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SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC

JUNE 9, 2018

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ScienceNews



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James Provost



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The power of great editors, their lessons and legacy

Wouldn't it be grand to have a test that could predict our risk of dreaded diseases like cancer? Signs of such a future exist, but it's not here yet, as senior writer Tina Hesman Saey explains in the second of our three-part series on

direct-to-consumer genetic testing (Page 22). The tests available today fall short in delivering what we would actually want to know. The raw data are gibberish to the average person, Saey reports, and often include errors or omit crucial information. What's more, we don't have enough science to interpret the findings. For now, it's very much a case of buyer beware.

I like to think that Warren Kornberg, who edited *Science News* in the late 1960s, would be happy with this series. I recently learned of Kornberg's death at age 90 from former Editor in Chief Tom Siegfried, whose writing continues to grace the *Science News* website. (More on that in a moment.)

I didn't know Kornberg, so I e-mailed Kendrick Frazier. He was hired by Kornberg, later became editor of *Science News* himself and now edits the *Skeptical Inquirer*. He quickly replied, saying he still feels a great sense of gratitude to Kornberg for fighting for high standards in science journalism. "Tall, slender, bald, he was the epitome of a hard-bitten, newspaper-type editor," Frazier wrote. "He wanted the week's science stories, and he wanted them to be clear and accurate. And with background and perspective. He could be very tough, but also had a sense of humor and could be gentle and understanding."

In 1997, *Science News* editor Julie Ann Miller interviewed Kornberg for the magazine's 75th anniversary special issue. Kornberg insisted that staff writers specialize in covering a specific field of science so they could interpret the field's findings correctly, Miller wrote, a practice we continue today. And he wanted *Science News* stories to be in magazine form, with context, rather than the "inverted pyramid" newspaper form, which emphasizes "breakthroughs." These days, we provide both breaking news coverage and the deeper context.

After he left *Science News*, Kornberg went on to the National Science Foundation, where he edited *Mosaic*, which was the NSF's flagship magazine, and nurtured a generation of science journalists.

Yes, there's a theme here: A magazine like *Science News* doesn't exist for almost 100 years by accident. We have been blessed with a long chain of gifted, inspiring, fearless editors who have kept us going through good times and bad, and who have insisted that we hold ourselves to the highest standards. I've got a lot to live up to.

On that note, a recent blog post by Siegfried on notable quotes from physicist Richard Feynman is a master class in how a great writer can turn a Top 10 list into an illuminating excursion through a scientist's mind (*SN Online*: 5/11/18).

Siegfried's final Feynman quote made me laugh out loud: "The first principle is that you must not fool yourself — and you are the easiest person to fool." Until we recognize how easily we can be fooled, Siegfried notes, we will be. An apt reminder of the importance of critical thinking and informed skepticism in this era of misinformation, science denialism and fake news.

— Nancy Shute, Editor in Chief

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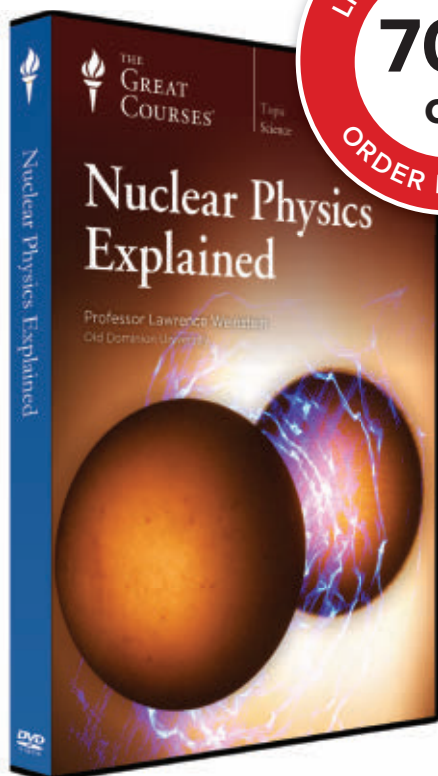
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Excerpt from the June 8, 1968 issue of *Science News*

50 YEARS AGO

Apollo milestone at last

The spacecraft fire that killed three Apollo astronauts and rocked the space agency a year and a half ago is still being felt.... Last week, after a series of delays... a major milestone was finally reached: the first manned tests of an Apollo spacecraft to include all the new equipment and safeguards incorporated since the fire.

UPDATE: Since that lunar program reboot, hundreds of NASA astronauts have made it to space, and 12 astronauts have walked on the surface of the moon. After NASA retired the U.S. Space Shuttle program in 2011, American astronauts have had to rely on Russia's Soyuz spacecraft to reach the International Space Station (SN: 6/11/16, p. 4). Once again, U.S. spacecraft, from SpaceX and Boeing, are planned to take American astronauts into space, but delays have pushed those efforts back to late 2019 and 2020.



Oak processionary caterpillars have noxious hairs. The long ones aren't the problem; it's the short, near-invisible hairs.

IT'S ALIVE

Time for a rash of processionary caterpillars

Of course the guy is wearing a full-body protective suit with face mask good and snug. He's about to confront a nest of little fluffy caterpillars.

Insect control can get surreal in the London area's springtime battle against the young of oak processionary moths (*Thaumetopoea processionea*). The species, native to southern Europe, probably hitchhiked into England as eggs on live oak trees in 2005, the U.K. Forestry Commission says.

When a new generation's caterpillars finish their second molt into a sort of preteen stage, their short barbed hairs called setae can prick an irritating, rash-causing protein into any fool who risks a poke. Even people who'd never torment, or even touch, a caterpillar can suffer as stray hairs waft on spring breezes. And there are plenty of those tiny barbs to waft all summer long.

That's because caterpillars aren't much for house cleaning. The baggy silk nest that a group of caterpillars spins high in several kinds of oak trees accumulates cast-off skins still hairy with the toxic protein.

The name "processionary" comes from the caterpillars lining up head to rump. "A column of caterpillars moving together like a train," is how evolutionary biologist Jim Costa of Western Carolina University in Cullowhee, N.C., describes it. A little rearrange-

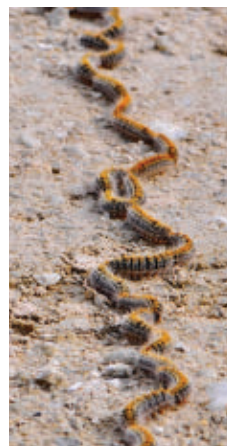
ment can get processions trudging round and round in a circle.

England's ongoing battle against these oak leaf-stripping caterpillars has gripped the news, but other nations have irritating processions of their own, says entomologist Terrence Fitzgerald of State University of New York at Cortland.

One of the London invader's cousins, a pine processionary moth, or *T. pityocampa*, may be edging northward in Europe as the climate warms. In the United States, dark and spiky caterpillars of the buck moth *Hemileuca maia* show up largely unmarked in pockets in the East, but are a traditional vexation of spring in New Orleans.

Annoyances aside, these creatures show the glorious, underappreciated social side of insects, Fitzgerald says. Ants, bees, wasps and termites live extremes of social life,

but caterpillar group nesting and caravanning are respectable social habits too. If fish or birds did that, he grumbles, they'd be dubbed "fabulous animals." Inspired by such accomplishments, Costa published the 2006 book, *The Other Insect Societies*. True, caterpillars don't have the same degree of sociality as ant and honeybee queens with their empires of sterile workers (caterpillars are too young for sex anyway). But then people aren't that specialized either, and we certainly consider ourselves pretty social. — Susan Milius

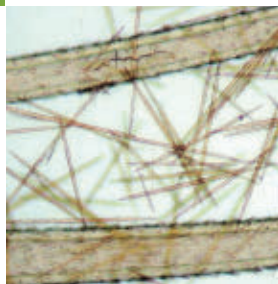


Pine processionary caterpillars, like related oak eaters, embark on classic, single file marches.

The fluff that's irritating London

A single oak processionary caterpillar can sport as many as 630,000 hairlike setae, each less than a half millimeter long. These hairs can detach and land wherever the breeze carries them, retaining their power to irritate long after the caterpillars are gone. Lately, those hairs are getting around the London area.

Entomologist Andrea Battisti of the University of Padova in Italy has been studying processionary caterpillars for nearly 40 years. He knows well the very early symptoms of exposure: burning eyes, the beginning of a skin rash, an itchy feeling, swelling and irritation. To avoid spreading the misery to other parts of the body, undressing carefully, putting contaminated clothes in a long, hot wash and showering without touching the affected areas is a must, he says. Another danger includes inhaling setae, which can cause wheezing and shortness of breath. In some cases, fever, dizziness and vomiting also follow a caterpillar encounter.



The hairlike structures (magnified 200 times) of the oak processionary caterpillar provoke unpleasant reactions.

A protein in the setae, called thaumetopoein, is a cause of the bad reactions. (Chitin in the setae may also produce an immune response.) Somewhat reassuring is that reactions are not widespread. A survey of residents living within 500 meters of oak trees infested with oak processionary caterpillars in suburban Vienna, Austria, found that 57 of 1,025 respondents reported symptoms, mostly itchiness and skin inflammation. — *Aimee Cunningham*

TEASER

A cold-weather clue to migraines

In Finland, 88 percent of people have a genetic variation that increases their risk for migraines. But in people of Nigerian descent, that number drops to 5 percent. That particular genetic mutation, a new study suggests, may have somehow made people better suited to handle cold environments. But the change comes with a downside: It may have also raised the prevalence of these severe headaches in certain populations, researchers report May 3 in *PLOS Genetics*.

Migraines are more common in Europeans than Africans and the mutation follows the same pattern. The mutation is in a stretch of DNA that controls a gene, *TRPM8*, that makes a cold-sensitive protein.

Using a global database of human genetic information, evolutionary geneticist Aida Andrés and her colleagues showed a correlation between the frequency of the mutation, previously tied to migraine susceptibility, in a given population and that population's latitude. Differences in temperature may have led to the geographic variation, though the scientists still aren't sure exactly how the mutation affects *TRPM8*. Perhaps the mutation conferred some benefit to early humans who moved north from Africa, suggests Andrés, of University College London. The connection to migraine appears to be a side effect. The researchers acknowledge, however, that the science of migraines isn't so simple. One variant can't fully explain why these headaches are more common in certain populations. — *Laurel Hamers*

SCIENCE STATS

Globetrotting leaves a big carbon footprint

Going green may mean staying at home.

Global tourism contributes about 8 percent of total greenhouse gas emissions to the atmosphere, researchers report May 7 in *Nature Climate Change*. That carbon footprint, based on 2013 data, is about three times as big as previous estimates of tourism-related emissions.

The jump is largely because the new study does more than just tally up emissions from the traveling itself, like hopping a flight, going on a road trip or taking a cruise. The analysis also looks at the impact of the goods and services that tourists enjoy, from food to shopping to hotel stays.

Who has the biggest carbon footprint? The United States topped the list, as both a top destination for tourists and a source of tourists. Other prosperous nations, such as Canada and Germany, also have a big footprint. Increasingly wealthy nations, such as China and Mexico, are catching up. — *Carolyn Gramling*

8

percent

Proportion of total greenhouse gas emissions due to global tourism

6.5

gigatons

Amount of tourism-related emissions predicted for 2025; rising 2 gigatons from 2013 as travel spending increases



Honeybees and other insects could lose a lot of territory if global warming exceeds 1.5 degrees Celsius.

EARTH & ENVIRONMENT

A little less warming could save species

Half a degree may be key to the survival of many animals, plants

BY CAROLYN GRAMLING

Limiting global warming this century to just 1.5 degrees Celsius above pre-industrial temperatures would be a boon to the planet's biodiversity. This lower warming threshold, compared with warming of 2 degrees, would preserve much larger swaths of the geographic ranges of tens of thousands of land-based species of plants, insects and vertebrates, a study suggests.

Using a combination of climate simulations and data on the distribution of more than 115,000 terrestrial species worldwide, scientists saw distinct differences in future biodiversity depending on how much warming the planet experiences. At 2 degrees of warming by 2100, 18 percent of insect species, 16 percent of plant species and 8 percent of vertebrate species would see their geographic ranges shrink by more than half. Under 1.5 degrees of warming, those numbers would fall to 6 percent of insects, 8 percent of plants and 4 percent of vertebrates, the team reports in the May 18 *Science*.

"Losing half the range is a pretty big impact, because that means [the organisms] stop contributing as much to the ecosystem," says study coauthor Rachel Warren, an environmental scientist at the University of East Anglia in England. These contributions include air and water purification, plant pollination and nutrient cycling.

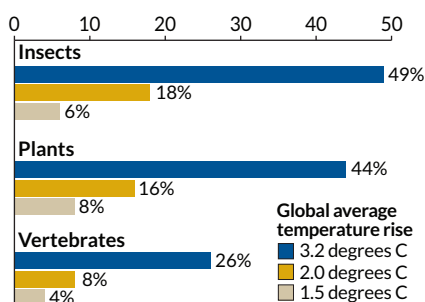
Until a few years ago, 2 degrees was

the magic number. If nations could limit the rise in the global average temperature to 2 degrees, scientists thought, the world would be relatively "safe" — with little change to sea levels, species habitats or climate conditions. But concerns arose that the target would still incur too great a cost, Warren says.

Many small islands and less-developed countries, which will probably be hit hardest by climate change, have lobbied for a more stringent reduction in greenhouse gas emissions to hold global warming to just 1.5 degrees by 2100. The Paris Agreement on climate change reached in 2015 reflected that concern, as delegates agreed to limit warming to "well below" 2 degrees (*SN*: 1/9/16, p. 6).

Losing ground Different global warming scenarios (increases of 3.2 degrees Celsius, 2 degrees or 1.5 degrees above preindustrial temperatures) will have very different impacts on the geographic ranges of terrestrial plants and animals. SOURCE: R. WARREN ET AL./SCIENCE 2018

Percentage of species projected to lose more than half their range by 2100



But the scientific literature contained little information about the effects of a lower warming target, Warren says. "The scientific community has really been playing catch-up since the agreement." As part of the Paris Agreement, the Intergovernmental Panel on Climate Change is expected in late 2018 to finalize a report on the impacts of 1.5 degrees of warming.

In their study, Warren and colleagues used species distributions from the Global Biodiversity Information Facility database. The inclusion of insects — a first for such a study, Warren says — is particularly important because they are at the base of many food chains and because of their ecosystem contributions, including cycling nutrients in soils and pollinating plants.

Based on the current geographic range of each species, the team determined statistically what climatic niche each species preferred. Then the researchers projected how climatic conditions would change globally under three warming scenarios: 1.5 degrees, 2 degrees and 3.2 degrees. The latter represents predicted warming under current pledges to limit greenhouse gas emissions. To reach the target of well below 2 degrees, countries would need to reduce emissions even further by 2030 and beyond. The final step was to track the movement of those niches around the globe in response to climate change and measure by how much they grew or shrank.

