SN
SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
MARCH 30, 2019

Human Fear Confuses Search Dogs

CBD Demand Gets Ahead of Science

Relic Neutrinos Mark the Sky

Death Smells Good to Hermit Crabs

Saber-Toothed Secrets

New evidence says these fierce predators took care of one another

Urgent: Special Summer Driving Notice

To some, sunglasses are a fashion accessory…

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Departments

COVER *Smilodon* cats used powerful forelimbs to pin down prey and big canine teeth to make the kill. *Sergio de la Rosa*

FROM TOP: PEXELS.COM; SLEPKOV BIOPHOTONICS LAB/TRENT UNIV.; STEVE NICOL

The science of CBD lags behind its marketing

Treatments for pain and other common health problems often fall short, leading to untold misery and frustration. So it's not hard to understand the lure of a treatment that promises to be benign, natural and good for just about everything that ails you. Enter cannabidiol, or CBD.

So far, the U.S. Food and Drug Administration has approved only one drug containing the chemical: a treatment for rare and severe forms of epilepsy. But that hasn't stopped people from trying CBD to relieve arthritis, morning sickness, pain, depression, anxiety, addiction, inflammation and acne. And it hasn't kept companies from marketing the heck out of CBD-infused anything. It's the sort of situation that gets us wondering: What's the science here?

The science is skimpy at best, neuroscience writer Laura Sanders reports in this issue (Page 14). Clinical trials, some of which included children, were conducted to determine safety and efficacy before the FDA approved the first CBD-based epilepsy drug in 2018. But much less research has been done on CBD with regard to other ailments.

Adding to the intrigue, CBD can be extracted from marijuana, though CBD lacks the capacity to induce a buzzy high like its sister molecule THC. So government restrictions have been tight, and scientists have had a hard time getting access to CBD for studies. That makes it less likely that we'll get clear answers anytime soon on whether CBD is indeed a panacea, or just another triumph of hype.

The surplus of unknowns hasn't stopped companies from marketing hundreds of CBD products as treatments, attempting to avoid scrutiny by adding disclaimers that the products "are not intended to diagnose, treat, cure or prevent any disease." But with such large gaps in the research, people trying these products in the hope of benefit become inadvertent guinea pigs.

The process of science may be frustratingly slow, but it can get the job done. In the last decade, clinical trials on vitamin D, for example, have found that despite much excitement surrounding the "sunshine vitamin," there's no definitive evidence of benefits in preventing heart disease or cancer. In our recent cover story "D is for discouraging," contributing correspondent Laura Beil described the years of effort needed to develop that data (*SN: 2/2/19, p. 16*).

As journalists, we see a big part of our mission as making sure that people have access to accurate, timely information about medical research, so people can make informed decisions for themselves and their families. That's especially important when it involves products that people can self-prescribe. These two articles — by skilled journalists who put weeks of effort into reading studies, talking with researchers and investigating the business side — are great examples of how sophisticated and useful consumer science journalism can be. Most people look for health information online, but Googling a term like "CBD oil" serves up a muddle of marketing masquerading as impartial information.

CBD may end up being a worthwhile treatment for some problems beyond epilepsy; it's too early to know. But while we wait for the evidence, it's essential to know where the science stands right now. — *Nancy Shute, Editor in Chief*

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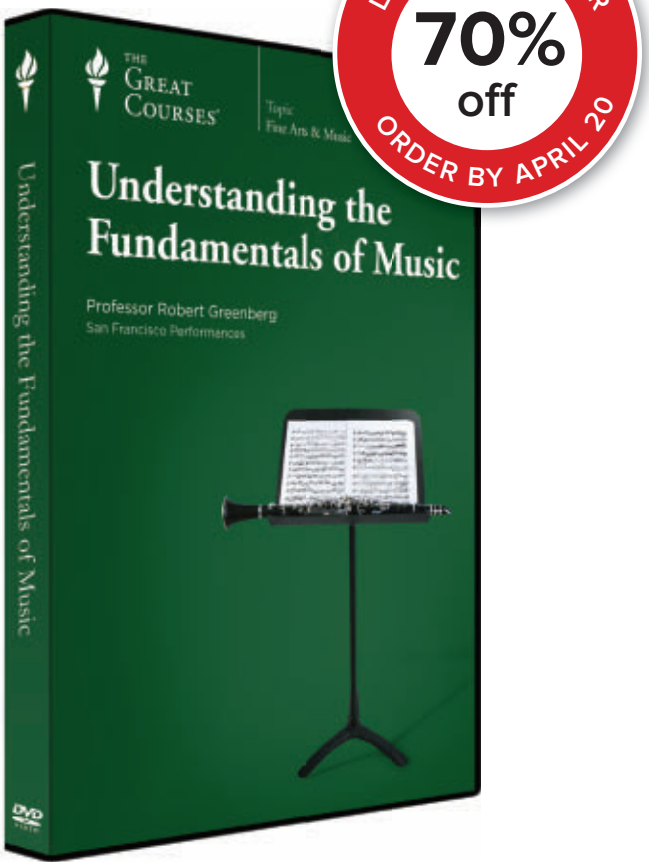

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Excerpt from the April 5, 1969 issue of *Science News*

50 YEARS AGO

The physician as addict

The rate of drug abuse or addiction among physicians is from 30 to 100 times that of the general public.... The American Medical Association estimates that some 60,000 of the country's 316,000 doctors misuse drugs of various kinds. The drug abuser among physicians has a predisposing personality for addiction, and suffers from overwork and fatigue. Since drugs are readily available, they are an occupational hazard.

UPDATE: The "30 to 100 times" figure was found to be inflated, partly as a result of statistical methods used at the time. But drug abuse remains a problem among physicians today. A 2018 review in *Current Opinion in Anesthesiology* says 15.4 percent of doctors say they abuse drugs or alcohol, compared with an estimated 12.6 percent among the public. Most commonly abused are alcohol, painkillers like opioids and stimulants such as cocaine. Abuse likely occurs due to easy access and work stress, as well as burnout, which a 2018 report in *Mayo Clinic Proceedings* says affects 54.3 percent of doctors.

SOAPBOX

It's time to start taking the search for E.T. seriously

The radio telescope at Arecibo Observatory in Puerto Rico is one of several used in SETI work.

Long underfunded and considered a fringe scientific field, the search for extraterrestrial intelligence — known as SETI — may be ready to go mainstream.

Determined to make that happen, astronomer Jason Wright convened a "ragtag group in a tiny room" in January in Seattle at a meeting of the American Astronomical Society. The group's goal was to plot a course for putting SETI on NASA's agenda. Specifically, the group is writing at least nine papers arguing that scientists

THE –EST

Utah tattoo tool dates to nearly 2,000 years ago

FROM TOP: PHOTOSPIRIT/ALAMY STOCK PHOTO; A. GILLREATH-BROWN *ET AL/ J. ARCHAEOL. SCI. REP.* 2019

A tattoo-making tool, with a business end consisting of two pigment-stained cactus spines, dates to almost 2,000 years ago.

While taking an inventory of stored artifacts excavated in Utah in 1972, archaeologist Andrew Gillreath-Brown thought he recognized one: a tattooing tool. That previously overlooked find dates to nearly 2,000 years ago, making it the oldest known tattoo implement from western North America.

The tool consists of a wooden handle bound at one end with split leaves of the yucca plant that hold in place two cactus spines, each stained black at the tip. Microscope and chemical analyses determined that the stains probably contain carbon, a common element in ancient and modern tattooing. Experiments with replicas of the Utah artifact showed that the instruments could incise lines of charcoal-based ink onto fresh pig skin.

Ancestors of Pueblo people, who lived in the Bears Ears region in Utah around the same time as the tool was dated, wielded the implement at a time when foraging was giving way to farming, Gillreath-Brown and colleagues report online February 28 in the *Journal of Archaeological Science: Reports*.

The oldest known tattoos are on Ötzi the Iceman's 5,250-year-old body (*SN: 1/23/16, p. 5*). But there have been few ancient tattoo tools found anywhere in the world. And until now, none from the U.S. Southwest has dated to more than 900 years ago. Further east in Tennessee, pigment-stained bone needles and other tattooing items from 3,500 to 1,600 years ago were excavated in 1985, says Gillreath-Brown, of Washington State University in Pullman. Obsidian flakes unearthed in the Solomon Islands, east of Papua New Guinea, were likely used to create tattoos about 3,000 years ago. — *Bruce Bower*

should search the universe for "technosignatures" — signs of alien technology, such as radio signals or waste heat.

The papers will go into a 2020 report to Congress on the astronomical community's priorities. Called "Astro 2020: Decadal survey on astronomy and astrophysics," the report will help determine which telescopes fly and which studies are funded through the next decade. "The stakes are high," says Wright, of Penn State. "If the decadal survey says, 'SETI is a national science priority, and [the National Science Foundation] and NASA need to fund it,' they will do it."

Modern SETI searches began with astronomer Frank Drake in 1960 using a radio telescope in Green Bank, W.Va., to listen for signals from an intelligent civilization. NASA started a SETI program in 1992, only to see it canceled within a year by Congress. Private groups then picked up the baton, with the SETI Institute started in 1985 by astronomers including Jill Tarter, and

Astronomer Jason Wright (third from left) and his students visited the Green Bank Telescope during Penn State's first SETI graduate course in 2018.

Breakthrough Initiatives launched in 2015 by Russian billionaires Yuri and Julia Milner. Still, the technosignature search hasn't become a self-sustaining scientific discipline, Wright says.

Wright himself is a newcomer to SETI, entering the field with a 2014 study on searching for heat from alien technology. He says SETI is no longer so taboo for career-minded astronomers, with "the ascension of geek culture" helping the field gain legitimacy. "Now it's like all the top movies are comic books and science fiction," he says. SETI researchers were encouraged when NASA requested a report in 2018 on technosignatures and how to look for them. Wright also organized the meeting that prepared that report, posted online December 20 at arXiv.org.

The SETI situation has also evolved in the last decade with the discovery of thousands of exoplanets — some similar enough to Earth in temperature and size to raise hopes that some exoplanets host life. NASA's planned James Webb Space Telescope will search those exoplanets' atmospheres for biosignatures, or signs of biological life. No one has yet found any biosignatures outside of Earth, let alone technosignatures. But searching for one makes ignoring the other a bit odd, Wright says. "Astrobiology and the search for life has become such a big part of what NASA does," he says. "The fact that it won't look for intelligent life has become ever more incongruous with its other activities." — *Lisa Grossman*

SCIENCE STATS

As ocean temperatures rise, fish catches are on the decline

Finding the fish is going to get harder as climate change heats the world's oceans. Already, rising water temperatures over 80 years have reduced the sustainable catch — the amount that can be harvested without long-term population damage — of 124 fish and shellfish species by an average of 4.1 percent, a study finds.

Overfishing has exacerbated some of that decline. In heavily fished regions such as the Sea of Japan, the sustainable catch has fallen as much as 35 percent.

The study, in the March 1 *Science*, examined 235 fish and shellfish populations across 38 ocean regions from 1930 to 2010. In that time, ocean surface temperatures rose an average of about half a degree Celsius, though the changes varied by location. Overall, about 8 percent of the fish and shellfish populations declined during the eight decades of ocean warming. — *Carolyn Gramling*

4.1
percent
Global average decrease in the amount of fish that can be harvested sustainably from the oceans since 1930

MYSTERY SOLVED

Why microwaved grapes catch fire

Here's a homemade plasma recipe: Cut a grape in half, leaving the two sections connected on one side by the grape's thin skin. Heat in a microwave for a few seconds. And, boom: From the grape erupts a plasma fireball — a hot mixture of electrons and charged atoms, or ions.

This trick has been floating around the internet for decades, with explanations focusing on the importance of the connecting skin. But two whole grapes bumped up against one another do the same thing, as do waterlogged beads called hydrogels, researchers report in the March 5 *Proceedings of the National Academy of Sciences*.

The team found that the grapes act as resonators for the microwave radiation, much like a flute resonates with sound waves. A grape is the right size for electromagnetic waves to get trapped within the fruit. Thermal imaging shows a hot spot appearing where the two grapes meet. There, salts in the grape skin are ionized, producing a plasma flare.

