't sure how black holes grew so big so early.

THE -EST

Distant quasar hails from universe's infancy

The farthest quasar yet spotted sends its light from the universe's toddler years. The quasar, called J1342+0928, existed when the universe was only 690 million years old, right when the first stars and galaxies were forming.

Quasars are bright disks of gas and dust swirling around supermassive black holes. The black hole that powers J1342+0928 has a mass equivalent to 800 million suns. It is gobbling gas and dust so fast that its disk glows as bright as 40 trillion suns, astronomer Eduardo Bañados of the Observatories of the Carnegie Institution for Science in Pasadena, Calif., and colleagues report online December 6 in *Nature*.

"The newly discovered quasar gives us a unique photo of the universe when it was 5 percent of its present age," Bañados says. "If the universe was a 50-year-old person, we would be seeing a photo of that person when she/he was 2½ years old." This quasar is only slightly smaller than the previous distance record-holder (*SN: 7/30/11, p. 12*). Scientists still aren't sure how early supermassive black holes like these grew so large. "They either have to grow faster than we thought, or they started as a bigger baby," says study coauthor Xiaohui Fan of the Steward Observatory in Tucson. — *Lisa Grossman*

INTRODUCING

New dinosaur species was an odd duck

It may have walked like a duck and swum like a penguin, but a flipper-limbed creature discovered in today's Mongolia was no bird. The strange new species is the first known nonavian dinosaur that could both walk and swim.

To compensate for a long swanlike neck, this dino's center of mass shifted toward its hips, allowing the critter to stand erect, similar to ducks and other short-tailed modern birds, scientists report in the Dec. 21 *Nature*. Those adaptations, along with the flipperlike forelimbs, suggest the animal, *Halszkaraptor escuilliei,* may have spent much of its time in the water, say vertebrate paleontologist Andrea Cau of the Giovanni Capellini Geological Museum in Bologna, Italy, and colleagues. To study *H. escuilliei* in 3-D while the fossil was still partially embedded in rock, the researchers used synchrotron radiation scanning. High-energy X-rays illuminated structures in fine detail without causing damage.

Halszkaraptor escuilliei (illustrated) was a dinosaur with flipperlike forelimbs, a long neck for snatching aquatic food and an upright posture similar to a duck's.

H. escuilliei lived in the Late Cretaceous about 75 million to 71 million years ago and belonged to a diverse line of theropods called Maniraptora, which includes both nonavian dinosaurs and birds. Though many theropods, such as the tyrannosaurs, were primarily carnivorous, *H. escuilliei*'s jaw, snout and number of teeth suggest it preferred fish. — *Carolyn Gramling*

FROM TOP: ROBIN DIENEL/COURTESY OF THE CARNEGIE INSTITUTION FOR SCIENCE; LUKAS PANZARIN

News

EARTH & ENVIRONMENT

Extreme weather linked to humans

Climate change to blame for some of 2016's severe events

BY CAROLYN GRAMLING

For the first time, scientists have definitively linked human-caused climate change to extreme weather events.

Several extreme events that occurred in 2016 — including a deadly heat wave that swept across Asia — simply could not have happened due to natural climate variability alone, three new studies find. The studies were part of a special issue of the *Bulletin of the American Meteorological Society* released December 13.

These findings are a game changer — or should at least be a conversation changer, Jeff Rosenfeld, editor in chief of the bulletin, said at a news conference that coincided with the studies' release. "We can no longer be shy about talking about the connection between human causes of climate change and weather."

For the last six years, the bulletin has published a December issue containing studies of extreme weather events from the previous year that seek to disentangle the role of anthropogenic climate change from natural variability. The goal from the start has been to find ways to improve the science of attributing such events, said Stephanie Herring of the National Oceanic and Atmospheric Administration's National Centers for Environmental Information in Boulder, Colo., lead editor of the latest issue.

To date, the bulletin has published 137 attribution studies. But this is the first time that any study has found that a weather event was so extreme that it was outside the bounds of natural variability — let alone three such events, Herring said.

In addition to the heat wave in Asia, the other events were the record global heat in 2016 and the growth and persistence of a large swath of high ocean temperatures, nicknamed "the Blob," which extended into the Bering Sea off the coast of Alaska. The unusually warm waters, which lingered for about a year and a half, have been linked to mass die-offs of birds, collapsed codfish populations in the Gulf of Alaska and altered weather patterns that brought drought to California.

Many of the other 24 studies in the new issue found a strong likelihood of human influence on extreme weather events but stopped short of saying they were completely out of the realm of natural variability. One study found that an already strong El Niño in 2016 was probably enhanced by human influence, contributing to drought and famine conditions in southern Africa. And greenhouse gas–driven warming of sea surface temperatures in the Coral Sea was the main factor driving an increase in coral bleaching risk along the Great Barrier Reef, another study found. But not all of the studies linked 2016's extreme events to human activity. Record-breaking rainfall in southeastern Australia between July and September, for instance, was due to natural variability, one study found.

With hurricanes, wildfires and drought, 2017 was chock-full of extreme event candidates for next year's crop of attribution studies. Already, the likelihood of human influence on the extreme rainfall from Hurricane Harvey is the subject of three independent studies. The storm dropped up to 1.3 meters of water in and around Houston in August. The three studies, discussed in a separate news conference December 13, found that human influence probably increased the hurricane's total rainfall, by anywhere from at least 15 to at least 19 percent.

1.3
meters
Amount of water dropped by Hurricane Harvey in one city outside Houston

15–19
percent
Minimum boost in Harvey's rainfall attributed to human-driven climate change

The studies in the *Bulletin of the American Meteorological Society* "speak to the profound nature of the impacts we're now seeing," says Michael Mann, a climate scientist at Penn State who was not involved in any of the studies. But Mann says he's concerned that many researchers are too focused on quantifying how much human influence was responsible for a particular event, rather than how human influence affects various processes on the planet. One example, he notes, is a better understanding of the established link between rising temperatures and increased moisture in the atmosphere that is also implicated in Hurricane Harvey's extreme rainfall.

Another possible issue with attribution science, he says, is that the current generation of simulations may not be capable of capturing some of the subtle changes in the climate and oceans — a particular danger when it comes to studies that find no link to human activities.

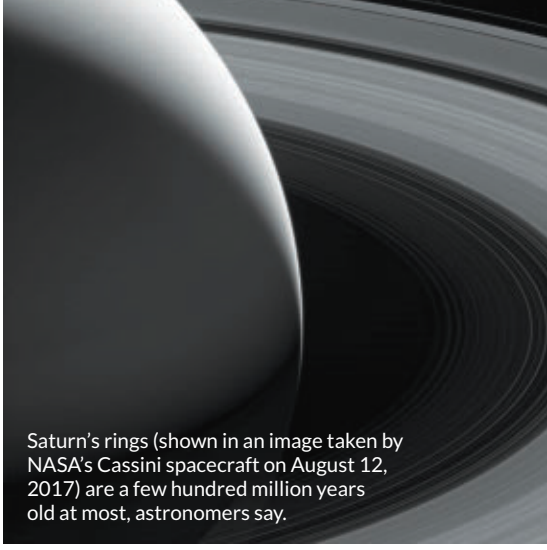
It's a point that climate scientist Andrew King of the University of Melbourne in Australia, who authored the paper on Australia's rainfall, noted at the news conference. "When we find no clear signal for climate change, there might not have been a human influence on the event, or [it might be that] the particular factors of the event that were investigated were not influenced by climate change," he said. "It's also possible that the given tools we have today can't find this climate change signal."

Rosenfeld noted that people tend to talk about the long odds of an extreme weather event happening. But with studies now saying that climate change was a necessary condition for some extreme events, discussions about long odds no longer apply, he said. "These are new weather extremes made possible by a new climate." ■

ATOM & COSMOS

Saturn sports relatively young rings

Planet didn't always have icy bands, new Cassini data show



Saturn's rings (shown in an image taken by NASA's Cassini spacecraft on August 12, 2017) are a few hundred million years old at most, astronomers say.

BY LISA GROSSMAN

Saturn's rings are a recent addition — only about a few hundred million years old.

That finding suggests the rings are remnants of at least one moon, rather than ancient remains of the stuff that formed the planet, researchers reported.

Scientists have puzzled over the origins of Saturn's rings (*SN: 11/12/16, p. 10*). If the rings had formed with Saturn some 4 billion years ago, a constant bombardment of debris from the more distant solar system should have made the icy bands appear darker than they do. But scientists thought the rings were too heavy to have formed more recently, when there was less material for Saturn to pull into the rings.

Cassini may have settled the issue. Before its mission ended in September, the spacecraft swooped between Saturn and its rings 22 times. Those moves let astronomers measure the difference in the gravitational tug the probe felt from Saturn versus from the rings and the planet together. The B ring, which makes up 80 percent of the total ring mass, is 15 billion billion kilograms, or two-fifths the mass of Saturn's moon Mimas, planetary scientist Luciano Iess of Sapienza University of Rome said December 12.

That's lightweight enough for the rings to be young, says planetary scientist Larry Esposito of the University of Colorado Boulder. In 1983, Esposito used data from the Voyager spacecraft to estimate the ring's mass and got a similar answer. "But I always thought that was an underestimate," he says.

The dust raining down on the rings supports the rings' youth, too, planetary scientist Sascha Kempf of the University of Colorado Boulder reported December 13. Using 12 years of Cassini data, Kempf and colleagues showed that the still-bright rings collect too much dust pollution to have maintained their youthful shine for billions of years. "The ring can only have a pollution age of a few hundred million years or so," Kempf said.

How the rings formed remains a mystery. Paul Estrada of the SETI Institute in Mountain View, Calif., one of Kempf's collaborators, says ring formation might not be a one-off event. Instead, Saturn might go through cycles of rings and then moons. In 2016, scientists calculated that if an outermost Saturn moon had moved in a bit, that motion could destabilize the whole moon system and force the orbs into orbits where Saturn's gravity would shred the moons into rings. Those rings could accrete into new moons and later go through the whole process again. ■

MEETING NOTES

Jovian spot runs deep

Jupiter's Great Red Spot has deep roots. Data from the first pass of NASA's Juno probe over the incessant storm show that its clouds stretch at least 350 kilometers down into the planet's atmosphere. That means, at a minimum, the storm is nearly as deep as the International Space Station is high above Earth.

Juno has been orbiting Jupiter since July 2016; it made its first close flyby of the red spot about a year later. As the spacecraft passed 9,000 kilometers above the giant storm, Juno's microwave radiometer peered through the deep layers of cloud, measuring the atmosphere's temperature down hundreds of kilometers, Juno coinvestigator Andrew Ingersoll of Caltech said December 11. The radiometer probes different layers of the atmosphere by measuring the gas in six different microwave wavelengths. Ingersoll and colleagues found that the gas beneath the red spot's surface gets warmer with depth, and a warm zone at the same location as the spot was visible down to 350 kilometers.

Juno principal investigator Scott Bolton of the Southwest Research Institute in San Antonio notes that the spot could go deeper. Juno will use gravity data to try to detect the storm at depths of thousands of kilometers. — *Lisa Grossman*

Maps underestimate U.S. flood risk, scientists warn

U.S. flood maps are underestimating the risk for tens of millions of people, researchers reported December 11.

The U.S. Federal Emergency Management Agency estimates that about 13 million people live in a "1-in-100-year" floodplain zone, a region that has a 1 percent chance of flooding in any given year. But the agency's risk assessment largely focuses on larger streams and rivers, and lacks assessments of risk along smaller tributaries, says Oliver Wing, a geographer at the University of Bristol in England.

After amassing a wealth of data, Wing and colleagues found that about 40 million people in the United States live in 1-in-100-year risk zones. Based on estimated future land development, that number will climb to 60 million by 2050, and to 75 million by 2100, the team predicts. But those figures account only for development in areas currently at risk, Wing says. As the planet warms, rainfall patterns around the globe will shift — and some parts of the United States will see their flood risks rise. — *Carolyn Gramling*

JPL-CALTECH/NASA, SPACE SCIENCE INSTITUTE

The fleshy part of a scallop is studded with eyes (blue) that each contain an intricate mosaic mirror, new research shows.

LIFE & EVOLUTION

Tiny, square crystals help a scallop see

Mollusk eye uses mosaic mirror to focus light on two retinas

BY LAUREL HAMERS

There's stiff competition for the most elaborate eyeballs in the animal kingdom, but a mollusk that turns up on dinner plates might be a finalist.

Each of a scallop's eyes — it has up to 200, each about a millimeter wide — contains millions of perfectly square, flat crystals that form a mirrored mosaic, new research shows. And that shiny surface is curved in a way that lets a scallop focus light onto two different retinas.

Scientists have long known that scallop eyes are unusual. In the 1960s, a biologist showed that each eye uses a mirror to focus light into images. Most other animals' eyes use lenses (*SN: 5/28/16, p. 22*). The natural mirror is made of crystals of guanine — better known as one of the four bases of DNA. At the time, imaging technology wasn't good enough to show how the bivalves build the mirror.

Now, cryo-electron microscopy is bringing those blueprints out of their shell, biologist Benjamin Palmer and colleagues report in the Dec. 1 *Science*.

"It's such an unusual visual system," says marine ecologist Daniel Speiser of the University of South Carolina in Columbia, who wasn't part of the study. "The closer you look, the more puzzling it gets."

For one thing, the guanine crystals are squares, says Palmer, of the Weizmann Institute of Science in Rehovot, Israel. "That's really weird," he says. "It's the first time we've seen a perfect square!"

Guanine doesn't form crystal shapes that evenly pack together in the lab. So, somehow, the scallop controls the crystallization process, Palmer says. The square crystals fit together edge to edge like bathroom tiles to form a smooth surface that minimizes image distortion.

A single crystal is transparent. But

BODY & BRAIN

Hospital limits access to opioids

New prescription guidelines don't leave patients in pain

BY AIMEE CUNNINGHAM

To halt the misuse of opioids, it may help to slash the number of pills prescribed.

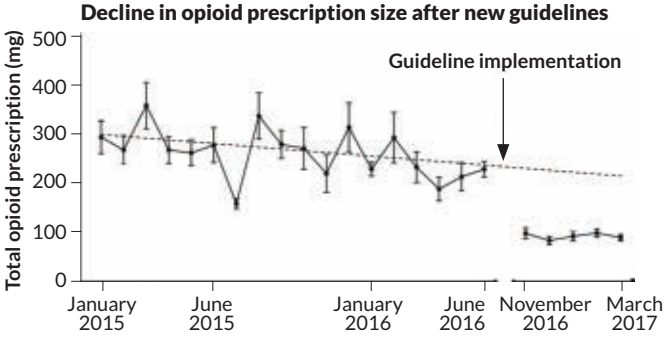
Five months after the implementation of new opioid prescription guidelines at a hospital in Michigan, about 7,000 fewer pills went home with patients — a drop that might reduce the risk of accessible pills leading to substance abuse. Importantly, the reduction didn't leave patients who had undergone a routine surgery with more pain, researchers report online December 6 in *JAMA Surgery*.

