SN
SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
AUGUST 19, 2017

Milky Way's Stolen Matter

Roots of Rwandan Genocide

Spiders Master Spin Control

No Swap Meet for Tardigrades

Tough on TICKS

Eradication is futile, but scientists might disarm the bloodsuckers

"I've gotten many compliments on this watch. The craftsmanship is phenomenal and the watch is simply pleasing to the eye."
—M., Irvine, CA

"GET THIS WATCH."
—M., Wheeling, IL

Back in Black: The New Face of Luxury Watches
"...go black. Dark and handsome remains a classic for a reason"
— Men's Journal

I'll Take Mine Black...No Sugar

In the early 1930s watch manufacturers took a clue from Henry Ford's favorite quote concerning his automobiles, "You can have any color as long as it is black." Black dialed watches became the rage especially with pilots and race drivers. Of course, since the black dial went well with a black tuxedo, the adventurer's black dial watch easily moved from the airplane hangar to dancing at the nightclub. Now, Stauer brings back the "Noire", a design based on an elegant timepiece built in 1936. Black dialed, complex automatics from the 1930s have recently hit new heights at auction. One was sold for in excess of $600,000. We thought that you might like to have an affordable version that will be much more accurate than the original.

27 jewels and hand-assembled parts drive this classic masterpiece.

Basic black with a twist. Not only are the dial, hands and face vintage, but we used a 27-jeweled automatic movement. This is the kind of engineering desired by fine watch collectors worldwide. But since we design this classic movement on state of the art computer-controlled Swiss built machines, the accuracy is excellent. Three interior dials display day, month and date. We have priced the luxurious Stauer ***Noire*** at a price to keep you in the black… only 3 payments of $33. So slip into the back of your black limousine, savor some rich tasting black coffee and look at your wrist knowing that you have some great times on your hands.

An offer that will make you dig out your old tux. The movement of the Stauer ***Noire*** wrist watch carries an extended two year warranty. But first enjoy this handsome timepiece risk-free for 60 days for the extraordinary price of only 3 payments of $33. If you are not thrilled with the quality and rare design, simply send it back for a full refund of the item price. But once you strap on the ***Noire*** you'll want to stay in the black.

Exclusive Offer—Not Available in Stores

Stauer Noire Watch ~~$399~~†
Your Cost With Offer Code **$99** + S&P **Save $300**
OR 3 credit card payments of $33 + S&P

1-800-333-2045

Offer Code: NWT329-06
You must use this offer code to get our special price.

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

Stauer®
14101 Southcross Drive W.,
Dept. NWT329-06
Burnsville, Minnesota 55337
www.stauer.com

BBB ACCREDITED BUSINESS **Rating of A+**
CONSUMER AFFAIRS ACCREDITED

27-jewel automatic movement • Month, day, date and 24-hour, sun/moon dials • Luminous markers • Date window at 3' o'clock • Water resistant to 5 ATM • Crocodile embossed leather strap in black fits wrists to 6½"–9"

Stauer…Afford the Extraordinary.™

VOL. 192 | NO. 2

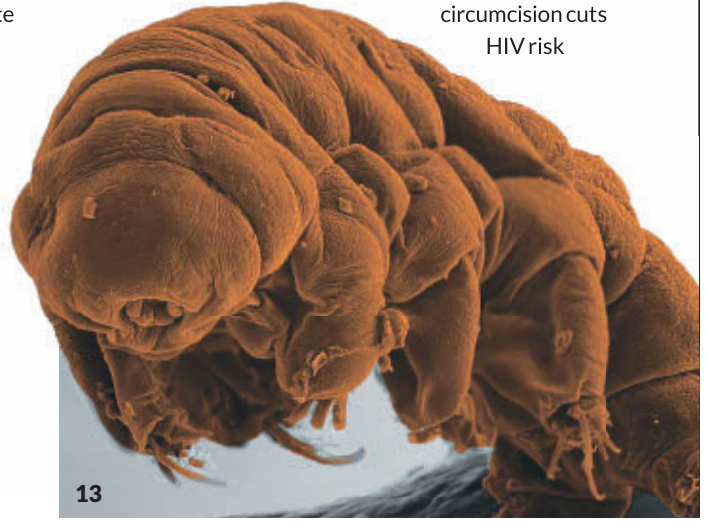
ScienceNews


22

Features

News


14


13


26

Departments

COVER Ticks are tiny creatures that carry even tinier pathogens that are a big threat to humans. *Alfred Pasieka/Getty*

CLOCKWISE FROM TOP: PHOTONONSTOP/ALAMY; COURTESY OF TANGLED BANK STUDIOS; K. ARAKAWA AND H. HIGASHIYAMA; © SOUTH TYROL MUSEUM OF ARCHAEOLOGY

A lot of life on planet Earth is awful and incredible

In deciding on a cover image for this issue, the *Science News* team had a difficult choice to make: Do we print a picture of a tick that reminds readers how much we all despise these critters? Or, do we go with a closeup view that masks ticks' revolting character and makes you wonder: "Ooh. What's that?" We chose to highlight hostilities to match the story headline, "Bulletins from the tick wars."

"I have pangs now and then that I put so much tick rage and too little tick wonder into the story," life sciences writer Susan Milius told me. Her story, on Page 16, covers the ways researchers are trying to keep ticks from spreading diseases, from genetically manipulating mouse hosts to luring ticks to their death with raccoon-sized robots. Milius has a knack for helping readers appreciate all aspects of nature: the gross and charming, maddening and pleasant, horrifying and awe-inspiring. On behalf of tick wonder, she offers the following observations, which didn't make it into the story:

- What must it be like to feed on an animal thousands of times your size — to grab on as your meal brushes by and cling there for a day or more? "Maybe it would be as if people, with only their own two feet for transport, had to survive by feeding on trains and airplanes," Milius says.
- Blood feeds can be so rare and massive that a tick's body can grow 200 to 600 times its original weight. That's akin to an average-sized human gaining more than 20,000 pounds from a single meal.
- And ticks are prey as well as predators. "When they're engorged — their lovely gross shape that most people hate — that's a really nice little protein bar for somebody," says tick specialist Holly Gaff. Ticks feasting on buffalo in Africa are lunch for iconic birds known as oxpeckers. An oxpecker is "basically eating the buffalo, very slowly," Gaff says.

Isn't biology amazing? Milius is full of such tidbits, like the fact that there are 18,000 types of non-honeybee bees, many of which also pollinate plants — a gem from my early days editing with Milius (*SN: 4/9/11, p. 18*). Or the fact that a cicada nymph molts four times during its long life underground, before leaving its final crusty shell on my maple tree, shutters and backyard shed. When cicadas took over the yard this summer, my first reaction was "ew." But revisiting Milius' "Mystery in synchrony" story (*SN: 7/13/13, p. 26*) reminded me that we share planet Earth with some beautiful and bizarre life-forms.

Milius isn't alone in her animal (and plant!) appreciation. In this issue, physics writer Emily Conover describes how spider silk deforms when it twists, giving spiders the power to resist excessive spinning (Page 5). And two writers tackled tardigrade biology recently: Though water bears, it turns out, rarely swap genes, as molecular biology writer Tina Hesman Saey reports on Page 13, they still have the impressive ability to survive everything but the boiling away of the oceans, as intern Maria Temming writes online (*SN Online: 7/14/17*).

The world can be a scary place, with real risks. Take steps to protect yourself, including keeping blood-hungry ticks away. But also take steps — reading *SN*, for one — to feed your sense of wonder. — *Elizabeth Quill, Acting Editor in Chief*

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

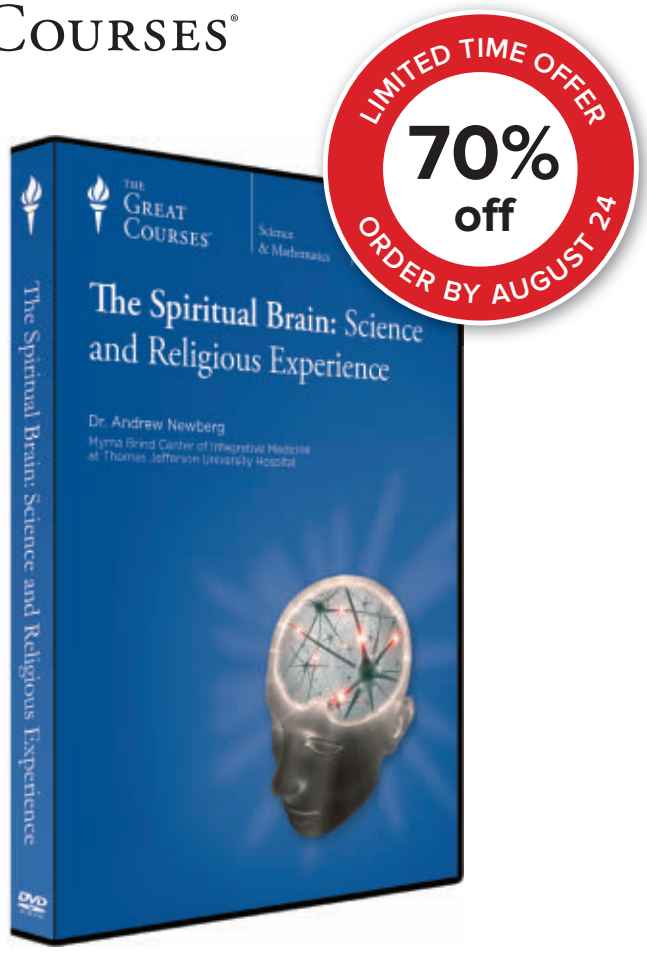
Subscriber services:
E-mail member@societyforscience.org
Phone (800) 552-4412 in the U.S. or (570) 567-1191 outside of the U.S.
Web www.sciencenews.org/join
For renewals, www.sciencenews.org/renew
Mail *Science News*, PO Box 1205, Williamsport, PA 17703-1205

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

THE GREAT COURSES®



Are Our Brains Wired to Worship?

Does God exist? Do we have a soul? Can we make contact with a spiritual realm? Religion plays such a prominent role in the human experience and is so pervasive across cultures that, whatever your beliefs, you have probably pondered these questions. Now, neurotheologians are studying the reasons why.

In the 24 riveting lectures of **The Spiritual Brain**, award-winning scholar and practicing neuroscientist Dr. Andrew Newberg, Director of Research at the Myrna Brind Center of Integrative Medicine at Thomas Jefferson University Hospital, examines the emerging science on the connection between brain function and spirituality. You'll investigate the neural activity of the religious brain, the effects of spiritual belief and practice on mental and physical health, and many other fascinating areas of research.

Offer expires 08/24/17

THEGREATCOURSES.COM/9SN

1-800-832-2412

The Spiritual Brain: Science and Religious Experience

Taught by Professor Andrew Newberg
MYRNA BRIND CENTER OF INTEGRATIVE MEDICINE
AT THOMAS JEFFERSON UNIVERSITY HOSPITAL

LECTURE TITLES

1. A New Perspective on Ancient Questions
2. Why Do We Have a Spiritual Brain?
3. Brain Function and Religion
4. How Does Science Study Religion?
5. Believers and Atheists
6. Spiritual Development
7. The Myth-Making Brain
8. The Brain and Religious Rituals
9. The Biology of Spiritual Practices
10. Religion and Health
11. Religion and Mental Health
12. Religion and Brain Dysfunction
13. Transmitters to God
14. Stimulated States and Religious Experiences
15. Near-Death Experiences and the Brain
16. The Believing Brain
17. The Brain's Influence on Religious Ideas
18. Revelation, Salvation, and the Brain
19. The Brain's Influence on Religious Behavior
20. How the Brain Changes God
21. How God Changes the Brain
22. Why God Won't Go Away
23. The Mystical Mind
24. Reality and Beyond

The Spiritual Brain:
Science and Religious Experience
Course no. 1682 | 24 lectures (30 minutes/lecture)

SAVE UP TO $195

DVD	~~$254.95~~	NOW $59.95
Video Download	~~$214.95~~	NOW $39.95
CD	~~$179.95~~	NOW $39.95
Audio Download	~~$129.95~~	NOW $24.95

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

Priority Code: 148807

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.

Excerpt from the August 19, 1967 issue of *Science News*

50 YEARS AGO

Ductile, strong steel

Fundamental scientific knowledge of the behavior of metallic crystals has led to the design of a new series of alloy steels, stronger and tougher than those now available. The new alloys can be stretched from two to five times more than previous ones, yet also have high strength.... The alloys, called TRIP steels, are produced by [the process] Transformation Induced Plasticity.

UPDATE: TRIP steels are still used in cars. But the quest for a strong, lightweight steel continues, spurred by better knowledge of how a material's nanostructure affects its overall properties. One surprising approach: embedding tiny, brittle iron-aluminum grains within steel. A bit of nickel helps position the grains properly and prevents small cracks from spreading, researchers reported in 2015 in *Nature*. Another method makes steel with variable nanoscale layers, similar to bone (*SN: 4/15/17, p. 5*). The inconsistent microstructure disrupts emerging cracks, preventing them from traveling in a straight line.

THE SCIENCE LIFE

Battling for Yemen's survival

Women line up for clean water in war-torn Yemen, home to an ongoing cholera outbreak.

Rowa Mohammed Assayaghi teaches people how to wash their hands. In Yemen, that's life-saving work.

The Middle Eastern country is facing the world's largest cholera outbreak, with nearly 409,000 suspected cases and 1,885 deaths from late April to late July, the World Health Organization reports. That tally is higher than 2015's worldwide reported cholera deaths. A bacterial infection spread by feces-contaminated water, cholera causes diarrhea, vomiting and dehydration. The outbreak, which began in October 2016 and ramped up in April, is a result of a two-year civil war.

"The war ... greatly affected all service sectors such as the health sector, water supply, sanitation, electricity, transportation and roads, hygiene services and so on," says Assayaghi, a medical microbiologist at Yemen's Sana'a University.

More than half of Yemen's 27.4 million residents lack access to clean water, according to UNICEF. Most wells are contaminated by garbage, septic backups and rainwater runoff — perfect conditions for *Vibrio cholerae* to thrive.

It's possible that people are also contracting *E. coli* from "charity water" being brought in to help. "We found high count

RETHINK

Lizardlike critter was a landlubber

A round belly, stubby feet and a tapering tail made one armored reptile a lousy swimmer. Despite earlier reports, *Eusaurosphargis dalsassoi* might not have swum at all, scientists now say.

E. dalsassoi was first identified in 2003. Fossils were found near Monte San Giorgio at the Swiss-Italian border alongside the remains of marine reptiles and fish that lived roughly 240 million years ago. That association led scientists to conclude the creature was aquatic. But a complete skeleton of *E. dalsassoi* unearthed in 2002 in the Swiss Alps and recently assembled contradicts that idea.

At just under 20 centimeters long, the fossil, probably of a youngster, shows that *E. dalsassoi* widened at the stomach and slithered forward with stiff elbow and knee joints and spadelike claws. That's not a swimmer's build, paleontologist Torsten Scheyer of the University of Zurich and colleagues report June 30 in *Scientific Reports*.

Armed with rows of small spikes along its back and spear-shaped plates framing its head, sides and tail, the animal resembled today's girdled lizards. The researchers speculate that this particular *E. dalsassoi* died on a beach and then got washed into the ocean. — *Ashley Yeager*

A complete fossil of *Eusaurosphargis dalsassoi* (below) suggests that the extinct reptile (illustrated, top left) wasn't a good swimmer.

FROM TOP: THANA FAROQ/CARE; BEAT SCHEFFOLD/PALEONTOLOGICAL INSTITUTE AND MUSEUM/UNIV. OF ZURICH; T. SCHEYER/PALEONTOLOGICAL INSTITUTE AND MUSEUM/UNIV. OF ZURICH

of *E. coli*" in samples of the water, she says. That one-two punch could be making the cholera outbreak more severe, says Nagi Alhaj, a microbiologist and Assayaghi's former colleague. Alhaj fled to Malaysia when his toddler son was injured in an air strike soon after the war began. "My country has been destroyed by war and microbe," he says.

Only a handful of Yemen's hospitals and clinics remain functional enough to deal with the fallout. The epidemic is so severe that the United Nations scrapped plans to deliver more than a million cholera vaccines so health workers could focus on treating the sick. All that's left to defend against *V. cholerae* is a patchwork of dedicated aid workers, health care professionals and scientists, Assayaghi among them. She had been studying viruses to treat cancer. But the war and collapsing economy put that work on hold.

14.5 million
Residents of Yemen who lack clean water

Assayaghi, age 40, travels to cholera-affected regions, teaching people how to avoid contracting or spreading the disease. "Focusing on health awareness is one of the most important measures to follow," she says.

She shows people how to sterilize what water they have via filters, chlorine tablets and boiling. She distributes soap and instructs people on what to do if family members start showing symptoms: Wear gloves, wash hands after contact, give the person oral rehydration solution the moment diarrhea appears and go to the nearest health center.