Plasma erupts when two grapes, or a grape and a hydrogel bead (shown), are heated in a microwave.

The effect makes for a neat kitchen fireworks display. But beware: It could damage your microwave. — *Emily Conover*

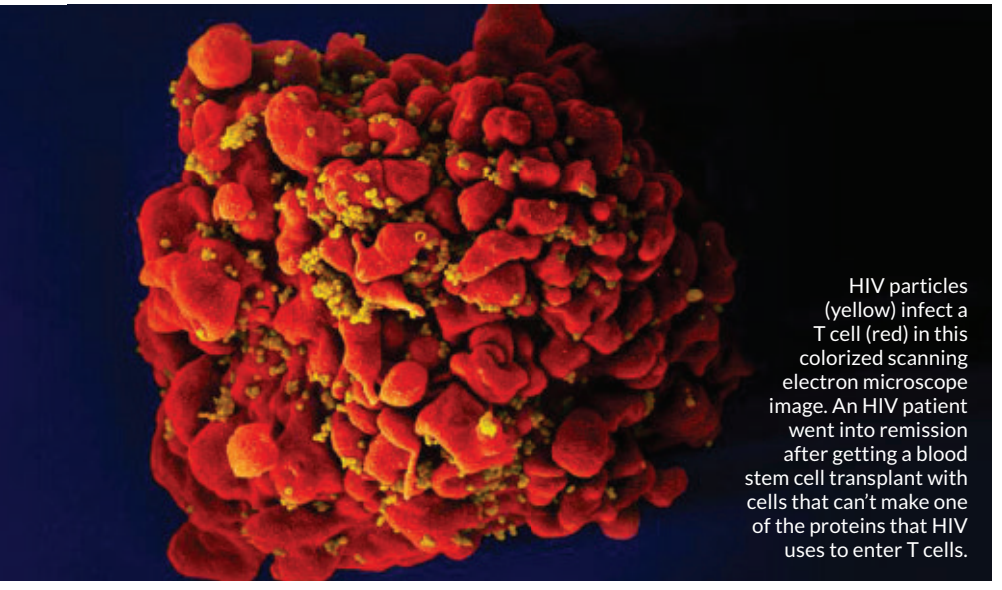
FROM TOP: CHRISTIAN GILBERTSON; NEFSC/NOAA; SLEPKOV BIOPHOTONICS LAB/TRENT UNIV.

Watch a video of grapes sparking into plasma at **bit.ly/SN_Grapes**

BODY & BRAIN

A second HIV patient is in remission

After a blood stem cell transplant, virus is undetectable



HIV particles (yellow) infect a T cell (red) in this colorized scanning electron microscope image. An HIV patient went into remission after getting a blood stem cell transplant with cells that can't make one of the proteins that HIV uses to enter T cells.

BY AIMEE CUNNINGHAM

For only the second time in recorded medical history, a person's HIV infection has gone into remission.

The patient — a man diagnosed in 2003 with HIV, the virus that causes AIDS — had received a blood stem cell transplant in 2016 as treatment for Hodgkin's lymphoma, a cancer of the lymphatic system. The blood stem cells came from a donor with a mutation that makes cells resistant to an HIV infection.

Subsequent testing over 12 months showed the patient's HIV had fallen to undetectable levels. So 16 months after the procedure, the patient stopped taking antiretroviral medication under medical supervision. He has remained in remission ever since, with HIV levels measuring less than one copy per milliliter of plasma, researchers report online March 5 in *Nature*.

Although it's too early to call the patient cured, "it's pointing in that direction," says coauthor Ravindra Gupta, an infectious disease specialist at the University of Cambridge.

> Although it's too early to call the patient cured, "it's pointing in that direction."
>
> **RAVINDRA GUPTA**

Nearly 37 million people worldwide were living with HIV in 2017, with 1.8 million people newly infected that year, according to the Joint United Nations Programme on HIV/AIDS. Antiretroviral therapy has helped many patients live longer by reducing virus levels in the blood, but the multidrug regimen needs to be taken for life.

During an HIV infection, the virus ambushes immune cells called T cells and makes copies of itself. To enter the T cell, HIV first binds to a cell surface protein called CD4 and then grabs onto another surface protein, usually CCR5. But some HIV variants grab the protein CXCR4 instead or can use either protein.

Once it was clear that the patient, who has chosen to remain anonymous, would undergo a stem cell transplant for Hodgkin's lymphoma, physicians were able to locate a donor with a defect in both copies of the *CCR5* gene. That meant the donor's T cells couldn't make the CCR5 protein. And without this protein, most HIV variants can't get into the cells. Because the patient had HIV that needs to bind to CCR5, doctors suspected — correctly — that the transplant would halt the HIV infection.

The case provides "solid evidence for remission," says Hans-Peter Kiem, a physician who studies cell and gene therapy at the Fred Hutchinson Cancer Research Center in Seattle. The "only way to tell whether [this is a] long-term remission or cure is longer follow-up."

The first case to hint that an HIV cure might be possible was reported in 2009 in the *New England Journal of Medicine*. That case involved the "Berlin patient," later identified as Timothy Ray Brown, who had undergone a cancer treatment that was similar to but more severe than what the patient described in the report in *Nature* received. Having a second person in remission means the first case "wasn't a chance event," Gupta says.

Brown's cancer treatment included two blood stem cell transplants from a donor with a defect in both copies of the *CCR5* gene along with two rounds of full body irradiation. The second patient had chemotherapy and only one stem cell transplant.

While these transplants appear to be effective at stopping HIV, they are not an option for most HIV patients. Naturally having the defect in both copies of the *CCR5* gene is very rare and is more likely in those of Caucasian descent, making it extremely difficult to find transplant matches for most people.

Another approach may be to manipulate the ability of a patient's own T cells to make the CCR5 protein, and there are clinical trials under way in the United States testing different methods of preventing CCR5 from functioning in patients.

"We need to learn how to make this work" with a patient's own cells in order for the approach to be available more widely, Kiem says. ■

NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES

Neutron star merger fired off a fast jet

Collision may reveal the source of distant gamma-ray bursts

BY LISA GROSSMAN

When a pair of ultradense cores of dead stars smashed into one another, the collision shot a bright jet of charged subatomic particles through space.

Astronomers had thought no such jet had made it out of the wreckage of the neutron star crash, first detected in August 2017. But new observations using radio telescopes from around the world show a high-speed stream of particles escaping from the debris, researchers report in the March 1 *Science*.

The work is part of an emerging consensus that the merger produced a jet, and the findings could shed light on the origins of short gamma-ray bursts, mysterious flashes of high-energy light.

According to theory, a pair of crashing neutron stars should merge into another dense object, possibly a black hole. In the process, a combination of extreme energies and magnetic fields could launch a bright jet of electrons and protons moving close to the speed of light. Scientists think that such jets are seen from afar as short gamma-ray bursts, or GRBs. But no one had ever directly observed a neutron star collision producing the bursts.

The 2017 neutron star crash, the first directly observed merger, provided the first chance to test the idea, says study coauthor and astrophysicist Giancarlo Ghirlanda of the National Institute for Astrophysics in Merate, Italy. That merger occurred 130 million light-years from Earth in the galaxy NGC 4993. The smashup was spotted when the Advanced Laser Interferometer Gravitational-Wave Observatory, or LIGO, and its sister experiment, Advanced Virgo, detected ripples in spacetime called gravitational waves caused by the crash.

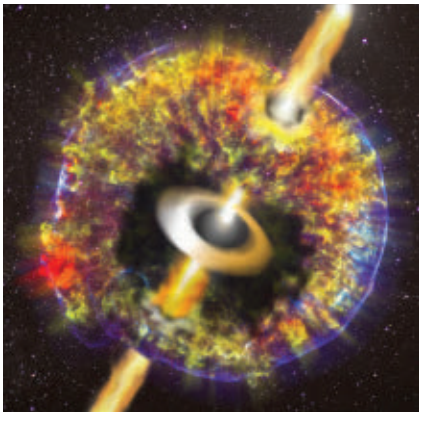
In addition to the gravitational waves, the neutron star crash emitted light in every wavelength astronomers checked, from long radio waves to short gamma rays (*SN: 11/11/17, p. 6*). Those extra observations let astronomers tease out details of the crash and its aftermath.

Scientists initially didn't find any jet-like gamma-ray emissions. Gamma rays were emitted after the crash, but they were much dimmer and lingered much longer than expected from a GRB.

Those observations led astrophysicist Kunal Mooley of Caltech and colleagues to suggest that a jet formed but was choked by a bubble of neutron-rich material kicked out of the neutron star collision (*SN Online: 12/20/17*). That bubble absorbed the jet's energy, giving the bubble a long-lasting glow but smothering the jet itself.

Now, Ghirlanda and colleagues report signs that the jet eventually burst free from the bubble. The team observed the site of the crash with 32 radio telescopes in March 2018, more than 200 days after the merger. Combining signals from all the telescopes to act as one big telescope let the team zoom in on the scene.

A jet that lost its energy to a neutron-rich bubble would appear as a relatively large sphere on the sky. But Ghirlanda's group saw a tiny, compact source of light, covering 1.5 milliarcseconds of sky — about the size of a nickel seen from 1,000 kilometers away. That light suggests that "a jet was launched, and it emerged successfully," Ghirlanda says.



A bright jet of fast-moving particles fled the scene after two neutron stars collided, spewing additional material and potentially forming a black hole (shown in this artist's illustration).

O.S. SALAFIA, G. GHIRLANDA, CXC AND GSFC/NASA, B. WILLIAMS *ET AL*

What's more, the jet is moving in Earth's general direction but 20 degrees off to the side. "This is the first time in history that we have observed a jet which is not pointing toward the Earth," says Ghirlanda's collaborator Om Sharan Salafia, an astrophysicist also at the National Institute for Astrophysics. That means the jet has some observable structure, with faster-moving particles in a central core and slower particles toward the edges — sort of like a fire hose surrounded by spray.

Two other studies also suggest that the neutron star merger shot a jet through space. Mooley and colleagues used three radio observatories to check in on the merger 75 to 230 days after the crash and observed a jet moving at the speed of light away from the crash site, the team reported in *Nature* in September 2018.

The way the merger's light began quickly dimming 150 days after the collision also supports the idea that a jet burst into view and then faded, says Wen-fai Fong, an astrophysicist at Northwestern University in Evanston, Ill. If the dimming had been more gradual, it would have hinted that the jet was still trapped in the bubble as the bubble cooled. Fong's team reported observations of the merger up to 290 days after the crash in August 2018 in the *Astrophysical Journal Letters* and has continued to observe the site.

"It's amazing that the astronomical community is using all of these different techniques to come to the same conclusion," Fong says.

The fact that the first observed neutron star merger produced a jet like the one expected from short GRBs is good news for existing GRB theories. "If this neutron star merger didn't produce a successful jet, we'd have to say, well, what are short GRBs?" Fong says. "We were a little bit worried that we'd have to explain short GRBs as a whole different phenomenon."

To know how common jets are in neutron star clashes, astronomers will have to observe more collisions. Researchers might not have to wait long: The next LIGO and Virgo observing runs start this spring. "We're all very excited about what the future holds," Fong says. ■

BODY & BRAIN

To combat malaria, treat mosquitoes

Giving drugs to insects might stem the spread of the disease

BY AIMEE CUNNINGHAM

The fight against malaria may someday include ridding mosquitoes of the parasites that cause the disease.

Treating female lab mosquitoes with an antimalarial drug stopped parasites from developing in the insects. Mosquitoes were exposed to the treatment when they landed on a drug-coated surface for as little as six minutes, comparable to how long mosquitoes stop on protective bed nets while hunting for a meal, researchers report online February 27 in *Nature*.

"People have been exploring ways to control insect pests for an awful long time," says Joshua Yukich, a malaria epidemiologist at Tulane University in New Orleans who was not involved in the research. A strategy that kills malaria parasites in mosquitoes "is pretty exciting." Adding antimalarial compounds to insecticide-treated bed nets may make the nets even more effective, he says.

Malaria, caused by *Plasmodium* parasites and spread by *Anopheles* mosquitoes, can be fatal: In 2017, there were 219 million cases, mostly in Africa, and 435,000 deaths, mainly in children.