"The decline in opioid volume after the intervention was dramatic," says physician Mark Bicket of Johns Hopkins University School of Medicine, who was not involved in the study.

About 50 percent of people who misuse opioids get them from a friend or relative for free; 22 percent obtain them from a doctor, according to the U.S. Department of Health and Human Services. Michael Englesbe, a surgeon at the University of Michigan in Ann Arbor, says that part of doing a better job of managing patients' pain "will be preventing chronic opioid use after surgical care and making sure fewer pills get into the community."

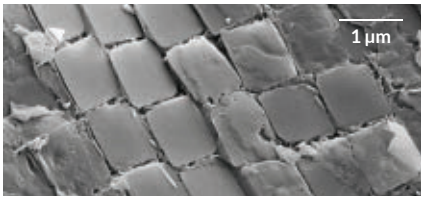
Englesbe and colleagues began their study with 170 people who had minimally invasive gallbladder-removal surgery at a University of Michigan hospital from 2015 to 2016. All had received an opioid prescription. Of those patients, 100 completed a survey detailing how much of the prescription they took, whether they also used a common painkiller such as acetaminophen and how they rated their pain during the first week after surgery.

The 170 people typically received a prescription equivalent to 40 to 60 tablets, each with 5 milligrams of hydrocodone. Seven of the 170 patients requested an opioid prescription refill. The 100 patients who completed the survey used



Pill purge
At a hospital in Michigan, new guidelines for prescribing opioids after minimally invasive gallbladder surgery reduced average prescription sizes (shown) but didn't increase refill requests.

FROM TOP: SHANEKATO/ISTOCKPHOTO; R. HOWARD *ET AL/JAMA SURGERY* 2017



Cryo-electron microscopy images show that the mirror in a scallop eye is made of square crystals that form a reflective mosaic.

each scallop eye stacks 20 to 30 tiled sheets to create a reflective surface. The whole contraption is something like a telescope that pieces together hexagonal mirrors into one giant curve.

The eye mirror isn't a perfect hemisphere: It has a 3-D shape that allows the scallop to focus light on one of two retinas, depending on incoming light's angle. One retina is tuned to dim light from peripheral vision; the other best captures movement in bright light.

"This is a new idea for how the scallop can make use of both retinas in the same eye," Speiser says — a question that has long vexed scallop experts. ■

very little of their prescriptions, usually from one to 12 pills. And the patients' average pain score on a scale of zero (no pain) to 10 (the worst imaginable) was 5.

Based on these data, the hospital implemented guidelines in November 2016 for opioid prescriptions following this type of gallbladder surgery. The researchers recommended prescriptions of 15 opioid pills, plus the use of common painkillers.

In the five months after the guidelines went into effect, 200 patients had the gallbladder surgery. Five asked for an opioid prescription refill. Eighty-six of the patients filled out a survey and reported that they used even less of their prescriptions — from zero to nine pills — than the pre-guidelines survey group. These patients also noted the same average pain score as the previously surveyed group and similar common painkiller use.

Englesbe and colleagues have also developed opioid prescribing recommendations for other routine surgeries, such as appendix removal and hernia repair, for the state of Michigan. ■

B.A. PALMER *ET AL*/*SCIENCE* 2017

MATTER & ENERGY

Galileo experiment re-created in space

Equivalence principle holds up in satellite-based gravity test

BY EMILY CONOVER

Galileo's most famous experiment has taken a trip to outer space. The result? Albert Einstein was right yet again. The experiment confirms a tenet of Einstein's theory of gravity with greater precision than ever before.

According to science lore, Galileo dropped two balls from the Leaning Tower of Pisa and showed that they fell at the same rate no matter their composition. Although it seems unlikely that Galileo actually carried out this experiment, scientists have performed a similar but much more sensitive experiment in a satellite orbiting Earth. Two hollow cylinders within the satellite fell at the same rate over 120 orbits, or about eight days' worth of free fall time, researchers with the MICROSCOPE experiment report in the Dec. 8 *Physical Review Letters*. The cylinders' accelerations match within two trillionths of a percent.

The cylinders' accelerations match within two trillionths of a percent.

The finding confirms a foundation of Einstein's general theory of relativity known as the equivalence principle. The principle states that an object's inertial mass, which sets the amount of force needed to accelerate it, is equal to its gravitational mass, which determines how the object responds to a gravitational field. As a result, items fall at the same rate — at least in a vacuum, where air resistance is eliminated — even if their masses or materials differ.

The result is "fantastic," says Stephan Schlamminger, a physicist at OTH Regensburg in Germany who was not involved in the study. "It's just great to have a more precise measurement of the equivalence principle because it's one of the most fundamental tenets of gravity."

In the satellite, a hollow platinum-alloy cylinder is centered inside a hollow titanium-alloy cylinder. The cylinders should fall at the same rate. But a violation of the equivalence principle might make one fall slightly faster.

As the two objects fall in their orbit around Earth, the satellite uses electrical forces to keep the pair aligned. If the equivalence principle didn't hold, adjustments needed to keep the cylinders in line would vary with a regular frequency, tied to the rate at which the satellite orbits and rotates. "If we see any difference in the acceleration, it would be a signature of violation," says Manuel Rodrigues, a MICROSCOPE researcher at the French aerospace lab ONERA in Palaiseau. But no hint of such a signal was found.

With about 10 times the precision of previous tests, the result is "very impressive," says physicist Jens Gundlach of the University of Washington in Seattle. But "the results are still not as precise as what I think they can get out of a satellite measurement."

A space-based experiment eliminates certain pitfalls of modern-day land-based equivalence principle tests, such as groundwater flow altering the mass of surrounding terrain. But temperature changes in the satellite limited how well the scientists could confirm the principle, as these variations can cause parts of the apparatus to expand or contract.

MICROSCOPE's ultimate goal is to beat other measurements by a factor of 100, comparing the cylinders' accelerations to see whether they match within a tenth of a trillionth of a percent. With additional data yet to be analyzed, the scientists may still reach that mark.

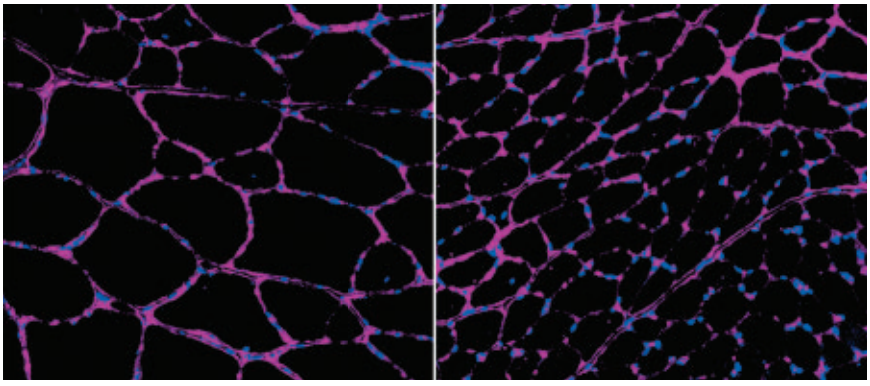
Confirmation doesn't mean that all is hunky-dory in physics. Scientists still don't know how to combine general relativity with quantum mechanics, the physics of the very small. Some attempts to merge the two theories predict violations of the equivalence principle on a level that's not yet detectable. That's why scientists think the equivalence principle is worth testing to ever more precision. ■

GENES & CELLS

New CRISPR tool turns on genes

Molecular editor treats mice's diseases without cutting DNA

BY TINA HESMAN SAEY



A new type of CRISPR/Cas9-based gene therapy turned on muscle-building genes in mice. Mice that got the therapy had larger muscle fibers (magenta, left) than untreated animals (right).

A new twist on gene editing makes the CRISPR/Cas9 molecular scissors act as a highlighter for the genetic instruction book. Such highlighting helps turn on specific genes.

Using the new tool, researchers treated mouse versions of type 1 diabetes, kidney injury and Duchenne muscular dystrophy, the team reports in the Dec. 14 *Cell*. The method may make some types of gene therapy easier and could be a boon for researchers hoping to control gene activity in animals, scientists say.

CRISPR/Cas9 is a two-part molecular scissors. A short guide RNA leads the DNA-cutting enzyme Cas9 to specific places in the genetic instructions that scientists want to slice. Snipping DNA is the first step to making or fixing mutations.

In the five years or so since CRISPR/Cas9 was first wielded, scientists have modified the technique to make a variety of changes to DNA (*SN: 9/3/16, p. 22*). Many of those modifications involve breaking the Cas9 scissors so they can't cut. Strapping other molecules to this "dead" Cas9 allows scientists to alter genes or change gene activity.

The new tool, known as CRISPRa, could be used to turn on dormant genes. For instance, doctors might turn on alternate copies of genes to compensate for missing proteins or to reinvigorate genes that grow sluggish with age. So far, researchers have mostly turned on genes with CRISPRa in cells growing in lab dishes, says Charles Gersbach, a biomedical engineer at Duke University who was not involved in the new study.

Being able to precisely turn on genes in an animal and influence health is a "great advance," Gersbach says. Previous CRISPR gene activators were too big to fit in the viruses that deliver the tools to cells.

In the new study, Juan Carlos Izpisua Belmonte of the Salk Institute for Biological Studies in La Jolla, Calif., and colleagues shrank the tool, using guide RNAs just 14 or 15 units long instead of the usual 20. The researchers also "killed" and modified the guide RNA instead of the DNA-cutting enzyme.

The short leash still leads Cas9 to specific spots in DNA, but once there, the enzyme — though still capable of cutting — doesn't snip DNA. Another piece of RNA tacked onto the "dead" guide attracts proteins that help turn genes on.

In one experiment, the team restored diabetic mice's ability to make insulin. In type 1 diabetes, the immune system destroys the cells in the pancreas that normally make insulin to control blood sugar. Belmonte's group infected diabetic mice with viruses carrying the activators stuck to dead guides. The activator-guide combination turned on the *Pdx1* gene in the liver, causing liver cells to make insulin and partially reverse the mice's diabetes. The liver cells were transformed into cells that do an important job of the pancreas.

"Labs have been trying to do that for decades," says physician scientist Kirk Wangensteen of the University of Pennsylvania's Perelman School of Medicine. Such experiments might also help scientists understand what factors determine a cell's identity.

But to do the gene therapy in humans, scientists would need to tackle another problem. The diabetes experiment used mice engineered to make Cas9. But people don't naturally make the enzyme, and the dead guide, activator and Cas9 system won't all fit in a virus. So Belmonte's team tested whether two viruses could be used to deliver all the pieces to target cells.

The researchers studied mice with a muscle-wasting disease that mimics Duchenne muscular dystrophy, which is caused by mutations in a huge gene called *dystrophin*. There's no way to cram that gene into a virus to do traditional gene-replacement therapy, but turning on other genes can compensate and bulk up muscles. So in the dual-virus experiment, the scientists turned on a muscle-building gene called *follistatin*.

The dead guide plus activator for turning on *follistatin* was packaged in one virus and Cas9 in another virus. Both viruses were used to infect muscle cells in the hind legs of mice that had muscle wasting. Treated mice had more muscle mass in their hind legs than untreated mice did.

Much higher levels of gene activity were triggered in these experiments than scientists have achieved before, says cancer biologist Michael Hemann of MIT. High levels of activity are probably needed to produce enough protein to correct diseases.

Hemann says the new activator system will be useful for research, but the technology's safety and efficacy must be demonstrated before the therapy can be used in people. Researchers, he says, always have a challenge getting the therapy to the right place in the body. ■

H.-K. LIAO *ET AL*/*CELL* 2017

MATTER & ENERGY

Weird materials may follow the rules

High-temperature superconductors match standard theory

BY EMILY CONOVER

A misfit gang of superconducting materials may be losing their outsider status.

Certain copper-based compounds superconduct, or transmit electricity without resistance, at unusually high temperatures. It was thought that the standard theory of superconductivity, known as Bardeen-Cooper-Schrieffer theory, couldn't explain the oddballs. But new evidence suggests that the standard theory does apply, researchers report in the Dec. 8 *Physical Review Letters*.

All known superconductors must be chilled to work. Most must be cooled to temperatures that hover above absolute zero (–273.15° Celsius). But some copper-based superconductors work at temperatures above the boiling point of liquid nitrogen (about –196° C). Finding a superconductor that functions at even higher temperatures — above room temperature — could provide big energy savings and new technologies (*SN: 12/26/15, p. 25*). So scientists are intent upon understanding the physics behind known high-temperature superconductors.

When placed in a magnetic field, many superconductors display swirling vortices of electric current — a hallmark of the standard superconductivity theory. But for copper-based superconductors, known as cuprates, scientists couldn't find whirls that matched predictions, suggesting that a different theory was needed to explain how the materials superconduct. Now, physicist Christoph Renner of the University of Geneva and colleagues have found vortices that agree with the standard theory in a high-temperature copper-based superconductor.

Vortices in superconductors can be probed with a scanning tunneling microscope. As the microscope tip moves over a vortex, the instrument records a change in electric current. Renner and colleagues realized that, in their copper compound, there were two contributions to the measured current: one from superconducting electrons and one from nonsuperconducting ones. The nonsuperconducting contribution was present across the material's entire surface and masked the signature of the vortices.

Subtracting the nonsuperconducting portion revealed the vortices, which were in line with standard superconductivity theory. "That, I think, is quite astonishing. It's quite a feat," says physicist Mikael Fogelström of Chalmers University of Technology in Gothenburg, Sweden.

The result lifts some of the fog surrounding cuprates, which have so far resisted theoretical explanation. But plenty of questions still surround the materials, Fogelström says. "It leaves many things still open, but it sort of gives a new picture." ■

ATOM & COSMOS

Artificial intelligence finds new planet

Algorithm's detection adds 8th world to Kepler 90's family

BY MARIA TEMMING

Our solar system is no longer the sole record-holder for most known planets circling a star.

An artificial intelligence algorithm sifted through data from the planet-hunting Kepler space telescope and discovered an overlooked planet orbiting Kepler 90 — making it the first star besides the sun known to host eight planets. This finding, announced in a news conference December 14, shows that the kinds of computer codes used to translate text and recognize voices can also help discover strange new worlds.

The discovery, to be reported in an upcoming *Astronomical Journal*, can also help astronomers better understand our galaxy's planetary population. "Finding systems like this that have lots of planets is a really neat way to test theories of planet formation and evolution," says astronomer Jeff Coughlin of the SETI Institute in Mountain View, Calif., and NASA's Ames Research Center in Moffett Field, Calif.