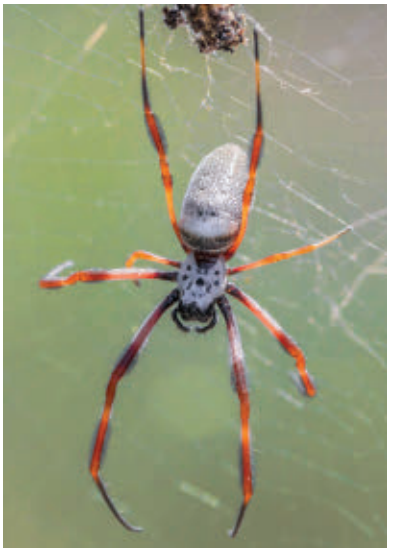
When not volunteering, Assayaghi tries to continue some research despite intermittent electricity and scarce supplies. She remains in Yemen because of her job and to take care of her father and two sisters. "I am responsible for my family," she says. Taking them all abroad would be too costly. If she could, Assayaghi says, she would leave Yemen immediately. — *Cassie Martin*

MYSTERY SOLVED

Spider spin control

A strange property of spider silk helps explain how the arachnids avoid twirling wildly at the end of their ropes.

Researchers from China and England harvested silk from two species of golden orb weaver spiders, *Nephila edulis* and *Nephila pilipes*, and tested it with a torsion pendulum. The device has a hanging weight that rotates clockwise or counterclockwise, twisting whatever fiber it hangs from. When a typical fiber is twisted, the weight spins back and forth around an equilibrium point, eventually returning to its original orientation.



Silk from orb weaver spiders (*Nephila edulis* shown) deforms when twisted, enabling a steady dangle.

But unlike several fibers the scientists tested — copper wires, carbon fibers and even human hair — the spider silk deformed when twisted. That distortion changed the silk's equilibrium point and cut down on the back-and-forth spinning, the scientists report in the July 3 *Applied Physics Letters*. Eventually, scientists might design spin-resistant ropes for mountain climbers, who, like spiders, should avoid doing the twist. — *Emily Conover*

Tube worms near seafloor vents eat well and live long.

THE -EST

Growing old down deep

Some deep-sea tube worms get long in the tooth ... er, tube. Living several decades longer than its shallow-water relatives, *Escarpia laminata* has the longest known life span for a tube worm, aging beyond 300 years, researchers report in the August *Science of Nature*.

E. laminata lives 1,000 to 3,300 meters deep in the Gulf of Mexico, near seafloor vents that seep energy-rich compounds that feed bacteria that feed the tube worms. In 2006, biologists marked 356 *E. laminata* in their natural habitat and measured how much the creatures had grown a year later. To estimate the ages of tube worms of different sizes, the researchers plugged *E. laminata*'s average yearly growth rate — along with estimates of birthrates and death rates, based on observations of another 1,046 tube worms — into a simulation. The species's typical life span is 100 to 200 years, the researchers calculate, but some larger tube worms may be more than 300 years old.

With few large predators, deep-sea tube worms have got it good, says study coauthor Alanna Durkin, a biologist at Temple University in Philadelphia. "Once they find a seat at the buffet, they're pretty set for hundreds of years." The researchers' methodology appears robust, says ocean scientist David Reynolds of Cardiff University in Wales, who was not involved in the work. Although variable environmental conditions could affect growth rate over time, he says. — *Maria Temming*

News

Exchanging gas with other galaxies may be one way galaxies, like M81 (left) and M82 (right), grow, new simulations suggest.

ATOM & COSMOS

Half of Milky Way matter may be alien

Galactic winds blew in gas from elsewhere, researchers propose

BY ASHLEY YEAGER

Galaxies may grow by swiping gas from their neighbors.

Nearly half the matter in the Milky Way may have been siphoned from the gas of other galaxies, new simulations suggest. That gas provides the raw material that galaxies use to build their bulk. The finding, scheduled to appear in the *Monthly Notices of the Royal Astronomical Society*, reveals a new, unexpected way for galaxies to acquire matter and could give clues to how they evolve.

"These simulations show a huge amount of interaction among galaxies, a huge dance that's going on," says astronomer Romeel Davé of the University of Edinburgh. That dance, and the subsequent exchange of atoms, could be what establishes a galaxy's character — whether it's small or big, elliptical or spiral, quiet or bursting with star formation. If confirmed, this discovery would be a major advance in understanding galaxy formation, Davé says.

Astronomers thought galaxies got their matter in two main ways. First, atoms clumped together to form stars and then galaxies not long after the Big Bang. Some of those atoms were eventually ejected by supernovas but recycled again and again into the same galaxies.

The new simulations show a third way. Powerful supernovas could eject atoms, in the form of gas, into intergalactic space. Galactic winds moving at several hundred kilometers per second could then push those atoms toward other galaxies. When the particles near a galaxy's gravitational pull, they could get sucked in and serve as the basis for stars, planets, dust and other material in their new home. This exchange would be difficult to spot because the gas atoms don't give off light like stars do.

Claude-André Faucher-Giguère, a theoretical astrophysicist at Northwestern University in Evanston, Ill., and colleagues spotted the exchange in computer simulations that show how galaxies formed and evolved after the Big Bang.

In the simulations, up to half of the atoms in large galaxies were pulled in from other galaxies. Because more massive galaxies have more gravity, they tended to pull atoms from the ejected material of small galaxies. The exchange appears to take millions to billions of years as atoms travel the vast space between galaxies. ■

MATTER & ENERGY

Copper films are never truly flat

Microscopic valleys and ridges may impede electrical flow

BY EMILY CONOVER

Like the surface of an alien planet, thin sheets of copper display a complex topography of ridges and valleys. These never-before-seen undulations may spell trouble for electronic gadgets: The zigzagging surface could contribute to the electrical resistance of miniature copper wires that snake throughout computer chips.

Using a scanning tunneling microscope, scientists observed nanoscale peaks and dips on a sheet of copper, with angles of a few degrees, researchers report in the July 28 *Science*. "We were absolutely shocked," says materials scientist John Boland of Trinity College Dublin. Conventional wisdom was that the copper would lay mostly flat.

Copper and other metals are a conglomeration of smaller bits, known as grains. Within each grain, the atoms are neatly arranged, but at grain boundaries, the pattern is disrupted. In the type of copper the researchers studied, nanocrystalline copper, the grains are particularly small; each has around 1 million atoms. Boland and colleagues showed for the first time that, in films of nanocrystalline copper just tens of nanometers thick, peaks and dips appear where misaligned grains meet.

"This is a completely new observation," says materials scientist Peter Nellist of the University of Oxford, who was not involved in the study. Metals that have the same crystalline structure as copper might show similar behavior, he says.

Copper's rippled surface could add to the electrical resistance of copper nanowires. Electrons traveling through the material would have to change direction to navigate the landscape, impeding their progress. In an electronic device, extra resistance can generate heat or drain battery power faster.

"Now that we know it's happening, we can think about how we can control it," Boland says. For example, scientists might be able to add another material to copper wires, such as aluminum, which could change how the grains meet. ■

Cows make powerful HIV antibodies

In a first, immunization elicits broad defense against AIDS virus

BY AIMEE CUNNINGHAM

An unlikely hero has emerged in the quest to fight HIV: the cow. In a first for any animal, including humans, four cows injected with a type of HIV protein rapidly produced powerful antibodies against the virus, researchers report. Learning how to induce similar antibodies in humans may be key to a successful HIV vaccine.

The antibodies, called broadly neutralizing antibodies, can stop infection from a variety of HIV types. The cows generated these antibodies as soon as 42 days after immunization, the scientists report online July 20 in *Nature*. For the small percentage of people estimated to develop these antibodies after a natural infection, it can take several years.

> Cows generated HIV antibodies as soon as 42 days after immunization.

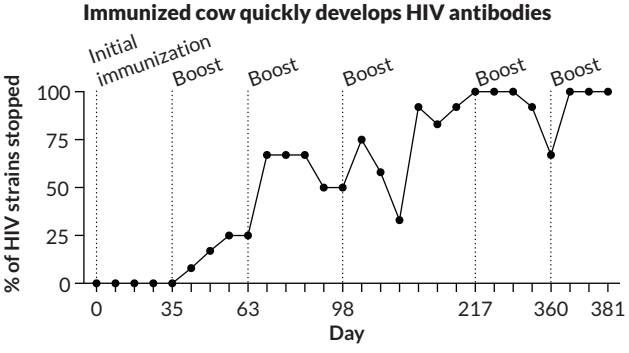
The work identifies "a new and much more efficient method to generate broadly active antibodies against HIV," says immunologist Justin Bailey of Johns Hopkins University School of Medicine, who was not involved in the study.

Making an HIV vaccine has proved difficult because the virus changes all the time. Different strains exist throughout the world, and the virus even mutates within an infected person's body. Most often, people develop antibodies that are specific to one strain but ineffective against others. HIV vaccines tested so far have not led to the production of broadly neutralizing antibodies.

About 1 percent of HIV-infected people eventually generate broadly neutralizing antibodies that are especially potent and effective against many types of HIV. The development of these antibodies, however, doesn't seem to help infected people. But when given to monkeys before exposure to a virus similar to HIV, the antibodies prevent infection.

Broadly neutralizing antibodies specific to HIV have a few quirky features, one of which is the presence of a long stretch of amino acids that sticks out from the antibody surface. This protruding part of the antibody binds to a viral site that remains the same between strains, because the virus needs it to gain entry to a cell. HIV's thick coat of surface sugars makes the viral binding site difficult to access. A longer stretch of amino acids seems to be able to pierce through "and reach in, almost like the long arm of the law," says Vaughn Smider, a molecular immunologist at the Scripps Research Institute in La Jolla, Calif.

In the few people infected with HIV who develop broadly neutralizing antibodies, this antibody region — called HCDR3 — has about 30 amino acids, about twice as long as what is usual for human antibodies. Although on the long side for a human, "that's actually kind of short for a cow," Smider says.



Fending off HIV

After an immunization with an HIV protein and several booster shots, cows develop broadly neutralizing antibodies against the virus. Here, one cow's response to 12 different types of HIV is shown. In an even larger test of 117 HIV types, the cow's antibodies stopped 96 percent of tested strains.

A special feature of bovine antibodies seems key to why cows in a new study generated broadly neutralizing antibodies against HIV. The work may help with vaccine development.

And so the idea to immunize cows was born. Since cows naturally make longer HCDR3s, Smider explains, the researchers thought that perhaps they would develop a broad and powerful immune response to HIV.

Smider and colleagues took serum — blood with the cells removed, leaving only antibodies — from four immunized cows and tested it against different types of HIV virus in a test tube. All of the cows developed broadly neutralizing antibodies. The researchers then tested one cow's antibodies on an even larger number of virus types. After 381 days, this cow's antibodies prevented 96 percent of the 117 HIV types from infecting cells in a lab dish. The researchers also isolated an antibody from this cow that had a long HCDR3 of 60 amino acids and stopped infection by 72 percent of the HIV types.

If researchers could induce antibodies with long HCDR3s in humans before immunization, Smider says, "then that could be the basis of getting a vaccine to work."

Since cows are so good at making broadly neutralizing antibodies, it also might be possible to turn the cow's handiwork into drugs for HIV treatment, if bovine antibodies are effective at stopping the virus in other animals, Smider says. ■

FROM TOP: MAYNAGASHEV/ISTOCKPHOTO; D. SOK *ET AL*/*NATURE* 2017

GENES & CELLS

‘Friendliness’ genes identified in dogs

DNA linked to sociability may have been key to domestication

BY ASHLEY YEAGER

DNA might reveal how dogs became man’s best friend.

Some of the same genes linked to the behavior of extremely social people can also make dogs friendlier, a new study shows. The result, published July 19 in *Science Advances*, suggests that dog domestication was the result of just a few genetic changes rather than hundreds or thousands of them.

“It is great to see initial genetic evidence supporting the self-domestication hypothesis, or ‘survival of the friendliest,’ ” says Brian Hare, an evolutionary anthropologist at Duke University who studies how dogs think and learn. “This is another piece of the puzzle suggesting that humans did not create dogs intentionally, but instead wolves that were friendliest toward humans were at an evolutionary advantage as our two species began to interact.”

> “This is another piece of the puzzle suggesting that humans did not create dogs intentionally.”
>
> **BRIAN HARE**

Not much is known about the genetics of dog domestication. Evolutionary geneticist Bridgett vonHoldt of Princeton University and colleagues published a study in 2010 comparing dog and wolf DNA. The biggest differences gave clues to why the animals don’t look the same. But major differences were also found in *WBSCR17*, a gene linked to Williams-Beuren syndrome in humans.

Williams-Beuren syndrome leads to delayed development, impaired thinking ability and hypersociability. VonHoldt and colleagues wondered if changes to the same gene in dogs would make them more social than wolves.

In the new study, vonHoldt and colleagues compared the sociability of dogs with that of wolves raised by humans. Dogs typically spent more time than wolves staring at and interacting with a human nearby, indicating the dogs were more social. Analyzing the genetic blueprints of those dogs and wolves, along with DNA data of other wolves and dogs, revealed variations in three genes associated with the social behaviors directed at humans: *WBSCR17*, *GTF2I* and *GTF2IRD1*. All three are tied to Williams-Beuren syndrome.

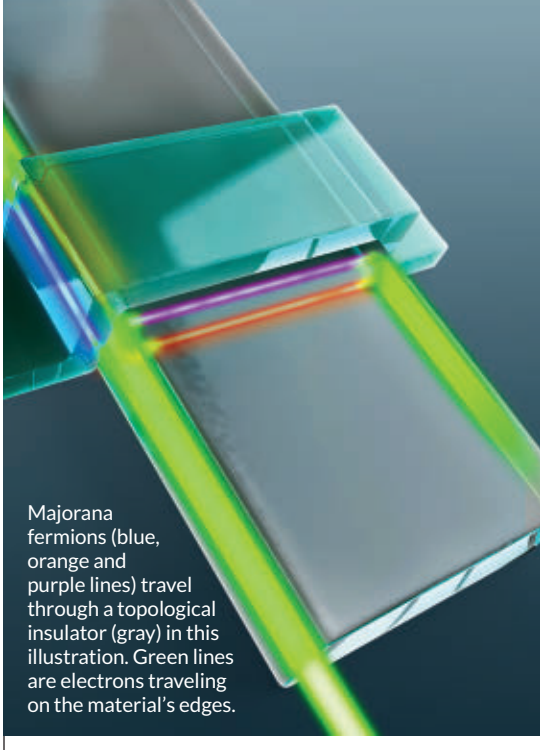
“It’s fascinating that a handful of genetic changes could be so influential on social behavior,” vonHoldt says.

She and colleagues propose that such changes may be intertwined with dog domestication. Previous ideas have suggested that dog domestication involved the development of advanced ways of analyzing and applying information about social situations, a way of thinking assumed to be unique to humans.

“Instead of developing a more complex form of cognition, dogs appear to be engaging in excessively friendly behavior that increases the amount of time they spend near us and watching us,” says study coauthor Monique Udell, who studies animal behavior at Oregon State University in Corvallis. In turn, she says, that gives dogs “the opportunities necessary for them to learn about our behavior and what maximizes their success when living with us.”

The team notes, for instance, that in addition to contributing to sociability, *WBSCR17* variants represent an adaptation to living with humans. *WBSCR17* variants have been linked with the ability to digest carbohydrates, which would have helped dogs thrive on humans’ starch-rich diets. Links between domestication and another gene related to starch digestion, however, have recently been questioned (*SN Online: 7/18/17*).

The other variants, the team argues, would have also predisposed dogs to be hypersocial with humans, a trait that people would then have selected for as dogs were bred over generations. ■



Majorana fermions (blue, orange and purple lines) travel through a topological insulator (gray) in this illustration. Green lines are electrons traveling on the material’s edges.

BEIJING SONDII TECHNOLOGY CO. LTD.

MATTER & ENERGY

Signs of Majorana fermion detected

Layer cake of materials yields evidence of unusual particle

BY EMILY CONOVER

A particle that is its own antiparticle seems to have left its calling card within a solid material.

To observe the signature of that particle, a Majorana fermion, scientists coupled a thin film of a topological insulator — which conducts electricity on its edges but is insulating within — with a layer of a superconductor, in which electrons can flow without resistance. In this layer cake of materials, electrical conductivity varied in discrete jumps of the size expected for Majorana fermions, the researchers report in the July 21 *Science*.

“The experiment came out exactly in the way we predicted,” says theoretical physicist Shoucheng Zhang of Stanford University.