Overall, with increased warming, most species' ranges got smaller. That's for three basic reasons, Warren says. Some climatic niches migrated right into the sea and vanished. Others crept up mountain slopes until they could go no higher. And for some species, including many plants, the pace of climate change was too rapid for the species to migrate.

The study "is a great first approximation of the difference in these warming scenarios," says Lauren Buckley, an ecologist at the University of Washington in Seattle. However, she notes, the work's broad-brush approach means it can't take into account some of the physiology of these species or how each might respond to changing climates. ■

Frog-killing fungus traced to East Asia

Pandemic *Bd* chytrid probably emerged 50 to 120 years ago

BY SUSAN MILIUS

The biggest genetic study yet of a notorious frog-killing fungus finds that it probably originated in East Asia in the 20th century.

The chytrid fungus nicknamed *Bd* has astonished biologists in the last several decades by causing sudden mass die-offs among frogs and other amphibians in Australia, Panama and other places worldwide. But where and when the killer emerged and how it spread have been much-debated mysteries. Studies have proposed North and South America as well as Africa and Asia as the homeland where a once-obscure fungus turned deadly.

Building up enough genetic data to untangle the origins has taken some 10 years of field and lab work at more than 30 institutions around the world, says infectious disease epidemiologist Simon O'Hanlon of Imperial College London. The analysis finds four main lineages of *Batrachochytrium dendrobatidis* fungus and reveals that the worldwide killer group, *Bd*GPL, probably originated 50 to 120 years ago, O'Hanlon and colleagues report in the May 11 *Science*.

How the fungus traveled far and fast is less of a mystery. All the lineages show up in animals that have been traded internationally, often as pets, the team reports.

That's "one of the parts I found most worrisome," says longtime *Bd* researcher Karen Lips of the University of Maryland in College Park, who was not involved in the study. International standards for pathogen monitoring are only as strong as their enforcement. "Here in the U.S., there is no requirement for testing of imports for chytrids," she says.

Spread of known lineages is only one of her worries. Mingling animals with different infections around the world could encourage current fungi to create new forms. The study has already found examples of *Bd* hybrids.

Bd may now be one of the most discussed fungal killer of animals in the world. It didn't even have a name, however, when biologists were growing alarmed in the 1990s about amphibian declines and spooky die-offs. The fungus showed up now and then as researchers searched for the killer pathogen, but

was dismissed at first as a skin fungus taking advantage of a dying animal. At the time, chytrids were mostly little-studied fungi found in soil and water that couldn't kill a vertebrate animal as far as the world's small community of chytrid specialists knew.

By the time researchers gave the newfound menace its official name in 1999, the main killer lineage of *Bd* was spreading around the world. Various sleuthing efforts to backtrack its spread have yielded far-flung possible origins as well as extremes of time; one study calculated that the deadly pandemic form had originated as long as 26,400 years ago.

In the new study, the team determined the arrangement of DNA building blocks in 177 individual samples of *Bd* from around the world, including the first ones available from the Korean Peninsula and Taiwan. Adding in some earlier collections, the study draws on information from 234 samples.

Comparing the DNA samples let the researchers rough out a genealogical tree with the four main *Bd* lineages, including a previously unknown one from Korea now dubbed *Bd*ASIA-1. That lineage appears to be the closest yet found to the original ancestor, the researchers propose. *Bd*ASIA-1 shows exceptional genetic variety, something biologists expect from an original genetic pool that has sent out various emigrant versions. The Asian origin also fits with current thinking about the source of a sister chytrid, *B. salamandrivorans*, which is spreading into Europe and killing salamanders (*SN*: 11/29/14, p. 6).

Still, it's too early to say *Bd* emerged in Korea. That's because other places in East Asia might turn out to have lineages that are even closer to the species's origin than the Korean *Bd*ASIA-1, O'Hanlon says. There aren't that many East Asian samples in the current database, and none at all come from India. This study may have corralled the most samples yet, but resolving the *Bd* origins mystery in detail is going to take even more. ■



A genetic study traces an amphibian-killing fungus to East Asia. From there, international trade in such showy pets as this oriental fire-bellied toad may have helped launch the pathogen worldwide.

New insights into the death throes of sunlike stars may help solve a decades-old mystery about planetary nebulae (NGC 6302 shown).

ATOM & COSMOS

Puzzling planetary nebulae explained

Small, dying stars heat up fast enough to dazzle, simulations show

BY MARIA TEMMING

New insights into how stars like the sun die might help explain why astronomers find bright planetary nebulae where they're least expected. Simulations of how these stellar remnants form suggest that low-mass stars have cores that heat up fast enough to produce bright nebulae upon their demise, researchers report May 7 in *Nature Astronomy*.

A planetary nebula is what's left over when a sunlike star sheds its outer envelope of gas. Radiation from the stellar core, now exposed, sets the expanding shell of gas aglow, creating the kind of candy-colored clouds seen in spectacular Hubble Space Telescope images, like that of the Cat's Eye Nebula and the butterfly-shaped NGC 6302 (*SN Online*: 9/5/13).

Astronomers had thought a star's mass dictated what sort of nebula it produced, with more massive stars creating the brightest nebulae and stars with lower masses, like the sun, making nebulae too faint to see from another galaxy.

But that idea didn't match observations: The brightest planetary nebulae in older, elliptical galaxies — thought to be home to only low-mass stars — are just as luminous as those in younger, spiral galaxies, where massive stars abound. The puzzle has vexed astronomers for decades.

Now, Albert Zijlstra, an astrophysicist at the University of Manchester in England, and colleagues have simulated

planetary nebulae formation based on a new theory of stellar evolution. This theory says that after smaller stars shed their outer envelopes, their bare cores heat up more quickly than previously thought. That allows the cinderlike stellar core to pump more energetic radiation into the surrounding nebula before the gas expands too far out into space, ultimately making for a brighter nebula, explains Christophe Morisset, an astronomer at the National Autonomous University of Mexico in Mexico City who wasn't involved in the work.

Simulations showed that stars ranging from 1.1 to three times the mass of the sun produce nebulae with similar brightness. That result could explain why nebulae found in galaxies with stars that are 7 billion years old can be just as bright as those found in galaxies chock-full of 1-billion-year-old stars.

This finding marks "an important step forward" in understanding the universe's population of planetary nebulae, says Penn State astronomer Robin Ciardullo, who wasn't involved in the work.

But some mystery would still remain: For the most ancient elliptical galaxies with very small stars over 7 billion years old, the simulations didn't produce planetary nebulae bright enough to match what astronomers see in the sky. So there's still "a little ways to go" before astronomers can explain why bright nebulae are so ubiquitous, Ciardullo says. ■

HUMANS & SOCIETY

There's extra time to learn a language

Period for mastering grammar may extend beyond childhood

BY BRUCE BOWER

Language learning isn't kid stuff anymore. In fact, it never was, a provocative new study concludes.

A crucial period for learning the rules and structure of a language lasts up to age 17 or 18, say Joshua Hartshorne, a psychologist now at Boston College, and colleagues.

Previous research had suggested that grammar-learning ability flourishes in early childhood before hitting a dead end around age 5. If that were true, people who move to a new country and try to learn a second language after the first few years of life should have a hard time achieving the fluency of native speakers.

But that's not so, Hartshorne's team reports online May 2 in *Cognition*. In an online sample of unprecedented size, people who started learning English as a second language in an English-speaking country by age 10 to 12 ultimately mastered the new tongue as well as folks who had learned English and another language simultaneously from birth, the researchers say. Both groups, however, fell somewhat short of the grammatical fluency of English-only speakers.

New-to-English learners who started after ages 10 to 12 reached lower levels of fluency than those who started learning English at younger ages because time ran out — the ability to absorb grammar starts to plummet at around age 17.

In another surprise, modest amounts of English learning among native and second-language speakers continued until around age 30, the investigators found, although most learning happened in the first 10 to 20 years of life.

Earlier investigations have included too few monolingual and bilingual participants — typically no more than 250 per study — to reveal the entire timeline

of grammar learning, Hartshorne says. Aiming for a sample of tens of thousands of volunteers, he began by contacting friends on Facebook to take an online English grammar quiz, which used a person's responses to guess his or her native language and dialect of English. After completing the quiz, volunteers filled out a questionnaire that asked where they had lived, languages they had spoken from birth, the age at which they began learning English and the number of years they had lived in an English-speaking country.

As Hartshorne had hoped, the quiz was shared widely on Facebook and other social media, allowing the researchers to analyze responses of 669,498 native and nonnative English speakers. Statisti-

cal calculations focused on estimating at what ages people with varying amounts of experience speaking English reached peak grammar ability.

Modest amounts of English learning among native and second-language speakers continued until around age 30.

linguist at the University of California, San Diego.

For instance, Hartshorne's team can't yet say that language skill develops along a single timeline, Barner says. Different elements of grammar, such as using correct word order or subjects and verbs that agree with one another, might be learned at different rates, he says. It's also unclear whether the responses of

Other researchers who study language learning regard the new study as intriguing, but preliminary. "I see this as a first foray, a blast of data that, while powerful, lacks precision," says

David Barner, a psycho-

volunteers to an online, 132-item grammar test reflect how well or poorly they actually speak English.

What's more, language learning involves more than a crucial period for acquiring grammar, cautions linguist David Birdsong of the University of Texas at Austin. For instance, growing up speaking two languages at once puts poorly understood strains on the ability to grasp grammar, he says.

In the new study, people who were bilinguals from birth fell short of peak English grammar scores achieved by English-only speakers. That's consistent with evidence that bilinguals cannot easily turn off one language while speaking another, Birdsong says. Interactions between tongues spoken by one person may slightly depress how much can be learned about both languages, even if bilingual communication still reaches high levels, he suggests. ■

BODY & BRAIN

Memories may be encoded in RNA

Scientists claim to transfer recollections between animals

BY LAUREL HAMERS

Sluggish memories might be captured via RNA. The molecule, when taken from one sea slug and injected into another, appeared to transfer a rudimentary memory between the two animals, a new study suggests.

Most neuroscientists think long-term memories are stored by strengthening connections between nerve cells in the brain (*SN*: 2/3/18, p. 22). But the new results, reported May 14 in *eNeuro*, buoy a competing argument: that some types of RNA molecules, not linkages between nerve cells, are key to long-term memory storage.

"It's a very controversial idea," admits study coauthor David Glanzman, a neuroscientist at UCLA.

When poked or prodded, some sea slugs will reflexively pull their siphon,

a water-filtering appendage, into their bodies. Using electric shocks, Glanzman and his colleagues sensitized *Aplysia californica* sea slugs to have a longer-lasting siphon-withdrawal response—a very basic form of memory. The team extracted RNA from those slugs and injected it into slugs that hadn't been sensitized. These critters then showed the same long-lasting response to touch as their shocked companions.

RNA molecules come in different varieties that carry out specialized jobs, so it's not yet clear what kind of RNA may be responsible for the effect, Glanzman

says. But he suspects that it's one of the handful of RNA varieties, called non-coding RNAs, that is often involved in manipulating a gene's activity.

But even the few scientists who question whether the strength of nerve cell connections is the key to long-term memory storage don't necessarily buy Glanzman's ideas. The fact that untrained slugs become more sensitive to touch after RNA injection is "amazing," says biochemist Tomás Ryan of Trinity College Dublin. "But it doesn't go far enough to say that the memory has been transferred." ■

Placing RNA from one sea slug into another appeared to transfer a simple version of memory, a controversial study finds.



MATTER & ENERGY

Protons break the record for pressure

The particles' insides are more squeezed than a neutron star's

BY EMILY CONOVER

Pity the protons: Those little particles are under a lot of pressure. Protons' innards are more squeezed than any other substance yet measured, a study finds.

"It's really the highest pressure we have ever seen," says physicist Volker Burkert, a coauthor of the study, published in the May 17 *Nature*. Protons break the pressure record set by neutron stars, the incredibly dense dead stars that can form when a massive star explodes and its core collapses, squeezing more mass than the sun's into a remnant the size of a city.

The pressure in the proton's center averages a million trillion trillion times the strength of Earth's atmospheric pressure, report Burkert and colleagues from the Thomas Jefferson National Accelerator Facility in Newport News, Va. That's about 10 times the pressure found inside a neutron star. Scientists had predicted that such pressures might occur inside protons, but the new result is the first experimental proton pressure gauge.

The proton's internal pressure distribution has been a largely unexplored frontier, even though pressure is one of the proton's fundamental properties. "It's as important as electric charge or mass," says physicist Peter Schweitzer of the University of Connecticut in Storrs.

Protons are made up of smaller particles: quarks, which are electrically charged, and gluons, which transmit the strong nuclear force that holds protons together (*SN*: 4/29/17, p. 22). In the center of this ball of particles, Burkert's group reports, an intense pressure pushes outward. This record-breaking outward force is kept in check by an inward pressure from the proton's outer regions.

This pressure pattern parallels what happens in much larger objects. "In some sense, it's looking like a star," says Oleg Teryaev, a physicist at the Joint Institute for Nuclear Research in Dubna, Russia. Stars also have pressures that

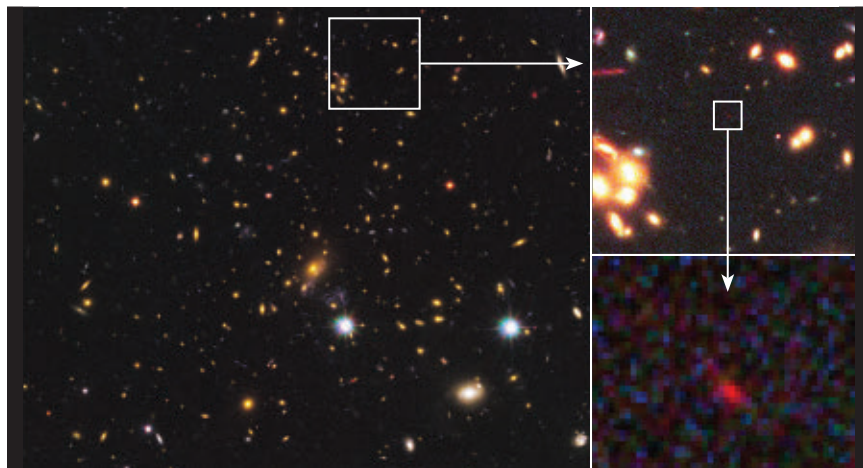
push outward in their centers, which counteract the inward pull of gravity.

To quantify the proton's squeeze, the researchers used data from a particle detector known as CLAS, short for the Continuous Electron Beam Accelerator Facility Large Acceptance Spectrometer, located at the Jefferson facility. The scientists shot electrons at liquid hydrogen, a plentiful source of protons, and watched what happened as electrons interacted with the protons' constituents and

ricocheted away. The new measurement is based on data from 2015 that was analyzed for the first time using a technique that could tease out the proton's pressure.