Kepler 90 is a sunlike star about 2,500 light-years from Earth in the constellation Draco. The latest addition to the star's family is a rocky planet about 30 percent larger than Earth called Kepler 90i. But with an estimated surface temperature higher than 400° Celsius, it's probably not habitable.

The seven previously known planets range from small, rocky worlds to Jupiter-sized — all packed closer to their star than Earth is to the sun. And there could be more. "There's a lot of unexplored real estate in the Kepler 90 system," study coauthor Andrew Vanderburg, an astronomer at the University of Texas at Austin, said in the news conference.

Astronomers have identified over 2,300 new planets in Kepler data by searching for tiny dips in a star's brightness when a planet passes in front. Kepler has collected too much data to go through it all by hand, so humans or computer programs typically verify only the most promising signals. Worlds that produce weaker light dips — including Kepler 90i — can get passed over. Vanderburg and Christopher Shallue, a software engineer at Google in Mountain View, designed a computer code called a neural network, which mimics the way the human brain processes information, to seek out such overlooked exoplanets.

A computer algorithm discovered that the star system Kepler 90, illustrated above, has an eighth world, dubbed Kepler 90i.

Researchers previously automated Kepler data analysis by hard-coding programs with rules about how to detect bona fide exoplanet signals, Coughlin explains. Here, Vanderburg and Shallue provided their code with more than 10,000 Kepler signals that had been labeled by human scientists as either exoplanet or nonexoplanet signals. By studying these examples, the neural network learned on its own what the light signal of an exoplanet looked like.

The trained neural network examined 670 star systems known to host multiple planets to see whether other searches had missed anything. It spotted Kepler 90i and a sixth, Earth-sized planet around the star Kepler 80. This feat marks the first time a neural network has identified new exoplanets in Kepler data, astrophysicist Jessie Dotson of NASA's Ames Research Center said at the news conference.

Vanderburg and Shallue plan to apply their neural network to Kepler's full cache of data on more than 150,000 stars to see what other unrecognized exoplanets might turn up. ■

BODY & BRAIN

Fracking linked to low birth weight

Moms' proximity to active sites may affect newborn health

BY AIMEE CUNNINGHAM

Living near a fracking site appears to be detrimental to infant health, a study eyeing the gas production practice in Pennsylvania suggests.

Babies of moms living within one kilometer of a hydraulic fracturing, or fracking, site in the state had a 25 percent greater chance of being born underweight than did babies whose moms lived at least three kilometers away, researchers report December 13 in *Science Advances*. The chance of having a low-birth-weight baby was 1 in 14 for the moms living closest to a fracking site, but 1 in 17 for moms three to 15 kilometers away, says study coauthor Janet Currie, an economist at Princeton University.

For babies born to moms living within one to three kilometers of a site, the chance of being underweight at birth was about 8 percent greater than for babies of the more distant moms, says Currie. The study found no ill effect on infants born to moms residing farther away, an indication that fracking's health impact may be highly local. In the study, distance of residences from the fracking sites was used as a stand-in for potential pollution exposure. The researchers did not measure actual pollution exposure, or figure out whether people faced exposure through water, air or both.

"These results point to a concern of fracking," says Pam Factor-Litvak, a Columbia University epidemiologist, but more work is needed to find the mechanism behind the apparent link to low birth weight. The associations between fracking and poor infant health could be caused by factors besides pollution, such as extreme levels of maternal stress, perhaps due to noise and traffic to and from the sites. "There is a definite need to study the health effects of fracking accounting for the short-term changes

WENDY STENZEL/AMES RESEARCH CTR/NASA

in air quality, the possible long-term changes in water quality and the associations with stress," Factor-Litvak says.

Fracking, which injects liquids underground at high pressure to extract oil and natural gas from hard to reach places, can contaminate water and air due to chemicals used in the process. Fracking often moves into areas that didn't previously have industrial activity, Currie says, providing the opportunity to measure health effects before and after fracking begins.

Currie and colleagues examined records of more than 1.1 million births in Pennsylvania from 2004 to 2013. The researchers took note of birth weight, which is often used as a sign of fetal health in studies of environmental pollution. Low-birth-weight babies, who weigh less than 5.5 pounds, have a greater risk of illness and delayed development.

In addition, the team compiled information from the Pennsylvania Department of Environmental Protection on the locations and opening dates of all active fracked sites in the state. As of 2014, there were over 7,500 fracking sites, most of which went live after 2009.

The researchers compared babies born to moms residing at different distances from fracking sites, as well as infants born before and after sites became active. The researchers controlled for moms' race, marital status and education — factors that can contribute to low birth weight.

Babies born to moms who lived closest to fracking sites, within a kilometer, had the highest probability of low birth weight. Out of more than 6,500 births to moms residing within one kilometer of a site over the 11 years studied, nearly 1,800 occurred when there was active fracking. The researchers found that 5 percent of babies born to moms living within a kilometer of not-yet active sites were underweight, whereas 7 percent of births that happened after sites became active were underweight. There was no change in the percentage of low-weight births to moms three to 15 kilometers from a site before and after fracking.

The researchers also investigated how distance from fracking sites affected an index of health measures, including prematurity and congenital anomalies. Those babies born to moms living closest to the sites were worse off.

"I don't think we are going to ban fracking throughout the United States," Currie says. But "knowing more about what the health effects are can help people to protect themselves" and inform policy regarding fracking. ■

MATH & TECHNOLOGY

Electric eel inspires new power source

Battery-like device mimics how charge builds in the animal's cells

BY MARIA TEMMING

New power sources bear a shocking resemblance to the electricity-making organs inside electric eels.

These artificial electric organs are made of water-based polymer mixes called hydrogels. Such soft, flexible battery-like devices, described in the Dec. 14 *Nature*, could power soft robots or next-gen wearable and implantable tech.

Jian Xu, an engineer at Louisiana State University in Baton Rouge, says this "very smart approach" to building potentially biocompatible, environmentally friendly energy sources "has a bright future for commercialization."

This new type of power source is modeled after rows of cells called electrocytes in the electric organ that runs along an electric eel's body. When an eel zaps its prey, positively charged potassium and sodium atoms inside and between these cells flow toward the eel's head, making each electrocyte's front end positive and tail end negative. This setup creates about 150 millivolts across each cell. The voltages of these electrocytes add up, like a lineup of AAA batteries powering a flashlight, explains biophysicist Michael Mayer of the University of Fribourg in Switzerland. Collectively, an eel's electrocytes can generate hundreds of volts.

Mayer and colleagues concocted four hydrogels that, when queued up in a particular order, mimic the function of a single electrocyte. The researchers devised a couple of strategies for stringing a four-gel artificial cell to other cells. One technique involved printing hydrogel grids onto two polyester sheets, and then laying one sheet on top of the other so the hydrogels crisscrossed like zipper teeth. Alternatively, printing all the hydrogels on a single sheet and then folding the sheet stacked the gels like pancakes.

The researchers designed the four hydrogels' chemical makeups so that as soon as all the gels of a single cell touched, their positively charged sodium atoms surged toward one end of the lineup and negative chloride atoms flooded toward the other. Each four-gel artificial cell generated 130 to 185 millivolts of energy; 612 artificial eel cells in tandem produced 110 volts — about the energy of a household outlet.

A polyester sheet with hydrogels (colored disks) printed in a precise configuration folds up so the hydrogels stack similarly to the cells in an electric eel's electric organ.

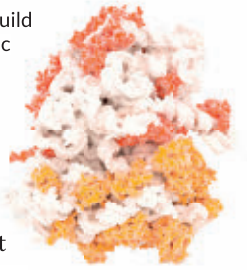
THOMAS SCHROEDER, ANIRVAN GUHA

But the artificial eel organs don't expend their energy as efficiently as their biological counterparts, Mayer says. So the hydrogel systems built for this study could only energize very low-power instruments. "The device we're closest to powering is probably a pacemaker," Mayer says. But he thinks that tweaking the hydrogel setup — perhaps by printing thinner gels, for example — could give these energy sources more oomph. ■

GENES & CELLS

Not all ribosomes do the same job

Cells' protein makers may specialize in what they build



Molecular machines that build proteins, ribosomes (atomic structure illustrated) may be more diverse than researchers thought.

BY TINA HESMAN SAEY

Protein factories in cells are picky about which widgets they construct, new work suggests. Known as ribosomes, these factories may craft only specialty products, instead of building all kinds of proteins.

And some of that specialization may influence the course of embryo development, geneticist and developmental biologist Maria Barna of Stanford University School of Medicine reported December 5 at a joint meeting of the American Society for Cell Biology and the European Molecular Biology Organization.

Ribosomes, themselves made up of many proteins and RNAs, read genetic instructions copied from DNA into messenger RNAs. The ribosomes translate those instructions to make other proteins that build cells and carry out cellular functions. A typical mammalian cell may carry 10 million ribosomes. "The textbook view of ribosomes is that they are all the same," Barna said.

But that view may change. Ribosomes actually come in many varieties, incorporating different proteins, Barna and colleagues have found. Each ribosome type may be responsible for reading a subset of messenger RNAs. For instance, ribosomes with the ribosomal protein RPS25 build all proteins involved in processing vitamin B12, Barna and colleagues reported in the July 6 *Molecular Cell*. Perhaps other processes are also controlled, in part, by having specific ribosomes build particular proteins, Barna said.

In unpublished work, Barna's group found that certain ribosome varieties may be important at different stages of embryonic development. The team coaxed embryonic stem cells in lab dishes to develop into many types of cells, then examined the proteins in ribosomes found in each cell type. Of the 80 ribosomal proteins examined, 31 were specialized for specific cell types, suggesting specialized ribosomes help set a cell's identity, Barna said.

The idea of diverse ribosomes goes against the classic textbook view, but "the concept is not heretical at all," said Vassie Ware, a molecular cell biologist at Lehigh University in Bethlehem, Pa. The idea may help explain why some people with mutations in certain ribosomal protein genes develop conditions such as Diamond-Blackfan anemia — in which the bone marrow doesn't make enough red blood cells — but don't have problems in other tissues, Ware said.

That disease is caused by mutations in the *RPL5* and *RPL11* genes, which encode ribosomal building blocks. If all ribosomes were alike, people with mutations in ribosomal components should have malfunctions all over the body, or might not ever be born. RPL5 and RPL11 proteins may be part of specialized ribosomes that are important in the bone marrow but not elsewhere. ■

MEETING NOTES

Fusing with blood vessels helps breast cancer spread

If you want to beat them, join them. Some breast cancer tumors may follow that strategy to spread through the body.

Breast cancer tumors can fuse with blood vessel cells, allowing clumps of cancer cells to break away from the tumor and ride the bloodstream to other locations, cell biologist Vanesa Silvestri of Johns Hopkins University School of Medicine reported December 4.

Previous work has shown that cancer cells in clusters have a better chance of spreading than loners (*SN: 1/10/15, p. 9*). But how clumps get into blood has been a mystery, in part because scientists can't easily see into tumors.

So Silvestri and colleagues devised a see-through blood vessel. The synthetic vessel ran through a transparent gel studded with tiny breast cancer tumors. A camera attached to a microscope allowed the researchers to record the tumors invading the artificial blood vessel. Sometimes the tumors pinched the blood vessel, eventually sealing it off. But in at least one case, a small tumor merged with the cells lining the faux blood vessel. Then tiny clumps of cancer cells broke away from the tumor and floated off in the fluid flowing through the capillary. More work is needed to confirm that the same process happens in the body, Silvestri said. — *Tina Hesman Saey*

Mini brains provide window into folding process

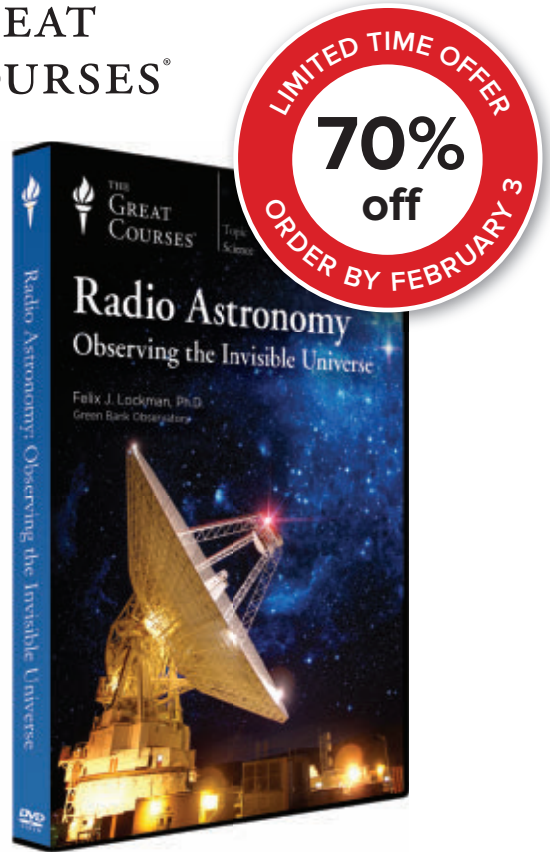
Flat brains growing on microscope slides may have revealed a new wrinkle in the story of how the brain gets its folds.

Cells inside the brains contract, while cells on the outside grow and push outward, researchers at the Weizmann Institute of Science in Rehovot, Israel, discovered from working with the lab-grown brains, or organoids. This push and pull results in folds in the organoids similar to those found in full-size brains, cell biologist Orly Reiner reported December 5.

Reiner and colleagues grew human brain stem cells between a glass microscope slide and a porous membrane. The apparatus allowed the cells access to nutrients and oxygen while giving the researchers a peek at how the organoids grew. The cells formed layered sheets that closed up at the edges, making the organoids resemble pita bread, Reiner said. Wrinkles formed in the outer layers about six days after the mini brains started growing. — *Tina Hesman Saey*

SOMERSAULT18:24/ISTOCKPHOTO

THE GREAT COURSES®



Pull Back the Curtain on the Unseen Universe

For a few hundred thousand years, we used our eyes as our primary astronomical tool. But all that changed in the 1930s when a young engineer named Karl Jansky detected radiation below the visible part of the spectrum emanating from an astronomical object—and radio astronomy was born.

Radio Astronomy: Observing the Invisible Universe takes you on a thrilling journey through astounding discoveries and a virtual tour of the world's most powerful radio telescopes with Felix J. Lockman, Ph.D., of the Green Bank Observatory as your guide. But perhaps the most astounding of all radio astronomy discoveries is this: The dominant molecular structures in interstellar space are based on carbon. That is not what scientists had expected. We have always labeled these molecules "organic" because life on Earth is carbon based. Now we know the chemistry of the entire Milky Way is organic, not just our home planet, and it is likely that any extraterrestrial galactic life would be related to us, at least on the molecular level. Will we find other organic life forms out there? Radio astronomers don't know. But they're certainly working on it.