Italian theoretical physicist Ettore Majorana originally proposed in 1937 that these fermions could be a new type of fundamental particle. Instead of having oppositely charged antiparticles, the electrically neutral Majorana fermions would be antiparticles of themselves. Scientists suspect that neutrinos — tiny

neutral particles that swarm through the cosmos — might be Majorana fermions, but there's no hard proof. Instead, the only Majorana fermions for which scientists have evidence are in the form of a "quasiparticle," a disturbance within a material that behaves like a single particle but actually is the result of the collective motion of many electrons. Rather than individually tracking the motions of each electron within a material, scientists think of the disturbance as its own particle, simplifying the math that explains how the material behaves.

Several previous experiments have found traces of these quasiparticle Majorana fermions (*SN: 11/15/14, p. 8*), but the new result reveals a different side of the quasiparticles. Unlike previously detected Majorana fermions, these are chiral, meaning that they travel along the edge of a 2-D layer of material in one direction, like cars circling a racetrack. "Certainly as far as chiral Majorana fermions go, this is the only definitive evidence that has been reported," says theoretical physicist Taylor Hughes of the University of Illinois at Urbana-Champaign, who was not involved with the research.

The new work is also the first evidence of a Majorana fermion that moves around like a true particle, instead of remaining stuck in one place. Earlier evidence for the quasiparticles was found in one-dimensional nanowires, in which a Majorana fermion sat motionless at each end of the wire, like a particle bound to a particular spot within a material.

Majorana fermions left their mark in the material (made of chromium, bismuth, antimony and tellurium overlaid with superconducting niobium) by tweaking a phenomenon known as the quantum anomalous Hall effect. In certain magnetic materials, the electrical conductivity of a thin layer of material changes in steps as a small magnetic field is varied, increasing and decreasing in jumps of a certain size. The signature of the Majorana fermions is a conductivity jump of half the normal size. Since the Majorana fermion is its own antiparticle, "in a very rough sense, it is half of a usual particle," Zhang says, resulting in half-sized jumps.

The detection of this signature is "really the only firm evidence of the presence of Majorana fermions," says study coauthor Kang Wang, a UCLA electrical engineer. He says previous hints of Majorana fermions could have been explained by other means.

"They have a nice, crisp result," says condensed matter physicist Ali Yazdani of Princeton University, strongly suggesting that chiral Majorana fermions are there. But, he says, "there are things that need to be checked out," such as whether the Majorana fermions really travel on the edge of the material as expected.

Majorana fermions may eventually find a purpose in quantum computers. Microsoft, for example, hopes to make topological quantum computers (*SN: 7/8/17, p. 28*) that would harness the particles' unusual properties to stave off the scrambling of delicate quantum information. ■

LIFE & EVOLUTION

In tests of planning, ravens act like apes

Some birds evolved ability to think ahead, experiments suggest

BY SUSAN MILIUS

Ravens have passed what may be their toughest tests yet of powers that, at least on a good day, let people and other apes plan ahead.

Lab-dwelling common ravens (*Corvus corax*) in Sweden at least matched the performance of nonhuman apes and some young children in peculiar tests of advanced planning ability. The birds faced such challenges as selecting a rock useless at the moment but likely to be useful later for working a puzzle box and getting food.

Ravens also reached apelike levels of self-control, picking a tool instead of a ho-hum treat when the tool would allow them to get a fabulous bit of kibble 17 hours later, Mathias Osvath and Can Kabadayi of Lund University in Sweden report in the July 14 *Science*.

"The insight we get from the experiment is that [ravens] can plan for the future outside behaviors observed in the wild," says Markus Böckle of the University of Cambridge. Böckle, who has studied ravens, coauthored a commentary in the same issue of *Science*.

In the wild, ravens cache some of their food, but that apparent foresight could be more of a specific adaptation that evolved with diet instead of some broader power of planning. The Lund researchers' tests, based on experiments with apes, tried to challenge ravens in less natural ways. The researchers say the birds aren't considered much of a tool-using species in nature, nor do they trade for food, as some tests required.

"The study for the first time in any animal shows that future planning can be used in behaviors it was not originally selected for" in evolution, Böckle says.

Ravens can pick out and reserve tools that might be useful in the future — as apes do.

M. OSVATH/LUND UNIV.

Some of the abilities required for the tests aren't completely out of the realm of what ravens do in nature, says Valérie Dufour of the French national research institute CNRS in Strasbourg. "Food-caching birds are naturally inclined to keep track of what they cache and where," she says. "Still, their flexibility in adapting these skills to other contexts is remarkable." ■

Watch a raven use a rock to get a treat at **bit.ly/SN_ravens**

ATOM & COSMOS

Giant solo planets are in limited supply

New estimate of starless worlds aligns with formation theories

BY ASHLEY YEAGER

Big rogue planets are rare. A census of Jupiter-mass planets that lack parent stars has determined these worlds are a tenth as common as once thought. The results appear online July 24 in *Nature*.

Planets can go rogue in two ways: They can get kicked out of their parent planetary systems or form when a ball of gas and dust collapses (*SN: 4/4/15, p. 22*).

Przemek Mróz of the Astronomical Observatory of the University of Warsaw and colleagues estimated the number of large rogue planets in our galaxy using the technique of microlensing. When an object as heavy as a planet passes in front of a distant background star, the planet's gravity acts as a magnifying glass. It distorts and focuses the light, giving up the planet's existence.

Mróz and colleagues looked at 2,617 microlensing events from 2010 to 2015 and determined which were caused by a rogue planet: For every typical star, called main sequence stars, there are 0.25 free-floating Jupiter-mass planets.

That result contrasts with a 2011 estimate that rogue Jupiters are almost twice as common as main sequence stars. About 90 percent of stars are main sequence stars, so that early estimate suggested there should be a lot of solo Jupiters.

"That result changed our conceptual framework of the universe just a little bit," says astronomer Michael Liu of the University of Hawaii in Honolulu. It challenged long-held ideas about how planets go rogue because the known methods wouldn't generate enough planets to account for all the wanderers.

The 2011 result was based on just 474 microlensing events. Since then, infrared telescope images haven't revealed as many free-floating planets as expected.

David Bennett, a coauthor of the 2011 study, agrees that the new census doesn't align with the previous estimate. The data do reveal four times as many Jupiter-mass failed stars called brown dwarfs than originally predicted. So some of the rogues in the first census may instead be failed stars, says Bennett, of NASA's Goddard Space Flight Center in Greenbelt, Md.

Liu says the latest census is more in line with planet-formation theories. Most rogues should be roughly Earth-mass because lighter planets get tossed out of planetary systems much easier than behemoths like Jupiter. But smaller planets are harder to detect.

The new analysis identified several events in which stars brightened and dimmed in less than half a day. Such short events hint at the existence of Earth-mass free-floaters. Determining whether those small planets are really rogue and counting them up will take better telescopes, the team notes. ■

HUMANS & SOCIETY

Humans' arrival in Australia redated

People may have reached the continent earlier than thought

BY MARIA TEMMING

The first humans may have arrived Down Under 65,000 years ago — 5,000 years earlier than previously thought possible, researchers report in the July 20 *Nature*.

Tools, paints and other artifacts from an ancient rock-shelter in Australia are giving new glimpses into early life on the continent. Archaeologists unearthed more than 10,000 relics of human handiwork from the deepest layer excavated at the site of Madjedbebe in 2012 and 2015. This cache included the oldest known polished ax heads, Australia's oldest seed-grinding and pigment-processing tools and possible spearheads.

"When people think about our ancient ancestors, they either tend to have a view that our ancestors must have been primitive, less culturally diverse, or they take the view that our ancestors were probably extraordinarily culturally impressive," says Peter Hiscock, an archaeologist at the University of Sydney who was not involved in the study. "This indicates the latter view. The moment people get to Australia, they're doing all this really smart stuff." They were probably building fires to light nighttime activities, grinding seeds for food and using ochre paints to decorate cave walls or their own bodies, Hiscock says.

Previous estimates of the earliest Australians — between 47,000 and 60,000 years ago — came from Madjedbebe artifacts found in 1989. But archaeologists doubted those results because it was unclear whether the artifacts were the same age as the surrounding sediment, says archaeologist Zenobia Jacobs of the University of Wollongong in Australia.

Jacobs and colleagues estimated the ages of the new finds by more precisely locating the artifacts underground and dating the sediment where they were found using optically stimulated luminescence dating, which reveals the last time a mineral grain was exposed to sunlight. This and other tests indicated the deepest artifacts ranged in age from about 53,000 to 65,000 years.

To say that humans first set foot in Australia exactly 65,000 years ago may be "a somewhat optimistic interpretation of the data," Hiscock says. Items buried in sand are liable to shift around a little. He suggests a more conservative estimate of 55,000 to 60,000 years ago. Still, Hiscock says, that narrowed range is a major improvement over the wide, uncertain time span that archaeologists were working with before. ■

The oldest known polished ax heads (one shown from different angles) were among the finds at Australia's earliest archaeological site.

C. CLARKSON *ET AL*/*NATURE* 2017

NORTH AMERICA'S

#1 Selling Walk-In Tub

Advanced Air System–
Introducing MicroSoothe!

The best walk-in tub just got better with breakthrough technology! ***Presenting the all new Safe Step Walk-In Tub featuring MicroSoothe.***® An air system so revolutionary, it oxygenates, softens and exfoliates skin, turning your bath into a spa-like experience. Constructed and built right here in America for safety and durability from the ground up, and with more standard features than any other tub.

- ✓ Heated seat providing warmth from beginning to end
- ✓ Carefully engineered hydro-massage jets strategically placed to target sore muscles and joints
- ✓ High-quality tub complete with a comprehensive lifetime warranty on the entire tub
- ✓ Top-of-the-line installation and service, all included at one low, affordable price

You'll agree – there just isn't a better, more affordable walk-in tub on the market.

Call today and receive exclusive savings of

$1500 OFF

FOR A LIMITED TIME ONLY

Call Toll-Free 1-888-825-7193

SAFE STEP WALK-IN TUB CO.

www.BuySafeStep.com

For your FREE information kit and DVD, and our Senior Discounts, Call Today Toll-Free

1-888-825-7193

CSLB 983603 F13000002885 13HV08744300

ADVERTISEMENT

GENES & CELLS

New genes give mums the blues

'Holy Grail' of flower color achieved for the first time

Researchers transformed pink and magenta chrysanthemums into various shades of blue and purple by adding two genes linked to blue coloration in other flowers.

BY EMILY DEMARCO

Mums are now a flower of a different color. Japanese researchers have added a hint of clear sky to the plant's palette, genetically engineering the first "true blue" chrysanthemums.

"Obtaining blue-colored flowers is the Holy Grail for plant breeders," says Mark Bridgen, a plant breeder at Cornell University. The results are "very exciting."

Compounds called delphinidin-based anthocyanin pigments are responsible for the natural blues in such flowers as pansies and larkspur. Mums lack those compounds. Instead, the flowers come in a variety of other colors, evoking fiery sunsets, new-fallen snow and all things chartreuse.

In previous attempts to engineer a blue hue in chrysanthemums — and roses and carnations — researchers inserted the gene for a key enzyme that controls production of these compounds, causing them to accumulate. But the resulting blooms skewed more violet-purple than blue.

True blue pigment remained elusive, scientists thought, because its origin was complex; multiple genes have been shown to be involved in its generation. But Naonobu Noda of the National Agriculture and Food Research Organization in Tsukuba, Japan, and colleagues were surprised to find that inserting only two borrowed genes into chrysanthemums created blue flowers. One gene, from Canterbury bells, got the enzyme process started; the other, from butterfly peas, further tweaked the pigment molecules.

Together, the gene double-team transformed 19 of 32 mums, or 59 percent, of the Taihei variety from having pink or magenta blooms into blue beauties. Additional analyses revealed that the blue color arose because of molecular interactions between the tweaked pigment and certain colorless compounds naturally found in many plants, including chrysanthemums. The two-part method could possibly be used in the production of other blue flowers, the researchers report July 26 in *Science Advances*. ■

BODY & BRAIN

Brain area controls dominance in mice

Group of nerve cells regulates response to social hierarchy test

BY LAUREL HAMERS

Boosting the activity of certain brain cells can help a mouse climb the social ladder.

Nerve cells in a brain region called the dorsomedial prefrontal cortex appear to control whether male mice are dominant or submissive, researchers report in the July 14 *Science*. The finding adds to the evidence that this region is involved in social interactions in mammals.

Like men flexing muscles or flaunting sports cars to win status, male mice compete to establish a social pecking order. In dominance tests, researchers pitted mice head-to-head in a plastic tube too narrow for the animals to pass each other. With no way forward, the lower-ranking mouse eventually retreats, pushed out by the more dominant male.

Researchers recorded the activity of individual nerve cells, or neurons, in mice's brains while mice engaged in the tube test. A group of neurons in the dorsomedial prefrontal cortex fired faster when mice were pushing forward to claim space and fired more slowly as the mice retreated, says study coauthor Hailan Hu, a neuroscientist at Zhejiang University in Hangzhou, China.

Hu's team then manipulated the activity of those neurons and once again measured the mice's performance. Mice with these neurons inactivated via druglike small molecules didn't try as hard on the task and were more likely to lose the competition. Genetically engineered mice whose neurons were activated with light, however, won against opponents that had previously beaten them.

The tube experiment measures dominance dynamics in pairs of mice, not large groups, points out James Curley, a neurobiologist at the University of Texas at Austin. "Whether the same mechanism underlies social dominance under all contexts is yet to be discovered."

Other factors, such as size, can also influence a mouse's ability to win. But, Hu says, persistence is key, and this group of neurons appears to affect that quality. "In risk tests, what's important is how much effort you want to put into the competition," she says. "Some mice quit easily."

Mouse studies like this one don't translate directly to humans. But such studies allow scientists to investigate the neurobiology of dominance behaviors in levels of detail not possible in people.

Next, Hu wants to find out whether a similar brain mechanism holds for female mice, too. ■

SATOSHI YOSHIOKA/NARO

GENES & CELLS

Tardigrades aren't genetic mash-ups

New analyses contradict claims of extreme DNA swapping

BY TINA HESMAN SAEY

A peek at tardigrades' genetic diaries may dispel a rumor about an amazing feat the microscopic creatures were supposed to perform: borrowing large numbers of genes from other organisms.

Tardigrades — also known as water bears — hardly ever take DNA from other creatures, researchers report July 27 in *PLOS Biology*.

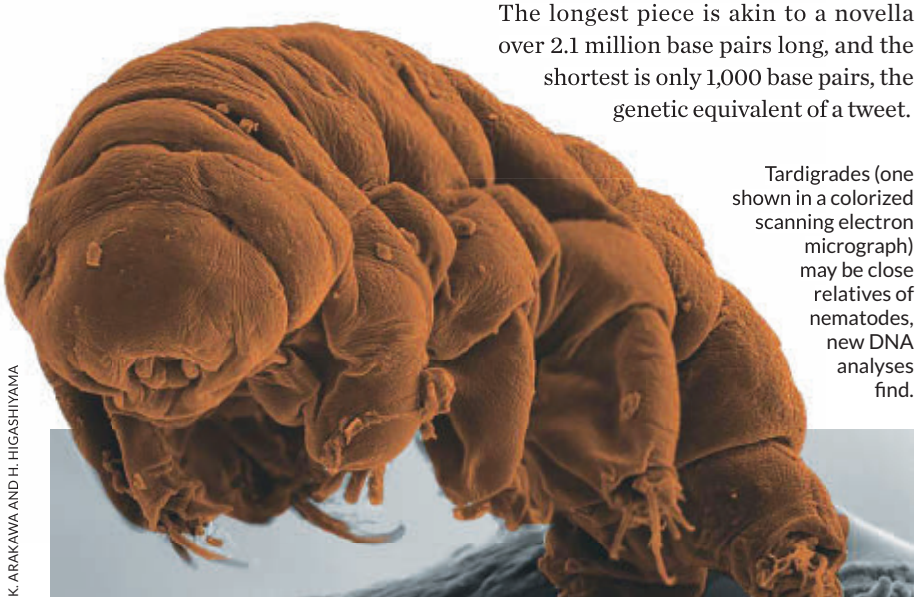
New DNA analyses of two species of water bear, *Hypsibius dujardini* and *Ramazzottius varieornatus*, also reveal some of the extreme survival strategies that make the creatures so tough, such as how they produce proteins that allow them to dry out. Dry tardigrades can survive extreme temperatures, radiation bombardments and even a trip to the vacuum of space (*SN Online: 7/14/17*). What's more, some claims in the study may reignite debate about tardigrades' proper place in the tree of life.

These glimpses of tardigrade biology stem in large part from a new detailed reconstruction of *H. dujardini*'s complete set of genetic instructions. This reconstructed genome is based on comparisons of three attempts to crack the tardigrade genome. The lab of evolutionary geneticist Mark Blaxter at the University of Edinburgh contributed one of the genomes. Another came from a group led by molecular biologist Kazuharu Arakawa of Keio University in Kanagawa, Japan. Blaxter, Arakawa and colleagues compared their versions of the tardigrade genome with one published by Bob Goldstein, a tardigrade biologist at the University of North Carolina at Chapel Hill, and colleagues.