The experiment studied the quarks in protons, but not gluons, because the electrons' energy was not enough for the electrons to fully probe protons. To make the pressure estimate, the team assumed the gluons' pressure contribution was the same as the quarks' — which is in line with some theoretical predictions.

Future particle accelerators, such as the planned Electron-Ion Collider, would allow for gauging the gluons' contribution to provide a better estimate of the pressure protons endure. ■



ATOM & COSMOS

Astronomers spot some of the earliest stars

A measly 250 million years after the Big Bang, what may be some of the first stars in the universe began to twinkle. Researchers used the Atacama Large Millimeter/submillimeter Array observatory in Chile to spot starlight emitted in galaxy MACS1149-JD1 (shown in the boxes above). At a distance of 13.28 billion light-years away, the galaxy is one of the farthest-known light sources visible from Earth. The emissions are a clue to the galaxy's redshift — a stretching of light that signifies the speed at which an object is moving away from an observer. Redshifts are clues to a celestial object's distance and age.

The galaxy's redshift suggests the starlight was emitted when the universe was about 550 million years old, an international research team reports in the May 17 *Nature*. But many of the galaxy's stars were already about 300 million years old, further calculations indicate. So the stars would have blinked into existence 250 million years after the universe's birth. That's earlier than the 550 million years ago that a previous study reported as the supposedly oldest starlight measured directly (*SN Online*: 2/9/15). But it's in the same ballpark as a recent estimate based on indirect evidence that suggested star formation began about 180 million years after the Big Bang (*SN*: 3/31/18, p. 6). — *Laurel Hamers*

More evidence of plumes on Europa

'90s spacecraft recorded hints of Jovian moon spraying water

BY LISA GROSSMAN

Jupiter's icy moon Europa may have been spitting into space for at least 20 years. A new analysis of old Galileo mission data suggests that the NASA spacecraft flew through a plume of water vapor from the moon during a 1997 flyby, researchers report May 14 in *Nature Astronomy*.

"We now have very compelling support for the idea that Europa does possess plumes," says study coauthor Xianzhe Jia, a planetary scientist at the University of Michigan in Ann Arbor.

Whether the moon has such geysers has been a lingering mystery. One of the most tantalizing results from Galileo, which orbited Jupiter from 1995 to 2003,

was evidence that Europa harbors a deep ocean of water beneath an icy shell. Then in 2012, data from the Hubble Space Telescope revealed high concentrations of charged hydrogen and oxygen atoms, or ions, over Europa's southern hemisphere, a potential sign of water vapor escaping into space (*SN: 1/25/14, p. 6*).

The putative plumes have played peekaboo ever since (*SN Online: 1/11/18*), continuing to intrigue astronomers hoping to one day search the moon's water for signs of life.

Jia and colleagues examined data from Galileo's closest Europa flyby, which brought the probe to within 206 kilometers of the moon. Over one spot near the equator, the probe detected sudden changes in the measurements from its plasma and magnetic field instruments. Using up-to-date computer simulations, the team showed that these changes are best explained by Galileo flying through an active plume. Radiation from Jupiter's magnetic field would have split water molecules into oxygen and hydrogen ions,

and those particles would have changed the direction of the magnetic field and the density of plasma within the plume. That spot is also near where, in 2014, Hubble picked up a second sign of escaping water (*SN Online: 9/26/16*).

Galileo found no other signs of plumes during its other Europa flybys, which were farther away from the moon. The lack of additional detections suggests that any plumes are relatively small, extending not much higher than 200 kilometers above the surface. It's also unclear if Europa's plumes would be spewing constantly or turning on and off.

Planetary scientist Cynthia Phillips of NASA's Jet Propulsion Laboratory in Pasadena, Calif., who worked on Galileo but was not involved with the new study, says it's exciting that scientists are using new tools on the old mission data. "During Galileo, we'd always known there was something weird during this flyby," she says. But she is still holding out for visual confirmation of the plumes. "Pictures, or it didn't happen." ■



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ATOM & COSMOS

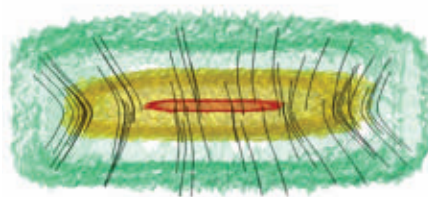
'Singing' space cloud seen in 3-D

Interstellar structure's true shape explains a lack of stars

BY LISA GROSSMAN

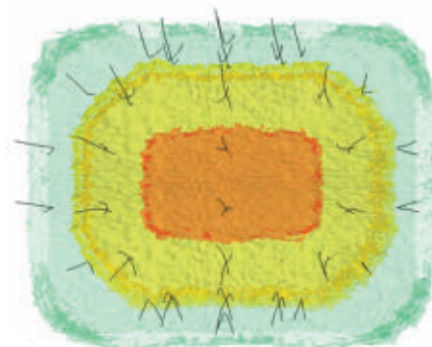
For the first time, astronomers have charted the 3-D shape of a cloud of interstellar gas. The map explains why this cloud has failed to form stars so far, and could help test theories of how star formation works.

Astrophysicists Aris Tritsis, now of the Australian National University in Canberra, and Konstantinos Tassis of the University of Crete in Heraklion, Greece, examined a narrow gas cloud located between about 490 and 650 light-years from Earth in the constellation Musca. What looked like a narrow wisp of cloud that should have been condensed enough to make stars instead stretches 20 light-years away from Earth, the researchers report in the May 11 *Science*.



Such interstellar clouds are the primary birthplaces of stars and come in all sorts of blobby shapes. On the sky, the Musca cloud, sometimes called the Dark Doodad Nebula, looks like a thin snake that's more than 25 light-years long. It has been "the poster child of a filament or cylindrical cloud," says Tritsis, who studied the celestial wisp while at the University of Crete.

The cloud's apparent shape, however, posed a puzzle. If the object was really a cylinder, its mass should have been compressed enough to create stars. But the cloud shows no sign of star formation. Still, astronomical objects can be seen in only two dimensions on the sky. Previous observations of the orientation of light around Musca had suggested that the cloud might extend into space, but



A 3-D reconstruction shows the Musca interstellar gas cloud in different orientations. Instead of being a cylinder, as suggested by an edge-on view (left), the cloud is a nearly square sheet (right). Colors represent the density of gas in the cloud, which increases toward the center. Gray lines trace the magnetic field.

it was impossible to tell how deep the cloud went just by looking at it.

So Tritsis and Tassis decided to listen to the cloud instead, analyzing data collected by the Herschel Space Observatory of the cloud's magnetic field. Thin stripes called striations are formed by magnetic pressure waves, similar to sound waves, rippling through the cloud and bouncing off of its edges. It's like the whole cloud is singing, Tritsis says.

MATH & TECHNOLOGY

New self-driving car finds its own way

Navigation system uses lasers to 'see' where the vehicle is going

BY MARIA TEMMING

A new kind of navigation system could help self-driving cars take the road less traveled.

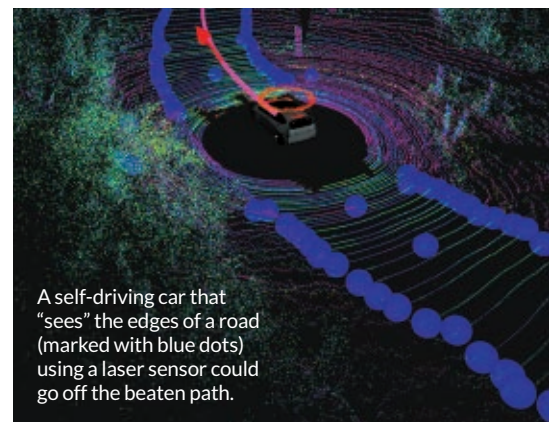
Most autonomous vehicles test-driving in cities navigate using 3-D maps marking every curbside and off-ramp with almost centimeter-level precision (*SN Online*: 11/21/17). But there are millions of miles of open road that tech companies aren't likely to plot in such detail any time soon.

Researchers now have developed a new autonomous navigation system that guides vehicles without such high-res maps, according to research presented May 22 in Brisbane, Australia, at the IEEE International Conference on Robotics and Automation. Cars equipped with this tech could hit the

road for excursions off the beaten path.

The navigation system charts a course down unfamiliar roads much like a human driver would — by continuously scanning its surroundings, albeit with a laser sensor, to gauge how close the car is to the edges of the road. Meanwhile, the car also follows a tool akin to a smartphone map app that provides GPS directions to a destination, as well as information about the rules of the road, like speed limits and the positions of stoplights, along the car's journey.

This system assumes that a car has a clear path down the road, but could be paired with other existing algorithms that use laser sensing to detect in-road obstacles, like other vehicles or pedestrians, to navigate more heavily trafficked



A self-driving car that "sees" the edges of a road (marked with blue dots) using a laser sensor could go off the beaten path.

roadways, says study coauthor Teddy Ort, a roboticist at MIT.

Ort and colleagues test-drove a car equipped with this navigation system on a one-lane road winding through a Massachusetts forest. The vehicle slowly cruised along a one-kilometer stretch without requiring any human intervention to keep it on the right track. The researchers plan to build a version of

FROM TOP: A. TRITIS; MIT CSAIL

The frequencies of these waves can reveal the size and shape of the object they're ringing through. Musca's waves exposed a nearly square sheet, extending about 20 light-years out into space away from Earth.

"They found a way to measure this depth," says astronomer Antonio Magalhães of the University of São Paulo, who was involved in earlier observations but not the new result. "They have a clever way to get this sheet-like structure."

That structure explains why Musca isn't forming stars — its gas is spread out more than previously thought. The cloud could start forming stars sometime in the next 10 million years, Tritsis says.

Many physical processes that affect when and how stars form, including magnetic fields, turbulence and gravity, are encoded in the shape of an interstellar cloud. So nailing down Musca's true form could help refine scientists' theories of how stars are born.

"Musca can be used as a laboratory to find all this stuff," Tritsis says. ■

this system that can spot lane markings painted on streets, so that the car can drive on more than one-way roads, Ort says.

The technology may be useful for future self-driving cars on cross-country road trips, though such vehicles would probably still use meticulous 3-D maps to weave through city traffic, says Raghvendra Cowlagi, an aerospace engineer at Worcester Polytechnic Institute in Massachusetts who wasn't involved in the work.

Self-driving cars with this navigation system may also need other kinds of sensors to work in different conditions, says Alexander Wyglinski, an electrical and computer engineer also at Worcester Polytechnic Institute. Since laser sensors don't work well in rain or snow, for example, these cars might need additional imaging technologies to drive safely in inclement weather (*SN: 12/24/16, p. 34*). ■

GENES & CELLS

How temperature controls turtle sex

Genetic switch helps explain why warm nests lead to females

BY LAUREL HAMERS

Toastier nests, rather than sex chromosomes, turn baby turtles female. Now, a genetic explanation for how temperature determines a turtle's sex is emerging: Scientists have identified a temperature-responsive gene that sets turtle embryos on a path to being either male or female. When researchers dialed down that gene's activity early in development, turtle embryos incubating at cooler climes that would normally yield males turned out female instead, researchers report in the May 11 *Science*.

Scientists have struggled since the 1960s to explain how a temperature cue can flip the sex switch for turtles and other reptiles (*SN Online: 1/8/18*). That's partly because gene-manipulating techniques that are well-established in lab mice don't work in reptiles, says study coauthor Blanche Capel, a developmental biologist at the Duke University School of Medicine. Previous studies have shown that certain genes, including one called *Kdm6b*, behave differently in developing male and female turtles. But until recently, nobody had been able to tweak those genes to directly test which ones control sex determination.

"This is the first venture down that path," says Clare Holleley, an evolutionary geneticist at the Australian National Wildlife Collection in Canberra who wasn't part of the study. "It's really quite a breakthrough."

In the study, Capel's lab collaborated with a group of Chinese researchers led by Chutian Ge of Zhejiang Wanli University in Ningbo. Ge's team recently developed a way to lessen the activity of particular reptilian genes by injecting viruses bearing snippets of artificial RNA into developing eggs.

The researchers used the technique to weaken the effects of *Kdm6b* in the embryos of red-eared slider turtles (*Trachemys scripta elegans*) before the gonads formed, then tracked the

embryos' development at 26° Celsius.

"To my delight, it resulted in complete sex reversal," Capel says. That temperature should have yielded all males. Instead, in two separate experiments done with gene-quieting viruses carrying different RNA snippets, 80 and 87 percent of surviving embryos became female.

Still, something as complex as sex determination can't be boiled down to a single gene. *Kdm6b* controls a gene called *Dmrt1*, which had recently been shown to direct male development, Capel's team also found. And while *Kdm6b* does behave differently as temperatures rise, it doesn't show the same response in all tissues. The gene probably doesn't directly sense temperature, but instead receives messages from some higher-up gene that reacts directly to temperature and directs *Kdm6b*'s behavior in different tissues, the researchers propose.

Whether *Kdm6b* plays the same role in other reptiles remains to be seen. A 2017 study coauthored by Holleley found that the gene influences the sexual fate of bearded dragons (*SN Online: 6/14/17*). But other genes in the same family, *Jumonji* genes, are also known to influence development in both reptiles and mammals. Those genes might not work exactly the same way in other reptiles.

"There's this huge diversity of sex-determining modes in reptiles," says Holleley. Even if *Kdm6b* is an important switch in other reptiles, "the genes that *Jumonji* genes are activating are probably going to be different in every reptile."

There are other wrinkles, too. "This is a really exciting finding, but we need to remember that everything in a lab is controlled," says wildlife zoologist Itzel Sifuentes-Romero of Florida Atlantic University in Boca Raton. Wild turtle eggs are subject to fluctuations in temperature and moisture while incubating, she says, which means the signals that temperature-sensitive genes are receiving are far more muddled. ■

BODY & BRAIN

New AI navigates like a person does

Virtual grid cells may offer insight into humans' sense of direction

BY MARIA TEMMING

An artificial intelligence that navigates much like mammals do could help solve a mystery about our own internal GPS.

Equipped with virtual versions of nerve cells called grid cells, the AI easily solved virtual mazes and planned new routes. That performance, reported in the May 17 *Nature*, hints that grid cells in real brains play a crucial role in path planning.

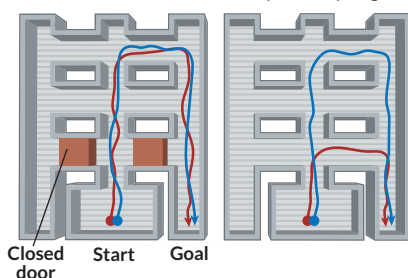
"This is a big step forward" in understanding our own navigational neural circuitry, says Ingmar Kanitscheider, a computational neuroscientist at the University of Texas at Austin who was not involved in the work.