Since 2000, an international effort in Africa has prevented some 663 million cases, researchers say, largely thanks to insecticide-treated bed nets. The nets kill mosquitoes and help protect sleepers from bites. But the emergence of insecticide-resistant mosquitoes threatens that progress.

Flaminia Catteruccia, a molecular entomologist at the Harvard T.H. Chan School of Public Health, and colleagues treated a glass surface with the antimalarial drug atovaquone. Mosquitoes landed on the glass and absorbed the drug through their legs. The compound then made its way to the gut, where it prevented *Plasmodium falciparum* parasites from developing. The strategy worked whether insects were exposed to the parasites before or after treatment.

Using antimalarial drugs to treat mosquitoes could result in the parasites becoming resistant to the drugs, endangering crucial therapies for humans, such as atovaquone. So the researchers want to test other antimalarial compounds.

Options include potential drugs that showed effectiveness in tests but didn't pass muster as a treatment because of problems with how the drugs were taken up in the human body or other issues. "We can repurpose drugs that are not good enough for human use," Catteruccia says.

Along with finding suitable drugs, researchers should develop formulations that remain active on bed nets for a few years, Yukich says. Long-lasting insecticide-treated nets keep their killing power for three years or so, even with daily use and repeated washing. ■

BODY & BRAIN

How singing mice belt out duets

Rodents' brains may offer clues to human conversation

BY LAURA SANDERS

In the understory of Central American cloud forests, musical mice trill songs to one another. Now a study of the charismatic creatures reveals how their brains orchestrate these rapid-fire duets.

This Alston's singing mouse in Costa Rica serenades the forest, perhaps negotiating its territory with other males.

B. PASCH

The results, published in the March 1 *Science*, show that the brains of singing mice split up the musical work. One brain system directs the patterns of notes that make up songs; another coordinates duets with another mouse, which are carried out with split-second precision.

"A quirky animal from the cloud forest of Costa Rica could give us a brand-new insight" into the rapid give-and-take in people's conversations, says coauthor Michael Long, a neuroscientist at New York University School of Medicine.

In the lab, Alston's singing mice (*Scotinomys teguina*) can get quite loud. "Once an animal calls, it's like a symphony that goes off," with repeating calls, says Bret Pasch, a biologist at Northern Arizona University in Flagstaff who has studied the singing mice for years but wasn't involved in the research. In the wild, these duets are thought to attract mates and help stake out territory.

One brain system is thought to control the contents of the mice's songs. But another part — the orofacial motor cortex, or OMC — orchestrates the split-second timing needed for the duets, Long and colleagues found.

When the team cooled the mice's OMC, slowing those nerve cells' activity, songs grew longer, suggesting that the brain region normally controls song timing. And when the researchers used a drug to silence the OMC, mice had trouble singing in response to another mouse's call.

"In a very clear and convincing way, they show that this structure is involved in this behavior," says Steffen Hage, a neurobiologist at the University of Tübingen in Germany who wrote an accompanying commentary in *Science*.

The singing mice's OMC may not align exactly with the brain areas that pace human chatter. Still, the results may eventually lead to parts of the motor cortex that enable human conversations, which can also proceed at fast clips. That pursuit might ultimately lead to therapies for disorders that affect communication, such as strokes and autism, Long says. ■

Watch mice sing a rapid-fire duet at **bit.ly/SN_SingingMice**

GENES & CELLS

Smell of fear hampers police dogs

Canines couldn't sniff out stressed people with a certain gene

BY TINA HESMAN SAEY

Some police dogs may smell fear, and that could be bad news for finding missing people whose genetic makeup leaves them more prone to stress.

Trained police dogs couldn't recognize stressed-out people with a particular version of a gene that's involved in stress management, geneticist Francesco Sessa reported February 22 at a meeting of the American Academy of Forensic Sciences. The study may help explain why dogs can perform well in training but have difficulty tracking people in the real world.

Previous studies have linked different versions of the serotonin transporter gene *SLC6A4* to stress management. People with the long version of the gene tend to handle stress better than people with the short version, said Sessa, of the University of Foggia in Italy.

He and colleagues recruited a man and a woman with the long version of the gene and a man and a woman with the short version. Each participant wore a scarf for a couple of hours a day to imprint their scent on the garment. Then the team brought the volunteers into the lab. In the first session, volunteers wore a T-shirt and weren't subjected to any stressors. After sniffing the scarves, two dogs had no trouble identifying any of the volunteers' shirts in a lineup of 10 T-shirts.

Next the researchers stressed the volunteers by having them do public speaking. Participants' hearts raced and their breathing became shallow, a sign of fear, Sessa said. That stress may have made their body odor change, too, confusing the dogs. The animals picked stress-stained T-shirts belonging to the man and woman with the long version of the gene from the lineup in two of three attempts. But neither dog could identify the T-shirts of the stressed people with the short version of the gene, suggesting that those people's natural scent changes more under stress.

Being stressed may alter some people's usual scent and throw search dogs off the track (a police dog in Northern Ireland is shown).

"It could be a plausible explanation" for why dogs can find some people more easily than others, says forensic scientist Cliff Akiyama, founder of Akiyama and Associates, a forensic consulting firm headquartered in Philadelphia. But that doesn't mean search dogs are useless. Many people are kidnapped by parents or other people the victims know, Akiyama says. So abductees aren't always afraid, perhaps leaving their scents unaltered. ■

GENES & CELLS

Long handshakes spread DNA far

Indirect transfers might affect crime scene investigations

BY TINA HESMAN SAEY

A 10-second handshake could transfer a person's DNA to an object that the person never touched.

In handshaking experiments, people who never picked up a knife became the major source of DNA on the handle about 7 percent of the time. That DNA was transferred to the knife when the person's handshaking partner grasped the knife handle, forensic scientist Cynthia Cale of the Houston Forensic Science Center reported February 21 at a meeting of the American Academy of Forensic Sciences.

In a separate study, the last person to touch an object was often not the one who left the most DNA behind, Leann Rizor, a forensic anthropologist at the University of Indianapolis, reported.

The findings suggest that even brief contact with another person or object could spread DNA far and wide, which could complicate crime scene investigations. While the results don't mean DNA evidence is unreliable, Rizor and Cale said, investigators should be careful to account for these accidental transfers.

It's probably rare to find people's DNA somewhere they haven't been or on something they haven't touched, says forensic geneticist Mechthild Prinz of John Jay College of Criminal Justice in New York City. Left-behind DNA is usually unstable and breaks down with time, she says. "We can't discount [the idea], but we shouldn't use it to throw the evidence out in every single case."

In Rizor's experiment, four students sat at a table and poured beverages from a pitcher. Other students watching the experiment were free to leave the room, talk and move around to simulate conditions in a restaurant. As each student handled the pitcher and a plastic cup, researchers swabbed the pitcher handle, cups and the students' hands for DNA.

DNA from students at the table was on the pitcher handle and on each other's cups, even though the volunteers handled only their own cup and the pitcher. DNA from the observers showed up too. Their DNA may have spread through spewed droplets as these onlookers talked, coughed or sneezed. Looking at the amounts of DNA on the objects, the researchers couldn't determine who handled the pitcher last or pinpoint how long a person touched the pitcher or cup.

Some of the results may be explained because people shed DNA at different rates, Prinz says. But it's unclear how often transferred DNA might skew investigations, she says. "We're all still trying to get a handle on how realistic this is." ■

STEPHEN BARNES/LAW AND ORDER/ALAMY STOCK PHOTO

LIFE & EVOLUTION

Junk food may curtail bear hibernation

Wildlife raiding human leftovers may risk faster cellular aging

BY SUSAN MILIUS

Mama bears may need to raise their snouts and join the chorus protesting junk food.

The more sugary foods that 30 female black bears scrounged from humans, the less time the bears were likely to spend hibernating, researchers found. In turn, bears that hibernated less tended to score worse on a test for aging at the cellular level, wildlife ecologist Rebecca Kirby and colleagues report in a study published February 21 in *Scientific Reports*.

The research grew out of an earlier project to see what black bears across Colorado were eating, says coauthor Jonathan Pauli, a community ecologist at the University of Wisconsin–Madison. Kirby, Pauli's Ph.D. student at the time, checked diets from hundreds of bears across the state. Hunters there are not allowed to set out bear bait, such as heaps of doughnuts, so the animals' exposure to human food comes mostly from scavenging.

When bears eat more human foods, their tissues pick up higher concentrations of a stable form of carbon called carbon-13. That extra carbon comes from plants such as corn and cane sugar. (These crop plants concentrate the atmosphere's normally sparse amounts of carbon-13 as they build sugar molecules in steps somewhat different from those in most of North America's wild plants.)

Looking for the telltale form of carbon in that study, the researchers found bears in some places scavenging "really high" proportions of people's leftovers, Pauli says. On occasion, these leftovers made up more than 30 percent of the diet.

In the new study, Kirby looked at the impact of diet on hibernation. Bears typically hibernate four to six months, during which females give birth. Kirby and colleagues focused on 30 free-roaming females around Durango monitored by Colorado's Parks and Wildlife department. The team tested bears for carbon-13 and determined that the ones that ate more human foods tended to hibernate for shorter periods of time.

The more a black bear snacks like a human, the more likely that bear is to skimp on hibernation, a new study finds.

Studies in smaller hibernating mammals hint that these seasonal metabolic slowdowns might delay the ravages of aging. If true, shortening hibernation bouts might have a downside for bears.

To measure aging, the researchers tested for relative changes in the length of telomeres. These repetitive bits of DNA form the ends of chromosomes in

LIFE & EVOLUTION

Hermit crabs are drawn to the dead

Smell of flesh may signal that an empty shell is up for grabs

BY YAO-HUA LAW

The death of a millionaire with no heirs draws an opportunistic crowd. So, too, does the demise of a land-dwelling hermit crab. Researchers working in Costa Rica found that the crabs are drawn to the smell of flesh from one of their own.

Dartmouth College biologist Mark Laidre, along with then undergraduate student Leah Valdes, put 20 plastic bottles on a beach, each holding hermit crab flesh. Within five minutes, almost 50 Ecuadorian hermit crabs (*Coenobita compressus*) swarmed around each sample, the pair reports online February 10 in *Ecology and Evolution*. "It's almost like they were celebrating a funeral," Laidre says.

The reality is more macabre. That scent of flesh signals that a fellow hermit crab is dead, which means an empty shell is available for the taking, Laidre says. The crabs "are all in an incredible frenzy to try to move into that leftover shell."

None of the roughly 850 known hermit crab species, most of which live in the sea, can grow their own shells. Instead, the crabs occupy shells originally left behind by dead snails. A hermit crab grows to the size of its shell; to grow further, the creature must find a larger shell.

To keep growing, hermit crabs must move into bigger and bigger shells. Land-based hermit crabs can smell a move-in opportunity.

For the 20 or so species of land hermit crabs, finding a shell can be especially challenging. Without the buoyancy of water to help lighten the load, big shells with lots of extra room to grow may be too heavy in the short term to tote around on land. Lighter shells may be too small.

Land hermit crabs can remodel their shells, making them bigger, Laidre reported in 2012. The animals use corrosive secretions and scraping to widen a shell's opening, remove the internal spiral and reduce wall thickness. Remodeling can nearly double the available space while trimming more than one-third the weight. But remodeling is taxing and slow. It's much faster to take over an already remodeled shell of another land hermit crab. Hence the strong attraction of land hermit crabs to smells that

FROM TOP: J. BICKING/SHUTTERSTOCK; M. LAIDRE

complex cells. As cells divide over time, telomere bits fail to get copied and telomeres gradually shorten. Various researchers propose that tracking this shortening can reveal how quickly a creature is aging. Among bears in the study, those that hibernated for shorter periods had telomeres that had shortened more quickly than those of other bears, suggesting the animals were aging faster.

Free-ranging bears didn't always cooperate with Kirby's needs for several kinds of data, so she does not claim to have made one direct and "definitive" link between bears eating more human food and shortening telomeres as a sign of aging. So far, Kirby, now with the U.S. Fish and Wildlife Service in Sacramento, Calif., calls the evidence "suggestive."