"The new genome appears to be very accurate and complete," says Goldstein, who was not involved in the new study. "This is a big step toward further understanding these interesting organisms, and toward understanding how life can survive extremes."

Goldstein's first draft of the tardigrade genome wasn't a complete instruction manual. It was chopped into 16,175 pieces, typically about 13,000 base pairs long — more like notes on a stack of index cards than a coherent story. Base pairs are the information-carrying chemical units of DNA. Much of the information in the first draft has proved to be contaminated.

The new work is also an incomplete draft. But it has 1,421 genetic stretches averaging about 73,000 base pairs long. The longest piece is akin to a novella over 2.1 million base pairs long, and the shortest is only 1,000 base pairs, the genetic equivalent of a tweet.



K. ARAKAWA AND H. HIGASHIYAMA

Tardigrades (one shown in a colorized scanning electron micrograph) may be close relatives of nematodes, new DNA analyses find.

Goldstein and colleagues had reported that tardigrades imported about 17 percent of their genes from foreign sources using a type of DNA swapping known as horizontal gene transfer (*SN Online: 11/25/15*). But Blaxter and colleagues called that assertion into question, as their tardigrade genome showed hardly any foreign genes (*SN Online: 12/8/15*).

After comparing all three genomes, the researchers have now found that tardigrades borrowed only about 0.7 percent of their genes, 133 in total, from other organisms. For multicellular organisms, "that's about normal," Blaxter says. "Nothing particularly exciting."

Having three versions of the genome to compare helped the researchers distinguish between contamination and real horizontal gene transfer, says Max Telford, a phylogeneticist at University College London. "Presumably the contamination would be different in each sample, but the tardigrade DNA would be the same. So that gives you a big clue."

Even Goldstein is now convinced that tardigrades aren't super DNA-swappers. "The authors' analysis methods, and their methods for getting clean DNA, are certainly an improvement over our own earlier methods," he says.

Some of the new conclusions are more controversial. For instance, the researchers present evidence that tardigrades are close cousins, or a sister group, to worms called nematodes.

"I am not convinced," says evolutionary biologist Rosa Fernández of the Centre for Genomic Regulation in Barcelona. It has been a recalcitrant question, she says, exactly how tardigrades are related to seven other phyla of molting animals called ecdysozoans, a group that includes arthropods and nematodes. Because water bears have body segments and multiple legs, they have been considered close relatives of arthropods, such as spiders.

This study can't rule out coincidence or biases in the methods as explanations for why tardigrades and nematodes appear to be closely related, Fernández says. She and Telford both think tardigrades belong with arthropods, but, says Telford, "It's still an open question." ■

MATTER & ENERGY

Maxwell's demon's memory tested

Quantum experiment upholds second law of thermodynamics

BY EMILY CONOVER

Physicists have probed the memory of Maxwell's demon, a devious, hypothetical beast. By peeking at information retained by a lab version of the creature, scientists confirmed the role of information in saving the second law of thermodynamics from the onslaught of a tiny, superpowerful being intent on wreaking havoc.

Using a quantum version of Maxwell's demon, physicists measured the information stored in its memory and the energy it extracted from a system. The results, reported in the July 18 *Proceedings of the National Academy of Sciences,* illustrate that information plays a key role in the demon's attempts to distill energy.

Since 1867, when physicist James Clerk Maxwell proposed the demon, scientists wondered whether such a creature could violate the second law, a sacred tenet of physics. It declares that the entropy, or disorder, of a closed system cannot decrease over time.

Maxwell suggested that a nefarious tiny being could shuttle around molecules to decrease entropy — for example, by putting all the fast-moving molecules on one side of a box containing a gas and the slower ones on the other side. Such an improbable reconfiguration would break the second law, allowing the demon to illegally siphon off energy.

Almost a century later, a solution to this dilemma was found: The demon must record information about the molecules to manipulate them, and that information has physical relevance. Storing that information in its "brain" increases the demon's entropy, compensating for the entropy decrease the demon produces. As the demon extracts energy, it must delete its memory to store new info and manipulate other molecules. That deletion, Rolf Landauer determined in 1961, costs energy and releases entropy, and the demon's energy harvest is negated.

To show that the demon indeed remembered the system's properties, the researchers probed the quantum state of the demon's memory. "The state of the memory is very important," says Juan Parrondo, a physicist at Complutense University of Madrid, because it is what confirms that the second law still holds. "This is the first experiment which really addresses this question," Parrondo says.

In the experiment, performed by physicist Benjamin Huard and colleagues, the demon extracts energy from the system, a tiny circuit made of superconducting metal, which can carry electricity without resistance. Light tuned to a particular frequency causes the system to jump from a low- to a high-energy state, or vice versa, absorbing or emitting a photon, or particle of light, in the process. The demon — a superconducting cavity within which microwaves bounce back and forth — manipulates the system to ensure that energy can be drained from the system but not absorbed, allowing the demon to capture the energy released.

If the system is in the high-energy state, the demon allows the system to drop to lower energy, in the process spitting out a photon, which the demon can harvest for energy. But if the system is in the low-energy state, the demon prevents it from absorbing photons. The net result: Energy is sapped from the circuit. But, says Huard, of École Normale Supérieure de Lyon in France, "the information the demon learns about the system is encoded into its memory."

The team probed this memory through a process called quantum tomography, repeating the experiment many times and cataloging the state of the memory. As expected, the demon retained the info about what energy state the system was in. The researchers also measured the work extracted from the system in a more direct manner than in previous studies.

While the rules of thermodynamics were originally understood for large systems, physicists hope understanding how the rules translate to small scales will lead to more efficient quantum machines. ■

HUMANS & SOCIETY

Ötzi's copper came from afar

Ötzi the Iceman's copper ax was imported.

The mummy's frozen body and belongings were found in 1991 poking out of an alpine glacier in northern Italy. But Ötzi's ax originated about 500 kilometers to the south, in what's now central Italy's southern Tuscany region, say geoscientist Gilberto Artioli of the University of Padua in Italy and colleagues. Ötzi either acquired the copper as raw material or as a finished blade, the investigators report July 5 in *PLOS ONE*.

Researchers previously suspected the copper came from known ore deposits that are within 100 kilometers of the Iceman's final resting place. But comparing the mix of different forms of lead, or isotopes, in the ax with that in copper ore from present-day deposits across much of Europe indicated that the blade came from southern Tuscany.

Archaeological studies indicate that copper mining and production of copper items flourished in central Italy when Ötzi was alive, the researchers say. They propose that an extensive trade network funneled copper from southern Tuscany to the Iceman's alpine territory. — *Bruce Bower*

BODY & BRAIN

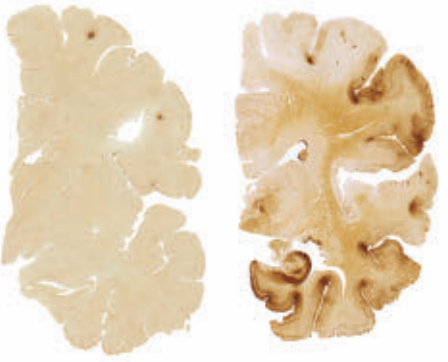
Most football players examined in new study had brain disease

A majority of football players whose brains were donated for research suffered a degenerative brain disease during their lives, according to the largest sample of players ever studied. The finding provides more evidence that the repetitive injuries to the brain sustained while playing American football are associated with degenerative brain disease, scientists say.

Of 202 deceased former football players, 177 were diagnosed with chronic traumatic encephalopathy, or CTE, which can cause a host of mood and behavioral issues as well as thinking and reasoning problems. Among 111 men who had played in the National Football League, 110 — 99 percent — had developed the disease, researchers report in the July 25 *JAMA*. Three of 14 high school players also showed signs of the brain disease, as did 48 of 53 college players. Researchers relied on autopsies to make the diagnoses and interviewed family and friends about the symptoms players had experienced.

This doesn't mean all football players experience CTE. Many of the families who donated the brains could have done so because their loved ones had noticeable symptoms, so the sample is not necessarily representative of the general football population.

The only way to diagnose CTE is with an autopsy. Finding a way to detect the disease in patients will be crucial for understanding how common CTE is in the NFL and among former college and high school players. — *Aimee Cunningham*



Clumps of a protein called tau (dark areas) become more distributed in the brain as chronic traumatic encephalopathy, or CTE, progresses. The brain of a former college football player with mild CTE (left) is compared with the brain of an NFL player with severe CTE.

J. MEZ ET AL/ JAMA 2017

ATOM & COSMOS

Possible exomoon spotted

The first evidence for an exomoon — a moon orbiting a planet orbiting a distant star — may have been spotted in data from the Kepler space telescope.

Alex Teachey and David Kipping of Columbia University analyzed the dips in light from exoplanets passing, or transiting, in front of their stars. A second, smaller dip that appears ahead of or behind the planet could reveal a moon. Such exomoons, researchers have speculated, may be among the best places in the universe to look for extraterrestrial life (*SN: 2/9/13, p. 5*).

In a paper posted online July 26 at arXiv.org, Teachey, Kipping and citizen scientist Allan Schmitt present the first evidence for an exomoon candidate: Kepler 1625b i. The team analyzed 284 planets that seemed like good candidates for hosting detectable moons.

The object, if it exists, orbits a planet about the size of Jupiter around a star about 4,000 light-years away. Because the potential moon is probably Neptune-sized, the team nicknamed it "Neptmoon." The team plans to check if the moon is really there by using the Hubble Space Telescope to watch for another transit.

"We threw all of our tests at it, and it passed them," Kipping says. "But we were still pretty suspicious. We knew the best way to confirm it was to get more data." — *Lisa Grossman*

EARTH & ENVIRONMENT

Rising temperatures may mean fewer passengers on airplane flights

As if air travel weren't annoying enough, new research suggests that global warming could force planes to carry fewer passengers to get off the ground. While a little more legroom might sound good, it could make flying more expensive.

Researchers examined the impact of rising temperatures on five types of commercial planes flying out of 19 of the world's busiest airports. In the coming decades, an average of 10 to 30 percent of flights that take off during the hottest time of day could face weight restrictions.

That's because warmer air particles are more spread out, generating less lift under a plane's wings as it goes down the runway. So a plane must be lighter to take off. In some cases, a Boeing 737-800 would have to jettison more than 700 pounds — several passengers' worth of weight — the researchers report online July 13 in *Climatic Change*. — *Maria Temming*

BODY & BRAIN

Penis microbes may up HIV risk

Out-of-whack microbes in the vagina can raise HIV risk — and now there's evidence that the makeup of the penis microbiome matters, too. The greater the number of anaerobic bacteria tucked under the foreskin, the more likely an uncircumcised man is to become infected with the virus, Cindy Liu of George Washington University in Washington, D.C., and colleagues report July 25 in *mBio*.

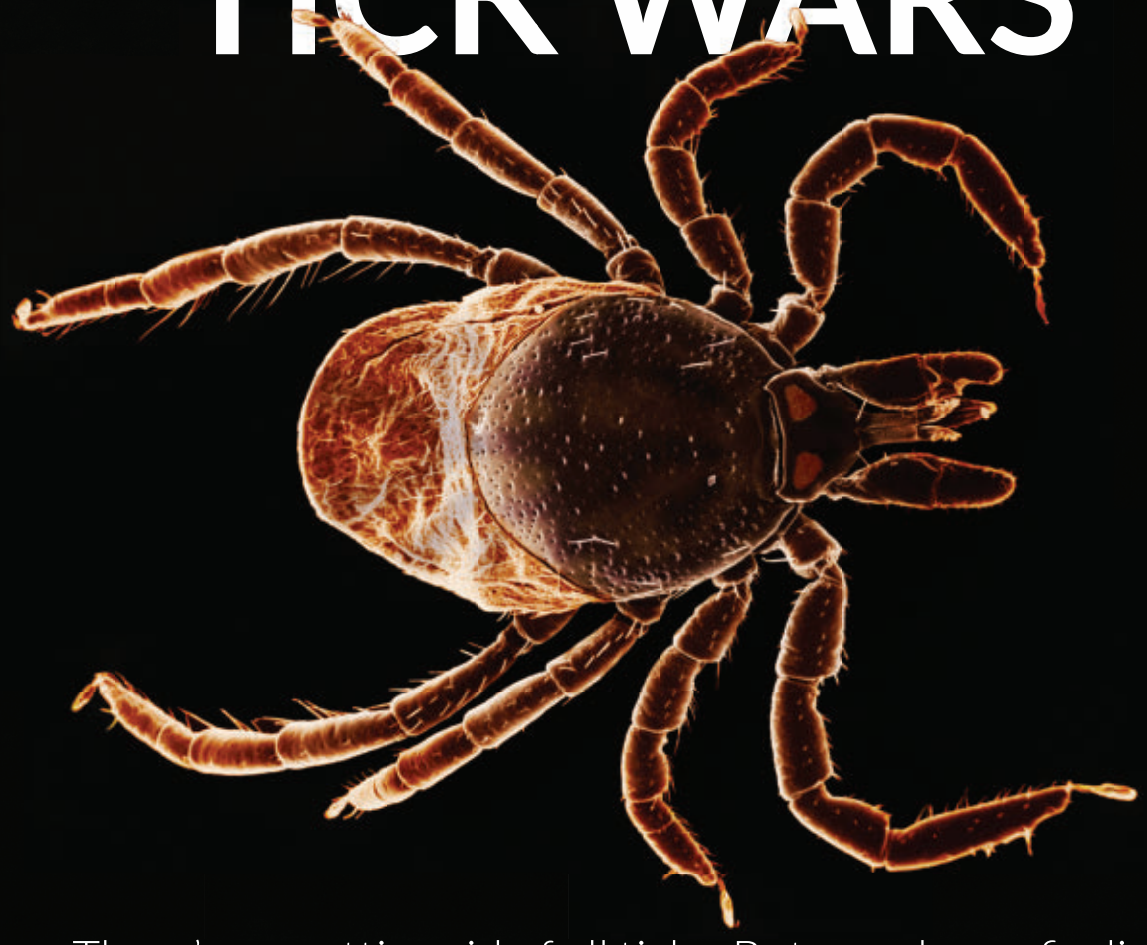
The researchers swabbed the penises of heterosexual Ugandan men to collect bacteria. Two years later, the team compared the bacterial composition of 46 uncircumcised men who contracted HIV during the study with that of 136 uncircumcised men who didn't.

The total amount of penile bacteria didn't differ. But men with 10 times as many *Prevotella*, *Dialister*, *Finegoldia* and *Peptoniphilus* anaerobic bacteria had a 54 to 63 percent increased risk of HIV after controlling for other risk factors.

The results may help explain why circumcision cuts HIV risk, says Thomas Hope, a cell biologist at Northwestern University's medical school in Chicago: Removing the foreskin takes away a moist hideout for bacteria that thrive in oxygen-starved places. But, Hope says, the study draws only an association between the microbiome and HIV — not necessarily cause and effect.

It's not clear how certain bacteria might raise HIV risk, but men with more anaerobic penis bacteria also had higher levels of inflammatory cytokine proteins, which call immune cells to the scene. Recruiting an immune response might have an unintended consequence — a free ferry ride for HIV into the bloodstream. — *Laurel Hamers*

Bulletins from the TICK WARS



You'd be wrong to call this black-legged tick an insect. Ticks have eight legs, like spiders and scorpions, not an insect's six. Only a few of the world's 900 or so tick species carry diseases, but those illnesses can be nasty.

DAVID M. PHILLIPS AND ERIC COHEN/SCIENCE SOURCE

There's no getting rid of all ticks. But people are finding ways to outsmart them **By Susan Milius**

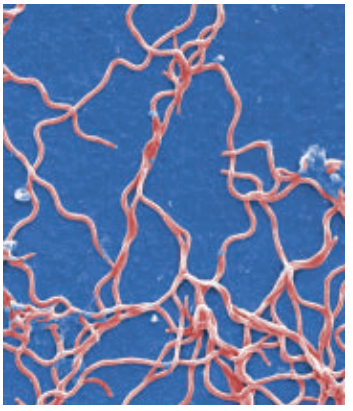
Thanks, Holly Gaff. Soon, anyone straining to tweeze off a mid-back tick can find answers to the obvious question: What if humankind just went after the little bloodsuckers with killer robots?

Gaff, who calls herself a mathematical eco-epidemiologist, at Old Dominion University in Norfolk, Va., is one of the few people collecting real field data on the efficacy of tick-slaying robots. This summer, she's been supervising a field test of a terminator named TickBot deployed to try making mowed grass safe for children. Researchers will start analyzing results in early fall.