Grid cells project an imaginary hexagonal lattice onto a mammal's surroundings. Neuroscientists have suspected that the cells not only provide

an internal coordinate system, but also help plan direct paths between points.

To test that idea, neuroscientist Caswell Barry of University College London and colleagues at Google DeepMind created an AI that had virtual nerve cells whose activity resembled that of real grid cells.

Pathfinder An AI with virtual grid cells (red) and an AI without them (blue) learned to solve a maze (sample paths, left). Only the AI with grid cells took a shortcut when it opened up (right).



The group trained the AI to navigate virtual mazes by giving the system reward signals when it reached its destination.

The AI bested an expert human player and other artificial neural networks at solving the virtual mazes. When a door opened to provide a shortcut through the maze, the new AI took the more direct route. AI systems without artificial grid cells took the long way around.

These findings support the idea that grid cells help mammals devise the most straightforward directions to destinations. The study also demonstrates that AI is "a very powerful tool" for testing neuroscience theories, Barry says.

But there are limitations to using AI to study the brain. Because the system is meant to learn on its own, researchers can't tell why it made a specific decision, says neuroscientist Francesco Savelli of Johns Hopkins University. Virtual grid cells clearly helped the AI navigate more efficiently, he says, but it's still unclear precisely how the AI used those cells. ■

HUMANS & SOCIETY

How farming got to Southeast Asia

Ancient Chinese rice growers brought agriculture, languages

BY BRUCE BOWER

People who moved out of southern China cultivated big changes across ancient Southeast Asia, an analysis of recovered human DNA finds.

Chinese rice and millet farmers spread south into a region stretching from Vietnam to Myanmar. There, they mated with local hunter-gatherers in two main pulses, first about 4,000 years ago and again two millennia later, says a team led by Harvard Medical School geneticist Mark Lipson. The influx brought agriculture to the region and led to the spread of Austroasiatic languages that are still spoken in parts of South and Southeast Asia, the team reports online May 17 in *Science*.

Over the last 20 years, accumulating archaeological evidence has pointed to

the emergence of rice farming in Southeast Asia between 4,500 and 4,000 years ago, accompanied by tools and pottery showing links to southern China. Austroasiatic languages now found from Vietnam to India contain words for "rice" and "agriculture," suggesting that ancient arrivals from southern China spoke an Austroasiatic tongue. Questions have remained, though, about where Austroasiatic languages originated and whether knowledge about farming practices, rather than farmers themselves, spread from China into Southeast Asia.

DNA from ancient Southeast Asians provides "clinching evidence" for the spread of farming via southern Chinese groups, says archaeologist Charles Higham of the University of Otago in Dunedin, New Zealand.

DNA preserves poorly in hot, humid regions. A group led by study coauthor Ron Pinhasi, an archaeologist at the University of Vienna, recently found that human DNA in a skull bone surrounding inner ear structures survives best. In the new study, DNA was extracted from

that bone type in 18 skeletons unearthed at five Southeast Asian sites dating to around 4,100 to 1,700 years ago.

Farmers at Vietnam's Man Bac site about 4,000 years ago had a close genetic tie to modern Austroasiatic speakers, especially in southern China, Lipson's group says. About 25 to 30 percent of Man Bac farmers' ancestry came from hunter-gatherers, perhaps due to interbreeding of rice growers and foragers in southern China before any migrations occurred. Many populations today that speak Austroasiatic languages also display a similar genetic signature. Two of eight Man Bac farmers had genetic signs of additional hunter-gatherer ancestry, probably acquired in Southeast Asia.

At sites in Vietnam and Myanmar that are about 2,000 years old, farmers inherited a genetic makeup that differed from the makeup of the earlier Man Bac crowd, but still closely resembled the DNA of modern inhabitants of southern China. A second southern Chinese migration into Southeast Asia probably led to those DNA tweaks, the researchers say. ■

Kilauea won't cause mass harm

Major explosions aren't part of the volcano's repertoire

BY CAROLYN GRAMLING

A thick cloud of dark gray ash burst out of Kilauea's summit crater on May 17, reaching as high as nine kilometers into the atmosphere. A day earlier, several "ballistic" blocks, some as large as a toaster, shot out of the crater and rained down into the national park surrounding the Hawaiian volcano's summit.

The explosions were the most powerful yet in the latest eruptive phase of the world's most active volcano. Authorities issued advisories to residents of Hawaii's Big Island for ashfall and volcanic smog, or vog. Vog is a toxic haze that forms when sulfur dioxide erupted from a volcano reacts with sunlight, moisture, oxygen and other gases in the atmosphere.

The eruption has been dramatic, and an ongoing health hazard for local residents. It also wasn't a complete surprise: For about a week before the ash cloud erupted, the U.S. Geological Survey had warned that a steam explosion was becoming increasingly likely. Kilauea's summit crater has had such steam explosions before, most recently in 1924.

But there's explosive, and then there's explosive. Contrary to some social media reports, Kilauea is not about to become another Krakatoa, the Indonesian volcano that erupted powerfully in 1883 and killed tens of thousands of people.

One reason that Kilauea and Krakatoa are so different in their explosiveness is



Kilauea is no Krakatoa, but the Hawaiian volcano's ongoing eruption is a danger to local residents. Lava flows reacting with ocean water form corrosive clouds known as "laze," shown here on May 21.

silica. Krakatoa, which last erupted in 2017, is a stratovolcano, with tall, steep sides made of ash and lava. Its magma is relatively high in silica. The high silica concentration makes the magma more viscous, or resistant to flow, so any gases it contains struggle to expand. But the change in pressure when the magma reaches Earth's surface means the gases can suddenly expand — explosively.

Kilauea, by contrast, is a shield volcano: Its magma is relatively low in silica and flows easily, oozing out in characteristic ropy flows called pahoehoe and thick, blocky flows called aa. Kilauea's magma also tends to be lower in gas concentrations, and what gas there is finds it easier to escape, so less pressure builds up within the magma. As a result, the volcano is far less likely to explode.

Kilauea has been erupting more or less continuously from a vent on its eastern flank called Pu'u O'o since 1983. But in April, the volcano entered a new eruptive phase when a series of fissures opened in a different area of the volcano's lower east rift zone — a region that is right in the middle of a populated neighborhood. In May, over 1,700 residents were evacuated as lava swallowed houses, roads and cars.

This new phase does represent a dramatic change in character for the volcano, says Erik Klemetti, a volcanologist at Denison University in Granville, Ohio. Kilauea had been "doing the same thing, constantly, for the last 35 years," he says. "Now it's having more explosive eruptions that it hasn't had in over a hundred years, and it's moved to a new location. It will take a while to figure out why."

Another change was happening at

the volcano's summit. On May 15, USGS scientists told reporters that a lava lake once visible within the caldera had completely sunk out of sight. That was a cause for some concern, the scientists said: As the magma drops further within the central column of the volcano, rocks forming the column may become unstable and topple into the magma. Meanwhile, groundwater in the rocks around the column may also seep in. That potent mix of water and hot rocks could produce steam explosions that could send rockfall shooting back out of the crater.

Such a process may have been responsible for the ballistic blocks observed on May 16. The good news: These blocks have a limited range; they won't travel past the bounds of the national park surrounding the summit, USGS officials said. Much of Hawaii Volcanoes National Park has been closed since May 11.

For people on the Big Island, ash and vog remain the biggest hazards, depending on which way the wind is blowing. In addition to respiratory concerns, ash can make roadways slick and contaminate water reservoirs. Another potential hazard is laze, or lava haze — a corrosive cloud containing hydrochloric acid and tiny particles of glass that forms when molten lava enters seawater. And sulfur dioxide continues to leak from the fissures on Kilauea's lower east rift zone, a concern for nearby communities.

Still, it's important to keep the eruption in a global and historical perspective, Klemetti says. The May 17 explosion at Kilauea's summit was big for the Hawaiian volcano but not so large compared with other eruptions, he says. "The scale of an explosive eruption is important." ■



On May 17, a U.S. Geological Survey webcam recorded this spray of ash from an explosive eruption at Kilauea's summit crater.

LIFE & EVOLUTION

Green blood has a surprising history

Odd color probably evolved 4 times in New Guinea's lizards

BY SUSAN MILIUS

Green blood is weird enough. But now the first genealogical tree tracing green blood in New Guinea's *Prasinohaema* lizards suggests something even odder.

These skinks have been lumped into one genus just because of blood color, says Christopher Austin, a biologist at Louisiana State University in Baton Rouge. Yet they don't all turn out to be close relatives. Green blood looks as if it arose four separate times in the island's lizards, he and colleagues propose May 16 in *Science Advances*.

These lizards do have crimson red blood cells, but that color is overwhelmed by extreme buildups of a green pigment called biliverdin at levels that could kill other animals (*SN*: 8/20/16, p. 4). Biliverdin forms as the oxygen-carrying hemoglobin molecules break

down in dead red blood cells. In humans, biliverdin is converted into bile, which, in excess, causes yellow jaundice.

To figure out how such a peculiar trait evolved, Austin's group compared segments of DNA and reconstructed the evolutionary history of green-blooded lizards and some close relatives. The greens didn't emerge as a single cluster but were scattered among the reds. The most probable explanation is that green blood evolved independently multiple times, Austin says. The team is now working out the full sequences of lizards' DNA building blocks and hoping to spot clearer evolutionary clues, such as particular mutations that helped red turn green. Austin hopes this research eventually will yield insights into human bile disorders.

High circulating biliverdin hasn't turned up in the blood of other reptiles,



A new family tree reveals that some of New Guinea's green-blooded lizards are not that closely related to each other.

mammals or birds. Older papers, however, argue for high biliverdin in some insects, a few fish families and two kinds of frogs.

Whether the pigment offers any advantage is a mystery. When Austin started studying lizards, he wondered if green blood would deter predators. "I tested the hypothesis by eating a few lizards myself and also feeding lizards to native birds and snakes," he says. "No ill effects." Now he's musing that biliverdin might discourage blood parasites such as malaria pathogens.

And the taste of a green-blooded lizard? "Like bad sushi," he says. ■

NEWS IN BRIEF

GENES & CELLS

Type A blood gives *E. coli* an assist

E. coli has a type and it isn't pretty. The bacterium is more likely to cause severe diarrhea in people with type A blood.

An illness-causing strain of *E. coli* secretes a protein that gloms onto the sugar molecules that decorate type A blood cells, but not type B or O. These sugar molecules also decorate cells lining the intestines of people with type A blood and appear to provide a handle for the bacterium to latch onto before releasing its diarrhea-causing toxins. A team led by researchers at Washington University School of Medicine in St. Louis reports the findings online May 17 in the *Journal of Clinical Investigation*.

In the study, 106 volunteers drank water laced with a strain of *E. coli* isolated from a person with severe diarrhea. Within five days, 81 percent of the type A or AB volunteers developed moderate to severe diarrhea; roughly half the people

with blood types O or B did. (Everyone received antibiotics to clear the *E. coli*.)

This discovery suggests that a vaccine targeting the bacterial protein — found in many *E. coli* strains — could be effective. That would help travelers as well as kids in the developing world, where repeated infections are linked to malnutrition and stunted growth. — Rachel Ehrenberg

EARTH & ENVIRONMENT

Satellite data back theory of North Korean nuclear site collapse

A new analysis indicates that North Korea's underground nuclear test site has at least partially collapsed.

Seismologists have been tracking the clandestine nuclear weapons program by analyzing vibrations that emanate from explosions at the test site under Mount Mantap (*SN*: 8/5/17, p. 18). Now, researchers have paired 3-D satellite images of Mount Mantap with seismic data to simulate how the mountain's interior might have changed after a hydrogen bomb test on September 3, 2017.

The simulations indicate that the blast, which set off a magnitude 6.3 earthquake, caused a cave-in above the detonation site, researchers say online May 10 in *Science*. A second rock collapse, about 700 meters south of the site, may have then caused a smaller quake.

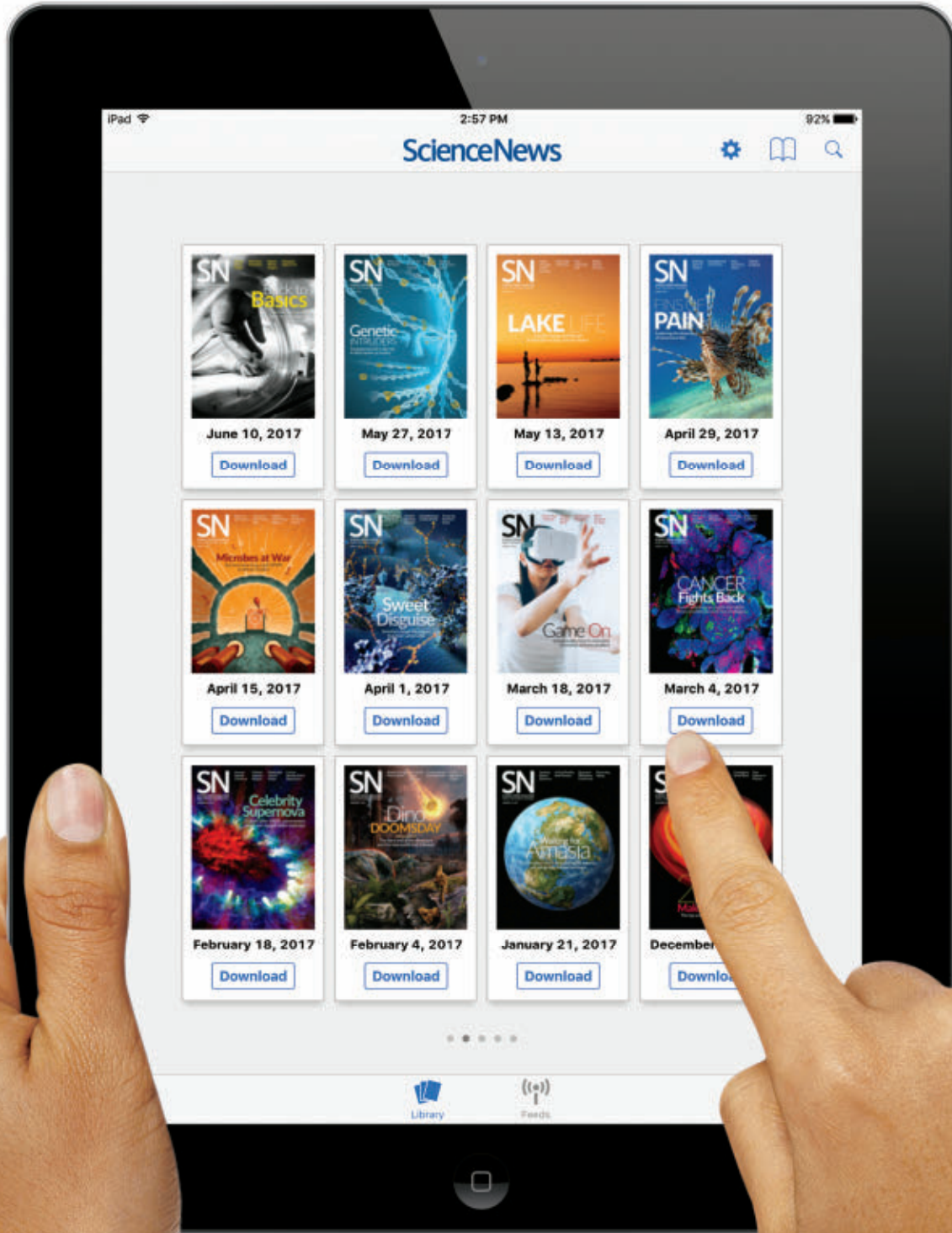
The rockfalls, which caused the top of Mount Mantap to sink half a meter, could have buried part or all of the test facility, rendering it unusable, says study coauthor Teng Wang, a remote-sensing researcher at the Earth Observatory of Singapore.