Using additional methods to measure telomeres could help clarify what is going on at the cellular level, says Jerry Shay, a telomere researcher at the University of Texas Southwestern Medical Center in Dallas. Still, he muses, the idea of connecting more human food, truncated bear hibernation and faster cell aging "may be correct." ■

suggest another is dead, Laidre says.

He and Valdes also found that land hermit crabs approached snail flesh, though the scent of snails appears to be far less alluring than that of their own species. Sea hermit crabs, however, didn't find the smell of another hermit crab's corpse more attractive than those of snails.

That makes sense to Laidre. For sea hermit crabs, upsizing to bigger, heavier shells is relatively easy, thanks to water's buoyancy. That, combined with the fact that there are also many more empty shells in the sea than on land, means that sea hermit crabs face less competition when looking for a home, he says.

By highlighting that shell availability is limited for land hermit crabs, the study makes an important point for conservation, says Chia-Hsuan Hsu, an ecologist at National Taiwan University in Taipei who studies hermit crabs. "We can tell the public: 'Don't take shells from the beach,'" he says. ■

ZOSIA ROSTOMIAN/LAWRENCE BERKELEY NATIONAL LAB

ATOM & COSMOS

Neutrinos revealed in galaxy patterns

Particles from the Big Bang may imprint their effects on the sky

BY EMILY CONOVER

Shadowy messengers from the Big Bang have seemingly left their mark on ring-shaped patterns imprinted on the sky.

Subatomic particles called neutrinos were released in huge numbers just one second after the universe's birth 13.8 billion years ago. These ancient neutrinos continually stream through the universe and are exceedingly hard to spot. But circular patterns of galaxies scattered across the sky reveal signs of the particles. The data hint that the neutrinos' gravity alters the rings, researchers report February 25 in *Nature Physics*. Since the neutrinos were released so early in the universe's history, scientists hope they can one day use the particles to better understand the cosmos in its first moments.

The study "shows that we can derive the early universe physics" by observing the recent universe, says Hee-Jong Seo, a cosmologist at Ohio University in Athens not involved in the research.

Spotting signs of the ancient particles is no easy feat. All neutrinos are notoriously difficult to detect. They have no electric charge and can pass straight through other matter. With large, highly sensitive detectors, scientists can spot neutrinos produced by everyday processes such as radioactive decay. But neutrinos released from the Big Bang, known collectively as the "cosmic neutrino background," are much more elusive. Although these cosmic relics suffuse the universe, the particles have so little energy that they have never been directly spotted.

So rather than trying to observe those relics, scientists look for neutrinos' influence on other cosmic signposts. For example, a pattern caused by sound waves in the early universe, known as baryon acoustic oscillations, should be distorted by the neutrinos. Those sound waves

Galaxies tend to cluster into rings (illustrated). Scientists have found that subatomic particles called neutrinos change the way matter is distributed in the circles.

spread outward through the universe like circular ripples on a pond, compressing matter into denser pockets. That process resulted in galaxies having a tendency to cluster in rings (*SN: 5/5/12, p. 17*).

But neutrinos can shift that matter around due to the particles' gravity, slightly changing the distribution of matter in the rings. "You're seeing the pull of the neutrinos," says cosmologist Daniel Green of the University of California, San Diego. Using data from the Baryon Oscillation Spectroscopic Survey, or BOSS, Green and colleagues studied the circular patterns of galaxies and saw evidence that the neutrinos were, in fact, pulling matter around from the inner side of the ring band toward the outer side.

Scientists have previously spotted signs of the ancient neutrinos in a glow leftover from the Big Bang. The cosmic microwave background, light that was released when the universe was just 380,000 years old, is also affected by the cosmic neutrino background. But this is the first time evidence of the particles' fingerprints on galaxies has been spotted.

"It's another hallmark of the success of standard cosmology," says cosmologist Kevork Abazajian. Still, the result is just scratching the surface of the cosmic neutrino background, making the measurement a proof of principle rather than a definitive detection, says Abazajian, of the University of California, Irvine.

In the future, improved surveys of galaxies might be sensitive enough to reveal unexpected tweaks to the ring patterns, which could be caused by the existence of undiscovered phenomena, such as hypothetical new types of neutrinos called sterile neutrinos (*SN: 6/23/18, p. 7*). ■

BODY & BRAIN

High-fiber diet may aid cancer therapy

Diverse gut microbes plus immunotherapy shrank tumors

BY TINA HESMAN SAEY

What a person eats may affect how well some immune therapies work against cancer. High-fiber diets may change gut microbes and make these therapies more effective, but taking probiotics could do the opposite.

Researchers looked at melanoma patients getting an immune therapy called PD-1 blockade, or checkpoint inhibition (*SN: 10/27/18, p. 16*). Those who ate a high-fiber diet were five times as likely to have the therapy halt the growth of or shrink tumors as those on diets low in fiber, researchers reported February 27 in a news conference held by the American Association for Cancer Research.

High-fiber diets seem to foster a more diverse collection of gut microbes, which is associated with better outcomes from PD-1 blockade therapy, said Christine Spencer, a research scientist at the Parker Institute for Cancer Immunotherapy in San Francisco. But probiotics — pills or food supplements that contain helpful bacteria — actually reduced patients' gut microbe diversity.

Only about 20 to 30 percent of cancer patients see their tumors stop growing or shrink with PD-1 blockade immune therapy. Spencer and colleagues had previously determined that bacteria in the Ruminococcaceae family seem to improve responses to the treatment, but the researchers didn't know why some people have more of those helpful bacteria than other people do.

Diet is one way to change a person's microbiome, the collection of bacteria, fungi and other microbes that live on and in the body. So Spencer and colleagues at MD Anderson Cancer Center in Houston surveyed 113 people with melanoma about their diets, including use of probiotics, and collected fecal samples.

The 46 patients who consumed the highest amount of fiber, from fruits, vegetables and whole grains, tended to have more of the bacteria associated with a good response to the immune therapy. And, in fact, those patients tended to get a positive effect from the therapy. Participants who ate more processed meat and excess sugar had fewer of those bacteria and had tumors that were more likely to grow despite immune treatment.

Over 40 percent of patients reported taking probiotics, and these patients had lower gut microbe diversity than people who didn't take the supplements. "A lot of people have perceptions that probiotics will have health benefits, but that might not be the case for cancer patients," Spencer said.

The new work adds to a growing number of recent studies that have hinted that probiotics may not offer the health benefits doctors and patients have hoped for.

Spencer and colleagues will present more data, including on probiotics' effect on immune therapy, April 2 at the cancer research association's annual meeting.

While preliminary, the new data suggest that there are ways to improve immune therapy, says infectious disease specialist Cynthia Sears of Johns Hopkins University School of Medicine. "It's intriguing and should definitely be followed up."

Many studies have linked high-fiber diets to decreased cancer risk and other health benefits. Even if eating more fruit and vegetables doesn't boost immune therapy's effectiveness, Sears says, "the upside is you're probably not hurting anyone with a high-fiber diet." ■

EARTH & ENVIRONMENT

Iron may turn icebergs green

Scientists may have finally figured out why some icebergs are green: Iron oxides could create the emerald hue.

Icebergs usually appear mostly white because light bounces off air bubbles trapped in the ice. But pure ice without air bubbles or contaminants — ice that often forms on a berg's underside — appears blue because it absorbs longer wavelengths of light (reds and oranges) and reflects shorter ones (like blues).

Why some capsized icebergs spotted near Antarctica have green undersides (one shown) has been less clear. In 2016, researchers found iron oxides in a decades-old sample of green ice. Iron oxides such as rust reflect red and orange light but absorb blue. If these particles, perhaps picked up from rocks crushed by glaciers flowing toward the ocean, get incorporated into ice forming underwater, the result would be a vibrant green, glaciologist Stephen Warren of the University of Washington in Seattle and colleagues say online February 7 in the *Journal of Geophysical Research: Oceans*. — *Jeremy Rehm*

STEVE NICOL

LIFE & EVOLUTION

Spiders eating weird stuff reveal complexity of Amazon food webs

Ecologist Rudolf von May has seen some wild things in Peru's Amazon rainforest. But a video taken by a colleague took things to a whole new level. The video captured a giant tarantula, about the size of a dinner plate, weeble-wobbling through the leaf litter with the body of what was later identified as a mouse opossum hanging from the spider's fangs.

From 2008 to 2017, von May and colleagues documented 15 instances of invertebrates preying on vertebrates in the Peruvian Amazon. Encounters included everything from a wandering spider gripping a Bolivian bleating frog to a centipede eating a venomous juvenile coral snake that the centipede had decapitated, the team reported online February 28 in *Amphibian & Reptile Conservation*.

"It is very valuable and necessary to document these interactions in the field because tropical ecosystems are super diverse," says von May, of the University of Michigan in Ann Arbor. That biodiversity makes it difficult to know exactly how organisms interact. At least now there's more proof of how broad and complex the Amazon food web is. — *Jeremy Rehm*

EMANUELE BIGGI, *AMPHIBIAN & REPTILE CONSERVATION*

A wandering spider in the Peruvian Amazon chows down on a tree frog.

BODY & BRAIN

FDA approves ketamine-based drug for severe depression

Doctors have a new weapon in the fight against particularly hard-to-treat depression: a drug based on the powerful anesthetic ketamine.

The drug — called Spravato and developed by Janssen Pharmaceuticals — was approved March 5 by the U.S. Food and Drug Administration as a treatment for severely depressed people who have tried at least two other treatments without success. Spravato is a nasal spray that must be delivered in a doctor's office and is intended to be used in addition to an oral antidepressant.

Other antidepressants often take weeks to kick in, but ketamine works within hours or days for some people. In a clinical trial, some patients experienced the effects of Spravato in two days.

Ketamine is a mixture of two mirror image molecules. Spravato is composed of one of them: esketamine. It's not yet clear how esketamine compares with ketamine in easing depression. Promising early research has led some doctors to administer ketamine — an anesthetic also used as an illicit drug that creates psychedelic hallucinations — to people who have shown no improvement from other treatments for severe depression. But large clinical trials of ketamine and its relatives are still needed. — *Laura Sanders*

HUMANS & SOCIETY

Hominids may have hunted rabbits as far back as 400,000 years ago

In Europe, Stone Age hominids added small, fast animals to the menu much earlier than once thought, scientists say.

Now-extinct members of the human genus, *Homo*, hunted rabbits and hares in southern France by about 400,000 years ago, researchers report March 6 in *Science Advances*. Hunters also bagged larger creatures such as goats and deer. The new finding may highlight the flexibility and innovativeness of these hominids.

The dietary shift away from eating primarily large game emerged long before a previously recognized change in ancient eating habits, concludes a team led by paleoanthropologist Eugène Morin of Trent University in Peterborough, Canada. In the later transition, Stone Age humans dramatically broadened what they ate, including a variety of small animals, starting about 36,000 years ago.

Morin's group studied 21 sets of fossils and stone tools from eight sites in southern France. In 17 sets, cuts made by stone tools, probably during butchery, were found on the remains of leporids (the family of rabbits and hares). Those sets date from 400,000 to 60,000 years ago.

Colony-dwelling rabbits were probably easier to hunt than solitary hares. The team suspects that starting about 40,000 years ago humans hunted hares regularly, possibly tracking them with dogs by 11,500 years ago (*SN: 2/16/19, p. 13*). — *Bruce Bower*

ATOM & COSMOS

Kepler telescope's first detection is finally confirmed as a planet

A decade after being found, the first exoplanet candidate spotted by the Kepler space telescope has been confirmed as a real world.

The planet orbits a star initially dubbed KOI 4, for Kepler Object of Interest 4. When the planet passed in front of the star, it blocked a bit of starlight from reaching Kepler in Earth's orbit, alerting astronomers to the planet's existence.

The Kepler team thought the star was about 1.1 times the width of the sun, which would make the planet about as big as Neptune. Then astronomers saw a second dip in starlight, presumably as the world passed behind the star. But a secondary eclipse shouldn't be visible for such a small planet, so the exoplanet candidate was dismissed as a false alarm.