Offer expires 02/03/18

THEGREATCOURSES.COM/6SN

1-800-832-2412

Radio Astronomy: Observing the Invisible Universe

Taught by Dr. Felix J. Lockman, Ph.D.
GREEN BANK OBSERVATORY

LECTURE TITLES

1. Radio Astronomy and the Invisible Universe
2. Thermal Radio Emission: The Planets
3. The Birth of Radio Astronomy
4. The Discovery of Interstellar Hydrogen
5. Radio Telescopes and How They Work
6. Mapping the Hydrogen Sky
7. Tour of the Green Bank Observatory
8. Tour of the Green Bank Telescope
9. Hydrogen and the Structure of Galaxies
10. Pulsars: Clocks in Space
11. Pulsars and Gravity
12. Pulsars and the 300-Foot Telescope
13. The Big Bang: The Oldest Radio Waves
14. H II Regions and the Birth of Stars
15. Supernovas and the Death of Stars
16. Radio Stars and Early Interferometers
17. Radio Source Counts
18. Active Galactic Nuclei and the VLA
19. A Telescope as Big as the Earth
20. Galaxies and Their Gas
21. Interstellar Molecular Clouds
22. Star Formation and ALMA
23. Interstellar Chemistry and Life
24. The Future of Radio Astronomy

Radio Astronomy:
Observing the Invisible Universe
Course no. 1878 | 24 lectures (30 minutes/lecture)

SAVE UP TO $190

DVD	~~$269.95~~	NOW $79.95
Video Download	~~$234.95~~	NOW $59.95

+$10 Shipping & Processing (DVD only)
and Lifetime Satisfaction Guarantee

Priority Code: 155968

For over 25 years, The Great Courses has brought the world's foremost educators to millions who want to go deeper into the subjects that matter most. No exams. No homework. Just a world of knowledge available anytime, anywhere. Download or stream to your laptop or PC, or use our free apps for iPad, iPhone, Android, Kindle Fire, or Roku. Over 600 courses available at www.TheGreatCourses.com.

LIFE & EVOLUTION

Fungus infects snakes indiscriminately

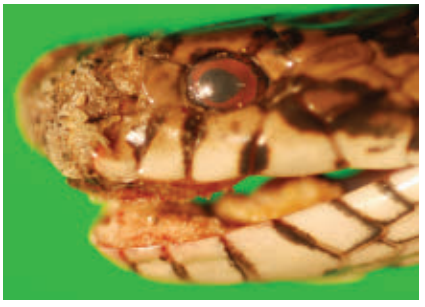
Any species may be at risk in eastern, Midwestern United States

BY LAUREL HAMERS

It doesn't matter if it's a burly rattler or a tiny garter snake. A deadly fungal disease that's infecting snakes in the eastern and Midwestern United States doesn't appear to discriminate by species, size or habitat, researchers report December 20 in *Science Advances*.

The infection, caused by the pathogen *Ophidiomyces ophiodiicola*, can cover snakes' bodies with lesions that make it hard for the reptiles to do normal snake things like slither and eat. Many die from the infection, either directly or indirectly. Snakes pick up the fungal spores from soil (*SN Online: 3/15/16*). The disease has been likened to the chytrid fungus that's wiping out amphibian populations (*SN: 3/5/16, p. 14*) and the white-nose syndrome that's killing bats (*SN: 4/30/16, p. 20*).

In snakes, the disease "could result in the downfall of vulnerable species" and "impact whole communities," says Bruce Kingsbury, a biologist at Indiana University–Purdue University Fort Wayne who was not part of the study. Snakes are important predators: If they go, then populations of small mammals that the snakes help control could boom, throwing ecosystems out of whack.



An emerging fungal disease in the United States covers snakes with lesions, such as the one on this milk snake, that can hurt a snake's ability to move and eat.

Snake fungal disease first gained widespread attention around 2008. It has now been documented in 23 species in the eastern and Midwestern United States, says herpetologist Frank Burbrink of the American Museum of Natural History in New York City. He and colleagues wanted to know whether certain risk factors might make these species more susceptible to the disease than the dozens of other types of snakes that live in the regions.

Burbrink's team hunted for patterns in the data on sick snakes to see whether infected species are related evolutionarily, for example, or whether they share certain behavioral traits or habitat preferences. But the fungus appears to be infecting species at random. It doesn't seem to matter whether a snake is big or small, lives primarily in water or burrows on land, or lays many eggs or just a few.

"It seems like any snake could be a candidate," Burbrink says.

There are still many questions about the disease. Scientists don't know how prevalent it actually is. It's also not clear how long the disease has been around, Burbrink says. He hopes that studying specimens from museum collections might help answer that question. ■

LIFE & EVOLUTION

Ground squirrels ignore the cold

Specialized protein may help the animals enter hibernation

BY LAUREL HAMERS

The hardy souls who push shorts season into December might feel some kinship with the thirteen-lined ground squirrel.

The critter hibernates all winter, but even when awake, the ground squirrel is less sensitive to cold than its nonhibernating relatives, a new study finds. That cold tolerance is linked to changes in a cold-sensing protein in the sensory nerve cells of the ground squirrel and another hibernator, the Syrian hamster, researchers report in the Dec. 19 *Cell Reports*. The altered protein may be an adaptation that helps the animals drift into hibernation.

In experiments, mice, which don't hibernate, preferred to hang out on a hot plate that was 30° Celsius versus one that was cooler. Syrian hamsters (*Mesocricetus auratus*) and the ground squirrels (*Ictidomys tridecemlineatus*), however, didn't seem to avoid the chill until plate temperatures dipped below 10° C, notes study coauthor Elena Gracheva, a neurophysiologist at Yale University.

A cold-sensing protein, TRPM8, wasn't as easily activated in the ground squirrels and hamsters as in rats, further work revealed. TRPM8 typically sends a sensation of cold to the brain when activated by low temperatures. (It's what makes fingers feel chilly when holding a glass of ice water.)

The researchers also studied the gene that contains the instructions to make TRPM8 in the ground squirrels. Six amino acid changes in one section of the gene explained the cold tolerance. Cutting-and-pasting the rat version of that gene fragment into the squirrel gene led to a protein that was more responsive to cold. Hamster TRPM8 also became more responsive with slightly different tweaks in the same region of the gene.

Making a cold-resistant protein sensitive to cold by transferring in a gene snippet from a different species is "really quite striking," says neurobiologist David McKemy of the University of Southern California in Los Angeles.

Cold tolerance may help these ground squirrels and hamsters transition from an active, awake state to hibernation, Gracheva says. If a mammal feels chilly, its body will expend a lot of energy to warm up and that will work against the physiological changes needed for hibernation. For example, while hibernating, ground squirrels slow their pulse and breathing and lower their core body temperature.

Modified TRPM8 probably isn't the only factor helping these ground squirrels ignore the cold, Gracheva says. "We think this is only part of the mechanism." ■

FAIRMONTSTATE.EDU/STEM

FAIRMONT STATE UNIVERSITY
SCIENCE AND TECHNOLOGY

JOAN ALTURO

Menopause Heats Up

Hormone replacement gets another look

By Aimee Cunningham

Internist Gail Povar has many female patients making their way through menopause, some having a tougher time than others. Several women with similar stories stand out in her mind. Each came to Povar's Silver Spring, Md., office within a year or two of stopping her period, complaining of frequent hot flashes and poor sleep at night. "They just felt exhausted all the time," Povar says. "The joy had kind of gone out."

And all of them "were just absolutely certain that they were not going to take hormone replacement," she says. But the women had no risk factors that would rule out treating their symptoms with hormones. So Povar suggested the women try hormone therapy for a few months. "If you feel really better and it makes a big difference in your life, then you and I can decide how long we continue it," Povar told them. "And if it doesn't make any difference to you, stop it."

At the follow-up appointments, all of these women reacted the same way, Povar recalls. "They walked in beaming, absolutely beaming, saying, 'I can't believe I didn't do this a year ago. My life! I've got my life back.'"

That doesn't mean, Povar says, that she's pushing hormone replacement on patients. "But it should be on the table," she says. "It should be part of the discussion."

Hormone replacement therapy toppled off the table for many menopausal women and their doctors in 2002. That's when a women's health study, stopped early after a data review, published results linking a common hormone therapy to an increased risk of breast cancer, heart disease, stroke and blood clots. The trial, part of a multifaceted project called the Women's Health Initiative, or WHI, was meant to examine hormone therapy's effectiveness in lowering the risk of heart disease and other conditions in women ages 50 to 79. It wasn't a study of hormone therapy for treating menopausal symptoms.

But that nuance got lost in the coverage of the study's results, described at the time as a "bombshell," a call to get off of hormone therapy right away. Women and doctors in the United States heeded the call. A 2012 study in *Obstetrics & Gynecology* showed that use plummeted: Oral hormone therapy, taken by an estimated 22 percent of U.S. women 40 and older in

1999–2000, was taken by fewer than 12 percent of women in 2003–2004. Six years later, the number of women using oral hormone therapy had sunk below 5 percent.

Specialists in women's health say it's time for the public and the medical profession to reconsider their views on hormone therapy. Research in the last five years, including a long-term follow-up of women in the WHI, has clarified the risks, benefits and ideal ages for hormone therapy. Medical organizations, including the Endocrine Society in 2015 and the North American Menopause Society in 2017, have released updated recommendations. The overall message is that hormone therapy offers more benefits than risks for the relief of menopausal symptoms in mostly healthy women of a specific age range: those who are under age 60 or within 10 years of stopping menstruation.

"A generation of women has missed out on effective treatment because of misinformation," says JoAnn Pinkerton, executive director of the North American Menopause Society and a gynecologist who specializes in menopause at the University of Virginia Health System in Charlottesville. It's time to move beyond 2002, she says, and have a conversation based on "what we know now."

End of an era

Menopause, the final menstrual period, signals the end of fertility and is confirmed after a woman has gone 12 months without having a period. From then on she is postmenopausal. Women reach menopause around age 51, on average. In the four to eight years before, called perimenopause, the amount of estrogen in the body declines as ovarian function winds down. Women may have symptoms related to the lack of estrogen beginning in perimenopause and continuing after the final period.

Probably the best-known symptom is the hot flash, a sudden blast of heat, sweating and flushing in the face and upper chest. These temperature tantrums can occur at all hours. At night, hot flashes can produce drenching sweats and disrupt sleep.

Hot flashes arise because the temperature range in which the body normally feels comfortable narrows during the menopause transition, partly in response to the drop in estrogen. Normally, the body takes small changes in core body temperature in stride. But for menopausal women, the slightest uptick in degree can be a trigger for the vessels to dilate, which increases blood flow and sweating.

About 75 to 80 percent of menopausal women experience hot flashes and night sweats, on and off, for anywhere from a couple of years to more than a decade. In a study in *JAMA Internal Medicine* in 2015, more than half of almost 1,500 women enrolled at ages 42 to 52 reported frequent hot flashes — occurring at least six days in the previous two weeks — with symptoms lasting more than seven years.

A sizable number of women have moderate or severe hot flashes, which spread throughout the body and can include profuse sweating, heart palpitations or anxiety. In a study of 255 menopausal women, moderate to severe hot flashes were most common, occurring in 46 percent of women, during the two years after participants' last menstrual period. A third of all the women still experienced heightened hot flashes 10 years after menopause, researchers reported in 2014 in *Menopause*.

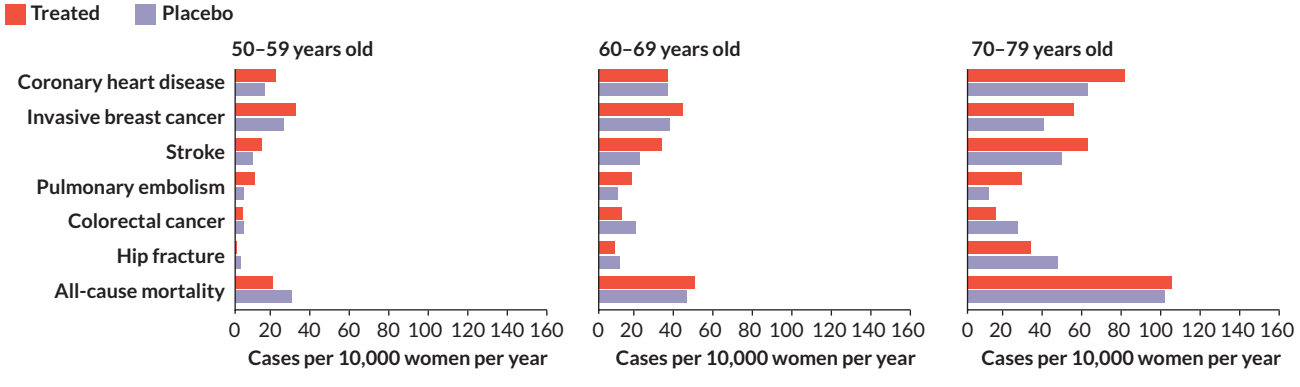
Besides hot flashes and night sweats, roughly 40 percent of menopausal women experience irritation and dryness of the vulva and vagina, which can make sexual intercourse painful. These symptoms tend to arise after the final period.

Alarm bells

In the 1980s and '90s, researchers observed that women using hormone therapy for menopausal symptoms had a lower risk of heart disease, bone fractures and overall death. Some doctors began recommending the medication not just for symptom relief, but also for disease prevention.

Observational studies of the apparent health benefits of hormone therapy spurred a more stringent study, a randomized controlled trial, which tested the treatment's impact by randomly assigning hormones to some volunteers and not

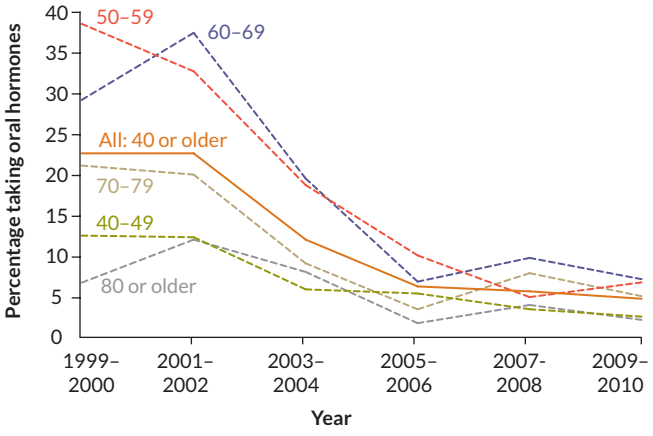
Absolute risk of health problems in combined hormone trial during treatment period



C. CHANG

Age matters In a 2013 reanalysis of a trial comparing hormone replacement therapy with a placebo, participants were split by age. Looking at the data in this way showed that absolute risk for health problems for women on a combined formulation of estrogen plus synthetic progesterone was lowest for the youngest women, who are most likely to experience menopausal symptoms. SOURCE: J.E. MANSON *ET AL*/*JAMA* 2013

Use of oral hormone therapy by U.S. women ages 40 and older



Fear factor After the 2002 release of results from a Women's Health Initiative trial, use of oral hormone replacement by women dropped across all ages, according to a National Health and Nutrition Examination Survey. SOURCE: B.L. SPRAGUE *ET AL/OBSTETRICS & GYNECOLOGY* 2012

others. The WHI hormone therapy trials assessed heart disease, breast cancer, stroke, blood clots, colorectal cancer, hip fractures and deaths from other causes in women who used the hormones versus those who took a placebo. Two commonly prescribed formulations were tested: a combined hormone therapy — estrogen sourced from horses plus synthetic progesterone — and estrogen alone. (Today, additional U.S. Food and Drug Administration–approved formulations are available.)