Ticks make formidable enemies. "Almost every control measure that has been tried has failed, and has failed miserably," Gaff says. "We are slowly coming to embrace the fact that you cannot eradicate ticks." What human ingenuity might do, however, is manage the risks and — dream big! — make ticks irrelevant.

That's an urgent hope. Data from the Cary Institute of Ecosystem Studies in Millbrook, N.Y., have for two years suggested 2017 will be a high risk one for Lyme disease in the Northeastern United States. Of the various illnesses that North America's ticks pass along, Lyme is the most

common, caused by a squiggle of a parasite called *Borrelia burgdorferi*. The disease can bring on an eerie red bull's-eye rash, flulike misery and risks of long-term neurological and joint troubles if not treated early. In 2015, the U.S. Centers for Disease Control and Prevention tallied about 30,000 confirmed cases. Considering gaps in case reporting, some estimates put the number closer to several hundred thousand.



Borrelia burgdorferi, a crowd of the parasites shown here, infect ticks and cause Lyme disease in humans.

So bring on the robots and other science revenge fantasies. It's time to rethink humankind's defenses against ticks. Pesticides and tick checks just aren't doing the trick.

There may be ways to attack ticks without touching a single molecule of their die-hard little bodies. Ecologists have made progress in tracing what ticks need from the woods and lawns where they lurk. For instance, researchers believe that it was a bumper crop of acorns in 2015 that, through a Rube Goldberg series of consequences, created conditions for a perfect tick storm two years later. Breaking key ecological connections could knock back the tick menace in the future.

Molecular biologists are focusing on tick survival tricks. Researchers are looking for weak spots inside tick guts and trying to take advantage of ticks' reckless abandon in mating. Biology is proving as important as electronics in the robot line of defense.

Though, Gaff warns, the top design is not the laser-blazing Armageddon that a recently tick-bitten human might crave.

Ticks attack

First, a quick intro to ticks.

Unlike mosquitoes, ticks are pure vampires, consuming nothing but blood. Mosquitoes get colloquially called vampires, but blood is just their version of a pregnancy craving, a female-only nutrient gorge to aid reproduction in an adult life of sipping flower nectar.

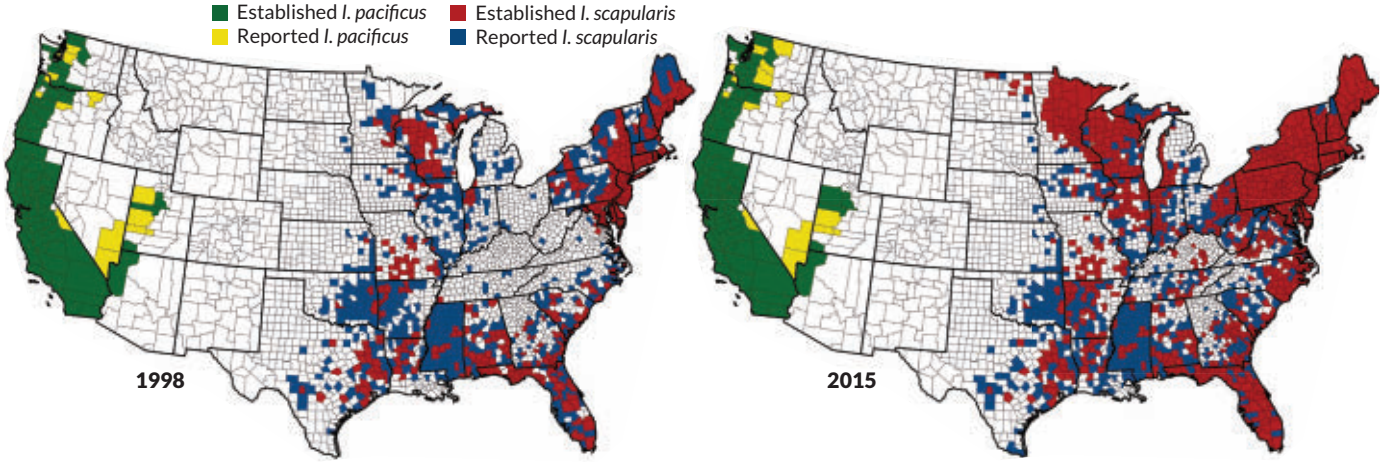
For most of the troublesome tick species in North America, including the black-legged ticks that spread Lyme, blood is the elixir that lets them transition to the next life stage — from larva to nymph to adult. And after a single meal, an adult female can lay 1,000 or even 15,000 eggs without anything else to eat for the rest of her life. Hard ticks, the Ixodidae family, which includes the black-legged variety, typically have only two or three meals of any kind during the entire two or three years they live.

> After a single meal, an adult female tick can lay 1,000 or even 15,000 eggs.

Soft ticks are gluttons, relatively speaking. Many move into mammal dens for a bedbug lifestyle. These ticks hide and, whenever they get hungry, just crawl over to the resident dinner.

For ticks without live-in prey, many "quest," as the ambush is called. Ticks climb to some promising spot like the top of a grass blade, raise their front legs and just wait until something brushes by. But there are also ticks that hunt vigorously, even pursuing human prey.

On the rise Between 1998 and 2015, the number of U.S. counties that have recorded black-legged ticks (*Ixodes scapularis*) and western black-legged ticks (*Ixodes pacificus*) increased almost 45 percent. Data include well-established populations of the disease-carrying creatures as well as places with fewer reports.



FROM TOP: JANICE HANEY CARR/CDC; R.J. EISEN, L. EISEN AND C.B. BEARD/*J. MED. ENTOMOL.* 2016



White-footed mice (left), Virginia opossums (center) and chipmunks (right) carry ticks and their parasites. Virginia opossums, fastidious groomers, don't spread disease nearly as well as the others.

A visit to Dennis Bente at the University of Texas Medical Branch in Galveston is unforgettable, in part because of a video of a *Hyalomma* tick chasing down one of Bente's collaborators. The tiny brown creature scurries like a frantic ant in an almost-straight line over bare dirt, onto a boot and finally into a hand reaching down to grab it. This hunter doesn't live in North America.

Ticks can spread a wide variety of diseases. Despite its name, Rocky Mountain spotted fever, which brings a higher risk of fatality than Lyme, is more common in the central United States and the South than in the Rockies. Other tickborne diseases are lately getting attention: A tick-bitten baby in Connecticut in April became the state's first reported victim of the rare, but potentially fatal Powassan virus, thought to enter the bloodstream in just 15 minutes after a tick starts feeding. And medical journals are publishing discussions of whether a tick bite might lead to a sudden, deadly allergy to red meat. With a possible threat even to our beloved hamburger, new approaches to fending off ticks can't come soon enough.

Super reactors

The most dramatic way of rendering a disease irrelevant is a vaccine. One company raised hopes for this approach in April in Washington, D.C., at the World Vaccine Congress by announcing the start of human safety tests of a new Lyme disease formulation. The only Lyme vaccine for humans in the United States was withdrawn voluntarily in 2002 when controversy stalled sales. (Dogs can still get a Lyme vaccination.)

A device developed by the U.S. Department of Agriculture uses paint rollers to swipe a deer with a tick-killing agent as the animal reaches in for food.

The strategy for the new Lyme vaccine isn't like the familiar flu or tetanus vaccines because the pathogens get killed outside the human body. The company, Valneva, based in Lyon, France, has redesigned a protein, OspA, used in previous Lyme vaccines. The vaccine trains the human immune system to fight OspA, found on the surface of *B. burgdorferi*. When a black-legged tick starts sucking human blood, human immune cells get slurped in too and kill the Lyme-causing pathogens before they leave the tick's gut. "The idea of this vaccine ... is vaccinating the tick," says CEO Thomas Lingelbach.

Even if the new vaccine proves to be safe and effective, its first shot in a doctor's office, in the most optimistic view, is five to 10 years away.

There may be a bigger-picture way to imagine vaccines, however, than targeting each disease with its own shot. Ecologist Richard Ostfeld of the Cary Institute is one of the people hoping for a vaccine that stops the tick itself, and thus all the diseases it may pass along. By the luck of the great lottery of genetics, Ostfeld has a hyperactive immune response to tick saliva. Think of it as a natural version of what a tick vaccine might achieve.

Despite "many, many dozens of tick bites" over his career monitoring Lyme disease risk, Ostfeld has not gotten sick. He often wakes in the middle of the night with a "burning sensation" somewhere on his body. "I ... put on my glasses and, sure enough, there's a little dark spot surrounded by what's already turned kind of red." Warned by his vigilant immune system, he pulls off the dark bit of tick, which is usually dead or dying.

Maybe it's a thing among tick scientists. Sam Telford of Tufts University's veterinary school in North Grafton, Mass., who also studies the ecology of Lyme disease, has a similar reaction. Bites, he says, "itch like crazy." A vaccine that makes people itch doesn't sound very marketable, but blood that somehow poisons ticks sounds good.

A vaccine to protect cattle against debilitating blood loss from bites already targets the tick itself. Newer ways of targeting ticks are being developed for livestock, and for humans, though protecting our species poses extra challenges.

Fix the landscape

"It would be lovely if we could get a vaccine," says biochemist Kevin Esvelt of MIT. "But there's a certain elegance to tackling the heart of the

CLOCKWISE FROM TOP LEFT: SZASZ-FABIAN JOZSEF/SHUTTERSTOCK; JASONONDREICKA/ISTOCKPHOTO; EDARLINGPHOTO/ISTOCKPHOTO; USDA, WAYNE RYAN

problem, which is ecological." In several papers posted online at bioRxiv.org in 2016 and this year, Esvelt and colleagues laid out an approach that could slash Lyme risks by causing genetic changes in one of the mammals that ticks feed on, changes that could spread across whole landscapes.

The view of Lyme as an ecological disease blames much of the rise in cases on the suburbanization and fragmentation of once-wild countryside in North America. The shifts have fueled population booms in mammals such as white-footed mice that easily become great scurrying reservoirs of Lyme parasites. Ticks gorge on the mouse blood and a high percentage ingest the parasites.

Deer pick up a lot of the Lyme-spreading black-legged ticks. Yet deer aren't biologically friendly to *B. burgdorferi*. The mice make a much better parasite paradise than deer do and are more likely to transmit those parasites.

The common name, "deer tick," was a fluke of early misidentification, Ostfeld says. The tick was easy to collect on deer. But taxonomists realized the hard tick is just a northern form of the long-known black-legged tick, which dines on many mammals. In fact, just how deer abundance affects tick abundance was the No. 1 outstanding uncertainty about Lyme listed in a 12-person consensus published in the June 5 *Philosophical Transactions of the Royal Society B*.

Fighting Lyme disease appeals to Esvelt, who, like his pediatrician wife, grew up in the low-tick landscapes of the West Coast where Lyme is rare. In Massachusetts now, he says, "to both of us, it's just horrific that a) there are that many ticks out there, and b) that they give you horrific diseases." He especially regrets that neither of his two kids, nor anyone else's, can tromp around outdoors, like he used to, carefree.

Esvelt calls the work of his lab, which plans to engineer a Lyme-resistant mouse, "sculpting evolution." He and colleagues aim to tackle big biological problems like Lyme spread by using the insights of evolutionary biology plus the powerful gene-editing tool known as CRISPR/Cas9 (*SN: 9/3/16, p. 22*). But Esvelt wants to use that power with a startling openness and extreme public oversight.

"Right now, people don't trust scientists to ensure that technologies are well understood before throwing them out there," he says. "We have to fix that somehow."

Before he even started to create a Lyme-resistant mouse in the lab, he asked for public meetings on the two Massachusetts islands where he hopes to test mice: Martha's Vineyard and Nantucket. He got the green light to begin from citizen steering committees on both islands. But they still have the power to shut down the tests at milestones in the project. If the citizens nix the idea, he will walk away.

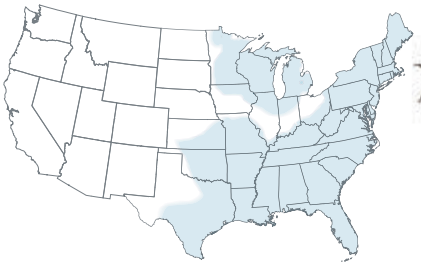
Originally Esvelt planned to sculpt Lyme disease into insignificance by acting on the ticks directly, driving down their numbers or changing them to be less dangerous. "But I talked to a lot of tick biologists who said, 'Look, it's not gonna happen.'" The black-legged ticks take so long to reproduce that the plan would only succeed "if you're willing to wait about 50 years," he says.

It's actually faster to work with a mammal, the white-footed mouse. For the first tests, on islands,

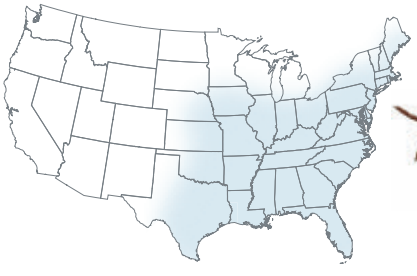
Ticks east and west

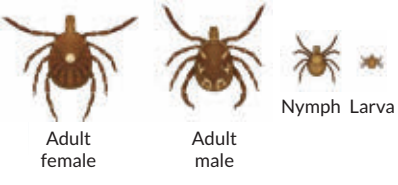
Of the nine or so tick species that spread diseases in North America, the three highlighted below cause the most trouble. Maps show U.S. habitats.

Black-legged tick (*Ixodes scapularis*)
Spreads Lyme disease and others, including anaplasmosis, babesiosis and Powassan disease.

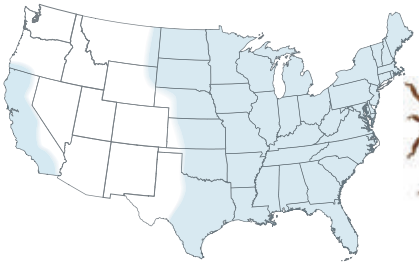


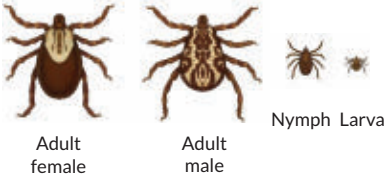
Lone star tick (*Amblyomma americanum*)
Transmits ehrlichiosis, tularemia and STARI, a disease easily confused with Lyme.



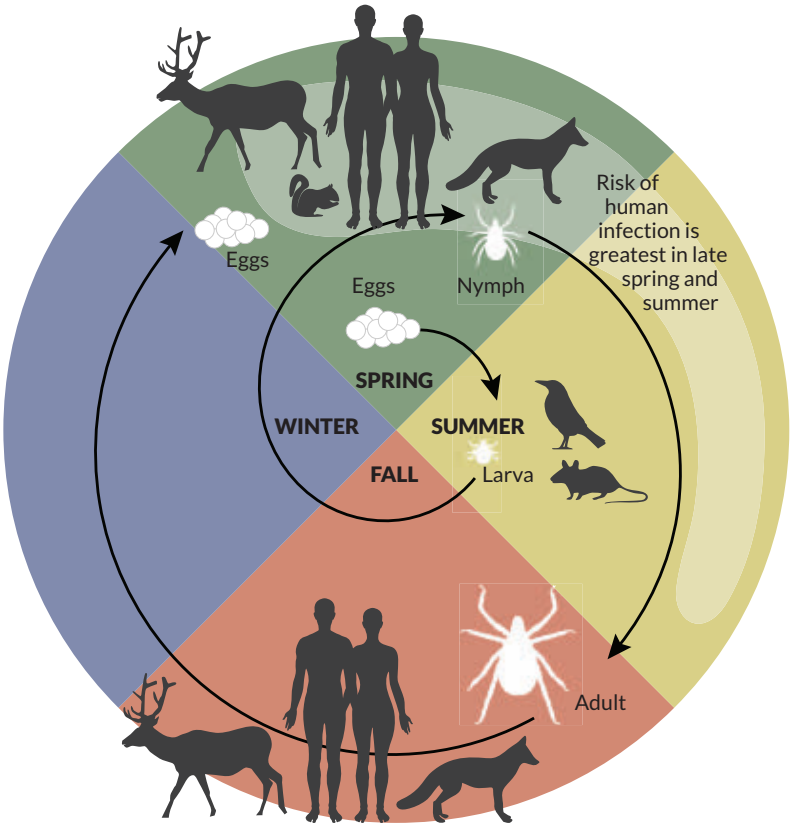


American dog tick (*Dermacentor variabilis*)
Spreads tularemia and Rocky Mountain spotted fever.