The results support a paper published online April 27 in *Geophysical Research Letters* that suggested a Mantap collapse. That study led some media to speculate that the real reason North Korea pledged in April to halt nuclear testing was because the test site was no longer usable.

Ultimately, experts would have to inspect the site to confirm the facility is out of order, says Douglas Dreger, an earth scientist at the University of California, Berkeley and coauthor of the study in *Science*. — Maria Temming

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FASHION FORWARD

Advanced textiles may add serious gadgetry to clothes

By Maria Temming and Mariah Quintanilla, Illustrations by James Provost



In the future, leaving your phone charger at home will mean only one thing: You forgot to put on pants.

Just as smartphones untethered users from their desktop computers, smart clothing is poised to bring personal electronics out of our pockets and onto our sleeves.

The current generation of wearable technology that includes smart glasses and watches is still more marginal than mainstream. Google Glass fizzled out, and nearly a third of the people who buy fitness trackers lose interest over time. But gadget-packed garments may have an edge when it comes to seamless integration into our lives.

“One conference, somebody stood up and [said], ‘I get that wearable technology is a thing, but I just don’t think I’m going to be willing to get up every single day and remember to put something on,’” recalls wearable technology researcher Lucy Dunne. “I looked at her and said, ‘You’re wearing clothes right now. I’m pretty sure you do that already.’”

Plus, technology-laden clothing is “right next to and against your body. It has a large surface area compared to personal devices, and it goes with us everywhere,” says Dunne, of the University of Minnesota campus in St. Paul. “That kind of access is...rich with opportunity.”

Some advanced apparel is already for sale, like gloves threaded with heat-conducting wires to warm fingers on extra cold days, or bathing suits equipped with UV sensors to alert suntanners when they are close to overbaked. But engineers have set their sights on a vast menu of souped-up clothes that could make daily life more convenient — or just better looking.

Job one, though, is to refashion conventional electronics. Typical battery packs and digital displays are too rigid and heavy for weaving into everyday duds. Engineers are getting creative to make lightweight, flexible devices that keep clothing comfortable and still perform as well as their clunky counterparts. Once researchers have built something that works well and is reasonably wearable, they still have to make sure their stuff is sturdy enough to withstand daily wear and tear, not to mention runs through the laundry.

Most next-gen clothing is years away from hitting retail racks. In fact, a lot of the tech hasn’t left the lab yet. But fashionistas and gearheads can look forward to a future where electronic clothes are in vogue. Here’s a sneak peek.

1. Change your fashion on the fly

Clothing woven from color-changing yarns could give a whole new meaning to the phrase “goes with anything.”

Most existing color-changing textiles, like sun-activated T-shirts with designs that go from white to rainbow, are triggered by shifts in ambient lighting or body heat. Now, researchers have created clothes that change color with the tap of a smartphone screen.

These garments, presented April 4 in Phoenix at the Materials Research Society spring meeting, are made from yarns as thick as a few strands of human hair. Each yarn comprises a copper wire sheathed in a polymer sleeve. The polymer could be polyester, nylon or some other material, depending on how soft or sturdy you want your fabric, says optics and photonics researcher Joshua Kaufman, a codeveloper of the yarns at the University of Central Florida in Orlando.

The polymer sleeves are laced with pigments that shift color in response to temperature changes too subtle for the wearer to feel. The wearer controls the clothing’s appearance by sending Wi-Fi signals from a smartphone to a battery attached to

the garment. The battery feeds electric current into the yarn's copper wire, heating the pigment to activate a color switch. These yarns could make clothes that rotate between solids, stripes, plaids and other patterns.

Fashion trendsetters and people who just can't decide what to wear in the morning probably stand the most to gain from this technology.

But it could have benefits for the rest of us, too. Spilled food on your light-colored shirt at lunch? Hide the stain with a darker hue. Want to wear a lighter shade when you're out in the sun or biking home in the dark? Tap an app. Need to sneak in a second-day wear after skipping laundry day? No problem.

This kind of fabric could also be used for bags, car upholstery, curtains and furniture, says optics and photonics researcher Ayman Abouraddy, also at Central Florida. "We don't anticipate more than a year or two before you could buy something [made of these fabrics] from the mall," he says.

2. Never forget your ID or keys

Someday, you may be able to embellish your clothes with enough data to get you in the building.

Researchers have created passcode-storing clothes made with thread that contains silver or copper filings. Normally, the magnetic poles of atoms in those metallic threads are pointed in random directions. But holding a magnet close to the thread aligns all the poles in a single section of cloth to point either north or south. Those magnetic orientations encode a bit of data, a 1 or 0, which an instrument called a magnetometer can read.

This data-embedded fabric, presented last October in Quebec City at the Association for Computing Machinery's Symposium on User Interface Software and Technology, holds onto its magnetic information through washing, drying and ironing—at least for the short term. The strength of the data signal wanes by about 30 percent over the course of a week.

The material can be remagnetized with the same or a different pattern of 1s and 0s, but the researchers first have to build a device that can rewrite this data, similar to the tech used to reprogram hotel keycards, says Justin Chan, a computer scientist and engineer at the University of Washington in Seattle.

Chan and Washington colleague Shyam Gollakota have written magnetic codes into neckties, belts and wristbands, but the tech is still in the nascent stage. Right now, each 1 or 0 is about 2 centimeters across. The researchers are working on packing more data into smaller swatches, Chan says.

Once data-storing clothing is available, you could simply scan your sleeve to enter your office or apartment building. To some people, that may not seem like much of an advance. But the forgetful types who misplace their keys every other



Superthin, flexible motion detectors (like the sheet of sensors above) could be embedded in clothing to monitor wearers' posture or movements during physical therapy.

day might appreciate one less thing to scramble for on the way out the door.

3. Micromanage your moves

Training yourself to drive a golf ball, play piano or just sit with better posture could get a whole lot easier, thanks to motion-sensing clothes that detect the slightest twitch.

"If you want to know exactly what somebody's doing—whether or not they're bending their knee in a healthy way, or what their heart rate and muscle activity is telling you about their emotional state—then you need sensors everywhere," Dunne says.

To that end, industrial engineer Joshua DeGraff and colleagues have

built superthin motion detectors that can be embedded in anything from shoulder braces to shoe soles.

The key component of these sensors is a sheet of material called buckypaper—a dense mesh of carbon nanotubes about as thick as a red blood cell is wide. Normally, buckypaper conducts electricity with no problem (*SN: 3/8/14, p. 18*). But stretching the material creates gaps in the nanotube network that stymie the flow of electric charge. DeGraff's team at Florida State University in Tallahassee is using that weakness as an advantage. Connecting a piece of buckypaper to a circuit and measuring changes in electrical resistance across the paper can reveal how much the buckypaper has been stretched.

Sensors fashioned by DeGraff's team register as little as a 0.005 percent change in material length. The sensors,



described last November in *Materials and Design*, could be powered by watch-sized batteries, DeGraff says.

Buckypaper sensors could prove useful for people who need to micromanage their movements in the short term — like physical therapy patients whose rehab requires them to move in exactly the way their therapist prescribed.

4. Add light to your life

Light-up clothes of the future will look and feel less like your uncle's ugly Christmas sweater and more like the sleek suits in the movie *Tron: Legacy*.

Actress Claire Danes lit up the 2016 Met Gala in a gown laced with LEDs. But standard, semiconductor-based LEDs are too stiff and brittle to make comfortable daywear, says Seonil Kwon, an engineer at the Korea Advanced Institute of Science and Technology in Daejeon, South Korea. Organic LEDs, or OLEDs, on the other hand, are razor-thin and superpliable.

An OLED display contains a layer cake of organic, or carbon-based, material films. The OLED lights up when a power source — like a battery — drives electric charge from one layer of organic material to another, where negative electrons pop into positive holes in the material. Whenever a positive hole and negative electron pair off, they release a brief flash of light. Many positive-negative meetups per second keep the OLED lit.

OLEDs are typically built on panes of plastic or glass, but Kwon and colleagues have created OLEDs on fabric. The researchers lay these OLEDs, just 200 nanometers thick, atop a polyester film that's laminated onto fabric made of tightly woven, superfine polyester fibers. The setup is more flexible than the plastic platforms used to make bendy displays.

The new fabric-based OLEDs are bright enough to rival current display technology, Kwon and colleagues reported last July in *Scientific Reports*. Each OLED emits only a single color, but engineers could make fabric-based screens with many color-changing OLED pixels to display messages. Kwon's group made OLED threads too, for lettering and patterns, reporting the work in the Jan. 10 *Nano Letters*.

Are there consumers who find the act of pulling a phone from their pocket so burdensome that they want to tote a smartphone screen on their sleeve? Who knows. But clothes sporting single-color OLEDs could light up pedestrians and bikers at night. Kwon also imagines creating OLED garments that glow white to provide light therapy. Some people who



suffer from seasonal affective disorder find relief by sitting near a special lamp called a light therapy box, which gives off white light to mimic outdoor sunlight (*SN*: 4/23/05, p. 261). A shirt or underside of a hat brim that glows white could offer light therapy that goes where you go.

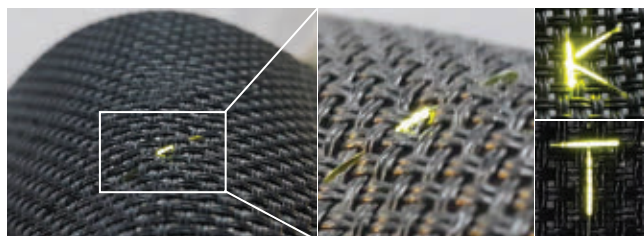
5. Power up with sun and your moves

After a full day's work, "no one wants to have to take off their shirt and plug it in," says Rajan Kumar, a nanoengineer at the University of California, San Diego. Long battery life in smart clothing is key. So why not design wearables that continuously convert sunshine and motion energy into electricity?

Researchers debuted this kind of energy-harvesting fabric in 2016 in *Nature Energy*. Primarily made of synthetic polymers and wool fibers, the fabric is lightweight, flexible and breathable. A 4-by-5-centimeter piece worn for a run in the sun can charge up a cell phone, says Stanford University materials scientist and engineer Jun Chen, who did the work in the lab of Zhong Lin Wang at Georgia Tech.

The sunlight-catching patches of fabric are threaded with photovoltaic wires. When sunshine strikes a wire, light particles knock electrons out of atoms in one layer of material, leaving behind positively charged holes. Another electron-conducting layer of the wire collects those loose electrons, while a third layer gathers up the positively charged holes. That charge separation creates a voltage to produce electricity that can power devices.

Meanwhile, other patches of this fabric transform the energy of motion into electricity. These swatches contain strips of a polymer called PTFE — which hoards electrons — interlaced with copper wires — which easily give up electrons. Whenever the fabric is folded or compressed, some of the copper wires' electrons rub off on the PTFE strips.



Engineer Seonil Kwon and colleagues created organic LED threads that glow yellow when turned on (shown) to make light-up garment patterns.

This process builds up static charge, just like combing your hair or peeling off a sweater in the winter. When the fabric relaxes, the negatively charged PTFE strips separate from the positive copper wires, creating voltage to power devices. Strips of this material could be sewn into sleeves to generate energy from the swing of your arms, or into the soles of shoes to get energy from footsteps, says Georgia Tech's Wang, a materials scientist and engineer.

The energy this fabric gathers up when you're moving around or sitting in the sun could also be stored in a capacitor or battery attached to the garment (SN: 11/26/16, p. 5). The storage device might be made of ink containing zinc-silver oxide printed directly onto clothing, as described in 2017 in *Advanced Energy Materials*. Or perhaps the energy could be stored in zinc-ion yarn batteries, like ones reported in the April 24 *ACS Nano*.

This energy-harvesting material could also be built into tents that, when bathed in sun or rustled by wind, could charge campers' devices.

6. You as a walking generator

If clothing were packed with thermoelectric generators, body heat could be turned into electricity.

Researchers at North Carolina State University in Raleigh work with a button-sized generator containing a grid of semiconductor rods sandwiched between two ceramic plates. When one side of the generator is hotter than the other — say, when that side is close to your skin while the other is exposed to air — electrons at the warm end of each semiconductor rod get jittery. These electrons diffuse toward the cold side of the device, creating a tiny voltage across the rod. Connecting the positive end of each rod to the negative end of the next adds up these voltages like stacking batteries in a flashlight.



Daryoosh Vashaee, an electrical engineer at NC State, and colleagues embedded these thermoelectric generators in a T-shirt. If someone wearing the shirt is just sitting around, the generator doesn't produce much power because the temperature difference between skin and the surrounding air is so small. But if that person gets up and walks or jogs, a boost in body temperature will heat the side of the generator inside the T-shirt, while wind cools the exposed side of the generator. In one test, the generators pumped out six microwatts of power per square centimeter when the wearer was walking and $18 \mu\text{W}/\text{cm}^2$ during jogging, the researchers reported in 2016 in *Applied Energy*.

Unfortunately, that's nowhere near enough to power a smartwatch or a phone. But generators a couple centimeters across could feed low-power sensors like heart monitors. And researchers are trying to boost the generators' efficiency to support more power-hungry electronics. If researchers can make thermoelectric generators better powerhouses even when a wearer is seated, this tech would have one advantage over sunshine-motion harvesting clothing: You could power up your stuff while vegging out on the couch. ■

Explore more

- Wen Wang *et al.* "Harnessing the hygroscopic and biofluorescent behaviors of genetically tractable microbial cells to design biohybrid wearables." *Science Advances*. May 19, 2017.