The 2002 WHI report in *JAMA*, which described early results of the combined hormone therapy, shocked the medical community. The study was halted prematurely because after about five years, women taking the hormones had a slightly higher risk of breast cancer and an overall poor risk-to-benefit ratio compared with women taking the placebo. While the women taking hormones had fewer hip fractures and colorectal cancers, they had more breast cancers, heart disease, blood clots and strokes. The findings were reported in terms of the relative risk, the ratio of how often a disease happened in one group versus another. News of a 26 percent increase in breast cancers and a 41 percent increase in strokes caused confusion and alarm.

Women dropped the hormones in droves. From 2001 to 2009, the use of all hormone therapy among menopausal women, as reported by physicians based on U.S. office visits, fell 52 percent, according to a 2011 study in *Menopause*.

But, researchers say, the message that hormone therapy was bad for all was unwarranted. "The goal of the WHI was to evaluate the balance of benefits and risks of menopausal hormone therapy when used for prevention of chronic disease," says JoAnn Manson, a physician epidemiologist at Harvard-affiliated Brigham and Women's Hospital in Boston and one of the lead investigators of the WHI. "It was not intended to evaluate its role in managing menopausal symptoms."

Along with the focus on prevention, the WHI hormone therapy trials were largely studies of older women — in their 60s and 70s. Only around one-third of participants started the trial between ages 50 and 59, the age group more likely to be in need of symptom relief. Hormone therapy "was always primarily a product to use in women entering menopause," says Howard Hodis, a physician scientist who focuses on preventive medicine at the University of Southern California's Keck School of Medicine in Los Angeles. "The observational studies were based on these women."

Also lost in the coverage of the 2002 study results was the absolute risk, the actual difference in the number of cases of disease between two groups. The group on combined hormone therapy had eight more cases of breast cancer per 10,000 women per year than the group taking a placebo. Hodis notes that that absolute risk translates to less than one extra case for every 1,000 women, which is classified as a rare risk by the Council for International Organizations of Medical Sciences, a World Health Organization group. There was also less than one additional case for every 1,000 women per year for heart disease and for stroke in the hormone-treated women compared with those on placebo.

In 2004, researchers published results of the WHI study of estrogen-only therapy, taken for about seven years by women who had had their uteruses surgically removed. (Progesterone is added to hormone therapy to protect the uterus lining from a risk of cancer seen with estrogen alone.) The trial, also stopped early, reported a decreased risk of hip fractures and breast cancer, but an increased risk of stroke. The study didn't change the narrative that hormone therapy wasn't safe.

Timing is everything

Since the turn away from hormone therapy, follow-up studies have brought nuance not initially captured by the first two reports. Researchers were finally able to tease out the results that applied to "the young women — and I love saying this — young women 50 to 59 who are most apt to present with symptoms of menopause," says Cynthia Stuenkel, an internist and endocrinologist at the University of California, San Diego School of Medicine in La Jolla.

In 2013, Manson and colleagues reported data from the WHI grouped by age. It turned out that absolute risks were smaller for 50- to 59-year-olds than they were for older women, especially those 70 to 79 years old, for both combined therapy and estrogen alone. For example, in the combined hormone therapy trial, treated 50- to 59-year-olds had five additional cases of heart disease and five more strokes per 10,000 women annually compared with the same-aged group on placebo. But the treated 70- to 79-year-olds had 19 more heart disease cases and 13 more strokes per 10,000 women annually than women of the same age taking a placebo. "So a lot more of these events that were of concern were in the older women," Stuenkel says.

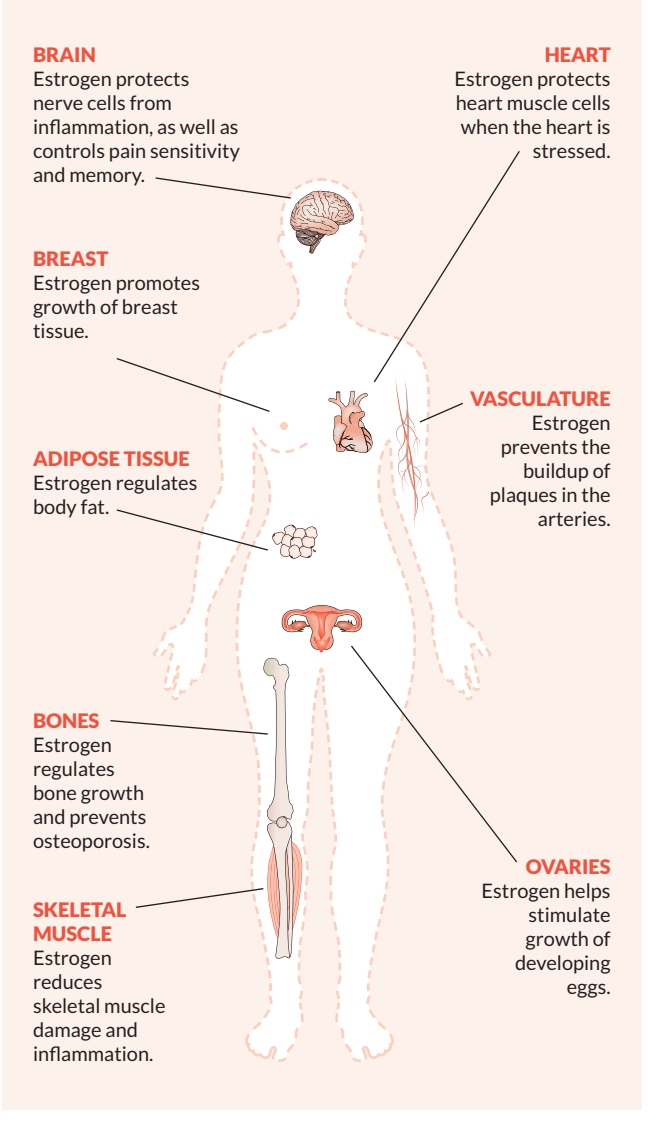
A Danish study reported in 2012 of about 1,000 recently postmenopausal women, ages 45 to 58, also supported the idea that timing of hormone treatment matters. The randomized

C. CHANG

controlled trial examined the use of different formulations of estrogen (17β-estradiol) and progesterone than the WHI. The researchers reported in *BMJ* that after 10 years, women taking hormone therapy — combined or estrogen alone — had a reduced risk of mortality, heart failure or heart attacks, and no added risk of cancer, stroke or blood clots compared with those not treated.

These findings provide evidence for the timing hypothesis, also supported by animal studies, as an explanation for the results seen in younger women, especially in terms of heart disease and stroke. In healthy blood vessels, more common in younger women, estrogen can slow the development of artery-clogging plaques. But in vessels that already have plaque buildup, more likely in older women, estrogen may cause the plaques to rupture and block an artery, Manson explains.

Helper hormone Estrogen, produced primarily by the ovaries, has beneficial effects throughout the body in premenopausal women.
SOURCE: E. MORSELLI *ET AL/NATURE REVIEWS ENDOCRINOLOGY* 2017



C. CHANG

Recently, Manson and colleagues published a long-term study of the risk of death in women in the two WHI hormone therapy trials — combined therapy and estrogen alone — from the time of trial enrollment in the mid-1990s until the end of 2014. Use of either hormone therapy was not associated with an added risk of death during the study or follow-up periods due to any cause or, specifically, death from heart disease or cancer, the researchers reported in *JAMA* in September 2017. The study provides reassurance that taking hormone therapy, at least for five to seven years, "does not show any mortality concern," Stuenkel says.

Both the Endocrine Society and the North American Menopause Society state that, for symptom relief, the benefits of FDA-approved hormone therapy outweigh the risks in women younger than 60 or within 10 years of their last period, absent health issues such as a high risk of breast cancer or heart disease. The menopause society position statement adds that there are also benefits for women at high risk of bone loss or fracture.

Today, the message about hormone therapy is "not everybody needs it, but if you're a candidate, let's talk about the pros and cons, and let's do it in a science-based way," Pinkerton says.

Hormone therapy is the most effective treatment for hot flashes, night sweats and genital symptoms, she says. A review of randomized controlled trials, published in 2004, reported that hormone therapy decreased the frequency of hot flashes by 75 percent and reduced their severity as well.

More than 50 million U.S. women will be older than 51 by 2020, Manson says. Yet today, many women have a hard time finding a physician who is comfortable prescribing hormone therapy or even just managing a patient's menopausal symptoms, she says.

Stuenkel, who says many younger doctors stopped learning about hormone therapy after 2002, is trying to play catch up. When she teaches medical students and doctors about treating menopausal symptoms, she brings up three questions to ask patients. First, how bothersome are the symptoms? Some women say "fix it, get me through the day and the night, put me back in order," Stuenkel says. Other women's symptoms are not as disruptive. Second, what does the patient want? Third, what is safe for this particular woman, based on her health? If a woman's health history doesn't support the use of hormone therapy, or she just isn't interested, there are nonhormonal options, such as certain antidepressants, and also nondrug lifestyle approaches.

Menopause looms large for many women, Povar says, and discussing a patient's expectations as well as whether hormone therapy is the right approach becomes a unique discussion with each patient, she says. "This is one of the most individual decisions a woman makes." ■

Explore more

- The 2017 hormone therapy position statement of the North American Menopause Society. *Menopause.* July 2017.

Mucking Up MARS

Microbes from Earth may complicate human junkets to the Red Planet

By Lisa Grossman

Scientists are racing to figure out how to keep astronauts and potential life on Mars safe from one another before humans arrive at the Red Planet.

SPACEX/FLICKR

The Okarian rover was in trouble. The yellow Humvee was making slow progress across a frigid, otherworldly landscape when planetary scientist Pascal Lee felt the rover tilt backward. Out the windshield, Lee, director of NASA's Haughton Mars Project, saw only sky. The rear treads had broken through a crack in the sea ice and were sinking into the cold water.

True, there are signs of water on Mars, but not that much. Lee and his crew were driving the Okarian (named for the yellow Martians in Edgar Rice Burroughs' novel *The Warlord of Mars*) across the Canadian Arctic to a research station in Haughton Crater that served in this dress rehearsal as a future Mars post. On a 496-kilometer road trip along the Northwest Passage, crew members pretended they were explorers on a long haul across the Red Planet to test what to expect if and when humans go to Mars.

What they learned in that April 2009 ride may become relevant sooner rather than later. NASA has declared its intention to send humans to Mars in the 2030s (*SN Online: 5/24/16*). The private sector plans to get there even earlier: In September, Elon Musk announced his aim to launch the first crewed SpaceX mission to Mars as soon as 2024.

"That's not a typo," Musk said in Australia at an International Astronautical Congress meeting. "Although it is aspirational."

Musk's six-year timeline has some astrobiologists in a panic. If humans arrive too soon, these researchers fear, any chance of finding evidence of life — past or present — on Mars may be ruined.

"It's really urgent," says astrobiologist Alberto Fairén of the Center for Astrobiology in Madrid and Cornell University. Humans take whole communities of microorganisms with them everywhere, spreading those bugs indiscriminately.

Planetary geologist Matthew Golombek of NASA's Jet Propulsion Laboratory in Pasadena, Calif., agrees, adding, "If you want to know if life exists there now, you kind of have to approach that question before you send people."

A long-simmering debate over how rigorously to protect other planets from Earth life, and how

best to protect life on Earth from other planets, is coming to a boil. The prospect of humans arriving on Mars has triggered a flurry of meetings and a spike in research into what "planetary protection" really means.

One of the big questions is whether Mars has regions that might be suitable for life and so deserve special protection. Another is how big a threat Earth microbes might be to potential Martian life (recent studies hint less of a threat than expected). Still, the specter of human biomes mucking up the Red Planet before a life-hunting mission can even launch has raised bitter divisions within the Mars research community.

If humans arrive too soon, any chance of finding evidence of life on Mars may be ruined.

Mind the gaps

Before any robotic Mars mission launches, the spacecraft are scrubbed, scoured and sometimes scorched to remove Earth microbes. That's so if scientists discover a sign of life on Mars, they'll know the life did not just hitchhike from Cape Canaveral. The effort is also intended to prevent the introduction of harmful Earth life that could kill off any Martians, similar to how invasive species edge native organisms out of Earth's habitats.

"If we send Earth organisms to a place where they can grow and thrive, then we might come back and find nothing but Earth organisms, even though there were Mars organisms there before," says astrobiologist John Rummel of the SETI Institute in Mountain View, Calif. "That's bad for science; it's bad for the Martians. We'd be real sad about that."

To avoid that scenario, spacefaring organizations have historically agreed to keep spacecraft clean. Governments and private companies alike abide by Article IX of the 1967 Outer Space Treaty, which calls for planetary exploration to avoid contaminating both the visited environment and Earth. In the simplest terms: Don't litter, and wipe your feet before coming back into the house.

But this guiding principle doesn't tell engineers *how* to avoid contamination. So the international Committee on Space Research (called COSPAR) has debated and refined the details of a planetary protection policy that meets the treaty's requirement ever since. The most recent version dates from 2015 and has a page of guidelines for human missions.

In the last few years, the international space community has started to add a quantitative component to the rules for humans — specifying how thoroughly to clean spacecraft before launch, for instance, or how many microbes are allowed to escape from human quarters.

"It was clear to everybody that we need more refined technical requirements, not just guidelines," says Gerhard Kminek, planetary protection officer for the European Space Agency and chair of COSPAR's planetary protection panel, which sets the standards. And right now, he says, "we don't know enough to do a good job."

In March 2015, more than 100 astronomers, biologists and engineers met at NASA's Ames Research Center in Moffett Field, Calif., and listed 25 "knowledge gaps" that need more research before quantitative rules can be written.

The gaps cover three categories: monitoring astronauts' microbes, minimizing contamination and understanding how matter naturally travels around Mars. Rather than prevent contamination — probably impossible — the goal is to assess the risks and decide what risks are acceptable. COSPAR prioritized the gaps in October 2016 and will meet again in Houston in February to decide what specific experiments should be done.