Now researchers have revised KOI 4's width. Ashley Chontos dug into unconfirmed Kepler candidates in 2016 as a graduate student at the University of Hawaii in Honolulu. By measuring the way sound waves ripple through KOI 4's interior, she and colleagues determined the star is about three times as wide as the sun. That means the diameter of KOI 4's planet would be about three times larger than first estimated. That's big enough for the world to block enough starlight that Kepler would notice a secondary eclipse, Chontos said March 5 in Glendale, Calif., at NASA's Kepler & K2 Science Conference.

After the findings were double-checked with ground-based telescopes, the star was renamed Kepler 1658 and the planet Kepler 1658b. — *Lisa Grossman*

Watch a tarantula dragging a mouse opossum at **bit.ly/SN_Tarantula**

The Allure of CBD

At a recent event in Bend, Ore., Samantha Montanaro tastes a fizzy drink that contains CBD purified from hemp plants.

People seek health benefits despite lack of evidence

By Laura Sanders

A few months back, a new storefront appeared in my small Oregon town. Its shelves were packed with tinctures, jars of salve, coffee beans, bath bombs — even beard oil. This motley collection shared a single star ingredient: CBD.

Produced by the cannabis plant, CBD is the straitlaced cousin of marijuana's more famous component — the THC that delivers a mind-swirling high. CBD, or cannabidiol, has no such intoxicating effects on the mind. Yet the molecule has captured people's attention in a profound way, sold as a remedy for pain, anxiety, insomnia and other ailments — all without the high.

That neighborhood shop, CBD Scientific, is far from alone in its efforts to sell people on the benefits of CBD, which is found in both marijuana and hemp, two versions of the *Cannabis sativa* plant. CBD is popping up in products in pet stores, coffee shops and the health and beauty sections of mainstream grocery stores. It's even being brewed into beer. I left the shop with a $5 bottle of water infused with "5,000,000 nanograms" of CBD.

> "A lot of the products that people are taking may not be what they think."
>
> SUSAN WEISS

So far, messages of CBD's purported health benefits come from people trying to sell CBD products — not from scientists, says Margaret Haney, a neurobiologist who directs the Marijuana Research Laboratory at Columbia University. A gaping chasm separates the surging CBD market and the scientific evidence backing it. While there are reasons to be excited about CBD, the science just isn't there yet, Haney says.

Scientists still don't know all of the targets CBD hits in the human body, nor what effects it may have, if any. With the exception of tests in people with rare forms of epilepsy, large studies that compare CBD with placebos in people are rare. Much of the existing research was done with cells in the lab or in lab animals, with results that don't necessarily translate to people.

And there's always the chance that for some people, CBD's magic is made not by the compound itself but by a powerful placebo effect; people who expect good outcomes are more likely to see benefits.

Researchers are stepping into the void, lured by promising early data. Small trials are under way looking at the effect of CBD on anxiety, pain, opioid addiction, depression and other health problems. National Institutes of Health funding for CBD studies went from zero in 2014 to an estimated $16 million in 2018.

"We're very interested in CBD," says Susan Weiss, director of the Division of Extramural Research at the National Institute on Drug Abuse in Bethesda, Md. Still, she urges caution to people eager to try CBD. Because of lax oversight, there's no telling what's inside many of those tinctures, oils, rubs and foods for sale online and in stores. "A lot of the products that people are taking may not be what they think," she says.

Despite the risks and warnings, it seems safe to say that the collective fascination with CBD isn't going to wear off anytime soon. "People think it's great for everything," says cognitive neuroscientist Kent Hutchison of the University of Colorado Boulder. That can't possibly be true, he says. "But I do think it's going to be great for some things. We just need to figure out what those things are."

Mystery molecule

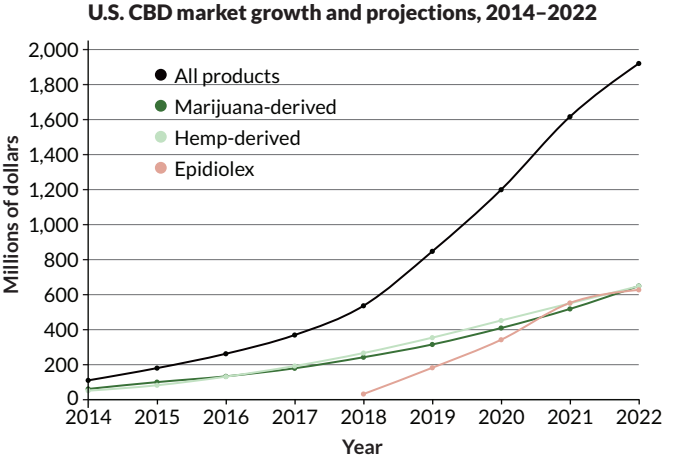
Each morning, Samantha Montanaro of Portland, Ore., drops a CBD tincture under her tongue. "I'm kind of testing out my own body with this," she says. "I'm finding that it really helps with anxiety and stress."

Montanaro isn't alone; CBD testimonials are increasingly easy to find. In 2016, Montanaro, now 35, cofounded Tokeativity, a global cannabis community for women. Back then, "CBD wasn't even a thing," she says. But the first sparks of the CBD movement caught fire fast. "It's been pretty crazy to watch how things have evolved," she says. Some bullish analysts predict that the CBD market in the United States will balloon from hundreds of millions of dollars in 2018 to almost $20 billion by 2022.

Ziva Cooper directs UCLA's Cannabis Research Initiative and fields a lot of questions about CBD. Her answers invariably disappoint. "When I tell [people] we don't have very much evidence in people, they're actually surprised," she says. When it comes to CBD's benefits, "there's actually very little out there to hang our hats on."

The one exception is for rare forms of childhood epilepsy. Neurologist Elizabeth Thiele of Massachusetts General Hospital in Boston had a young patient who was having over 100 seizures a day. After other treatments had failed, the boy's

Booming business U.S. sales of CBD-containing products are on the rise, and industry watchers expect a growing market in years to come. Epidiolex, an antiseizure drug made available in 2018, is the only prescription medication containing CBD. Sales figures beginning with 2018 are estimates. SOURCE: NEW FRONTIER DATA 2018, *HEMP BUSINESS JOURNAL*

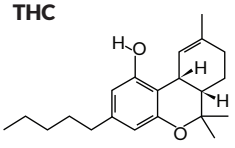


OPPOSITE PAGE: MARIAH HAGENBACH FOR TOKEATIVITY BEND MAMAS; THIS PAGE: E. OTWELL

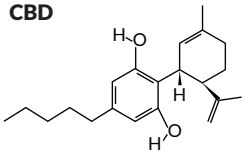
A tale of two plants

Both hemp and marijuana, two versions of *Cannabis sativa*, produce THC and CBD, though in varying amounts. Marijuana plants have higher amounts of THC, the chemical responsible for pot's high; hemp plants have higher levels of CBD. THC and CBD have similar chemical structures, but their effects are very different.

THC



CBD



Hemp

- High levels of CBD
- THC concentration: ≤0.3%
- Per 2018 Farm Bill, no access restrictions

Marijuana

- Low levels of CBD
- THC concentration: 0.3% to almost 30%
- Access is heavily restricted

parents began searching for a source of CBD oil, which they desperately wanted to try after learning about promising early results in animals. The family flew to England, so the boy could try the CBD formulation made by GW Pharmaceuticals. The child's results, Thiele says, were remarkable. After a week of CBD, his daily seizures had fallen to single digits.

That result ultimately led to clinical trials, one of which included 171 people, mostly children, with Lennox-Gastaut syndrome, a rare and severe seizure disorder. In addition to their normal medication, half of the participants got doses of CBD that were rigorously tested and standardized by the drug's maker. The other half received their regular treatment plus a placebo. After 14 weeks, the people taking CBD saw a median drop in monthly seizure frequency of about 44 percent; seizures in people who took the placebo dropped almost 22 percent. Thiele and her colleagues published those results in March 2018 in the *Lancet*.

Side effects were manageable, the researchers found. Diarrhea, sleepiness, poor appetite and vomiting were more likely to occur in the people who took CBD than in those who got the placebo. Along with results from several other trials, those data were strong enough to prompt the U.S. Food and Drug Administration to approve the CBD drug, called Epidiolex, last June.

Despite rigorous testing of Epidiolex, big gaps in knowledge on how the drug works in epilepsy remain. Researchers don't know how CBD tames seizures. Because the molecule comes from cannabis, the early assumption was that CBD latches onto the same chemical receptors that THC connects to, one primarily in the brain and one mainly on immune cells. It turns out, however, that CBD doesn't seem to hit either of those receptors.

Instead, studies in rats and mice point to two different targets. One, called TRPV1, is known to play a role in pain sensation and maybe epilepsy, too. The other, called GPR55, might change the activity level of nerve cells in the brain, a feat that may be behind CBD's antiseizure power.

Scientists also don't know whether CBD keeps working year after year. For some of Thiele's patients, CBD seems to still be effective after five years of taking the drug, even allowing them to taper off some of their other medications, she says. But data from 92 other patients, presented in December at the American Epilepsy Society's annual meeting, suggest that CBD's benefits can start to fade after about seven months on the drug. About a third of the people in the study needed a dose increase after their CBD doses became less effective, researchers from Tel Aviv Sourasky Medical Center reported.

Research on CBD and other ailments lags way behind the epilepsy work. Early experiments, mostly on lab animals but some in small numbers of people, suggest that CBD might fight anxiety, ease schizophrenia symptoms and address pain.

One example: Healthy men who took CBD before a stressful public speaking task were calmer than those who took a placebo, researchers reported in October in the *Brazilian Journal of Psychiatry*. But only the 15 men who received doses of 300 milligrams were more relaxed. The 27 who took less or more CBD didn't see benefits. Other types of studies with

Some children with severe epilepsy, like this boy from Texas, have found remarkable relief from seizures with a drug called Epidiolex. The medication is the first CBD-based drug to get FDA approval.

FROM TOP: WALTHER OTTO MÜLLER/WIKIMEDIA COMMONS; LESLIE BOORHEM-STEPHENSON

people, and studies of mice and rats, have turned up anti-anxiety effects, too. But most of these studies looked at single doses of CBD, not consistent use.

Early evidence of CBD's promise against schizophrenia comes from a trial of 88 people with the disorder. After six weeks, people who had received a big daily dose of CBD (1,000 milligrams a day) in addition to their normal medication had more improvements in certain symptoms when compared with people who received a placebo. Those results hint that CBD might be a new type of drug for schizophrenia, researchers wrote this month in the *American Journal of Psychiatry*.

Studies in lab animals suggest that CBD may help relieve chronic pain. A study appearing in 2017 in *Pain* found that CBD could block osteoarthritis pain and nerve damage in rats. Hard data for humans are harder to find, but anecdotes abound. Pain clinician Kimberly Mauer of Oregon Health & Science University in Portland and colleagues at the OHSU Comprehensive Pain Center have seen an uptick in patients who say they're taking CBD. Their experiences are mixed, she says: "About half the patients say they get some benefit, and about half say they didn't notice anything."

No easy access

To answer the many outstanding questions about CBD's effects, scientists need access to the compound. But a complex web of U.S. regulations makes that difficult. CBD is subject to rules from both the FDA and the U.S. Drug Enforcement Administration. CBD produced by the marijuana plant remains on the DEA's list of the most restrictive class of drugs, Schedule 1, alongside LSD, ecstasy and other drugs deemed to have no accepted medical use and high potential for abuse. Access restrictions on industrial hemp, and by extension, the CBD that comes from hemp, were eliminated in the 2018 Farm Bill, signed into law in December. However, regardless of its provenance, CBD is still subject to FDA regulations, as well as any regulations imposed by states.

"As easy as it's gotten for the average person to go legally to buy recreational marijuana and consume it in many states, it's gotten harder for scientists," says Haney at Columbia. One of the few approved sources of CBD is a government-sanctioned cannabis facility at the University of Mississippi in Oxford. After she gets the CBD she needs for her studies, Haney is required to meticulously account for every milligram. "I have a gun safe in a locked room that I get into with my fingerprints to store both cannabidiol and marijuana."

With those restrictions, many scientists just can't do the studies they want, Hutchison says. "The whole thing is a little bit crazy. People can sell it everywhere, but it's very difficult for scientists to study its effects in humans."

A mobile pharmacology lab, dubbed the CannaVan, helps researchers at the University of Colorado Boulder study the effects of CBD on disorders such as anxiety.