Mariah Quintanilla is a former intern at Science News and now a freelance illustrator based in Northern California.



RISKS AND RIDDLES



Health risk results from genetic testing have a lot riding on them **By Tina Hesman Saey**

Results from Family Tree DNA, a genetic testing company, helped Lara Diamond find a branch of her family she thought had been lost in the Holocaust. Those 2012 results brought dozens of new people into her life.

Eager to find more relatives, Diamond, now 42, a professional genealogist in Baltimore, decided to try out all the companies that offer genealogical DNA testing to see what else she could learn. Results from one of them, 23andMe, hit her with an entirely different kind of life-changing knowledge: a high risk for breast cancer.

Browsing through the health and trait reports the company provides, Diamond reached the locked reports, which contain information about genetic variants that increase risk for developing breast cancer, Alzheimer's disease or Parkinson's. Customers have to choose to "unlock" that information since it can bring upsetting news.

Diamond considered her family history. "Because we have Alzheimer's and Parkinson's in my family, I said, 'OK, I'll think about those. But

we don't have breast cancer, so I'll open this *BRCA* thing,'" she says, referring to the family of genes linked to breast cancer.

To her shock, Diamond learned she has a variant in her DNA that alters one amino acid in the *BRCA2* protein, putting her at high risk for the disease. "One little stupid mutation. One amino acid. And it changes your whole life."

The next morning she called her doctor, who sent her to a genetic counselor. The counselor ordered a confirming DNA test from a lab certified to do medical diagnostic testing. Diamond also got a mammogram, an MRI, an ultrasound and blood work to screen for breast, ovarian and pancreatic cancers, because her variant boosts risk for all three. The MRI revealed a tiny spot of cancer deep in her breast, too small for the mammogram to detect. She decided to have a double mastectomy.

Her doctors are urging her to have her ovaries and fallopian tubes removed as well, to head off ovarian cancer. "I'm not ready to do that yet," Diamond says.

Now that Lara Diamond has been through a cancer diagnosis, she advises others on how to deal with the personal health information uncovered in genetic testing.

MATTHEW RAKOLA

Genetic testing goes mainstream

This feature is the second part of a series across three magazine issues on consumer genetic testing.

LAST ISSUE

An Open Book

Getting a read on your DNA sparks more questions than answers

THIS ISSUE

Risks and Riddles

When it comes to health, genetic testing results have a lot riding on them

JUNE 23, 2018

Finding Family

When your ethnic background depends on the test you take

For these stories and more, visit bit.ly/SN_DNAdelege

Diamond had been mostly interested in what her genes could reveal about her family history, not the health information they hold. But millions of genetic testing customers want to know their medical future. Even though most consumer genetic testing companies collect data on thousands of gene variants that may have an impact on health, companies such as 23andMe are allowed to give only limited information about genetic health risks. The companies' reports focus mainly on ancestry or basic physical traits (*SN*: 5/26/18, p. 20).

So the marketplace has devised a work-around: Consumers who want to know about their risks for diabetes or several other diseases can turn to third-party services to analyze the raw DNA results generated by testing companies. New research suggests, however, that some of the answers people find through these third-party services are wrong and could prevent people from listening to their doctors or genetic counselors. That is, if the person bothers to go see one.

The market responds

Diamond got her health-related results in 2013, just before the U.S. Food and Drug Administration told 23andMe to stop giving consumers health information. The company had to demonstrate to the FDA that the information it provides is accurate and communicated in an easy-to-understand way. In 2017, 23andMe won approval to slowly add back reports for certain health conditions.

Most recently, in March, the FDA granted approval for the company to tell customers if they have one of three genetic variants in the *BRCA1* and *BRCA2* genes. Those three variants are responsible for about 74 percent of inherited breast cancers among people of Ashkenazi Jewish heritage. Less than 0.1 percent of people of other ethnicities carry these variants.

Offering information on only three variants, when there are thousands in the two genes that increase risk for breast and ovarian cancers — as well as melanoma, prostate and pancreatic cancers — is troublesome, say health care providers, breast cancer advocacy groups and others.

With only a partial list of variants called out, test takers who don't carry one of those variants may misinterpret the results, worries Lisa Schlager, vice president of community affairs and public policy for FORCE, a hereditary breast cancer information and support group.

People who don't carry one of the variants may say, "I don't have a genetic risk that predisposes me to cancer. I'm safe," Schlager says. "But that

is absolutely not correct; you are only negative for three out of thousands of possible mutations. So our concern is that the public is not going to understand the limitations."

Yet Schlager and others admit that allowing companies like 23andMe to provide FDA-approved information and explain the results — however incomplete — may be the lesser of two evils.

"There's a sort of underworld that's been going on since the FDA stopped 23andMe from interpreting these results and giving them out to people," Schlager says. For a small fee, third-party analysis services stand eager to offer the interpretation that testing companies choose not to provide, or aren't allowed to provide under FDA rules. These services include Promethease, an early player in the consumer raw data analysis market, along with Genetic Genie, LiveWello and many, many others.

That's possible because customers of direct-to-consumer DNA testing services such as 23andMe, AncestryDNA and FamilyTreeDNA can download their raw DNA data to send to third-party analysis sites or apps. Those raw data consist of a list of spots, known as SNPs (pronounced "snips"), where customers' DNA varies. Some third-party analysis services will also look at a wider swath of information, data on protein-coding regions, called the exome. Genos is one testing company that provides raw data on the exome.

Helix, a testing company that provides "exome plus" data, has partner apps that customers can buy to analyze limited sets of their data. (Or, for \$499, you can download all of your raw data). So far, very few of the third-party analysis services are set up to process data from the entire genetic instruction book, or genome.

To write their reports, Promethease and the others find scientific studies that mention the genetic variants a customer carries and make inferences about the health risks of carrying those variants. "That has been an absolute nightmare," Schlager says. Consumers don't understand the information and often overreact.

Devil in the data

In Facebook groups for people with *BRCA* mutations, Diamond, who volunteers with FORCE, often encounters people who got a scary result from a third-party analysis site. "I have to talk a lot of people off the ledge," she says. "They will upload their data and these services tell them, 'You're *BRCA2* positive.' They understandably freak out." Many of those people would get an entirely different answer from medical diagnostic testing, she says.

“Don’t schedule any surgeries or screenings until you can talk it over with a professional.”

STEPHANY TANDY-CONNOR

Diamond makes a good point, says Stephany Tandy-Connor, a genetic counselor at Ambry Genetics in Aliso Viejo, Calif., the kind of clinical diagnostic company that doctors use for testing. She and colleagues examined test results of 49 people who received worrisome reports based on raw data generated by direct-to-consumer genetic testing companies between January 2014 and December 2016.

The people had gotten a doctor’s order to get retested by Ambry. The company did comprehensive testing of the supposedly faulty genes. More than half of the harmful variants (60 percent) flagged by consumer tests were verified by Ambry’s clinical test. The problem was, 40 percent of the harmful variants were false positives, the researchers reported March 22 in *Genetics in Medicine*. The results misstated that the people carried the variant when they actually didn’t.

The fault doesn’t lie with the third-party analysis service, Tandy-Connor says. Those companies simply analyze the raw data received from consumer testing companies. The errors were in the raw data. Often the testing companies are aware of the mistakes, but when they don’t use that information themselves, they don’t always bother clearing errors from the raw data, Tandy-Connor says.

Plus, the raw data don’t contain a full draft of a patient’s genome, as some consumers mistakenly think, Tandy-Connor says. Those data report only a few genetic spelling variations. Clinical testing labs, such as Ambry, use several methods to examine and reexamine disease-related genes to uncover all possible harmful variants. If each gene is a chapter in the body’s instruction manual, clinical tests read every letter in that chapter hundreds to thousands of times, Tandy-Connor says.

Clinical labs also check to see if paragraphs or even pages have been ripped out or glued into the

chapter. Such missing or added information, known as structural or copy number variants, might affect more than one gene (*SN*: 4/25/09, p. 16).

Contrast that approach with the genotyping, or SNP testing, provided by 23andMe, AncestryDNA and many other direct-to-consumer companies. “Basically they don’t read the whole chapter,” Tandy-Connor says. “They just spot-check three or four letters and don’t even look at the rest of it.”

Filling a gap

In 2006, even before 23andMe started offering consumer DNA tests, geneticist Greg Lennon and bioinformatician Mike Cariaso wanted to learn more about their own DNA. The two compiled SNPedia, a Wiki-style database of SNPs that are linked to diseases and traits in the scientific literature. Lennon and Cariaso’s app, Promethease, uses SNPedia to compile reports about the genetic variants in a user’s raw data.

The reports consist of long lists of variants with a description of what the scientific literature says about each variant. So even though 23andMe and other companies may not be allowed to give customers that information, Promethease can. Lennon says the difference is that his service doesn’t generate any DNA data. He simply serves up scientific literature pertaining to the data.

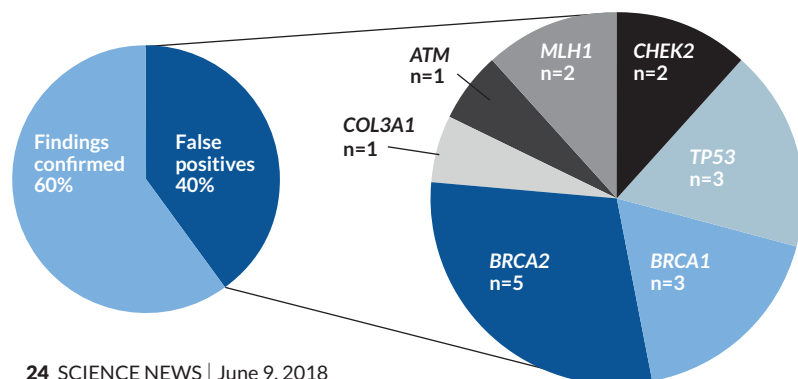
“If the science is credible, we’ll tell you about it,” Lennon says. “We are not going to suppress information.” It’s then up to the customers, their doctors and genetic counselors to decide how to proceed. “The flip side is that it’s easy for someone to misinterpret what they see in a Promethease report and panic over it,” he admits.

Consumers shouldn’t just assume that the information contained in their raw data is correct, or that third-party services have interpreted it correctly, Tandy-Connor says. In fact, genetic testing companies say buyers should beware of using raw data as medical information.

“Uninterpreted raw genotype data, including data that are not used in 23andMe reports, has undergone a general quality review. However only a subset of markers have been individually validated for accuracy,” Dave Hinds, a statistical geneticist at 23andMe wrote on April 23 in an “Ask Me Anything” forum on the website Reddit.

Genetic results should be confirmed in a clinical lab, Tandy-Connor adds. And, importantly, the information needs to be evaluated in the context of a person’s overall health and family history. “Take it to your doctor. Take it to a genetic counselor or some other genetic professional,” she

False alarm A clinical lab checked worrisome results that people received from consumer DNA testing companies. Of the variants flagged as harmful, 40 percent were false positives. All but one of the bad calls were in cancer risk genes: *BRCA1*, *BRCA2*, *TP53*, *CHEK2*, *MLH1* and *ATM*. SOURCE: S. TANDY-CONNOR ET AL./GENETICS IN MEDICINE 2018



says, “Certainly don’t act on it. Don’t schedule any surgeries or screenings until you can talk it over with a professional.”

Lennon doesn’t quibble with that advice. “We are 100 percent in agreement that anything seen in a consumer test should be confirmed,” he says.

But the message consumers take away from the Ambry study could have the opposite effect, he says: encouraging people to ignore the results of a consumer test.

“To say there are 40 percent false positives may dissuade people — people who are really carrying mutations — from having these things clinically checked out,” Lennon says. These people might think their result is also a false positive. “That kind of blanket message is a huge disservice to people who might otherwise have actually gone in and gotten confirmatory screening.”

Tandy-Connor disagrees. “I can see the angle he’s coming from, but I don’t share the same sentiment. I’m fairly confident most people would follow up. I mean, why else are they even doing this in the first place? If you’re not going to do anything about it, what was the point? Just freak yourself out and walk away?” Not likely.

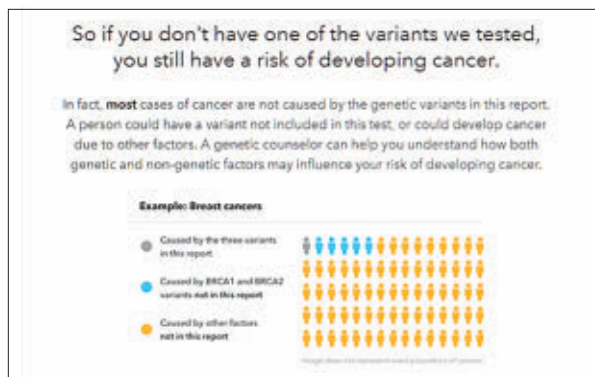
Matters in their hands

Consumers are using these third-party apps, but, according to a recent study, at least some people are taking their results to doctors and genetic counselors, says Catharine Wang, a behavioral scientist at Boston University School of Public Health. In an online survey on several social media sites, Wang and colleagues found that of 478 people who did a direct-to-consumer genetic test, 321, or more than two-thirds, used third-party analysis services to investigate ancestry or health information or both.

About 30 percent of those 321 people shared their results with a medical provider and 21 percent shared results with more than one provider, the researchers reported last year in *Molecular Genetics & Genomic Medicine*. Wang wasn’t surprised that not everyone brought their results to their doctors. “If you don’t find anything in your results, you’re not going to show it to your doctor,” she says. The study did not determine what percentage of people got a worrying result.

Those people who did tell their doctors about their results weren’t always happy with the responses. Doctors were dismissive, weren’t interested in the results or didn’t know what to do with them, 23 percent of respondents reported. Other times, patients had to educate their physi-

Risks explained Customers of 23andMe who want to unlock information on their breast cancer risk must click through several screens of information before learning the result. This screen explains that risk goes beyond the three variants reported.



cians about DNA testing. Some consumers went straight to genetic counselors.

In a separate online survey of 85 genetic counselors, about half said that they had been contacted by people who had used a third-party interpretation service, Wang and colleagues reported January 29 in *Translational Behavioral Medicine*. Counselors reported that patients turned to raw data analysis for several reasons: to get answers about mysterious symptoms, out of curiosity or to find out more about their health risks, including disease risks that the patients might pass on to their children.

According to the counselors, sessions didn’t always go well. “They were encountering resistance from the patient,” Wang says, as the counselors tried to correct misconceptions. Some consumers were overconfident about their knowledge, even when they were wrong. When counselors attempted to explain how DNA testing works and that raw data may contain errors, some people didn’t want to hear it. “Consumers just don’t know these nuances,” Wang says. “Sometimes they’re just not receptive to the information.”