Stick the landing

The steps required for any future Mars mission will depend on the landing spot. COSPAR currently says that robotic missions are allowed to visit "special regions" on Mars, defined as places where terrestrial organisms are likely to replicate, only if robots are cleaned before launch to 0.03 bacterial spores per square meter of spacecraft. In contrast, a robot going to a nonspecial region is allowed to bring 300 spores per square meter. These "spores," or endospores, are dormant bacterial cells that can survive environmental stresses that would normally kill the organism.

To date, any special regions are hypothetical,

Astrobiologist Pascal Lee (top) collects snow in the Canadian Arctic to test how far human-associated microbes venture from a mock Mars vehicle (bottom).

BOTH: A. SCHUERGER AND P. LEE/*ASTROBIOLOGY* 2015

because none have been conclusively identified on Mars. But if a spacecraft finds that its location unexpectedly meets the special criteria, its mission might have to change on the spot.

The Viking landers, which in 1976 brought the first and only experiments to look for living creatures on Mars, were baked in an oven for hours before launch to clean the craft to special region standards.

"If you're as clean as Viking, you can go anywhere on Mars," says NASA planetary protection officer Catharine Conley. But no mission since, from the Pathfinder mission in the 1990s to the current Curiosity rover to the upcoming Mars 2020 and ExoMars rovers, has been cleared to access potentially special regions. That's partly because of cost. A 2006 study by engineer Sarah Gavit of the Jet Propulsion Lab found that sterilizing a rover like Spirit or Opportunity (both launched in 2003) to Viking levels would cost up to 14 percent more than sterilizing it to a lower level. NASA has also backed away from looking for life after Viking's search for Martian microbes came back inconclusive. The agency shifted focus to seeking signs of past habitability.

Filling the gaps

Scientists met in 2015 to identify knowledge gaps that need to be filled before human boots on Mars will be safe for potential Martian life and for humans themselves. The gaps include:

Monitoring microbes

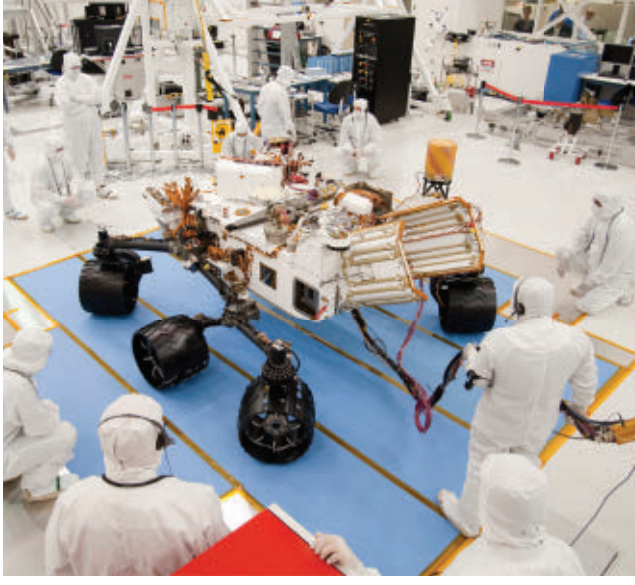
How do microbes respond to spaceflight and relocation, and do genetic changes occur in the organisms that could be passed to future generations? What microbes should be monitored and how should a Mars crew do so? How can a crew prevent contamination? How can a microbial infection on Mars be diagnosed and treated? When should an astronaut be quarantined or not allowed to return to Earth?

Controlling contamination

Do longer stays on Mars (500 days versus 30 days) mean more contamination, and do they require different planetary protection requirements than shorter stays? Do astronauts need protocols for verifying what microbes have escaped the spacecraft? What decontamination procedures are needed for inside and outside the spacecraft? What quarantine facilities are needed? How will scientists recognize special regions if they exist? What research is needed to plan and design resource extraction systems? What type of wastes can be intentionally left behind on Mars? What factors need to be considered to design extravehicular activity suits?

Natural transport of contamination

How well can microbes survive, grow and evolve in Mars environments? What happens to windblown dust on Mars? Could dust storms carry microbes from a lifeless region to a special region? Considering many pathways, how likely are humans to transport hardy Earth microbes to Mars? What will leak or vent out of pressurized containers or human facilities? How will scientists study microorganisms that can't be cultivated using current techniques? How far will microbes travel from human landing and habitation sites? What is the risk of humans contaminating subsurface resources, such as underground ice?



The Mars rover Curiosity was assembled and tested in a clean room before its 2011 launch, in part to limit the hitchhikers it carried from Earth.

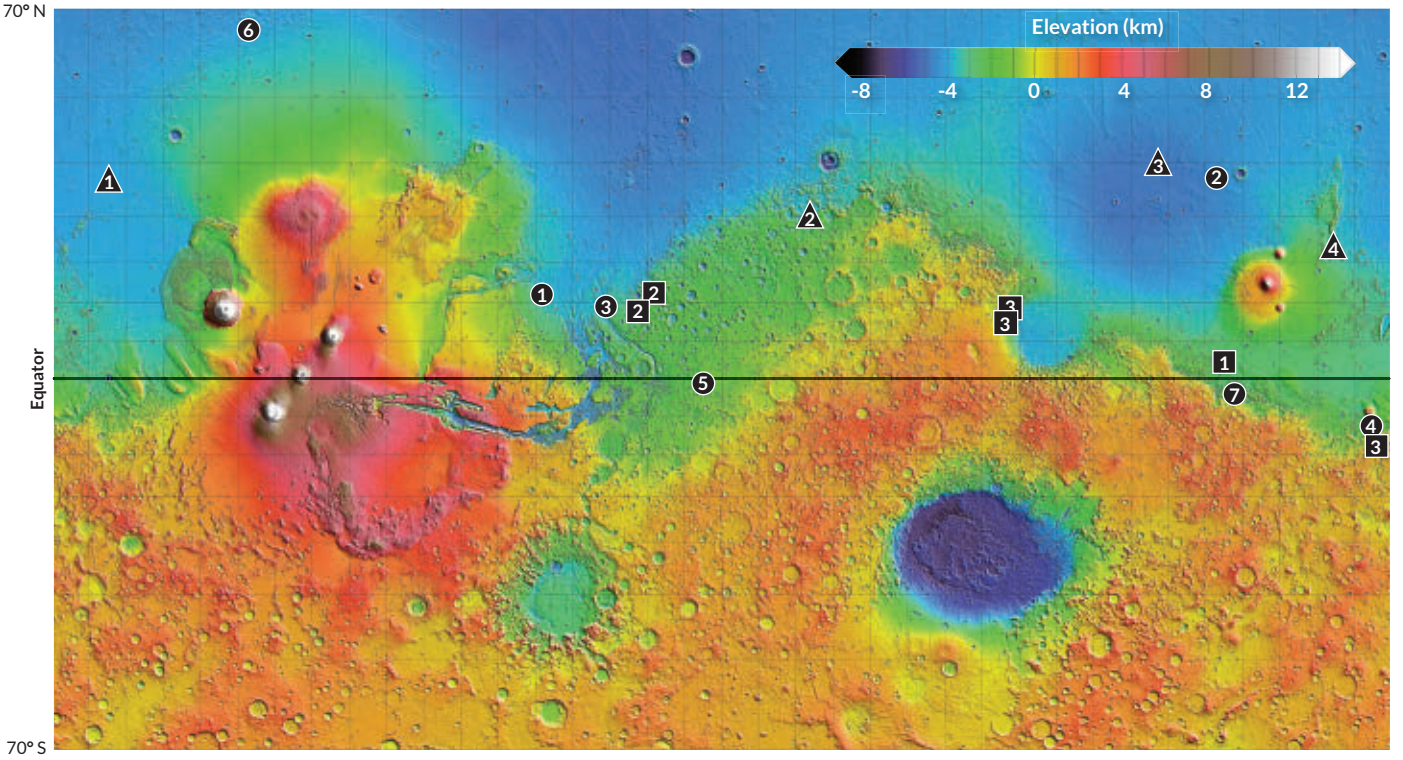
Although no place on Mars currently meets the special region criteria, some areas have conditions close enough to be treated with caution. In 2015, geologist Colin Dundas of the U.S. Geological Survey in Flagstaff, Ariz., and colleagues discovered what looked like streaks of salty water that appeared and disappeared in Gale Crater, where Curiosity is roving. Although those streaks were not declared special regions, the Curiosity team steered the rover clear of the area.

But evidence of flowing water on Mars bit the dust. In November, Dundas and colleagues reported in *Nature Geoscience* that the streaks are more likely to be tiny avalanches of sand. The reversal highlights how difficult it is to tell if a region on Mars is special or not.

If warm and wet conditions exist, that's exactly where humans would want to go. Golombek has helped choose every Mars landing site since Pathfinder and has advised SpaceX on where to land its Red Dragon spacecraft, originally planned to bring the first crewed SpaceX mission to Mars. (Since then, SpaceX has announced it will use its BFR spacecraft instead, which might require shifts in landing sites.) The best landing sites for humans have access to water and are as close to the equator as possible, Golombek says. Low latitudes mean warmth, more solar power and a chance to use the planet's rotation to help launch a rocket back to Earth.

That narrows the options. NASA's first workshop on human landing sites, held in Houston in October 2015, identified more than 40 "exploration zones" within 50 degrees latitude of the equator, where astronauts could do science and potentially access raw materials for building and life support, including water.

JPL-CALTECH/NASA



Where to? The most desirable places on Mars for human visits offer access to water in some form and are near the equator (for increased solar power and to get a boost when launching a return rocket). Rovers and landers have found evidence of a watery Martian past. Planners of future robotic and human missions have potential landing spots in mind. Map excludes polar regions.

Sites of successful landings of robotic missions

1. Viking 1 lander 1976
2. Viking 2 lander 1976
3. Pathfinder lander with Sojourner rover 1997
4. Spirit rover 2004
5. Opportunity rover* 2004
6. Phoenix lander 2008
7. Curiosity rover* 2012

(* ongoing)

Potential landing sites for upcoming robotic missions

1. InSight lander
2. ExoMars rover (two options)
3. Mars 2020 (three options)

Possible landing sites for human missions

1. Arcadia Planitia
2. Deuteronilus Mensae
3. Utopia Planitia
4. Phlegra Montes

Golombek helped SpaceX whittle its list to a handful of sites, including Arcadia Planitia and Deuteronilus Mensae, which show signs of having pure water ice buried beneath a thin layer of soil.

What makes these regions appealing for humans also makes them more likely to be good places for microbes to grow, putting a crimp in hopes for boots on the ground. But there are ways around the apparent barriers, Conley says. In particular, humans could land a safe distance from special regions and send clean robots to do the dirty work.

That suggestion raises a big question: How far is far enough? To figure out a safe distance, scientists need to know how well Earth microbes would survive on Mars in the first place, and how far those organisms would spread from a human habitat.

A no-grow zone

Initial results suggest that Mars does a good job of sterilizing itself. "I've been trying to grow Earth bacteria in Mars conditions for 15 years, and it's actually really hard to do," says astrobiologist Andrew Schuerger of the University of Florida in Gainesville. "I think that risk is much lower than the scientific community might think."

In 2013 in *Astrobiology*, Schuerger and colleagues published a list of more than a dozen factors that microbes on Mars would have to overcome, including a lot of ultraviolet radiation from the sun; extreme dryness, low pressure and freezing temperatures; and high levels of salts, oxidants and heavy metals in Martian soils.

Schuerger has tried to grow hundreds of species of bacteria and fungi in the cold, low-pressure and low-oxygen conditions found on Mars. Some species came from natural soils in the dry Arctic and other desert environments, and others were recovered from clean rooms where spacecraft were assembled.

Of all those attempts, he has had success with 31 bacteria and no fungi. Seeing how difficult it is to coax these hardy microbes to thrive gives him confidence to say: "The surface conditions on Mars are so harsh that it's very unlikely that terrestrial bacteria and fungi will be able to establish a niche."

There's one factor Schuerger does worry about, though: salts, which can lower the freezing temperature of water. In a 2017 paper in *Icarus*, Schuerger and colleagues tested the survival of *Bacillus subtilis*, a well-studied bacterium found in human gastrointestinal tracts, in simulated Martian soils with various levels of saltiness.

B. subtilis can form a tough spore when stressed, which could keep it safe in extreme environments. Schuerger showed that dormant *B. subtilis* spores were mostly unaffected for up to 28 days in six different soils. But another bacterium that does not

USGS ASTROGEOLOGY SCIENCE CENTER, GODDARD SPACE FLIGHT CENTER/NASA

To learn more about past and future landing sites, visit **bit.ly/SN_Marsvisits**

Life challenges

Astrobiologist Andrew Schuerger of the University of Florida and colleagues identified the challenges microbes would have to overcome to thrive on Mars:

- Ultraviolet radiation from the sun, which damages DNA
- Extreme dryness
- Low pressure, about 0.1 percent the ambient pressure on Earth
- An atmosphere that is high in carbon dioxide and low in oxygen
- Extremely low temperatures, with a global average of −61° Celsius
- Charged particles from the sun
- Cell-damaging, high-energy particles from interstellar space, which reach the surface because Mars lacks a strong magnetic field
- Ultraviolet light from static electricity discharge from blowing Martian dust
- Volatile oxidants in the atmosphere created by UV light from the sun
- Oxidizing soils across the planet
- Extremely high salt levels at some sites
- High concentrations of heavy metals in the soils
- Acidic conditions
- Perchlorates in the soils, which are toxic

SOURCE: A.C. SCHUERGER *ET AL/ ASTROBIOLOGY* 2013

form spores was killed off. That finding suggests that spore-forming microbes — including ones that humans carry with them — could survive in soils moistened by briny waters.

The Okarian's trek across the Arctic offers a ray of hope: Spores might not make it very far from human habitats. At three stops during the journey across the Arctic, Pascal Lee, of the SETI Institute, collected samples from the pristine snow ahead and dirtier snow behind the vehicle, as well as from the rover's interior. Later, Lee sent the samples to Schuerger's lab.

The researchers asked, if humans drive over a microbe-free pristine environment, would they contaminate it? "The answer was no," Schuerger says.

And that was in an Earth environment with only one or two of Schuerger's biocidal factors (low temperatures and slightly higher UV radiation than elsewhere on Earth) and with a rover crawling with human-associated microbes. The Okarian hosted 69 distinct bacteria and 16 fungi, Schuerger and Lee reported in 2015 in *Astrobiology*.

But when crew members ventured outside the rover, they barely left a mark. The duo found one fungus and one bacterium on both the rover and two snow sites, one downwind and one ahead of the direction of travel. Other than that, nothing, even though crew members made no effort to contain their microbes — they breathed and ate openly.