MAPS AND TICKS: CDC; DIME: KUZMIK_A/ISTOCKPHOTO



Long and varied life
The black-legged tick that spreads Lyme disease lives in the slow lane, taking more than a year to reach reproductive age, longer than some of the animals that it feeds on (shown). Eggs (center) hatch into tiny six-legged larvae but have inherited no Lyme pathogens from mom. Ticks pick up pathogens from later blood meals. A larva takes blood, often from something small like a mouse or bird, and transforms into a fully eight-legged nymph. Nymphs, roughly a year old but not sexually mature yet, seek more blood to reach adulthood.

he plans great caution. He won't even use a gene drive, the powerful way of deploying CRISPR/Cas9 so it overrides chancy natural inheritance and passes the desired genes to all offspring (*SN: 12/12/15, p. 16*). Instead he'll just release mice genetically tweaked to be bad transmitters of Lyme and let natural mouse powers spread the genes.

Those mice won't even be transgenic: They won't carry genes from any other species. He'll vaccinate island-captured mice in the lab, with an anti-Lyme vaccine or one that should confer an active immune response to tick bites. Then he'll identify genes that produce the most protective reaction and put a large selection of them into what should be a safer animal that's still "100 percent mouse," he says.

While he's tailoring safer mice for the island, however, he's imagining new gene drives for a larger, mainland campaign. The way forward may require making gene drives less powerful, so they sputter out after a certain number of generations — "daisy chains," he calls them, with loosely linked elements that fall apart easily.

Going for the gut

Ticks themselves probably have weaknesses that people haven't yet exploited. The study of microbes in human guts has revolutionized ideas about human health and physiology. So Yale University's Sukanya Narasimhan and Erol Fikrig are looking deep into the microbiome of the tick gut. Narasimhan describes the gut as a many-branched thing, "like a glove." Ticks do have consistent bacterial residents, which could perhaps be exploited, but interactions look complex.

Along with Lyme, black-legged ticks can deliver other unpleasantries, such as human granulocytic anaplasmosis. When *Anaplasma* pathogens first tumble into a tick gut, invasion isn't easy because some resident microbes form a biofilm along the gut lining that may be hard to breach. The pathogen, however, makes the tick secrete what's essentially antifreeze, Fikrig, Narasimhan and colleagues reported in the Jan. 31 *Proceedings of the National Academy of Sciences*. The secretions can prevent biofilms from forming and ease the way for pathogen infection.

The sex lives of ticks could offer opportunities for completely different kinds of defenses, says longtime tick specialist Daniel Sonenshine of Old Dominion, author of *Biology of Ticks*.

He imagines, for instance, protecting livestock or dogs with decoys, "little bits of plastic" treated with a chemical cocktail that includes 2,6-dichlorophenol. That's the come-hither substance female lone star and some other ticks release when they grab a mammal for a blood-feed. Like drinking venues for our species, mammals provide ticks with hot spots for finding mates. "These little plastic devices mimic a female tick," Sonenshine says. And believe it or not, plastic fooled males long enough for a pesticide on the decoy to kill the ticks. (Tick sex on humans is possible but not likely, Gaff says. Humans rarely carry enough ticks at once to generate much of a scene.)

TickBot may not look scary. But the cloth strips dragged behind it carry a pesticide that deals death to ticks tricked into grabbing on.

FROM TOP: CDC, T. TIBBITTS; H. GAFF *ET AL/TICKS & TICK-BORNE DIS.* 2015

Robot vs. tick

Tick biology is also important in designing a robot army. The concept behind TickBot came out of a collision of two very different visions of pest-fighter robotics.

As Gaff tells the story, engineers at the Virginia Military Institute in Lexington, "were under this mistaken idea ... that ticks live in trees and they fall on your head." The engineers' solution: Use lasers to shoot ticks out of trees.

When they called to enlist Sonenshine in the project, he had to break the bad news: no blasting into shrubbery; ticks are on the ground. His advice: Don't build a robot to attack ticks at all. Get the ticks to attack the robot.

Instead of a laser-shooting, macho terminator, the concept morphed into a panting raccoon-sized machine that kills with dragged strips of pesticide-carrying cloth. The engineers' four-wheeled buggy chugs slowly along following a looped guideline set up along a trail or in an open area.

As the bot works its way along, its motion, in some cases the passing shadow, will trick a tick into jumping at the cloth as it would the fur of a mouse or the sock of a hiker. But the big pull is carbon dioxide. Pest ticks "act like very lazy teenagers who don't move unless they're prodded," says James Squire, one of the Military Institute engineer designers. Adding CO_2 gets ticks' attention and strengthens the illusion of a breathing, warm-blooded something.

The engineers — Squire, David Livingston and Gerald Sullivan — "came up with this amazing system of tubing and carbon dioxide canisters" for releasing CO_2 from the bot, Gaff says. However, a student last year put a bit of dry ice in a cup with holes to mimic mammal breath. It worked and made the bot far easier to lug around.

Gaff remembers when she was first pulled in to do the field testing. "I was a huge skeptic coming in," she says. To test TickBot outdoors, she chose as the first site a path through a wooded park with what she calls "infinite ticks." There weren't many Lyme ticks there to test, but the creeping cart tricked so many of the abundant lone star ticks that — high praise from a tick scientist in summer — she sat on the ground and had lunch.

Within a day, however, more ticks moved onto the cleared path from the nearby woods, she and colleagues reported in 2015 in *Ticks and Tick-borne Diseases*. Still, the notion of robotic tick catchers may be catching on. Gregory Gray, who teaches at Duke University's Global Health Institute, worked with students from the local robotics club to design their own creeping, cloth-dragging cart.

And the TickBot team is now planning a bigger and faster robot that might ease the uncomfortable business of monitoring for cattle ticks on grazing land. Usually, people "dress up in woolly pajamas" as Squire puts it, and move through brush with an eye out for rattlesnakes in the Texas summer heat. The ticks grab the suit and are later counted. There's got to be a better way.

For the TickBot itself, summer 2017 brought testing on grass around a playground. Like a little Roomba vacuum cleaner (but with guide wires), it set out twice a week to carve a safe zone by whisking away ticks, Gaff says.

"I'm giving them their space, and I'm asking them to respect my space," she says. It's all part of the mind-set of surrendering to the notion that there will always be ticks. But someday maybe we won't care as much. ■

Climate with a touch of Lyme

Canada is a great place to look for teensy footprints of ticks moving into new areas opened up by climate change.

Parts of eastern Ontario in 2002 ranked, on average, as just too cold for Lyme-spreading ticks to survive. By 2012, satellite data indicated the area had warmed enough to become tick friendly, Angela Cheng of Queens University in Kingston and colleagues reported June 15 in the journal *Remote Sensing*. Earlier papers reached the same conclusion for other parts of southeastern Canada. Lyme is rising in Canada: Nationwide, 40 cases were reported in 2004. In 2016, Ontario alone had 343.

Where the disease moves depends on a lot more than climate, though. Landscape changes that trigger booms in mice and busts in coyotes, for example, can make a big difference. Yet the pattern of Lyme's emigration into Canada looks as if it really could be climate based, says coauthor Nicholas H. Ogden of the Public Health Agency of Canada in Ottawa.

The U.S. Environmental Protection Agency referred to Ogden's work in Canada when it included Lyme disease cases as an indicator of climate change in 2014 and 2016. He and other colleagues have been watching the pattern and pace of Lyme advance into Canada since the early 2000s.

Even the little park near his house has gone from a dud research site where he struggled to find any ticks to study to a danger zone where he demands full tick checks if his kids wander in. With climate change and ticks, he says, "we have gone from a hypothesis to a public health reality." — *Susan Milius*

Explore more

- Maria D. Esteve-Gassent *et al*. "Translating ecology, physiology, biochemistry, and population genetics research to meet the challenge of tick and tick-borne diseases in North America." *Archives of Insect Biochemistry and Physiology*. May 2016.

Part of the Kigali Genocide Memorial, these photographs of Rwandans killed in a 1994 mass slaughter put human faces on an unimaginable tragedy. Many factors other than obedience to authorities drove some Rwandans to kill others.

PHOTONONSTOP/ALAMY

Duty Bound Killings

Rwandan data offer a glimpse of what drives people to take part in genocide

By Bruce Bower

A string of state-directed, targeted mass killings left a bloody stain on the 20th century. A genocide more recent than the Holocaust is providing new insights into why some people join in such atrocities.

Adolf Hitler's many accomplices in his campaign to exterminate Jews throughout Europe have justifiably attracted the attention of historians and social scientists. But a 100-day spasm of unprecedented violence in 1994 that wiped out about three-quarters of the ethnic Tutsi population in the African nation of Rwanda has the potential to reveal much about how mass killings unfold at ground level.

There is no guarantee that a better, although inevitably incomplete, understanding of why certain members of Rwanda's majority Hutu population nearly eliminated a Tutsi minority will prevent future large-scale slaughters. The research is worth the effort, though, especially in a 21st century already marked by massacres of hundreds of thousands of people in western Sudan's Darfur region and in Syria.

Researchers have an advantage in Rwanda. When hostilities ended, Rwanda's government gathered extensive data on genocide victims and suspected perpetrators through a national survey. And local courts tried more than 1 million cases of alleged involvement in the violence, making the case documents available to researchers.

Genocide studies have often split offenders into organizers — mainly political and community leaders — and "ordinary men" who kill out of blind obedience to central or local authorities and hatred of those deemed enemies. But the extensive data from Rwanda tell a different story: An individual's willingness to take part in genocidal violence depends on many personal and social factors that influence whether and how deeply a person participates, says sociologist and Rwanda genocide researcher Hollie Nyseth Brehm of Ohio State University in Columbus.

Nyseth Brehm's findings may not apply to some of Rwanda's most avid killers, who eluded capture and fled the country as soon as hostilities stopped. But when it comes to the ordinary citizens swept up in the deadly campaign, involvement was not primarily about following political leaders' orders to eliminate Tutsis.

New reports by Nyseth Brehm and others fuel skepticism about the popular idea that regular folks tend to do as they're told by authorities. And a fresh look at a famous 1960s psychology study adds further doubt that people will blindly follow orders to harm or kill others.

20 percent
Proportion of Hutu men who seriously injured or killed at least once in Rwanda's genocide

In reality, only about 20 percent of Hutu men, an estimated 200,000, seriously injured or killed at least one person during the genocidal outbreak, estimates Rwanda genocide researcher Omar McDoom of the London School of Economics and Political Science.

"Why did four in five Hutu men not engage in the killing?" McDoom asks. That puzzle goes against the ordinary man thesis that "implies there are no individual differences in genocide participation," he says. He suspects participation hinged on personal motivations, such as wanting to defend Rwanda from enemies or make off with a Tutsi neighbor's possessions. Social circumstances, such as living in high-violence areas or having friends or family members who had already murdered Tutsis, probably played a role too. Nyseth Brehm agrees.

Local triggers

Genocides often fester before exploding. In Rwanda, Tutsi rebels attacked the Hutu-led government and set off a civil war several years before mass killings started. A turning point came when unidentified forces killed Rwanda's president, shooting down his plane on April 6, 1994. Over the next three months, the government orchestrated a massacre of Tutsis and any Hutus deemed friendly or helpful to Tutsis. Most scholars place the death toll at around 800,000, although estimates range from 500,000 to 1.2 million. Bands of Hutus scoured the countryside for their sworn enemies. Killings took place at roadblocks and in raids on churches, schools and other community facilities. Hutu women killed on a much smaller scale than men did, although they often aided those involved in the carnage.

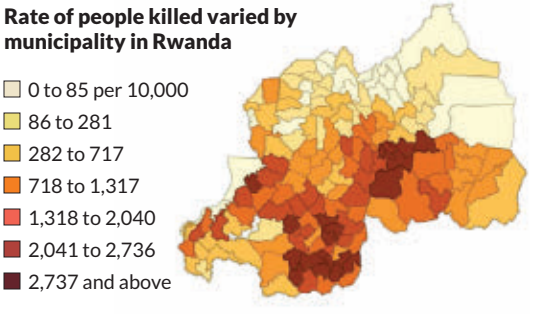
In many parts of Rwanda, local authorities appointed by the national government recruited Hutu men into groups that burned and looted homes of their Tutsi neighbors, killing everyone they encountered, says political scientist Scott Straus of the University of Wisconsin–Madison. In his 2016 book *Fundamentals of Genocide and Mass Atrocity Prevention*, Straus describes how Rwandan recruitment efforts coalesced into a killing machine. Politicians, business people, soldiers and others encouraged Hutu farmers to kill an enemy described as "cockroaches" in need of extermination. Similarly, Nazis portrayed Jews as cockroaches and vermin.

Despite the Rwandan state's best efforts to encourage nationwide Tutsi annihilation, local conditions shaped how the 1994 genocide unfolded, Nyseth Brehm reported in February in *Criminology*. She looked at 142 of the nation's 145 municipalities, known as communes. Some experienced as few as 71 killings, while in others, as many as 54,700 people were murdered, she found.

Communes with the fewest killings were those that had the highest marriage and employment rates, Nyseth Brehm says. In those settings, mainly farming communities where people knew and trusted each other, most citizens valued a peaceful status quo and discouraged a descent into mass killing, she suspects.

Curiously, violence was worse in areas with the largest numbers of educated people. That points to the effectiveness of anti-Tutsi teachings in

Rate of people killed varied by municipality in Rwanda



Death's geography
Murder rates during a 100-day genocide varied greatly across Rwanda's municipalities, or communes. A national survey indicated that areas of high violence (darker colors) had low levels of marriage and employment but high levels of education.

H. NYSETH BREHM/*CRIMINOLOGY* 2017

Type of perpetrator	Type of violence	Number of people killed	Motivations
Ordinary men	Personal killings, revenge, neighbor-on-neighbor violence, ordered by superiors	Minimal	Fear, greed, family and friend influences
Murderers in the middle	Organized, mobile killing squads	Extreme	Ideological, political advancement
"Big fish" organizers	Coordination of mass killings	Little direct participation in violence	Maintain and enhance power

Perp hierarchy Political scientist Cyanne Loyle splits participants in Rwanda's 1994 genocide into three groups. "Ordinary men" had a range of reasons for killing others. But ethnic and ideological zealots, often trained as killers, carried out most of the bloodshed in the name of power players who instigated and coordinated from a distance. SOURCE: C.E. LOYLE AND C. DAVENPORT

Rwandan schools, Nyseth Brehm suggests.

Her study relied on data from a postgenocide survey, published in 2004 by Rwanda's government, intended to document every person killed during the atrocity. Citizens throughout Rwanda told interviewers about individuals in their communities who had been killed during the outburst of slaughter. Reported and confirmed deaths were checked against records of human remains linked to the 1994 genocide. Comparisons were also made to Rwanda's 1991 census.

However, any data on killings during mass violence, including from the Rwandan survey, will be incomplete, Nyseth Brehm cautions. So she also analyzed data from 1,068,192 genocide-related cases tried in local Rwandan courts from 2002 to 2012. Of particular note, although most nongenocidal murders in Rwanda are carried out by men in their 20s, the average age of accused genocide perpetrators was 34.7 years old, Nyseth Brehm reported in the November 2016 *Criminology*.

Hutu men in their 30s joined the genocidal fray as a way to fulfill adult duties by defending their communities against an outside threat, she suggests. Preliminary analyses show that perpetrators tended to cluster in families; if one of several brothers killed Tutsis, the others were far more likely to follow suit.

Additional scouring of court data indicated that Rwandans who had siblings convicted of genocide killings were especially likely to have murdered Tutsis themselves. In earlier interviews of 130 Rwandans, some who had killed Tutsis and others who hadn't, McDoom similarly found that perpetrators tended to cluster in families.

Missing murderers

Unfortunately, the Rwandan genocide's most prolific players have eluded both the law and science, says political scientist Cyanne Loyle of Indiana University Bloomington. Investigators have so far interviewed only a handful of the powerful "big fish" who orchestrated the genocide, plus several hundred people tried and imprisoned for genocide participation. Survey and court data are limited to killers who either stayed in Rwanda after atrocities ended or were caught trying to flee the country.

But perpetrators with the most blood on their hands traveled in bands, wiping out tens of thousands of people at a time before hiding abroad, Loyle says. For instance, local officials lured large numbers of Tutsis to a school near the town of Murambi, where Hutu militias used machine guns, explosives and other weapons to kill more than 40,000 people in just three days.

"Scholars have studied Rwandans who killed on the sidelines while a larger and deadlier campaign was under way," Loyle says. "They have mistaken a sideshow for the main event."

Perpetrators of colossal atrocities at Murambi and elsewhere were less powerful than the government's genocide masterminds, Loyle says. These "murderers in the middle," however, were better equipped and far more effective at killing than common folk who got caught up in events, she contends.

There are no good estimates of how many members of large-scale killing squads escaped Rwanda and now live elsewhere. From 15,000 to 22,000 members of the Rwandan army and local militia groups were at large in the Democratic Republic of the Congo, near Rwanda's border, in January 2003, according to a report by the International Crisis Group, a nonprofit organization.

Nyseth Brehm acknowledges the difficulty of accounting for genocide perpetrators who eluded justice. She and others, including Straus, have interviewed genocide offenders who stayed in Rwanda, often imprisoned for their crimes. Many of those who fled must have traveled in groups that murdered on a grand scale, she says. Those mass killers represent crucial missing data on who participates in genocide, and for what reasons.