Some third-party interpretation services get into shady territory. LiveWello and Genetic Genie sometimes suggest clients take various vitamin supplements based on variants in certain genes. Some of the supplements are supposed to control DNA methylation, an important part of gene regulation, and reduce levels of a chemical called homocysteine in the blood. DNA methylation is a complex and delicately balanced system. Messing with it could cause problems.

Plus, methylation can’t be gauged by looking at someone’s DNA variants, says Preston Estep III, cofounder and chief scientific officer of Veritas Genetics. “SNPs cannot tell you — no amount of

genetic information, actually, can tell you — what the state of your DNA methylation is,” Estep says.

To be fair, the LiveWello website says it is not giving advice and people should talk to their doctors before taking supplements. But the disclaimer is easy to overlook.

The tendency is to think that any change to DNA

automatically means disease. But that’s not the case, says Gail Jarvik, a clinical medical geneticist at the University of Washington in Seattle. Some genetic diseases affect a small subset of people who carry the variants. For instance, just 24.4 percent of men and 14 percent of women who have two copies of a variant in the *HFE* gene will develop hemochromatosis, an organ-damaging iron buildup, Jarvik and colleagues reported in 2015.

Even for DNA changes that are strongly linked to disease, like those in the breast cancer genes, disease is not definite, Jarvik says. About 72 percent of women who carry a cancer-associated variant in the *BRCA1* gene and 69 percent of women with a harmful *BRCA2* variant will develop breast cancer by age 80, researchers reported last year in *JAMA*. “But a bunch of these women will never get breast cancer, even if they live a long life,” Jarvik says.

Because of the 23andMe test, Diamond knew her odds of getting breast cancer were high. But until her doctors found the cancer, she didn’t know if she might escape genetic fate.

“During the time between getting the 23andMe results and the cancer results I did a lot of, ‘Do I even want to know this?’” Diamond says. Ultimately, she is glad she knew. “They talk about early detection, but this was super early. Nothing on the mammogram. Nothing that you could feel. It’s the best-case scenario for having cancer, I guess.”

Diamond told her extended family that she carries a cancer-causing *BRCA2* variant and suggested they get tested, too. Many more people in Diamond’s family turned out to carry the variant than expected for a genetic change that has a 50/50 chance of being passed on to the next generation. “We just lose the coin flip a lot,” she laments.

Diamond says she never would have known she was at risk for breast cancer if not for the consumer test. She’s now grateful she and her family have the information, but says she’s wary of getting similar information from a third party.

“There’s goodness in being able to get your raw data,” Diamond says. Uploading raw data from one ancestry site to another allows people to find more long-lost relatives. “But when you upload it to these other services to get medical information, that’s what’s more dangerous ... because people may interpret it for themselves incorrectly.” ■

Explore more

- Catharine Wang *et al.* “Consumer use and response to online third-party raw DNA interpretation services.” *Molecular Genetics & Genomic Medicine*. November 2, 2017.

A peek into the womb

Decades ago, pregnant women had to wait about 40 weeks before knowing much about their baby. But swiftly moving technology offers increasingly detailed peeks into the womb.

Beyond generating adorable 3-D ultrasounds of scrunched-up faces, researchers can now analyze a fetus’s full genome from a simple blood draw from mom. But these genome-wide prenatal tests are not ready for prime time, three medical organizations argued in a position paper in the January *Prenatal Diagnosis*.

The method is undoubtedly powerful. Scanning the entire genome can reveal DNA abnormalities that more limited genetic tests might miss. But scientists don’t know enough about the performance of these tests, or their pitfalls, to recommend routine use, wrote representatives from the International Society for Prenatal Diagnosis, the Perinatal Quality Foundation and the Society for Maternal-Fetal Medicine.

How to interpret the information these tests provide is not always obvious. Many genetic quirks have little or no influence on human health, and sifting through a mountain of genetic data to identify the important signals isn’t easy. So far, large studies that could reveal the utility of these tests simply haven’t been done.

Ethical and practical issues dog these whole-genome tests, too. Identifying a potentially fatal genetic abnormality can be straightforward. But often, the relationship between genetics and outcomes is less clear. Researchers are still figuring out how specific genetic changes — or more likely, combinations of many genetic changes — relate to genetically influenced disorders such as autism spectrum disorder or to a risk of dementia in the baby’s distant future. How doctors or parents should handle this murkier information is an open question.

And then there are the genetic quirks that shape traits irrelevant to health, such as future height or eye color. In a recent survey, the majority of over 1,000 obstetricians/gynecologists expressed concern about ordering genetic tests that could reveal nonmedical traits. These doctors also wondered if genetic information overload would boost parents’ anxiety, leading to unnecessary and costly treatments, researchers reported in 2016 in *Prenatal Diagnosis*.

That’s not to say whole-genome tests should never be used. The tests should be considered when doctors suspect a genetic abnormality that hasn’t been uncovered by other methods, the position paper notes. When this happens, it’s best to also look at the parents’ genomes to get a clearer picture of the genetic trouble. These tests ought to always come with lots of discussions between health care providers and parents, before and after testing. — *Laura Sanders*



ScienceNews for Students

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



Hard-to-burn ‘smart’ wallpaper even triggers alarms

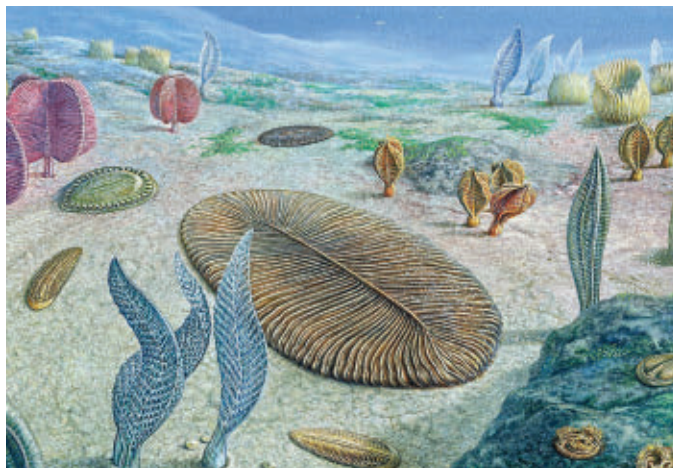
Wallpaper can transform the look of a room. A new type can also do double duty as a 24/7 fire sentry. This wallpaper is all but unburnable, and when it gets really hot, it can trigger warning lights and sound an alarm. One added benefit: It's nontoxic. Key to the new wallpaper is a network of nanowires inside it. The wires are made from hydroxyapatite, a mineral found in bones and teeth that is flexible on a nanoscale level. Researchers in China described their new wall covering March 13 in *ACS Nano*. The team hopes the product's traits will make it attractive for use in homes. — *Alexandra Taylor*

Read more: www.sciencenewsforstudents.org/wallpaper

Living Mysteries: Meet Earth's simplest animal

In the 1880s, scientist Franz Eilhard Schulze was one of the world's top experts on ocean sponges. Today, he is best known for discovering a drab animal no larger than a sesame seed. The animal had been hiding in one of Schulze's fish tanks. To this day, *Trichoplax adhaerens* remains the simplest animal known. A flat sheet three cells thick, it has no mouth, stomach, muscles, blood or veins. Yet *T. adhaerens* interests scientists because it shows what the very first animals on Earth might have looked like. The critter is even providing hints about how simple animals later evolved – with mouths, stomachs and nerves. — *Douglas Fox*

Read more: www.sciencenewsforstudents.org/simple-animal



Dirty air can harm your brain and stress the body

Emerging data show that air pollution can pose serious risks to anyone, including healthy children and teens. Pollutants too small to see can alter brain function. The pollutants can make it hard for kids to concentrate and can throw hormones – those chemical messengers that direct the body's activities – out of whack. In short, air pollution can seriously damage young minds and bodies. And over many years, scientists worry, these pollutants could place healthy young people at risk of developing high blood pressure, diabetes or even heart disease and strokes. — *Lindsey Konkel*

Read more: www.sciencenewsforstudents.org/dirty-air



EXHIBIT

Smithsonian traces the life cycle of an epidemic

In 1918, a pandemic of Spanish flu killed as much as 5 percent of the world's population. A hundred years later, scientists know much more about how to prevent and treat such diseases. But in some ways, the threat of a global outbreak is greater than ever. All it takes is one plane ride for a few localized cases of a disease to become an epidemic.

A new exhibit at the Smithsonian

National Museum of Natural History in Washington, D.C., traces the way infectious diseases still shape our world. The exhibit, called “Outbreak: Epidemics in a Connected World,” is centered around the concept of One Health — the idea that the health of humans, other animals and the environment are all intertwined, so protecting one requires protecting all (*SN*: 3/31/18, p. 20).

News coverage of disease outbreaks often focuses on the deaths they cause, notes Jonathan Epstein of EcoHealth Alliance, the exhibit's chief science adviser. One goal of the exhibit, he says, is “to give the public a look at how these things get started.” With that in mind, “Outbreak” highlights a handful of epidemics that have occurred in the last century, using each as a jumping off point to explore different aspects of preventing, tracing, treating and containing infectious diseases.

In addition to zeroing in on epidemics that have made international headlines, including Ebola and SARS, the exhibit features lesser-known diseases. Nipah virus, for instance, has infected people in Bangladesh who have drunk sweet date palm sap contaminated by infected bats. Simple

In a new Smithsonian exhibit, activist signs and buttons from the AIDS epidemic highlight some of the social consequences of infectious disease outbreaks.

preventive measures like encouraging people not to drink the raw sap or to filter it, so far, have prevented the virus from sparking an epidemic.

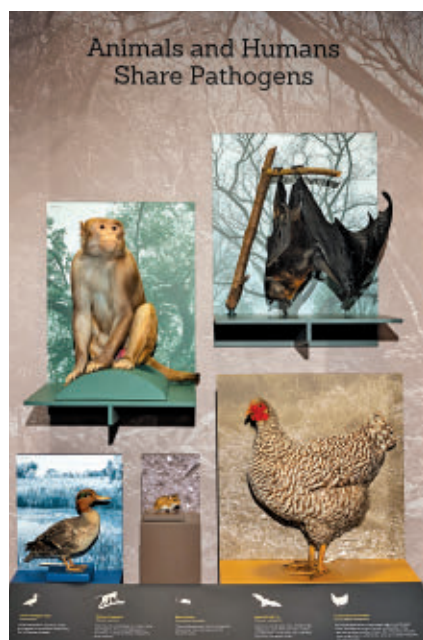
“Outbreak” is more focused on text and interactive screens than on artifacts, which makes sense given the microscopic subjects. But the exhibit does draw on the Smithsonian's extensive collections, showcasing arrays of preserved infectious disease vectors, such as ticks and mosquitoes, as well as bat and macaque specimens. As these display cases explain, monitoring the health of animal populations helps researchers put preventive measures in place before emerging infectious diseases can jump to humans.

As an entry point for discussing the social side of disease and the stigma that infected people can face, a collection of buttons and signs from AIDS

activists recalls the fight for public recognition and government action in the 1980s and '90s.

The content on display might not be a good fit for very young children, but interactive games and activities throughout increase the exhibit's overall kid appeal. In one game, played on touch screens, players each pick from a variety of roles — such as epidemiologist, wildlife biologist or community worker — and then cooperate to complete tasks that stem the tide of a fictional outbreak. (It's a good example of the broader message that stopping infectious diseases requires collaboration from many different kinds of experts.)

In case Washington isn't on your travel agenda, the Smithsonian is translating the content into multiple languages and sharing it with libraries, community centers and other institutions around the world to help them create their own pared-down versions of the exhibit. — *Laurel Hamers*



“Outbreak” explains how the health of humans and other animals are interconnected. Tracking animal diseases before they jump to people is one way to prevent some future epidemics.



Skeletons
Jan Zalasiewicz and
Mark Williams
OXFORD UNIV., \$24.95

BOOKSHELF

Life's scaffolding comes in many shapes and sizes

For much of life's reign on Earth, organisms got by without skeletons. But since that innovation evolved about 550 million years ago, there's been an evolutionary arms race of epic proportions.

One of the first competitors was *Cloudina*, a small seafloor creature whose exterior skeleton almost certainly evolved in response to predation: In

well-preserved groups of fossils, up to a fifth of these critters' exoskeletons show holes or other evidence of being attacked.

In the eras since, in response to predation and a wide range of other challenges, life has evolved a wild diversity of such structures, as described in the aptly named *Skeletons*. The book is another collaboration between paleobiologists Jan Zalasiewicz and Mark Williams, who previously wrote about oceans on Earth and other worlds (*SN*: 3/7/15, p. 29). As the authors point out, skeletons now take many forms and sizes, including the tiny carbonate and silicate shells secreted by marine microplankton and the giant frames of

blue whales. The authors even make the case that wood — a rigid, biologically built material — is a sort of skeleton.

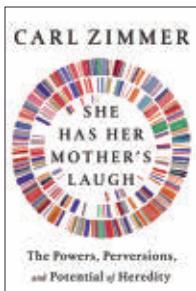
Zalasiewicz and Williams survey the various functions of skeletons. Exoskeletons, like those of *Cloudina*, often serve purposes besides body armor, acting as anchors for a creature's muscles and other tissues. For the first animals that left the seas (and for many creatures living in arid environments today), an exoskeleton helped prevent desiccation.

External skeletons do have their disadvantages. For one thing, an animal like a spider or scorpion that's fully enclosed in an exoskeleton must occasionally shed its armor as the animal grows, which temporarily leaves the creature vulnerable.

Taking another route, vertebrate animals evolved to grow their skeletons on the inside of the body. Some species, like whales and elephants, can grow to immense proportions but have had to develop different means of defending themselves.

Zalasiewicz and Williams don't limit their survey to biological scaffolding. As humans developed new technologies, synthetic skeletons emerged — and are “evolving” at an increasingly rapid pace, from the metallic exoskeletons that protected medieval knights to today's wearable robotic devices that help paraplegics walk (*SN*: 11/16/13, p. 22).

Overall, the book provides a fascinating look at skeletons throughout the ages and into the future. — *Sid Perkins*



She Has Her Mother's Laugh
Carl Zimmer
DUTTON, \$30

BOOKSHELF

Tour a fascinating, and dark, history of genetics

The Elephant Man, novelist Pearl S. Buck and Phoebus, god of the sun, all find their way into science writer Carl Zimmer's latest book. In *She Has Her Mother's Laugh*, Zimmer uses famous moments in history — and Greek mythology — to explain genetics and how researchers have come to understand heredity and try to manipulate it.