"We didn't see dispersal when conditions were much more conducive to dispersal" than they will be on Mars, Schuerger says.

The International Space Station may be an even better place to study what happens when inhabited space vessels leak microbes. Michelle Rucker, an engineer at NASA's Johnson Space Center in Houston, and her colleagues are testing a tool for astronauts to swab the outside of their spacesuits and the space station, and collect whatever microbes are already there.

"At this point, no one has defined what the allowable levels of human contamination are," Rucker says. "We don't know if we'd meet them, but more importantly, we've never checked our human systems to see where we're at."

Rucker and colleagues have had astronauts test the swab kit as part of their training on Earth. The researchers plan to present the first results from those tests in March in Big Sky, Mont., at the IEEE Aerospace Conference. If the team gets the tool flight-certified to test it on the ISS, the results could fill a knowledge gap about how much spaceships carrying humans will leak and vent microbes.

A Russian experiment on the ISS may be giving the first clues. In November 2017, Russian cosmonauts told TASS news service that they had found living bacteria on the outside of the ISS. Some of those microbes, swabbed near vents during spacewalks, were not found on the spacecraft's exterior when it launched.

Blowing in the wind

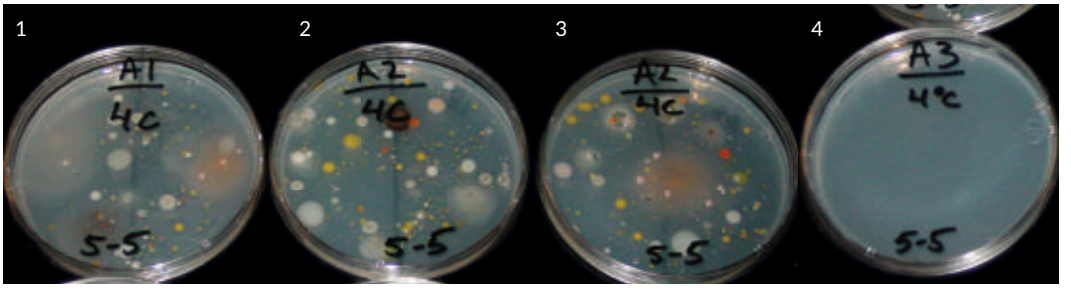
These results are important, says Conley, but they don't give enough information alone to write quantitative contamination rules.

That's partly because of another knowledge gap: how dust and wind move around on Mars. If Martian dust storms carry microbes far enough, the invaders could contaminate potential special regions even if humans land a safe distance away.

To find out, COSPAR's Kminek suggests sending a fleet of Mars landers to act as meteorological stations at several fixed locations. The landers could measure atmospheric conditions and dust properties over a long time. Such landers would be relatively inexpensive to build, he says, and could launch in advance of humans.

But these weather stations would have to get in line. There's a launch window between Earth and Mars every two years, and the next few are already booked. Weather stations would have to be stationary, so they couldn't be added to rover

Samples collected inside a mock Mars rover and grown in the lab were full of microbes from the rover's crew (1, 2 and 3). But nothing grew in most samples from outside the rover (4), suggesting microbes didn't travel far from the vehicle.



A. SCHUERGER AND P. LEE/*ASTROBIOLOGY* 2015

missions like ExoMars or Mars 2020.

That means it's possible that SpaceX or another company will try to send humans to Mars before the reconnaissance missions necessary to write rules for planetary protection are even built. If COSPAR is the tortoise in this race, SpaceX is the hare, along with a few other private companies. Only SpaceX has a stated timeline. Other contenders, including Washington-based Blue Origin, founded by Amazon executive Jeff Bezos, and United Launch Alliance, based in Colorado, are developing rockets that some analysts say could be part of a mission to the moon or Mars.

Now or never

Those looming launches prompted Fairén and colleagues to make a controversial proposal. In an article in the October 2017 *Astrobiology*, provocatively titled "Searching for life on Mars before it is too late," the team suggested sending existing or planned rovers, even those not at the height of cleanliness, to look directly for signs of Martian life.

Given the harsh Martian conditions, rovers are unlikely to contaminate regions that might turn out to be special on a closer look, the group argues. The invasive species argument is misleading, they say: Don't compare a microbe transfer to taking Asian parrots to the Amazon rainforest, where they could thrive and edge out local parrots. It would be closer to taking them to Antarctica to freeze to death.

Even if Earth microbes did replicate on Mars, the researchers wrote, technology is advanced enough that scientists would be able to distinguish hitchhikers from Earth from true Mars life (*SN: 4/30/16, p. 28*).

In a sharp rebuttal, published in the same issue of *Astrobiology*, Rummel and Conley disagreed. "Why would you want to go there with a dirty spacecraft?" says Rummel, who was NASA's planetary protection officer before Conley. "To spend a billion dollars to go find life from Florida on Mars is both irresponsible and completely scientifically indefensible."

There's also concern for the health and safety of future astronauts. Conley says she mentioned the idea that scientists shouldn't worry about getting sick if they encounter Earth organisms on Mars to a November meeting of epidemiologists who study the risks of Earth-based pandemics.

"The room burst out laughing," she says. "This is a room full of medical doctors who deal with Ebola. The idea that we know about Earth organisms, and therefore they can't hurt us, was literally laughable to them."

SPACEX

SpaceX hopes to build human habitats on Mars (illustrated here along with SpaceX's latest BFR spaceship). Scientists are just starting to figure out how to keep microbes from leaving such habitats and potentially harming native life.

Fairén has already drafted a response for a future issue of *Astrobiology*: "We acknowledge [that Rummel and Conley's points] are informed and literate. Unfortunately, they are also unconvincing."

The issue might come to a head in July in Pasadena, Calif., at the next meeting of COSPAR's Scientific Assembly. Fairén and colleagues plan to push for more relaxed cleanliness rules.

That's not likely to happen anytime soon. But with no concrete rules in place for humans, would a human mission even be allowed off the ground, whether NASA or SpaceX was at the helm? Currently, private U.S. companies must apply to the Federal Aviation Administration for a launch license, and for travel to another planet, that agency would probably ask NASA to weigh in.

It's hard to know if anyone will actually be ready to send humans to Mars in the next decade. "You'd have to actually believe them to be scared," says Rummel. "There are many unanswered questions about what Elon Musk wants to do. But I think we can calm down about people showing up on Mars unannounced."

But SpaceX has defied expectations before and may give slow and steady a kick in the pants. ■

Explore more

- Alberto Fairén *et al*. "Searching for life on Mars before it is too late." *Astrobiology*. October 2017.
- John Rummel and Catharine Conley. "Four fallacies and an oversight: searching for Martian life." *Astrobiology*. October 2017.

SCREENTIME

Website invites visitors into a 3-D human brain

In movies, exploring the body up close often involves shrinking to microscopic sizes and taking harrowing rides through the blood. Thanks to a new virtual model, you can journey through a three-dimensional brain. No shrink ray required.

The Society for Neuroscience and other organizations have long sponsored the website BrainFacts.org, which has basic information about how the human brain functions. Recently, the site launched an interactive 3-D brain, at www.BrainFacts.org/3D-Brain.

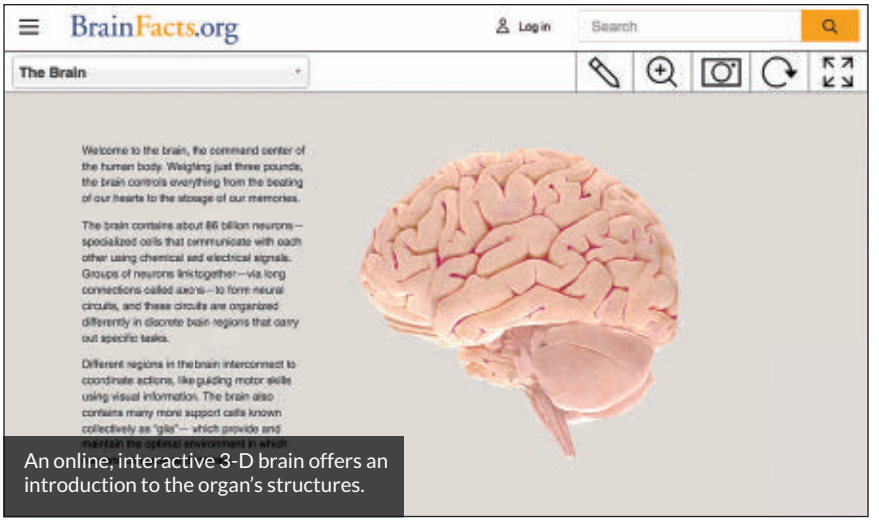
A translucent, light pink brain initially rotates in the middle of the screen. With a click of a mouse or a tap of a finger on a mobile device, you can highlight and isolate different parts of the organ. A brief text box then pops up to provide a structure's name and details about the structure's function. For instance, the globus pallidus — dual almond-shaped structures deep in the brain — puts a brake on muscle contractions to keep movements smooth.

Some blurbs tell how a structure got its name or how researchers figured out what it does. Scientists, for example, have learned a lot about brain function by studying people who have localized brain damage. But the precuneus, a region in the cerebral cortex along the brain's midline, isn't usually damaged by strokes or head injuries, so scientists weren't sure what the region did. Modern brain-imaging techniques that track blood flow and cell activity indicate the precuneus is involved in imagination, self-consciousness and reflecting on memories.

Clicking and dragging your mouse or finger allows you to rotate the brain. You can zoom in to view areas in detail or back out to get a bigger picture of a region's connection to the rest of the brain. A drop-down menu provides easy navigation to particular structures and gives more context for the brain's anatomy. At a glance, the menu outlines, for instance, that the limbic system contains the entorhinal cortex, amygdala and hippocampus. And the hippocampus is further composed of the subiculum and dentate gyrus.

Long, sometimes tongue-twisting names — such as the glossopharyngeal nerve — can be daunting. But the text boxes are easy primers, most no more than 50 to 100 words. Make it through the names and you'll learn interesting nuggets, like that the glossopharyngeal nerve oversees swallowing muscles and relays information about taste and touch in the mouth.

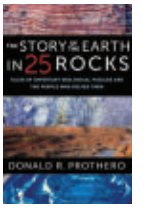
Anyone interested in the brain should find a trip through this interactive model a fun and informative journey.
— *Tina Hesman Saey*



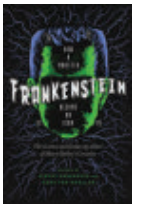
An online, interactive 3-D brain offers an introduction to the organ's structures.

BOOKSHELF

Counting Backwards
Henry Jay Przybylo
An anesthesiologist looks back on his 30-plus–year career and explains what scientists do — and don't — know about how anesthetics work. *W.W. Norton & Co., $25.95*

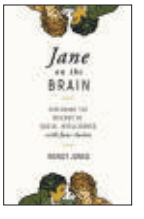


The Story of the Earth in 25 Rocks
Donald R. Prothero
Brief tales of science and history feature volcanic tuff, meteorites, chalk and other rocks that have revealed events in Earth's past or particular geologic processes. *Columbia Univ., $35*



Frankenstein: How a Monster Became an Icon
Sidney Perkowitz and Eddy von Mueller (eds.)
Experts reflect on Mary Shelley's most famous novel and its lasting influence on literature, pop culture and science. *Pegasus Books, $28.95*

The Spinning Magnet
Alanna Mitchell
A science journalist recounts how researchers came to understand Earth's magnetic field and ponders what will happen when the planet's magnetic poles eventually flip again. *Dutton, $28*



Jane on the Brain
Wendy Jones
Mr. Darcy and other characters from Jane Austen novels help illustrate concepts in psychology and neuroscience. *Pegasus Books, $27.95*

Using professional-grade microscopes and instruction from researchers, students on BioBus get a glimpse into the life of a scientist.

Society supports STEM with Action Grants

In December, Society for Science & the Public awarded STEM Action Grants to eight innovative organizations aiding community-based science, technology, engineering and mathematics projects. Through the STEM Action Grant Program, supported by Regeneron, the Society funds mission-driven organizations that promote science literacy. The following organizations received STEM Action Grants:

BioBus (New York) works to help minority, female and low-income students reach their full potential in science fields through hands-on experiments in a mobile lab. The grant will fund at least two additional trips to schools and give more than 300 students the opportunity to engage in scientific research.

CodeVA (Richmond, Va.) improves access to computer science education in Virginia. CodeVA's new program, Full STEAM Ahead, connects middle school girls to female science, technology, engineering, arts and mathematics (STEAM) professionals.

Georgetown Day School (Washington, D.C.), an independent pre-K–12 school with a mission to ensure equity to children of all backgrounds, will receive a grant to support its annual STEAM conference. The grant will give local D.C. high school students the opportunity to connect with and learn about STEAM professions.

Bird Conservancy of the Rockies (Brighton, Colo.) will use the grant to expand delivery of the Putting Birds in the Hands of Underserved Rural Youth program and other educational activities for low-income students in the Nebraska Panhandle, a predominantly rural region. The funds will also help extend the STEM-related programs to the Pine Ridge Indian Reservation for the first time, home to the Oglala Sioux Tribe.

Sci-Inspire (Washington, D.C.) received a grant to support its mission of strengthening U.S. science education by cultivating and sustaining partnerships between institutions of higher education and K–12 schools. University volunteers connect with students in various ways, such as mentoring kids with their science fair projects and supporting in-class teaching.

Intrepid Sea, Air & Space Museum (New York), an educational and cultural museum featuring the aircraft carrier U.S.S. *Intrepid*, a National Historic Landmark, is one of the world's most successful historic ship museums. The grant will support a new videoconference-based program, called Virtual Field Trips, for students who are unable to visit the museum in person.

Black Girls Dive Foundation (Owings Mills, Md.) empowers and engages young, underrepresented girls in marine STEM fields. The girls participate in many activities, including building underwater remotely operated vehicles, taking scuba lessons and working on the CORAL Project in Jamaica.

Science from Scientists (Bedford, Mass.) will use the grant to support and grow its mission to teach and inspire the next generation of scientists by providing STEM literacy and enrichment programs to schools and organizations. The funds will help expand the organization's In-School Module-Based programs.

NOVEMBER 11, 2017

SOCIAL MEDIA

Robots in disguise

Cephalopod-inspired synthetic skin that can change texture and inflate into 3-D shapes may one day be used for robot camouflage, **Maria Temming** reported in "Shape-shifting skin" (*SN: 11/11/17, p. 5*). Some readers on Twitter were less than excited about the technology.