Vicious virtue

In interviews by Nyseth Brehm, McDoom and others, perpetrators listed many reasons for joining the 1994 killing spree — hatred of Tutsis, a perceived need to protect nation and family, a

desire to claim a neighbor's property or a decision to join a suddenly popular cause, to name a few. Blind obedience to brutal leaders was far from the only reason cited.

That finding conflicts with the late psychologist Stanley Milgram's interpretation of his famous "obedience to authority" experiments. Milgram described those trials, in which volunteers were told to administer increasingly intense shocks to another person, as a demonstration of people's frequent willingness to follow heinous commands. He saw the experiments as approximating the more extreme situations in which Germans had participated in the Holocaust.

On closer inspection, though, Milgram's study aligns closely with what's known about Rwandan genocide perpetrators, says S. Alexander Haslam, a psychologist at the University of Queensland in Australia.

In Milgram's experiments, as in Rwanda and Nazi Germany, "those willing to harm others were not so much passive ciphers as motivated instruments of a collective cause," Haslam says. "They perceived themselves as acting virtuously and doing good things."

Although Milgram's tests upset some volunteers, most participants identified with his scientific mission to understand human behavior and wanted to prove themselves as worthy of the project, Haslam and psychologist Stephen Reicher of the University of St. Andrews in Fife, Scotland, conclude in a research review scheduled to appear in the 2017 *Annual Review of Law and Social Science*.

Milgram conducted 23 obedience experiments with New Haven, Conn., residents in 1961 and 1962 (*SN: 9/21/13, p. 30*). Most attention has focused on only one of those experiments. Volunteers designated as "teachers" were asked by an experimenter to continue upping the intensity of what they thought were electric shocks to a "learner" — who was actually in league with Milgram — who erred time and again on a word-recall test. Through screams, shouts and eventually dead silence from the learner, 26 of 40 volunteers, or 65 percent, administered shocks all the way to a maximum of 450 volts.

But experiments that undermined participants' identification with the scientific mission lowered their willingness to deliver the harshest shocks, Haslam and Reicher say. Fewer volunteers shocked to the bitter end if, for instance, the study was conducted in an office building rather than a university laboratory or if the experimenter was not physically present. An analysis of data available from 21 of the 23 experiments finds that 43.6 percent of 740 volunteers shocked learners to the limit.

Participants were most compliant when an experimenter encouraged them to continue shocking for the sake of the experiment (by saying, "The experiment requires that you continue"), the psychologists add. Participants never followed the order: "You have no choice, you must continue."

Milgram's archives at Yale University contain letters and survey responses from former participants reporting high levels of support for Milgram's project and for science in general. Many former volunteers told Milgram that they administered shocks out of a duty to collaborate on what they viewed as important research, even if it caused them distress at the time. Still, Milgram's recruits often admitted having had suspicions during the experiments that learners were not really being zapped.

Milgram was right that his experiments applied to real-world genocides, Haslam concludes, but erred in assuming that obedience to authority explained his results. From Milgram's laboratory to Rwanda's killing squads and Nazi concentration camps, orders to harm others are carried out by motivated followers, not passive conformists, he asserts.

If anything, that makes genocide all the more horrifying. ■

> Stanley Milgram's volunteers "perceived themselves as acting virtuously and doing good things."
>
> **S. ALEXANDER HASLAM**

Volunteers in "obedience to authority" experiments gave what they thought were shocks to "learners," such as the seated man below. Most volunteers did so because they supported the scientific project, researchers now say.

Explore more

■ Scott Straus. *Fundamentals of Genocide and Mass Atrocity Prevention*. United States Holocaust Memorial Museum, 2016.

TELEVISION

Nostalgic documentary relives triumphs of the Voyager mission

A Voyager spacecraft flies by Saturn in this computer-generated image from *The Farthest*.

A species gets only one chance to explore its solar system for the first time.

For humans, that chance began 40 years ago this month, when the twin Voyager spacecraft embarked on their "grand tour" of the solar system. A new PBS documentary airing on August 23, *The Farthest: Voyager in Space*, chronicles their journey to send home the first close-ups of the giant planets and to bring a message about life on Earth to the stars.

Voyagers' launch dates took advantage of a rare planetary alignment. In 1977, the giant planets — Jupiter, Saturn, Uranus and Neptune — lined up in such a way that a spacecraft could swing past all four in less than 15 years, stealing some gravitational oomph from each world as it went.

That lucky alignment happens only once every 176 years. When NASA's administrator went to President Richard Nixon to ask for funding for Voyager, he allegedly said: "The last time the planets were lined up like that, President Jefferson was sitting at your desk. And he blew it."

The Farthest: Voyager in Space
AIRS AUGUST 23
PBS | TANGLED BANK STUDIOS

The Voyagers almost blew it, too. The first craft (Voyager 2, confusingly) launched on August 20, 1977. It experienced so much shaking that its onboard computer — which had as much computing power as a modern car key fob — thought it was failing and put itself in safe mode.

Engineers got it back on track and fixed the problem for Voyager 1's launch. Then that spacecraft's rocket had a fuel leak during launch. The craft was within 3½ seconds of running out of gas before it accelerated enough to reach Jupiter.

These nail-biters are mostly told through personal, entertaining anecdotes from Voyager team members. Historical footage from press conferences and newscasts grounds the story in its era. Everyone has big '70s computers and big '70s hair. Cuts from shots of the scientists today to their younger selves emphasize how much time has passed. It's strange that such a high-tech and ambitious mission seems so vintage.

Even the Voyager footage of Jupiter and Saturn coming into view for the first time has a home video quality, especially compared with the sharp, colorful images that spacecraft send back from these planets today. Watching the footage felt like watching video of my parents' wedding: I recognize everyone, but they look so different.

But the sense of awe that the Voyager images sparked is palpable. At the time, every picture was the best planetary picture ever taken. Much of what is known about the outer solar system now — Jupiter's moon Io has volcanoes, Europa has an ocean, Neptune has a great churning hurricane that never stops — was glimpsed for the first time with Voyager.

The Voyager spacecraft are still out there, and one may have already left the solar system (*SN: 8/23/14, p. 6*). Good thing because both craft carry a message in a bottle: the Golden Record.

The Golden Record was a literal record to be played on a phonograph by any aliens that might encounter the spacecraft. The package included a needle, a speaker and graphical instructions on how to play the record. A listener would hear a two-hour sampling of sounds from Earth, including babies crying, whales singing, chimps screeching, trains, thunderstorms, Beethoven, Chuck Berry, greetings in 55 languages and astronomer Carl Sagan's son saying, "Hello from the children of planet Earth."

The Farthest weaves the story of exploration with the story of the making of the record. The record's producers and champions recount how they pulled the whole thing together in just six weeks. What to leave in — a map to Earth, in case the aliens want to visit — and what to leave out — full frontal nudity — was fiercely debated.

At times, refrains of "Wow!" and "It was a first" feel repetitive. Some of the stock footage and spacecraft animations are a little cheesy. But *The Farthest* is a tender tribute, tinged with nostalgia and existential awe. For those like me, who weren't alive or aware when the first pictures of Jupiter came back, *The Farthest* offers a sense of what we missed.
— Lisa Grossman

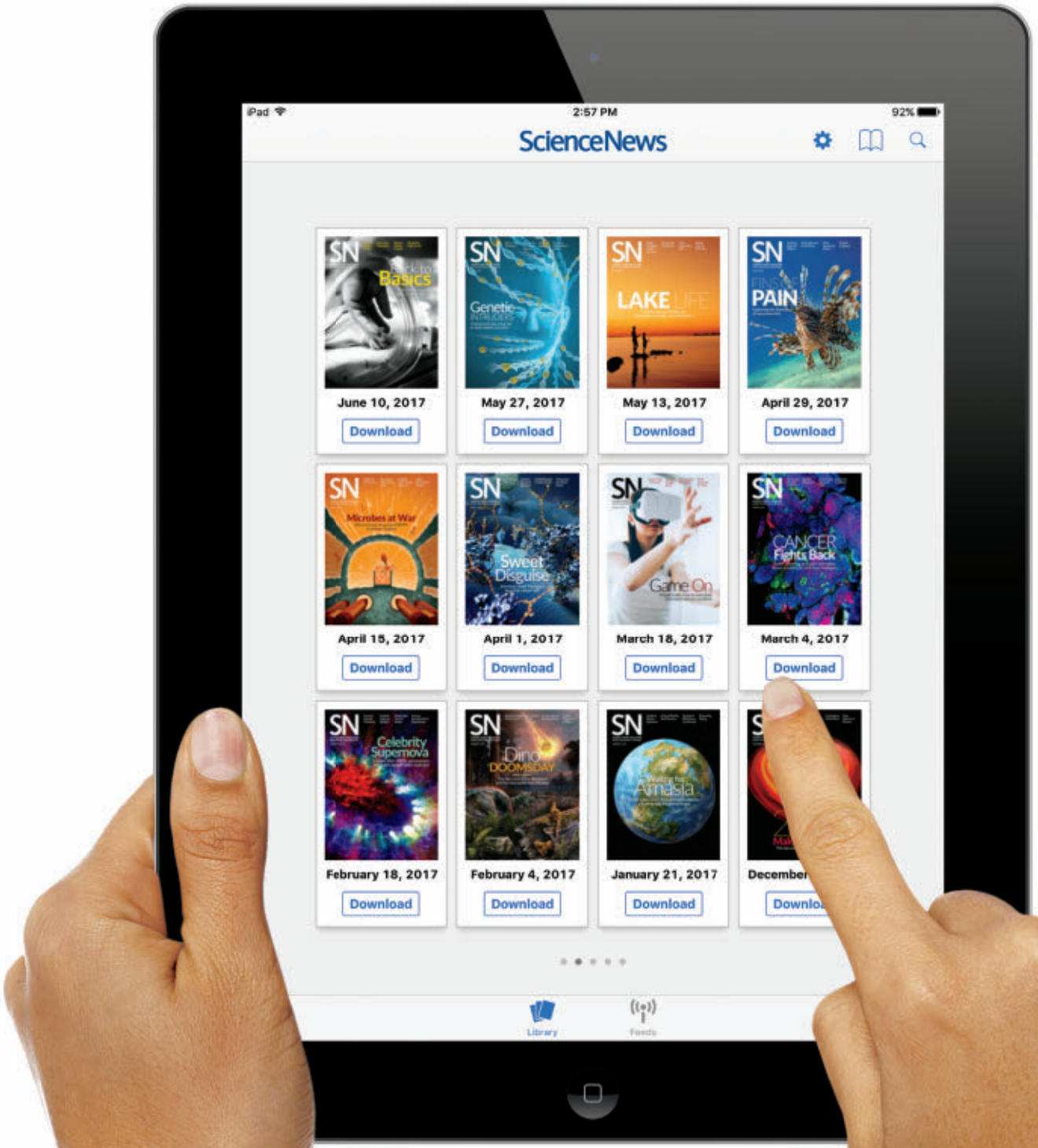
Editor's note: One of The Farthest*'s executive producers, Sean B. Carroll, is a member of the Board of Trustees of Society for Science & the Public, which publishes* Science News.

COURTESY OF TANGLED BANK STUDIOS

A subscription with benefits

Your subscribing membership includes access to the *Science News* app.

DOWNLOAD TO YOUR DEVICE TODAY



ScienceNews

Download on the App Store

Available on amazonkindle

GET IT ON Google Play

Science News for Students

***Science News for Students* (sciencenewsforstudents.org)** is an award-winning, free online magazine that reports daily on research and new developments across scientific disciplines to inquiring minds of every age — from middle school on up.

Beware the tap of the narwhal's tusk

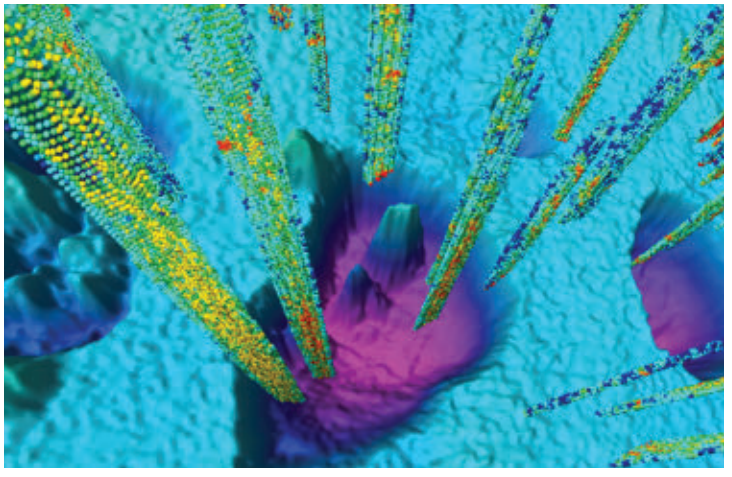
A new video shows narwhals exhibiting a behavior never seen before. They tap fish with their tusks before gobbling the fish up. "It's clear the whales are immobilizing fish before eating them," says Martin Nweeia of Harvard University. Less clear is how they do it, this narwhal expert observes. He suspects that the whales stun the fish with sound waves. Only some 177,000 narwhals exist. With little known about them, "every little discovery is important," says Marianne Marcoux, a Canadian government scientist. — *Sharon Oosthoek*

Read more: sciencenewsforstudents.org/narwhal

Think you're not biased? Think again

All people harbor general biases — beliefs and attitudes about groups of people that are based on race or ethnicity, gender, body weight or other traits. Most biases "develop over the course of one's lifetime through exposure to messages," notes Cheryl Staats of Ohio State University in Columbus. Those messages may come from hearing a sexist comment during a family dinner or banter from TV shows, movies or other media. People may not even be aware that such implicit biases influence their decisions. Yet they will. The good news is that people can learn to recognize implicit biases by taking simple online tests. And there are steps we all can take to overcome such unfounded attitudes. — *Alison Pearce Stevens*

Read more: sciencenewsforstudents.org/bias



Ancient Arctic 'gas' melt triggered enormous seafloor explosions

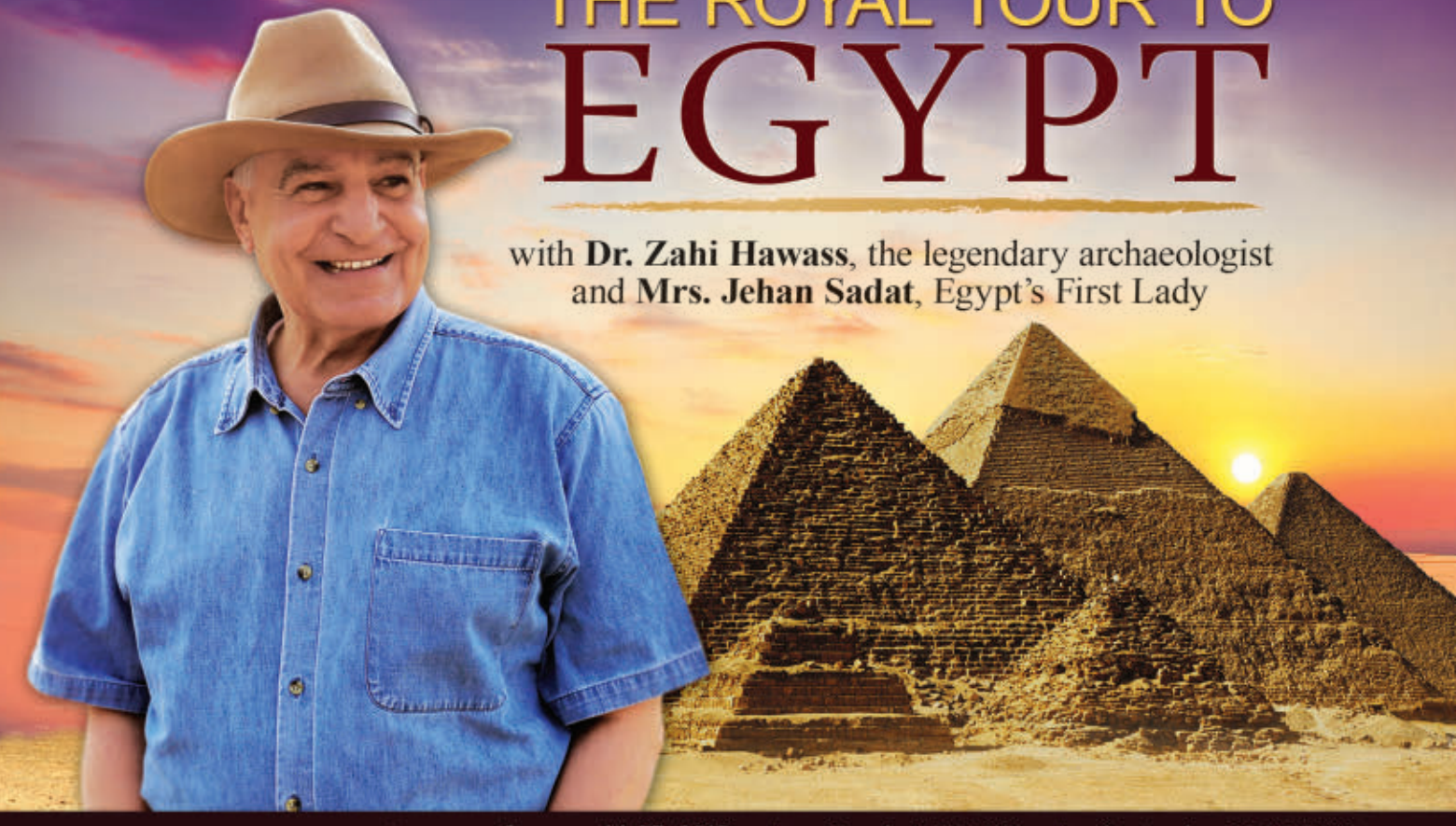
More than 100 craters, each up to a half-mile wide, pockmark the Barents Sea bottom. As domes of frozen methane destabilized within this seabed some 12,000 years ago, they blasted holes into bedrock. Triggered by the waning of the last Ice Age, these events are truly ancient history. But some newer methane domes in the area are now leaking methane like crazy. They could blow at any time, researchers worry. All it will take, they say, is a bit more warming. — *Beth Geiger*