Zimmer walks through centuries of exploration, settling into stories of scientists who tried to use simplistic notions of heredity to improve the human race. While investigating inheritance, Francis Galton, who coined the term “eugenics,” noticed that notable men had notable sons. He suggested in 1865 that England's well-being depended on a national breeding program to produce more talented people. His hereditary utopia would make a terrifying episode of TV's *Black Mirror*. Galton's work launched later efforts in the United States to erase undesirable characteristics through sterilization laws and mental capacity checks of immigrants. Eugenics also fed the Nazis' notion of a superior race. Zimmer doesn't shy away from the harmful impact of such research and describes the science that showed the flaws in such discriminatory thinking.

With more than 550 pages, the book covers a lot of ground,

from discoveries of inherited diseases like phenylketonuria to mosaics, individuals whose cells are not all genetically identical. In places, Zimmer uses the private lives of public figures to introduce advances in genetics. With so many examples, it's hard to grasp why he included certain stories. Some parts drag a bit, others zing.

We're all familiar with Joseph Merrick, the Elephant Man. How researchers came to understand why he was deformed is fascinating. In the early 2000s, scientists discovered that several people with the same disease, now called Proteus syndrome, had mutations in the *AKT1* gene important to controlling cell growth. There is current work on a drug to block the gene's actions. Too late for Merrick, but the work offers hope for people today with the disease.

For some readers, the parts of the book that cover recent history may feel like familiar walks down memory lane, with added context and details. Zimmer takes us back to research on Neandertals interbreeding with ancient humans (*SN*: 6/5/10, p. 5), Pima Indians and their high rates of type 2 diabetes, and CRISPR, the prized gene-editing tool (*SN*: 9/3/16, p. 22). Zimmer describes following CRISPR research as a reporter, witnessing “the beginning of something enormous.”

The book ends with cautionary tales about past attempts to toy with nature to fix environmental problems that turned into ecological disasters. Zimmer also points out future risks of gene manipulation that scientists and ethicists have just begun to consider. The next chapter on heredity, he notes, has as many warning signs as opportunities. — *Cori Vanchieri*



APRIL 14, 2018

SOCIAL MEDIA

Lost in translation

A new calculation using the 1961 Drake Equation indicates that if signals from an alien civilization ever reach Earth, it's likely that the aliens will already be dead, **Lisa Grossman** reported in "Ghostly alien signals may haunt the galaxy" (SN: 4/14/18, p. 9). Twitter user **@gparkeruk** poked fun at alien dispatches, referencing gold-plated records (one shown) that carried messages from earthlings into space in the 1970s:

"I worry that our first message from aliens will be on a big gold disc, and nobody will have a player."



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Pesky pesticides

Researchers are tracking tiny insects to learn how animals move around the planet, **Alexandra Witze** reported in "Mass migrations" (SN: 4/14/18, p. 22).

"There are several uncritical references to using pesticides to combat insect pests" in the story, reader **Christina Gullion** wrote.

Gullion noted that pesticides can be harmful not just to pests, but also to the beneficial insects that provide crucial ecosystem services. "Use of pesticides is selecting for resistant pests, as well as an important factor in the decline of beneficial insect populations," she wrote. "This was not mentioned as one of the factors in their decline, yet it is the factor that is most easily within the control of growers and gardeners." **Gullion** thought that *Science News* should report more on important developments in conservation and pest management in agriculture and horticulture.

Black hole puzzles

After Stephen Hawking's death in March, scientists reflected on the famed cosmologist's theories, including Hawking radiation, **Emily Conover** reported in "Stephen Hawking's legacy will live on" (SN: 4/14/18, p. 12).

In theory, Hawking radiation occurs when one member of a particle-antiparticle pair becomes trapped inside of a black hole, allowing the partner to escape. Many readers wondered how Hawking radiation could cause a black hole to evaporate over time. "It seems the black hole would be increasing in mass by the amount of energy contained in the particle it has just captured," reader **Larry Gioannini** wrote.

A particle can escape only if its trapped partner has negative energy, **Conover** says. "When a black hole absorbs a negative energy particle, that particle actually takes away some of the black hole's energy," she says. "Because energy and mass are equivalent in physics, according to Einstein's theory of special relativity, the black hole loses mass. So it will disappear if this process continues long enough."

Scientists get real

In her editor's note "How many scientists do you know in real life?" (SN: 4/14/18, p. 2), *Science News* Editor in Chief **Nancy Shute** wrote that the scientific and science journalism communities have more work to do to connect the public with scientists.

Shute's note resonated with readers.

"Great to see that the organization recognizes the separation between scientists and the general public," reader **Charles Martin** wrote. "Also great to see that *SN* recognizes that it is the scientific community's place to change that. Presentations at schools are great but don't really reach the general public. *SN* issues are one way, but why not consider a 'know a scientist' program nationwide? Think of the possibilities."

The editor's note stirred up memories for reader **Carolee Metcalfe Wende**. She recalled explaining to her young son that his father, a solar physicist, was a "doctor of the sun." "My son's face lit up with this most wonderful news! I think for the next year or so, he thought that his awesome father had something to do with the sun rising every morning," she wrote. **Metcalfe Wende**, a microbiologist, also recalled a plaster test-tube holder that her son made for her. "I had it with me at work every day for the rest of my career," she wrote. "Thank you so much for bringing it to people's attention that even though not all scientists are as notable as those mentioned in the article, we indeed are all around, all the time, living normal, everyday lives."



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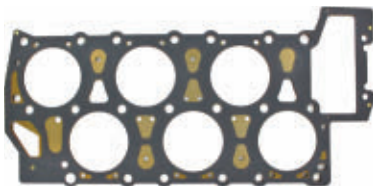
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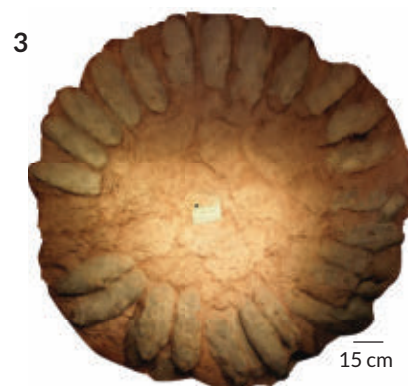
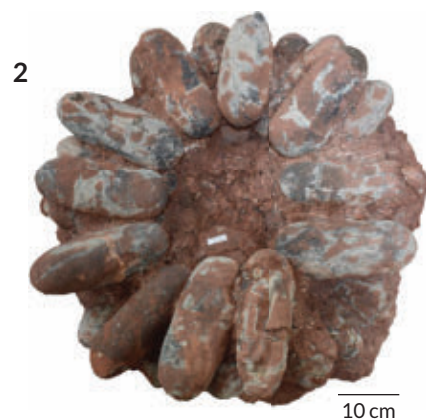
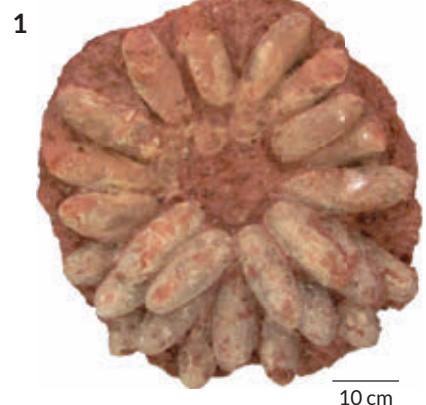
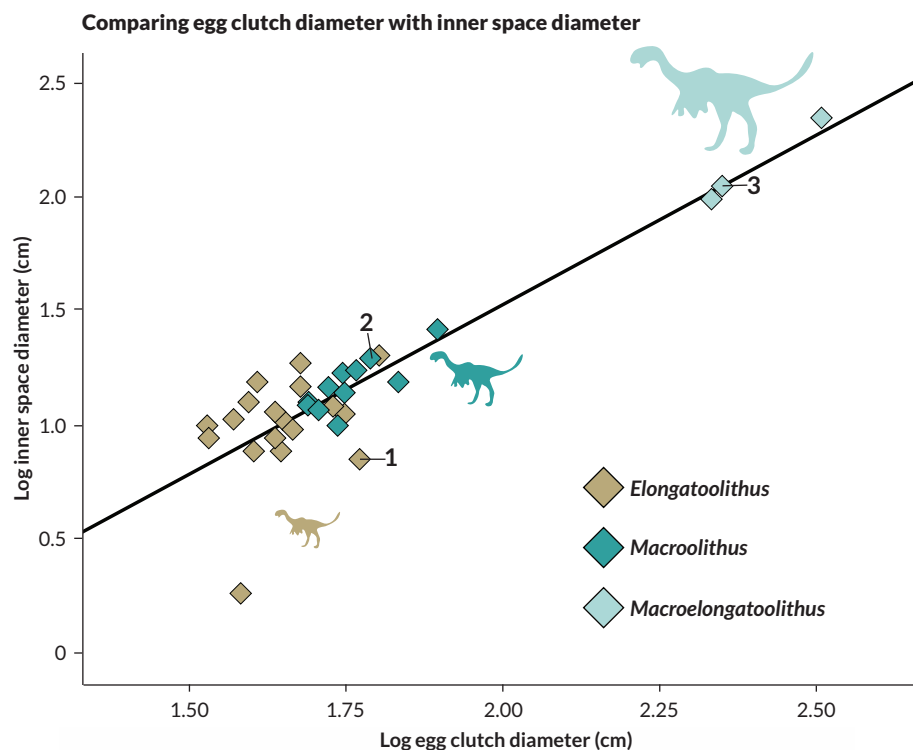
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How hefty dinos sat on their eggs

Brooding birds from chickadees to ostriches sit squarely on their eggs. But scientists thought some of the heavier dinosaur ancestors of birds might not have been able to do so without crushing the clutches. Now, a study finds that certain dinos with a little extra junk in the trunk had a clever brooding strategy: They sat within an open space at the center of a ring of eggs (illustration), rather than right smack on top of them as smaller dinos did.

Researchers studied about three dozen fossilized egg clutches belonging to different species of oviraptorosaurs, a group of feathered, meat-eating dinosaurs. It's impossible to determine an oviraptorosaur species from eggs alone, so the team divided the eggs into three types based on size (example image from each fossil group, 1 to 3 above). The

smallest eggs were assigned to *Elongatoolithus*, which probably included species with body masses ranging from a few tens of kilograms up to 100 kilograms — similar to ostriches. Medium-sized eggs went to *Macroolithus*, and the largest eggs went to *Macroelongatoolithus*. Dinosaurs that laid the biggest eggs may have weighed as much as 2,000 kilograms, about the size of a hippo.

The team measured a clutch's diameter and the diameter of its central space (graph). For the largest eggs, the space took up most of the clutch's area. That opening would have allowed big parents to plop in the center, reducing the weight load on eggs while still keeping them warm, paleontologist Kohei Tanaka of Nagoya University Museum in Japan and colleagues report in the May *Biology Letters*. — Carolyn Gramling

» GEOLOGIC ROAD TRIP OF THE MONTH

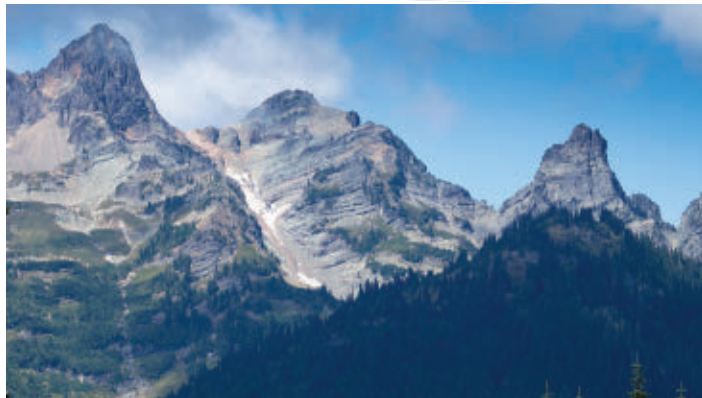
MT. RAINIER NATIONAL PARK

US 12—Cayuse Pass

WA 123 gives access to Mt. Rainier National Park's southeast corner. The highway rises from an elevation of 1,200 feet (365 m) in the south to 4,694 feet (1,431 m) at Cayuse Pass as it follows the Ohanapecosh River upstream nearly to the headwaters of Chinook Creek, its largest tributary. Bedrock exposures for the entire length of the drive consist of volcanic and sedimentary rocks of the Ohanapecosh Formation, deposited during Oligocene time. Even with the heavy vegetation at lower elevations, you can still see many exposures of the Ohanapecosh Formation, some of which clearly show bedding moderately inclined to the west.

Between mileposts 3 and 4, the Ohanapecosh Campground marks the former site of the Ohanapecosh Hot Springs, which grew from a backcountry destination in the early 1900s to a privately operated resort in the 1950s. Today, you can find warm seeps and deposits of travertine along the Hot Springs Nature Trail connecting the visitor center to loop B of the campground. Silver Falls, reached by a short trail 1.6 miles (2.6 km) north of the campground, or a quarter mile (400 m) south of Stevens Canyon Road, plunges 60 feet (18 m) over cliffs of the Ohanapecosh Formation.

As you head north on WA 123, you rise above the moss-covered outcrops of the lower elevations. Look northwest near milepost 9 to cliffs of the Ohanapecosh Formation dipping westward. Roadcuts in this vicinity have a greenish tint to them, created by fine particles of the mineral chlorite disseminated throughout the rock. The chlorite originated from high temperatures generated by the intrusion of the



The Cowlitz Chimneys, the eroded remnants of the Oligocene-age eruptive center of the Ohanapecosh Formation.

Tatoosh pluton. A quarter mile (400 m) north of milepost 10, glacial striations adorn the outcrop on the east side of the highway, although they are more easily seen by southbound travelers.

On both sides of Deer Creek, which WA 123 crosses between mileposts 12 and 13, look toward Mt. Rainier and the Cowlitz Chimneys, a series of sharp peaks eroded from shallow, erosion-resistant volcanic plugs and other intrusive bodies of the Ohanapecosh Formation. They likely mark an eruptive center of the Ohanapecosh. Glacial till, forming an exposure of mixed boulders and fine sediment, shows up just north of milepost 13, and the view southward from near milepost 14 shows the U-shaped profile of the Chinook Creek valley.

The best exposures of the Ohanapecosh Formation along this route consist of a quarter-mile-long (400 m) roadcut just north of milepost 15. Look carefully at these rocks to see that they are largely made of volcanic fragments and display some bedding surfaces inclined gently northward. Some dikes cut the rocks as well. In the remaining mile south of Cayuse Pass, look for exposures of glacial till on the east side of the road.

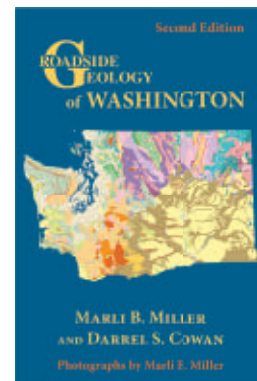


Silver Falls flows over outcrops of the Ohanapecosh Formation.

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