That's just what I want. Robots running around with quick disguise capabilities. That's a good idea. Uh-huh.
@HamillSparkles

Haven't you seen *Terminator*?
@Mk2Salamnder

Join the conversation

E-MAIL editors@sciencenews.org

MAIL Attn: Feedback
1719 N St., NW
Washington, DC 20036

Connect with us

Species shmecies

*In "The fuzzy art of defining species" (SN: 11/11/17, p. 22), **Susan Milius** asked scientists to define "species." Schoolbooks may define the concept as a group of organisms that create fertile offspring when mating with each other but not when mating with outsiders. But for researchers specializing in the topic, a single definition is hard to come by.*

"It seems to me that when it comes to animals and especially animal fossils, that biologists are always looking to maximize the number of species," online reader **Mark S.** wrote.

MJF Images disagreed: "Sometimes we learn of new species and sometimes we learn we have made a mistake. But naturally as we explore more environments (the deep seafloor, for example), we discover organisms we have never encountered. That addition to the list of known species is certainly not an attempt by biologists to artificially 'maximize' species counts."

Online reader **Casey Burns** thought scientists should move past the debate over lumping versus splitting and focus on the concept of "guilds." Guilds are collections of species that occupy the same niche in an environment, and are a way for researchers to gauge biodiversity.

Milius' essay focused on species, but "an identical discussion could be carried on about nearly any feature of science," wrote **sailor376**. "Real science is messy. Real science is fuzzy. All concepts and conclusions, all things 'proven,' need to be periodically reexamined."

Ticktock

*A new atomic clock's tick rate is about six times as precise as the previous record-holder, **Maria Temming** reported in "New atomic clock is most precise yet" (SN: 11/11/17, p. 8).*

Steve Capps wondered if gravity could affect atomic clocks: "Since time slows in a gravitational field, are atomic clocks so sensitive that perhaps moving them from the ground floor to the second or third floor of a building would have a measurable effect, given that gravity would be less on the higher floors?"

Atomic clocks indeed speed up when they are moved from the ground floor of a building to a higher floor, says **Jun Ye**, a physicist at JILA in Boulder, Colo. "In fact, even by just raising one's arm on the same floor, you can measure [that] time speeds up," **Ye** says.

Element factory

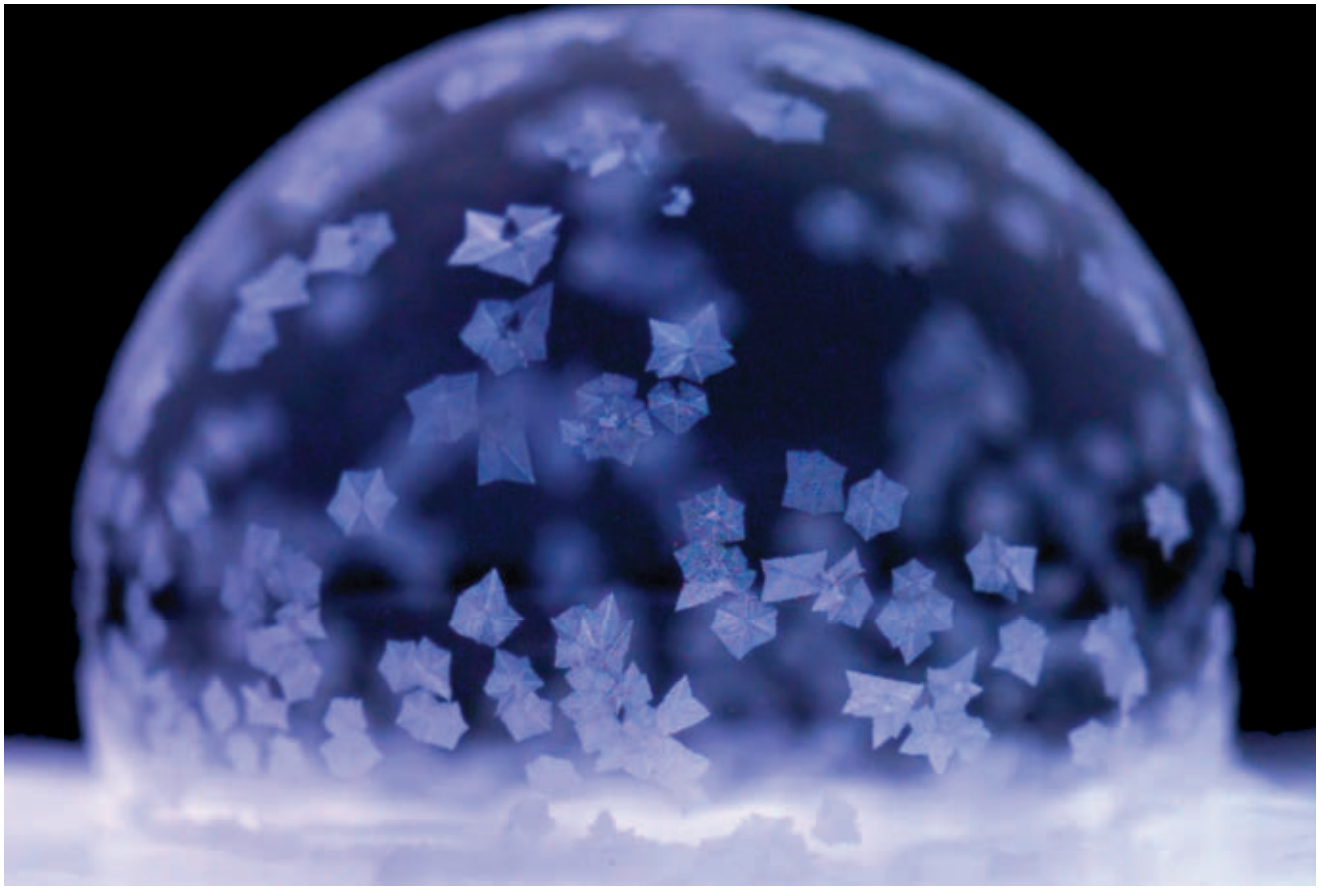
*A neutron star collision 130 million light-years away produced gold, silver, platinum and other heavy elements, **Emily Conover** reported in "Neutron star crash seen for first time" (SN: 11/11/17, p. 6).*

Reader **Tom Angelo** wondered how elements could form from a neutron star smashup if these stars lack protons and electrons.

Neutron stars aren't made entirely of neutrons. "The crust of a neutron star is made of lower-density material that contains protons, neutrons and electrons," **Conover** says. The most neutron-rich matter is deeper within the neutron star.

When the stars collide, the neutron-rich material gets expelled along with nuclei that form from the crust. "The nuclei serve as seed material for the process in which these elements form, swallowing up plentiful neutrons and growing heavier," **Conover** says. "When a nucleus can't take in any more neutrons, it will undergo beta decay, which converts a neutron in the nucleus into a proton, while releasing an electron and a lightweight particle called an anti-neutrino. That's how elements further along the periodic table are formed."

J.H. PIKUL *ET AL*/*SCIENCE* 2017



Why freezing soap bubbles look so beautiful

Frigid air can transform an ordinary soap bubble into a glittery snow globe. No shaking required.

When a bubble is placed in a freezer set to –20° Celsius, delicate ice crystals swirl gracefully across the soapy film (shown above), gradually growing larger until the bubble freezes solid. The phenomenon can also be observed when you blow soap bubbles outside in wintry weather.

Although the process is captured in a number of YouTube videos, it lacked a scientific explanation — until now. Researchers from Virginia Tech in Blacksburg explained the physics behind the miniature snowstorm on November 20 in Denver, during the American Physical Society Division of Fluid Dynamics meeting.

As ice crystals form at a bubble's base, the change from liquid to solid releases heat. This heat gets trapped in the bottom of the bubble (right, top box) because the orb's skin is too thin — about a hundredth of a millimeter — for heat to easily conduct.

As a result, the remaining liquid at the bottom of the bubble is warmer, and therefore has lower surface tension, than liquid at the top. That mismatch sets up currents in the fluid, causing it to stream from warmer to colder regions, a process known as Marangoni flow (right, bottom box). The flow is so strong, says engineer Jonathan Boreyko, who supervised the research, "it's ripping off the ice crystals that are growing from the bottom and taking them along for the ride." Eventually, the crystals grow large enough that they lock into place, and the whole bubble freezes.

— Emily Conover

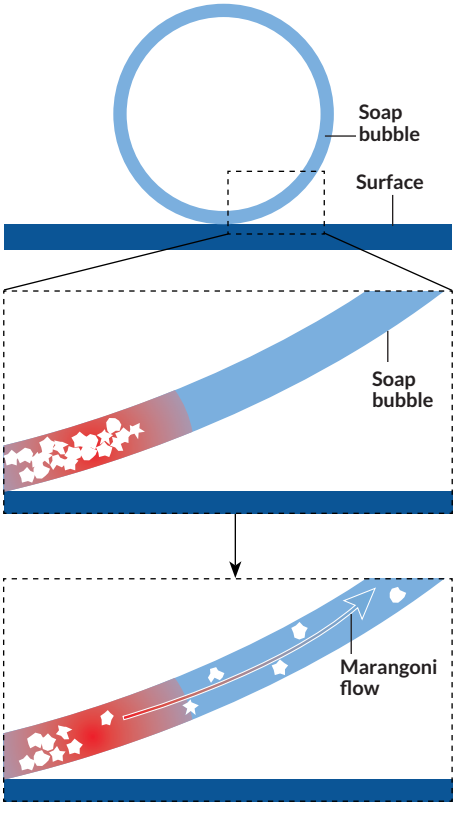


PHOTO: FARZAD AHMADI, CHRISTIAN KINGETT, J. BOREYKO; ILLUSTRATION: T. TIBBITTS

Watch a video of soap bubbles freezing at **bit.ly/SN_freezingbubbles**

STAR TREK™

HURRY! Limited to only 5,000!

Own the First-ever STAR TREK Cuckoo Clock

Sound and animation!

At the top of every hour, the *U.S.S. Enterprise* rotates through "space" at the top of the clock accompanied by the authentic theme music of the television show

A striking montage of The Original Series crew commands attention on the clock body

Hand-crafted, wooden cuckoo clock face is protected by glass and adorned by the *Star Trek* and *U.S.S. Enterprise* logos

Hand-painted finish and detailing are inspired by the futuristic design of the *U.S.S. Enterprise*

Each edition is hand-numbered and comes complete with a Certificate of Authenticity

This clock is set to stun

Now you can join the original crew of the *Starship Enterprise* every hour of the day with the *Star Trek Cuckoo Clock*, a Bradford Exchange design exclusive. With Captain Kirk in charge, you can beam aboard the *U.S.S. Enterprise* to find Mr. Spock, Dr. McCoy, Cmdr. Scott, Mr. Sulu, Lt. Uhura and Ensign Checkov appearing in vivid images on the front of the clock! Every hour brings a new adventure as the *Enterprise* does a fly-by to the tune of The Original Series theme song!

Shown much smaller than actual size of 21½ inches tall, including hanging pendulum and weights.

Requires two "D" batteries and one "AA" battery, not included.

The pendulum is designed to look like the *U.S.S. Enterprise* saucer while the weights resemble the nacelles

Officially Licensed by CBS Studios Inc.

www.bradfordexchange.com/trekclock

Don't miss the boat!

Part of 50 years of adventure, this out-of-this-world timepiece is custom crafted in an edition limited to just 5,000 worldwide and strong demand is expected. Act now to acquire your officially licensed clock at issue price, payable in five convenient monthly installments of only $39.99, for a total of $199.95*. Your purchase is risk-free, backed by our unconditional 365-day money-back guarantee. Send no money now. Just mail the Reservation Application today, or you could miss out!

*For information on sales tax you may owe to your state, go to bradfordexchange.com/use-tax

RESERVATION APPLICATION **SEND NO MONEY NOW**

THE BRADFORD EXCHANGE HOME DECOR

9345 Milwaukee Avenue · Niles, IL 60714-1393

YES. Please reserve the *Star Trek*™ Cuckoo Clock for me as described in this announcement.
Limit: one per order. Please Respond Promptly

Mrs. Mr. Ms.
Name (Please Print Clearly)

Address

City State Zip

E-mail (optional)

01-18030-001-E40311

*Plus $24.99 shipping and service; see bradfordexchange.com. Limited-edition presentation restricted to 5,000 issues. Please allow 4-8 weeks after initial payment for shipment. Sales subject to product availability and order acceptance.

240 YEARS IN THE MAKING

A watch legend at a legendary price.

Over 240 years ago, Abraham-Louis Perrelet, a watchmaker in Europe famous for building clocks at Versailles created a legendary watch movement. He invented the first watch with an automatic mechanical drive. These innovative movements required no batteries and never needed to be manually wound. Inspired by history, our Stauer *Versailles* has been painstakingly handcrafted to meet the demanding standards of vintage watch collectors.

Expert craftsmanship and precision…
only $149

This limited edition Stauer *Versailles* allows you to wear a watch far more exclusive than most new "upscale" models. Here is your chance to claim a piece of watchmaking history in a rare design that is priced to wear every day.

Turning back time. Every interior dial has been carefully engineered to replicate the "complications" of the earliest multifunction watches. Two interior dials display day and month and are run by a perpetual calendar mechanism. With an exhibition back, you can see into the heart of engineering and witness the 27-ruby jewel automatic movement and see the rotor spin to keep it wound— it's powered by the movement of your body.

Your satisfaction is 100% guaranteed. Experience the *Versailles* for 30 days. If you're not convinced you got excellence for less, send it back for a refund of the item price.

This offer might not appear for another 240 years. Originally priced at $495, the *Versailles* was already generating buzz among watch connoisseurs, but with the price slashed to $149, we can guarantee our limited-edition of 4,999 will not last. So, call today!

★★★★★
"Excellent craftsmanship Luxurious design, one of my best pieces. Affordable price. In a nutshell, 100% satisfied."
— J. from Kingwood, Tx

TAKE 70% OFF INSTANTLY!
When you use your OFFER CODE

Stauer Versailles Watch non-offer code price ~~$495~~†
Offer Code Price **$149** + S&P **Save $346**

You must use the offer code to get our special price.

1-800-333-2045

Your Offer Code: VSW127-01
Please use this code when you order to receive your discount.

"The automatic movement still amazes me, and today it's contained in some of the most iconic watches on the market." — **Business Insider**

Stauer® 14101 Southcross Drive W., Dept. VSW127-01, Burnsville, Minnesota 55337 www.stauer.com

† *Special price only for customers using the offer code versus the price on Stauer.com without your offer code.*

BBB ACCREDITED BUSINESS **Rating of A+**

CONSUMER AFFAIRS ACCREDITED

- **Automatic 27-ruby jewel movement** • **Stainless steel caseback & crown** • **Silver & rose gold-finished stainless steel band fits wrists up to 8.5"**
- **Exhibition back** • **Date window** • **Month/Day subdial** • **Embossed black dial with rose gold hands & hour markers** • **Water resistant to 3 ATM**

Stauer…Afford the Extraordinary.™