Hutchison and colleagues have figured out a legal workaround that doesn't require researchers to obtain supplies of CBD. The team is avoiding the government-grown cannabis, which can be quite different from the products in circulation, by testing the effects of the cannabis products that people are actually using. To do this, the researchers created a mobile pharmacology lab they call the CannaVan. The tricked-out Dodge contains equipment to study people after they've taken a product containing CBD (or THC) that they bought themselves. The researchers are currently collecting data on CBD's effects on anxiety and pain.

Buyer beware

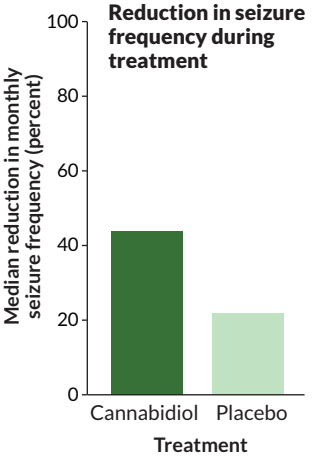
FDA rules say that CBD cannot be legally added to food and sold across state lines, sold as a dietary supplement or marketed with claims of treating diseases. But aside from sending some warning letters, the FDA has, so far, let the marketplace run uninhibited. (Some local health authorities, however, are beginning to flex their might, warning restaurants in New York City, for instance, to take CBD off the menu.)

Overall, no one really knows what's inside the bottles, rubs and coffees for sale. A study published in 2017 in *JAMA* gives a sense of the problem. Researchers ordered and tested 84 products sold online in 2016 as CBD-containing products. Of those, only 26 were labeled accurately (containing CBD within 10 percent of the claimed amount); 36 of the products had more CBD than their labels said; and 22 products had less. The researchers also found THC in 18 of the 84 samples.

Sophie Cloyd is a 30-year-old manager for the CBD company Ablis of Bend, Ore. She is also pregnant. I met her recently at a ski lodge, where she was offering beverage

Seizure stopper In people with severe forms of epilepsy, CBD plus normal treatment (dark green bar) curbed seizures to a greater extent than did a placebo coupled with normal treatment (light green bar), one trial showed.

SOURCE: E.A. THIELE *ET AL*/*THE LANCET* 2018



FROM TOP: COURTESY OF UC BOULDER; E. OTWELL

tastes and describing tinctures, oils and lotions. CBD, she says, has helped her manage this pregnancy, her second. She was prescribed the antinausea drug Zofran early in her pregnancy, but "the research on Zofran scared me more than the lack of research on CBD," she says.

Ablis, which makes CBD-infused fizzy drinks and other products, currently gets purified CBD from Colorado, Cloyd says. When the CBD arrives, the company sends it to an independent lab to confirm that it has the right amount of CBD, no pesticides and no THC. But not all CBD sellers test their products.

An unexpected THC dose might not be enough to get a user high, but it could still be a problem, as news reports have begun to point out. To ease his pain from psoriatic arthritis, a school bus driver in Beaverton, Ore., had been taking a daily dose of CBD oil. In early 2018, he failed a periodic drug test with high THC levels, which caused him to lose his job, Portland news channel KATU reported. Even seemingly small amounts of THC can build up in the body with repeated use.

A product might contain even worse surprises. Between December 2017 and January 2018, for example, 52 people fell ill in Utah, with symptoms such as hallucinations, vomiting and seizures, after taking what they thought was CBD. It turned out that the products, many labeled "Yolo CBD oil," contained a synthetic cannabinoid, and it had poisoned them.

Even if product labels were always accurate, people have no idea of the correct dose of CBD (assuming the right dose would be effective). "You see it marketed in doses like 10 milligrams," Hutchison says. "Well, 10 milligrams probably does nothing." For comparison, people who participated in one Epidiolex study took 20 milligrams per kilogram of body weight. To reach that daily dose, I'd need to chug 254 bottles of that 5 million nanogram CBD water I bought — at a cost of $1,270.

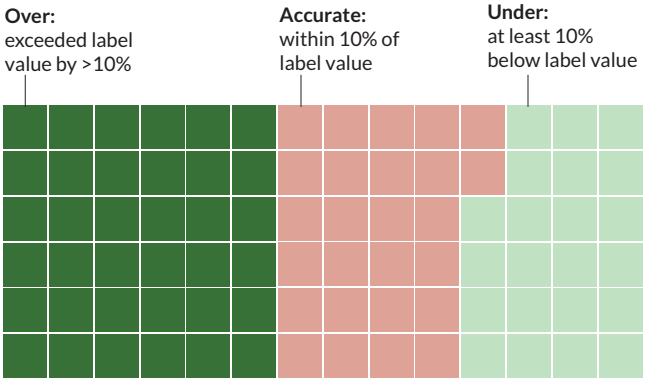
Haney makes the same point: "You're not getting anything resembling an effective dose when you get CBD added to your coffee, or you buy a mint with a little bit of CBD in it," she says.

There's even less known about CBD products that you rub on your skin. Scientists don't know that CBD in creams, oils and ointments actually makes it into the body. "I'm not convinced that anything you're rubbing on your body with CBD is even getting through," Haney says.

CBD is the star ingredient in gels, balms, oils, candy and more. Data on effectiveness are slim, yet people are eager to buy these products.

Off label Laboratory tests of CBD products bought online revealed that most of the products were mislabeled. Less than one-third of the 84 products tested had labels that accurately described the amount of CBD found within. SOURCE: M. BONN-MILLER *ET AL*/*JAMA* 2017

Accuracy of CBD levels listed on 84 product labels



At its heart, the trouble is that most CBD use isn't backed up by science, Haney says. "I am not against CBD," she says. In fact, she is about to start a study looking at CBD to treat nerve pain due to chemotherapy in cancer patients. "But I don't like marketers determining what it's good for and what it's not."

Hype run amok isn't anything new, says Mauer, the OHSU pain doctor. Consumers try lots of things before the science is definitive — keto diets, for instance, or vitamin D supplements (*SN: 2/2/19, p. 16*). And even if it turns out that the chemical doesn't work, the placebo effect might be enough to help reduce symptoms.

So far, the science on CBD isn't mature enough to weigh in, one way or another. But judging by the number of studies and clinical trials under way, this nascent research field is growing up fast, seeking to quickly fill the space between the science and what people want to know.

This research boom heartens Montanaro. Her message to the scientific community: "I would encourage curiosity," she says. "I'm not a doctor, and I'm not a scientist, but I certainly know my own body," and she says that CBD helps her. From her perspective, science has got some catching up to do. ■

Explore more

- Marcel O. Bonn-Miller *et al*. "Labeling accuracy of cannabidiol extracts sold online." *JAMA*. November 7, 2017.
- Kerstin Iffland and Franjo Grotenhermen. "An update on safety and side effects of cannabidiol: A review of clinical data and relevant animal studies." *Cannabis Cannabinoid Research*. June 1, 2017.

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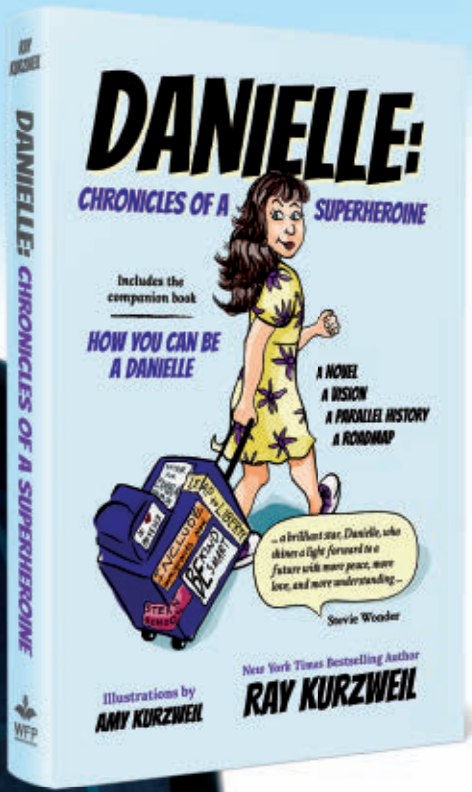
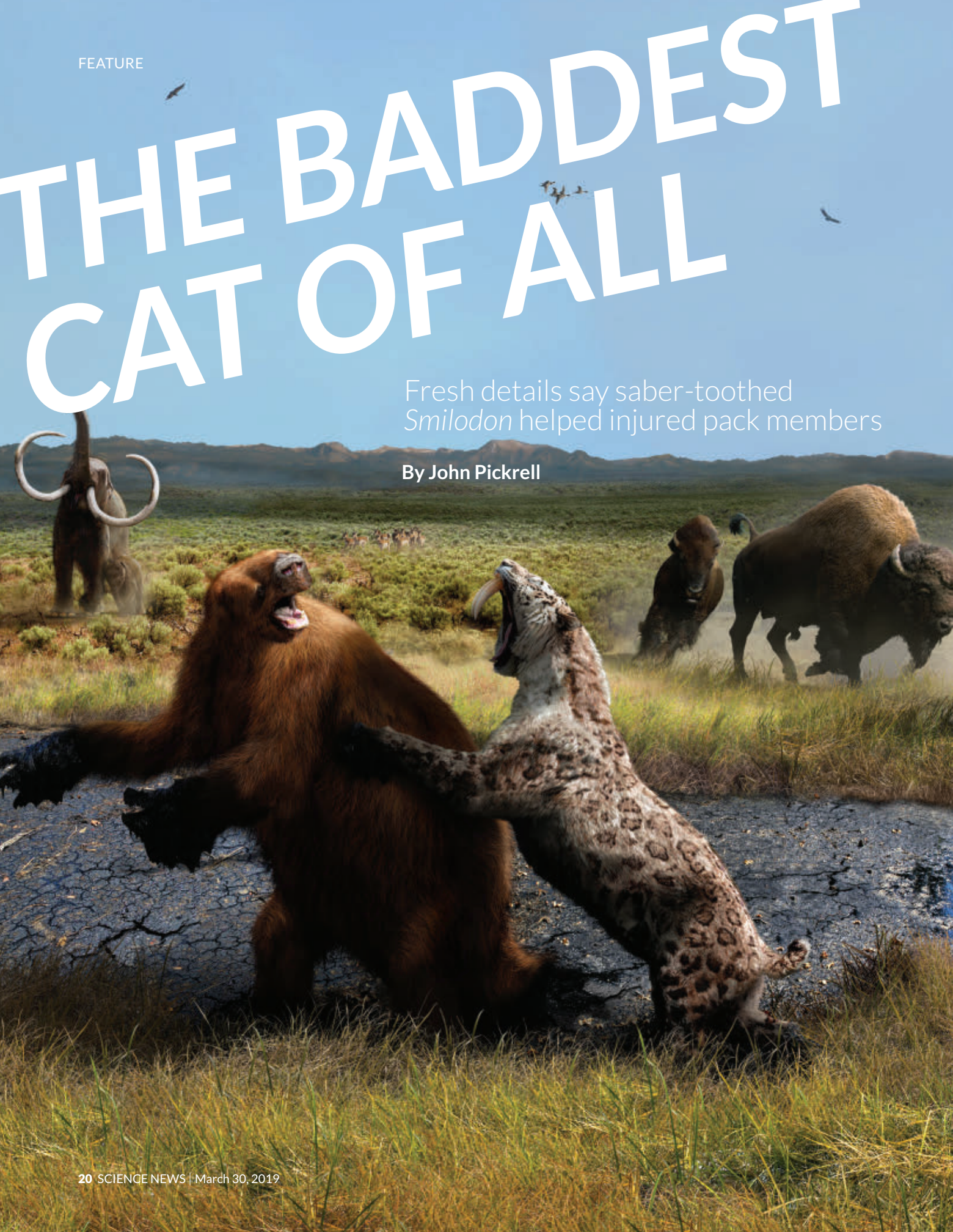


THE BADDEST CAT OF ALL

Fresh details say saber-toothed *Smilodon* helped injured pack members

By John Pickrell



The adolescent saber-toothed cat on a summertime hunt realized too late that she had made a terrible miscalculation.