Read more: sciencenewsforstudents.org/gas-melt

CLOCKWISE FROM TOP: WORLD WILDLIFE FUND; MONKEYBUSINESSIMAGES/ISTOCKPHOTO; ANDREIA PLAZA FAVEROLA/CAGE

THE ROYAL TOUR TO EGYPT

with **Dr. Zahi Hawass**, the legendary archaeologist
and **Mrs. Jehan Sadat**, Egypt's First Lady



TOUR DATES

January 14-27, 2018	March 4-17, 2018	September 16-29, 2018
February 1-14, 2018	March 18-31, 2018	October 15-28, 2018
February 15-28, 2018	April 1-14, 2018	November 1-14, 2018

Introducing the most exciting tour to Egypt ever offered. Visit the Land of the Pharaohs with the most famous archaeologist in the world – **Dr. Zahi Hawass**. For over 20 years he held all the keys to the Egyptian antiquities. Meet the former First Lady of Egypt – **Mrs. Jehan Sadat** in the residence of Egypt's president and Nobel Peace Prize winner, Anwar El-Sadat.

Thanks to the special permissions from the Minister of Antiquities, our Royal Tour offers private access to the Giza Plateau and the Luxor temple outside opening hours, the Great Sphinx enclosure and the Tombs of the Pyramid Builders in Giza, an active excavation site, closed to the general public.

Explore the wonders of the ancient Egyptian civilization, including enormous Karnak and Abu Simbel temples, tombs in the Valley of the Kings and much more! You will stay in a 5-star hotel in the shadow of the pyramids and sail on a luxury Nile Cruise ship.

Dr. Zahi Hawass: *"No one can tour Egypt like this. Except for you - when you come and join me. You will be able to visit many unique sites that actually very few people can see."*

Mrs. Jehan Sadat: *"I would love to invite you to visit Egypt with Archaeological Paths. They are really the best to come with to visit my country. You will see a part of history that I'm very proud of."*

Mrs. Jehan Sadat

For more information visit:
www.archaeologicalpaths.com

ARCHAEOLOGICAL PATHS

contact@archaeologicalpaths.com
US phone: 917-719-1974

JULY 8 & JULY 22, 2017

SOCIAL MEDIA

Sun spotting

Get ready! On August 21, a total solar eclipse will cut across the United States from coast to coast for the first time in nearly a century. If you plan to observe the celestial event (with protective eyewear, of course), tweet your eclipse photos and reactions to @ScienceNews using the hashtag #eclipse2017.

Total solar eclipse, 2012

Join the conversation

E-MAIL editors@sciencenews.org

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

Connect with us

Suck it up

Tubelip wrasses' slimy lips help the fish suck up dinner from coral reefs, ***Helen Thompson*** *reported in "The better to eat you with, my dear" (*SN: 7/8/17 & 7/22/17, p. 44*).*

"How do wrasses 'suck' if they have no lungs?" asked reader **John Coventry**.

Suction-feeding fish let their mouths do all the work, says marine biologist **David Bellwood**. "In just the same way that we suck a milk shake, it is decreasing pressure of our tongue and throat that moves the fluid. Fish do not have tongues, but they do have very powerful muscles," he says. Suction feeders create low pressure zones inside of their mouths, which causes water outside to rush in. Tubelip wrasses have the additional aid of mucus, which creates a seal between their mouths and reefs' razor-like ridges. **Bellwood** and colleagues think that this mucus sealant may help wrasses slurp up coral mucus, but the mechanics of the process are hazy.

Rub it in

A topical drug stimulated melanin production in samples of live human skin shielded from the sun, ***Aimee Cunningham*** *reported in "Sunless tanner could protect skin" (*SN: 7/8/17 & 7/22/17, p. 11*). It's an early step in developing a lotion or cream that might protect people against skin cancer.*

Ken Lapre asked if the tanner could be used to treat or cure vitiligo, which causes discoloration of the skin.

It is unknown at this point whether the sunless tanning approach would help people with vitiligo, **Cunningham** says. In this condition, melanocytes — the skin cells that make pigment — are destroyed. But there can be stages of vitiligo in which some melanocytes remain, says cancer biologist **David Fisher**. "If that were the case, then perhaps stimulating those cells to make more pigment might be beneficial."

Monkey see

A set of over 200 nerve cells in monkeys' brains work together to build a picture of a human face, ***Laurel Hamers*** *reported in "Brains encode faces piece by piece" (*SN: 7/8/17 & 7/22/17, p. 9*).*

"I thought I remembered reading other research indicating that a single neuron could recognize a familiar face," **Dan Roberts** wrote. He wondered how both findings could be true.

Researchers think that the two systems might work together, **Hamers** says. "The set of neurons described in the new research is a flexible way to represent any face a monkey might encounter." Single face-specific neurons (*SN: 6/25/05, p. 406*) reside in a different part of the brain and "are more like a speed dial tuned to a smaller number of familiar faces," **Hamers** says.

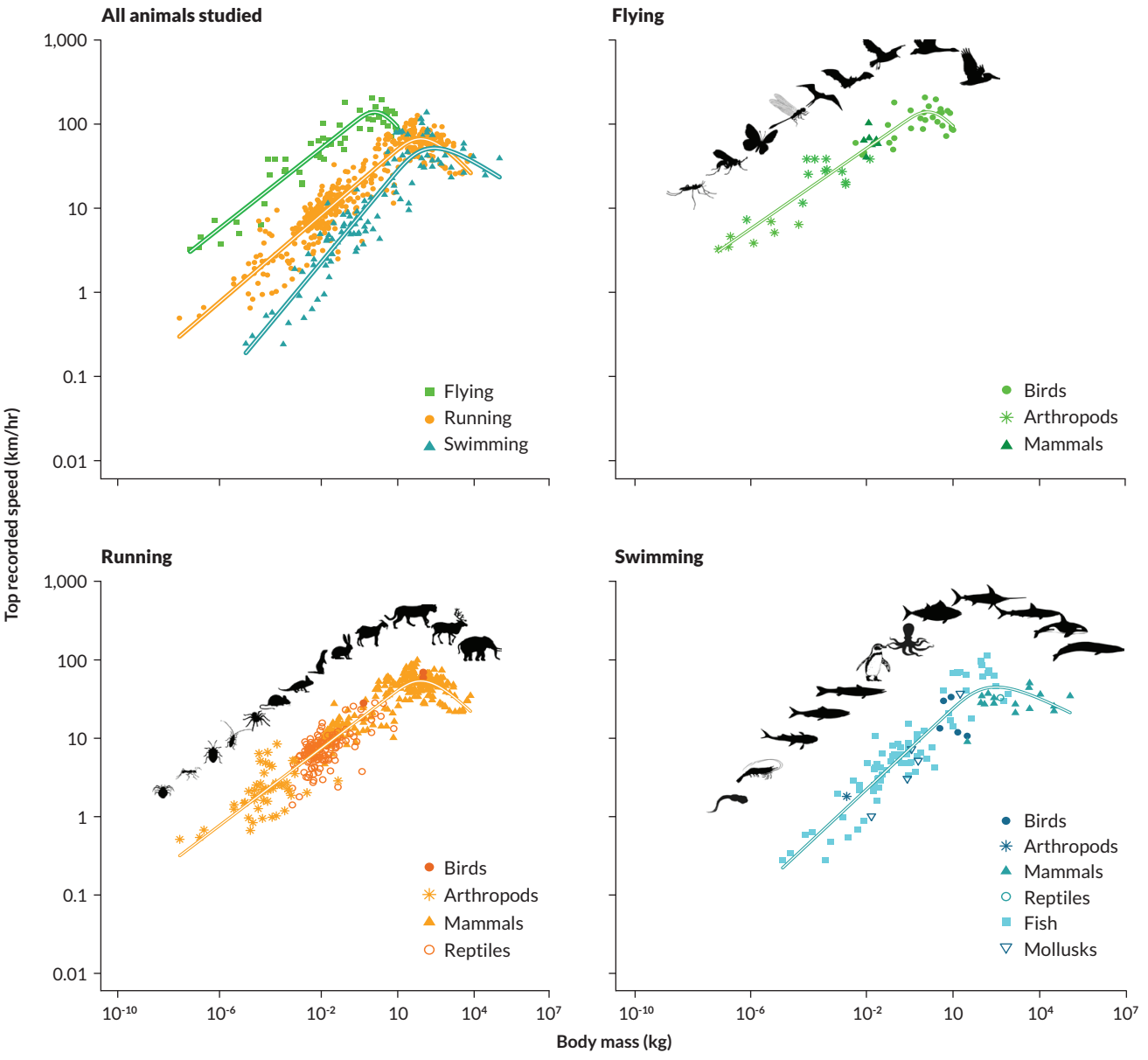
Black hole energy boost

Water waves scattering off a vortex in a lab setup exhibited rotational superradiance, an effect predicted to appear in black holes but difficult to detect, ***Emily Conover*** *reported in "Vortex of water acts like black hole" (*SN: 7/8/17 & 7/22/17, p. 14*). In space, light waves scattering off a rotating black hole may bounce away with more energy than they started with by stealing some of the black hole's rotational energy.*

Online reader **Christopher Studley** wondered if the energy boost from the black hole would accelerate the light waves beyond light speed.

The black hole's rotational energy isn't accelerating the light waves, **Conover** says. It increases the amplitude of the waves, or how bright the light is. "This is analogous to the height of the water ripples in the experiment," she says.

NASA GODDARD SPACEFLIGHT CENTER/FLICKR (CC BY 2.0)



Why midsize animals have the most zip

Speed has its limits — on the open road and the Serengeti. Midsize animals tend to be the speedsters, even though, in theory, the biggest animals should be the fastest. A new analysis that relates speed and body size in 474 species shows that the pattern holds for animals whether they fly, run or swim (graphs shown) and suggests how size becomes a liability.

This relationship between speed and size has long stumped scientists. Big animals have longer legs or flippers to get from point A to point B. And bigger bodies have higher metabolic rates and more fast-twitch muscle cells, needed to convert chemical energy into mechanical energy and rapidly accelerate. So, why aren't wildebeests faster than cheetahs?

The make-or-break factor is the time it takes an animal to accelerate to its top theoretical speed, an upper limit based on mass and metabolic rate, researchers report July 17 in *Nature Ecology & Evolution*. Fast-twitch muscle cells provide the power for acceleration but tire quickly. When an animal gets too big, it takes too long to accelerate, and these cells use up their energy before hitting top speeds. More modestly built critters need less time to accelerate to those speeds.

The researchers gathered speed and size data from past lab and field studies. The animals (some shown as icons) ranged in mass from 30-microgram Spanish mites to a blue whale weighing 108 metric tons. — *Helen Thompson*

M. HIRT *ET AL*/*NATURE ECOLOGY & EVOLUTION* 2017

3 EASY WAYS to watch the SOLAR ECLIPSE

If you weren't able to get to your local library for a pair of free eclipse-viewing glasses, you can still safely observe this amazing phenomenon with one of the simple techniques below.

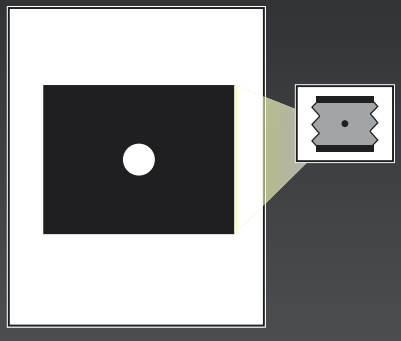
SOURCE: WWW.EXPLORATORIUM.EDU/ECLIPSE/HOW-TO-VIEW-ECLIPSE

REMEMBER: NEVER LOOK DIRECTLY AT AN ECLIPSE, EVEN THROUGH SUNGLASSES OR OTHER OPTICAL DEVICES.

1 DIY PINHOLE VIEWER

Gather two pieces of cardboard and some aluminum foil.

In one piece of cardboard, cut a 1-inch hole, then tape a pieceof foil over the hole. Now make a pinhole in the middle of the foil.

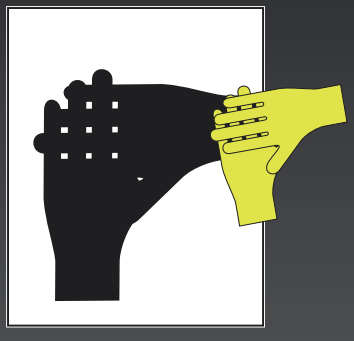


Use the other piece of cardboard (white is best for viewing) as a screen. With the sun behind you, hold the pinhole cardboard as far from your screen as you can and enjoy!

2 GET HANDS ON

Hold up both hands with your fingers overlapping at right angles.

The holes between your fingers make pinholes.



With the sun behind you, use a piece of cardboard (white is best for viewing) as a screen. Hold up your hands in front of the screen from a distance and enjoy the view!

3 THROW SOME SHADE

If you have shade trees in your location, try looking at the light spaces between the shadows of the leaves for an artistic take on the pinhole viewer.

With the sun behind you, use a piece of cardboard (white is best for viewing) as a screen. Capture the images through the shadows for a great viewing session!

SOCIETY FOR SCIENCE & THE PUBLIC

THE SOCIETY FOR SCIENCE & THE PUBLIC IS A CHAMPION FOR STRONG SCIENCE.
On August 21, people all around the country will spend a little time being thrilled by our solar system. Join the Society today and help us spark excitement about science all year long.
VISIT WWW.SOCIETYFORSCIENCE.ORG/JOIN

This Necklace Has a Secret Twist

FIVE stunning looks. ONE amazing price!

Leave it to the Italians to come up with a piece of jewelry that seems to defy the laws of physics. Then, leave it to Stauer to deliver a price that defies logic.

We're happy to present ***La Curva***— an Italian made precious metal miracle that delivers five fabulous looks in one— **all for under $100!**

Change your look with a simple twist: Wear as a Y-necklace, a choker, an Omega-style, or even as a coiled bangle or arm bracelet.

The genius behind this multi-talented piece of jewelry is an Arezzo-based company that is redefining not just the look of bold gold jewelry, but the feel.

The secret: the 18K gold-finished sterling silver has a special memory wire core that molds and bends effortlessly to achieve multiple looks. Faceted end caps are the perfect finishing touch.

La Curva is perfect for travel or when you need one piece of jewelry that will give you several fashionable looks when you don't have time for a lot of fuss.

No questions asked, 60-day money back guarantee.
We want you glowing with satisfaction. You have nothing to lose, except the opportunity to own a precious metal miracle.

Call today!

Raffinato™ Italy

"Crafted with a memory wire core, this design can twist and transform into many looks. The result is light weight yet amazingly strong."
— Paolo Veraldi,
Creator of La Curva Necklace

La Curva is the ultimate quick change artist. Wear as a Y- necklace, a choker, an Omega style or a coiled bangle or arm bangle.

Raffinato™ La Curva Necklace

Stunningly affordable at **$95** + S&P

- ***Made in Arezzo, Italy***
- ***18K yellow gold-finished .925 sterling silver over memory wire core***
- ***Necklace: 26"; clasp free***

Call today. There's never been a better time to let your elegance shine. 1-888-444-5949
Offer Code: RFD110-01. You must use the offer code to get our special price.

Raffinato™
14101 Southcross Drive W., Dept. RFD110-01, Burnsville, Minnesota 55337 www.raffinatoitaly.com
A collection of impeccable design & craftsmanship from Italy.