Already the size of a modern-day tiger, with huge canine teeth, she had crept across grassy terrain to ambush a giant ground sloth bellowing in distress. Ready to pounce, the cat's front paw sank into sticky ground. Pressing down with her other three paws to free herself, then struggling in what has been called "tar pit aerobics," she became irrevocably mired alongside her prey.

Scenarios much like this played out repeatedly over at least the last 35,000 years at California's Rancho La Brea tar pits. Entrapped herbivores, such as the sloth, attracted scavengers and predators — including dire wolves, vultures and saber-toothed *Smilodon* cats — to what looked like an easy meal. Eventually the animals would disappear into the muck, until paleontologists plucked their fossils from the ground in huge numbers over the last century.

Five million or so fossils have been found at the site. But "it's not like there was this orgy of death going on," says Christopher Shaw, a paleontologist and former collections manager at the La Brea Tar Pits and Museum in Los Angeles. He calculates that such an entrapment scenario, dooming 10 or so large mammals and birds, would have needed to occur only once per decade over 35,000 years to account for that bounty of fossils.

At La Brea, the collection of *Smilodon fatalis* fossils alone includes more than 166,000 bones, from an estimated 3,000 of the ill-fated prehistoric cats. Famed for their fearsome canines, which grew up to 18 centimeters long, *S. fatalis* weighed as much as 280 kilograms, bigger than most of today's largest lions and tigers.

Fossils of *S. fatalis*, the second largest of three *Smilodon* species that roamed the Americas during the Pleistocene Epoch, have been found across the United States and in South America, west of the Andes as far south as Chile. And a recent study put *S. fatalis* in Alberta, Canada, about 1,000 kilometers north of its previously known range.

But the La Brea fossil site, unique in offering up so many specimens, is the source of the vast majority of knowledge about the species. There, fossils of dire wolves and saber-toothed cats together outnumber herbivores about 9-to-1, leading scientists to speculate that both predators may have formed prides or packs, similar to modern lions and wolves. Yet a small number of experts argue against cooperative behavior for *Smilodon*, reasoning that pack-living animals would have been too intelligent to get mired en masse.

Paleontologist Larisa DeSantis examines *Smilodon* jawbones (one at bottom) from La Brea to look for evidence of injuries that may have hampered a saber-toothed cat's ability to hunt.

New studies may help settle the debate about *Smilodon*'s sociality, and answer questions about how the cat lived and why it died out 10,000 to 12,000 years ago.

"We have an innate curiosity to understand what it was doing and why it went extinct," says Larisa DeSantis, a vertebrate paleontologist at Vanderbilt University in Nashville. Now, she says, "we can answer these questions."

DeSantis is studying microscopic wear on fossil teeth and chemical signatures in the enamel to reveal *Smilodon*'s diet. Other scientists are doing biomechanical studies of the skull, fangs and limbs to understand how the powerful cat captured and killed its prey. Some researchers are extracting DNA from fossils, while others are gathering data on the paleoclimate to try to piece together why *Smilodon* died out.

"It's the *T. rex* of mammals ... a big, scary

On countless occasions over thousands of years, predator and prey alike — such as saber-toothed cats and giant ground sloths — became mired in the tar at what is now Rancho La Brea in southern California, leaving loads of fossils for researchers to study.

OPPOSITE PAGE: SERGIO DE LA ROSA; THIS PAGE, BOTH: COURTESY OF L. DESANTIS

predator," says Ashley Reynolds, a paleontology Ph.D. student and fossil cat researcher at the University of Toronto. She presented the Alberta fossil find in October in Albuquerque at the Society of Vertebrate Paleontology conference. Explaining why *Smilodon* cats continue to excite researchers, she says, "They're probably the baddest of all the cats that have ever existed."

Safety in numbers

Whether *Smilodon* was a pack hunter has long been debated (*SN: 10/28/17, p. 5*) because living in groups is rare among large cats today. But an unusual number of healed injuries in the *Smilodon* bones at La Brea makes it unlikely that these cats were solitary, DeSantis and Shaw reported in November in Indianapolis at a meeting of the Geological Society of America.

More than 5,000 of the *Smilodon* bones at La Brea have marks of injury or illness: tooth decay, heavily worn arthritic joints, broken legs and dislocated elbows that would have occurred before the animals' tar burial. Dramatic examples include crushed chests and spinal injuries, which the cats somehow survived. "You would actually wince to see these horribly, traumatically injured specimens," says Shaw, who is also coeditor of the 2018 book *Smilodon: The Iconic Sabertooth*.

One particularly debilitating injury was a crippled pelvis, but evidence of new bone growth shows that the animal lived long enough for healing to occur. "There was a lot of infection, pain and smelly stuff, and just a really awful situation for this animal, but it survived well over a year," Shaw says. "To me that indicates [the injured cat] was part of a group that helped it survive by letting it feed at kills and protecting it."

Shaw and DeSantis looked at a series of specimens with what were probably agonizing maladies in the teeth and jaws, including fractured canines and massive infections that left animals with misshapen skulls.

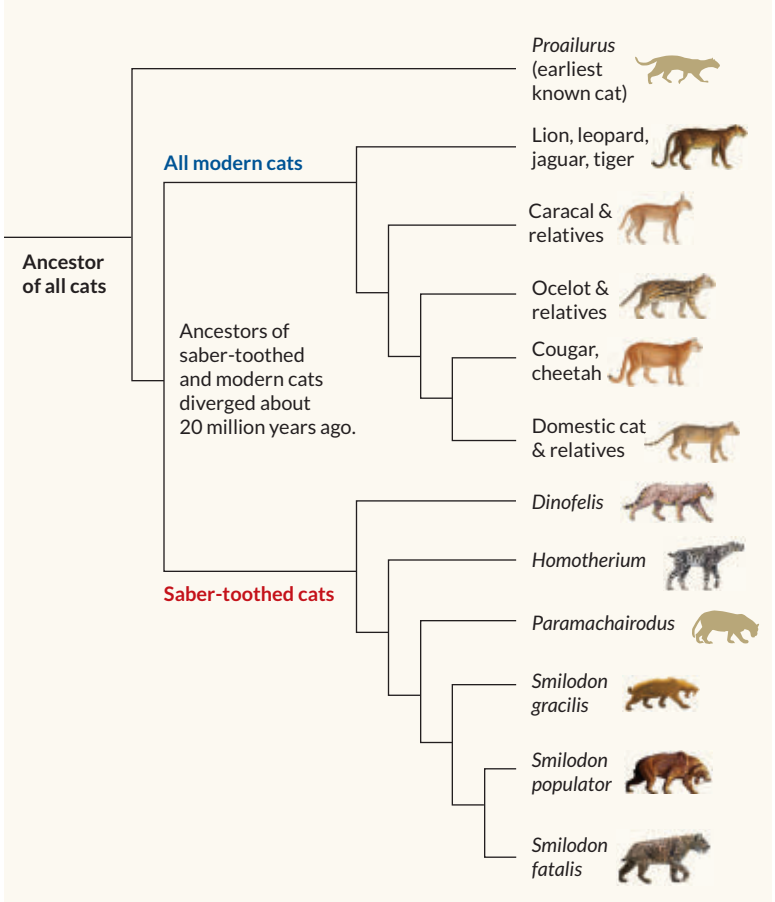
"These animals probably couldn't have gone out ... to kill anything," Shaw says. "You know how it is when you have a toothache. This is like that times 100."

DeSantis compared microscopic pits and scratches on the surface of the teeth of injured animals with microwear on the teeth of seemingly healthy *Smilodon* cats. The injured cats' dental surfaces indicated that the animals were eating softer foods, which would have been less painful to chew, "likely a higher proportion of flesh, fat and organs, as opposed to bone," she says.

The findings are consistent with the interpretation that *Smilodon* was a group-living animal, she says, and that the cats "allowed each other access to food when [injured pack members] couldn't necessarily take down their own prey."

Reynolds agrees that the healed injuries are persuasive evidence that *Smilodon* lived in groups. "When you see an animal with really nasty injuries that healed somehow, it does make you wonder if they were cared for."

Not everyone is convinced, however. Ecologist Christian Kiffner of the Center for Wildlife Management Studies in Karatu, Tanzania, has studied modern carnivores such as African lions and spotted hyenas. "Relatively long survival of *Smilodon fatalis* individuals after dental injuries had occurred does not necessarily provide airtight evidence for a specific social system in this species," he says. "It is very, very difficult to use patterns in Pleistocene carnivore [fossil] assemblages to make inferences about behavior of an extinct species."



Evolutionary distance *Smilodon* and its extinct relatives are on a separate branch of the family tree from all living cats. Those two groups diverged perhaps 20 million years ago. SOURCE: A.D. RINCÓN *ET AL/J. OF VERTEBRATE PALEO.* 2011

CATS, FROM TOP: C. CHANG; RICHARD LYDEKKER; JEAN CHARLES WERNER; REICHENBACH, DER NATURFREUND, 11-12; JEAN CHARLES WERNER; ICONOGRAPHIA ZOOLOGICA; DIBGD/WIKIMEDIA COMMONS (CC BY-SA 4.0); DANTHEMAN9758/WIKIMEDIA COMMONS (CC BY 3.0); C. CHANG; CHARLES R. KNIGHT; DANTHEMAN9758/WIKIMEDIA COMMONS (CC BY 3.0)

Even if the saber-toothed cats did live in groups, the animals' exact social structure remains an open question, Reynolds says. Modern lion prides have numerous females and several younger males led by an alpha male, with intense competition between male lions. As a result, males are much bigger than females, as the males must work hard to defend their positions.

Despite searching, scientists have not found obvious evidence of a size difference between the sexes in *Smilodon*; researchers can't even tell which La Brea fossils are male or female. Size differences between the sexes, if they existed, may have been small.

"That lack of sexual dimorphism is odd," says Blaire Van Valkenburgh, a UCLA paleontologist who studies fossil carnivores. Sex-related size differences are seen in many big cats today, most particularly lions. She thinks the lack of sexual dimorphism in *Smilodon* might hint at a different social structure. Perhaps males weren't competing quite so intensely for access to females. Maybe there was no single alpha male preventing the majority of males from making a move.

Family affair

Perhaps *Smilodon* groups had an alpha female rather than an alpha male, or an alpha pair. Such is the case in modern wolves and coyotes, which have less pronounced size differences between sexes than lions do. The prehistoric cats "could have had extended family structures [similar to wolves] where uncles and aunts hung around, because it probably took a while to raise the young saber-toothed cats," Van Valkenburgh suspects.

Kittens may have taken a long time, as long as 22 months, to get most of their adult teeth, she says. The upper canines took even longer, as much as three years or more, to reach their massive size, researchers reported in *PLOS ONE* in 2015. Modern lions, in contrast, typically have all of their adult teeth by 17 months, Van Valkenburgh says.

Smilodon kittens also probably went through a substantial learning curve before attempting to take down large prey. "It took longer for them to learn how to safely kill something without breaking their teeth or biting in the wrong place and hurting themselves," Van Valkenburgh speculates.

Pack living would enable this slower development: "If you're a social species, you can afford to grow at a slower rate than a nonsocial species because you have a family safety net," Reynolds says. She is studying *Smilodon* fossils from Peru's Talara tar pits for evidence of slow bone development using bone histology, examining thin cross sections under a microscope to determine such things as age and growth rate.

A saber-toothed *Smilodon fatalis* skeleton reveals the robust forelimbs the cat used to pin down prey and the long canines that delivered a fatal bite.

THE NATURAL HISTORY MUSEUM/ALAMY STOCK PHOTO

To understand how saber-toothed cats eventually took down prey, Van Valkenburgh joined paleobiologist Borja Figueirido of the University of Málaga in Spain and others. The group studied the biomechanics of *Smilodon*'s killing bite and how the animal used its sabers. That work, published in the October 22, 2018 *Current Biology*, adds to a consensus that the cat used its powerful forelimbs, which existed even in the youngsters (*SN Online: 9/27/17*), to pin prey before applying a lethal bite to the neck.

"The specialization of being a saber-toothed appears to have been partly to effectively take prey larger than yourself and to do that very quickly," Van Valkenburgh says. With the prey tightly gripped, a *Smilodon* cat would position itself so that one or two really strong canine bites would rip open the pinned animal's throat.

In contrast, lions suffocate prey — one lion may clamp its jaws around the neck, crushing the windpipe, while another uses its mouth to cover the victim's nose and mouth. Using this slower method would have increased *Smilodon*'s chances of injuring or damaging those precious canine teeth.

Diverging senses

Smilodon and its extinct saber-toothed relatives are on a branch of the cat family tree that is far from today's cats. Scientists think *Smilodon*'s branch diverged from the ancestors of all living cats about 20 million years ago. Given the evolutionary distance, researchers are still trying to determine how similar — or different — *Smilodon* was from its living feline cousins. A recent focus has been the cat's sounds and senses.

At the October vertebrate paleontology conference, Shaw presented evidence that *Smilodon* may have roared, as do lions, tigers, leopards and their close relatives. The clues come from 150 La Brea fossils that were once part of the hyoid arch, or larynx, in the *Smilodon* throat. (Tar pits stand out for preserving tiny bones rarely found elsewhere.) The small fossils are very similar in shape and style to those of roaring cats. House cats and others that purr have a different arrangement of bones.

Smilodon may have "used this type of communication as an integral part of social behavior," Shaw says. Roaring, however, is not a sure sign of pack living, Reynolds notes; most roaring cats today do not live in large groups.

How *Smilodon*'s sense of smell compared with living cats' is something else researchers wonder about. To probe this part of the extinct animal's biology, a team lead by Van Valkenburgh looked at *Smilodon*'s cribriform plate — a small, perforated bone inside the skull. Smell-sensing nerve cells pass through holes in the plate from the olfactory receptors in the nose to the brain. The size and number of holes are thought to correlate with the number of receptors and, therefore, the extent of an animal's sense of smell.

"We're going to have a much better handle on what was going on towards the end of their existence."

BLAIRE VAN VALKENBURGH

To confirm this link, Van Valkenburgh's team combined CT scans and 3-D images of skulls from 27 species of living mammals with information on the number of olfactory receptor genes. A CT scan of a skull revealed that *Smilodon* may have had slightly fewer olfactory receptor nerve cells than a domestic cat, the researchers reported at the paleontology conference. *Smilodon*'s sense of smell was perhaps 10 to 20 percent less keen than a modern lion's, says Van Valkenburgh, whose team reported the findings in the March 14, 2018 *Proceedings of the Royal Society B*.

Smilodon "might have relied more heavily on their eyes and their ears," she says. Perhaps, in an ancient evolutionary divergence, *Smilodon*'s level of reliance on smell went in a slightly different direction than in modern big cats.

Saber-toothed swan song

As the pieces of the *Smilodon* puzzle fall into place, perhaps the biggest remaining mystery is why the animal disappeared 10,000 to 12,000 years ago. Debate about the extinction of some of North America's large mammal species swings between blaming humans and climate change (*SN: 11/10/18, p. 28*). While humans, who probably arrived on the continent more than 15,000 years ago, and *Smilodon* certainly knew one another in the Americas, they may not have overlapped at La Brea, Shaw says. The earliest evidence of people in the Los Angeles Basin is about 11,000 years ago, by which time *Smilodon* may or may not already have gone. Nevertheless, human hunting of large prey elsewhere in the Americas could have led to a scarcity of food for the big cats, he says.

One theory holds that *Smilodon* went through tough times at La Brea when lack of prey forced the saber-toothed cats to consume entire carcasses including bones. This has been posited as the reason for all those broken teeth among the La Brea fossils. But DeSantis isn't convinced; she thinks breakages happened during scuffles with prey. She says dental microwear suggests that *Smilodon* was not eating great quantities of bone.

Some opportunistic carnivores, such as cougars, did eat bone and managed to survive to the modern day. Perhaps *Smilodon* couldn't adapt to hunting smaller prey when larger herbivores disappeared, also around 10,000 to 12,000 years ago (*SN: 11/24/18, p. 22*).

"A lot of the large prey on the landscape go extinct," DeSantis says. "You lose out on the horses, camels, giant ground sloths, mammoths and mastodon. That's got to have had an impact."

The challenge of dating fossils from the tar pits has been one hurdle to understanding exactly what was going on with *Smilodon* over time. Bones deposited over many thousands of years get jumbled by movement in the tar, for reasons experts don't fully understand. Plus, the tar itself becomes embedded in each specimen, complicating carbon dating.

However, new methods of chemically pretreating fossils to remove the tar have made carbon dating much easier and cheaper — and a multi-institutional project is now dating hundreds of *Smilodon* and other bones. Researchers will soon be able to track changes in *Smilodon* over the 35,000 years of prehistory recorded at La Brea and correlate fossil changes to known changes in climate over that time.

"We're going to have a much better handle," Van Valkenburgh says, "on what was going on towards the end of their existence." ■

Explore more

■ Lars Werdelin, H. Gregory McDonald and Christopher A. Shaw. *Smilodon: The Iconic Sabertooth*. Johns Hopkins University, 2018.

John Pickrell is a freelance writer based in Sydney.

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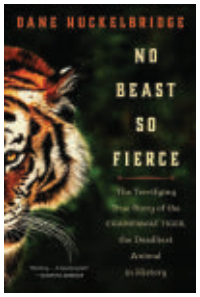


No Beast So Fierce
Dane Huckelbridge
WILLIAM MORROW, $26.99

BOOKSHELF

People were to blame for tiger's man-eating ways

At the heart of *No Beast So Fierce* is a simple and terrifying story: In the early 20th century, a tiger killed and ate more than 400 people in Nepal and northern India before being shot by legendary hunter Jim Corbett in 1907. Rather than just describe this harrowing tale, though, author Dane Huckelbridge seeks to explain how such a prolific man-eating tiger came to be, taking readers on a fascinating journey through the natural history of a tiger and the political history of Nepal and northern India.

Perhaps the first surprise is that Huckelbridge actually elicits sympathy for the tiger. This big cat, known as the "Man-Eater of Champawat," was not born with a taste for human flesh. The beast, when it was still fairly young, had some sort of encounter, probably with an unsuccessful hunter, that severely damaged the cat's mouth and caused the loss of two canine teeth. With that handicap, the Champawat tiger probably had to switch from hunting water buffalo and other large ungulates to easier-to-catch prey — humans — as a means to survive. This scenario is fairly common among man-eating big cats, Huckelbridge notes; we humans usually aren't meals until a cat is somehow forced to turn us into dinner.

But to understand how the tiger racked up such an impressive number of kills — 436 deaths over some seven years — one has to consider how the landscape of Nepal and India had become less hospitable to wildlife. As the British colonized the Indian subcontinent in the 19th century, prime tiger territory was destroyed to make way for people and agriculture. The loss of habitat forced many tigers to compete for land and prey, and the Champawat tiger, with its physical disadvantages, would have been unable to prevail without turning to humans. "What becomes clear upon closer historical examination is that the Champawat was not an incident of nature gone awry," the author writes, "it was in fact a *man-made* disaster."

And by the time the tiger was sneaking through the brush and snatching (mostly) women and children, the British had long banned Indian people from owning any sort of weaponry that might have allowed them to take on the beast. By the time anyone with appropriate weaponry could be summoned to help, the tiger would have moved on, Huckelbridge explains. Corbett, therefore, is presented not so much as some colonial savior but as the man who had permission to own a gun. He still gets credit for being determined enough to follow the cat from one village back to the animal's home base. Corbett was also smart enough to enlist the much-needed help of a traumatized populace to finally bring down the beast that had been stalking people for years.

Corbett's hunt is given sufficient room in the tale to satisfy readers who want details of the bloody kill. But it is somewhat anticlimactic, a sad end for a sad creature that had to be killed not because it was evil but because it was hungry. And the Champawat tiger was hardly the only man-eater created out of the Indian subcontinent's environmental and historical conflicts at the time; Corbett killed more than 30 of these troublesome, and troubled, tigers and leopards.

What the story of the Man-Eater of Champawat means for today's tigers is given shorter shrift than many readers might like. Fewer than 4,000 tigers exist in the world today, and their future remains uncertain.

Perhaps Huckelbridge dwells little on this challenge because there are no easy answers for how to move forward. "We've arrived at the point, it seems, where all can agree that tigers need to exist," he writes. But how to live with creatures that can devour us is something that communities still struggle with today.
— *Sarah Zielinski*

During the early 20th century, hunter Jim Corbett killed more than 30 man-eating big cats on the Indian subcontinent, including the Bachelor of Powalgarh (shown), a tiger he shot in 1930.

COURTESY OF WILLIAM MORROW

The Big Nine
Amy Webb
PUBLICAFFAIRS, $27

BOOKSHELF

Nine companies steer artificial intelligence

Whether artificial intelligence is humankind's best friend or greatest threat has been widely debated. We've all heard promises of device-studded smart homes conferring unprecedented convenience, as well as warnings of killer robots. *The Big Nine* is a different kind of story about the potential risks and rewards of AI.

Rather than questioning the character of thinking machines, futurist Amy Webb turns a critical eye on the humans behind the computers. With AI's development overwhelmingly driven by nine tech powerhouses, she asks: Is it possible for the technology to serve the best interests of everyone?

Webb shines a spotlight on the Big Nine: Google, Microsoft, Amazon, Facebook, IBM and Apple (the "G-MAFIA") in the United States, and Baidu, Alibaba and Tencent (the "BAT") in China. The G-MAFIA is beholden to capitalist market forces; the BAT serves the will of the Chinese government.

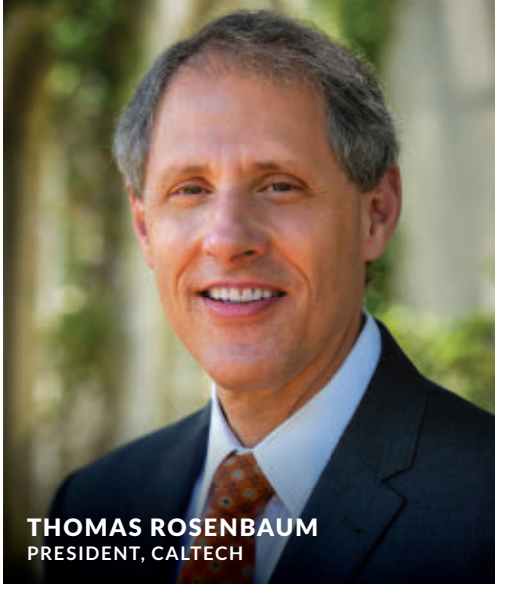
The book highlights warning signs of what happens when we increasingly rely on technology created by corporations that prioritize commercial and political interests over the public. These red flags include mismanagement of users' personal data in the United States and a state-sanctioned "social credit" system that monitors people's behavior in China. Webb generally holds the Big Nine accountable but occasionally pivots to defend the companies, which she believes are led by people with good intentions.

Readers who aren't as convinced of the Big Nine's noble intentions may at least agree with Webb that great power begets great responsibility. The second half of the book details three possible futures through 2069, ranging from a best-case scenario where the Big Nine commit to making user interests the No. 1 priority to a worst-case scenario where the Big Nine continue business as usual.

Webb's assessments are based on analyses of patent filings, policy briefings, interviews and other sources. She paints vivid pictures of how AI could benefit the average person, via precision medicine or smarter dating apps, for example, though she primarily focuses on people in the United States. Her forecasts are provocative and unsettlingly plausible.

Webb closes with a somewhat perfunctory call to action, including predictable steps like reading the G-MAFIA's terms of service. Unfortunately, *The Big Nine* may leave many readers feeling less like empowered citizens and more like extras in a film where tech giants and world leaders play the protagonists. But for anyone who wants a preview of how a few tech firms could reshape society in relatively short order, Webb's account is an accessible, intriguing read. — *Maria Temming*

CONVERSATIONS WITH MAYA



THOMAS ROSENBAUM
PRESIDENT, CALTECH

Maya Ajmera, President & CEO of Society for Science & the Public and Publisher of *Science News*, sat down to chat with Thomas Rosenbaum, President of the California Institute of Technology and an alumnus of the Westinghouse Science Talent Search. We are thrilled to share an edited summary of their conversation.

You're an alumnus of the 1973 Westinghouse Science Talent Search. How did the competition impact your life and are there any particular moments that still stand out for you?

While the process of putting together an independent project had its merits, what really sticks with me is the experience I had in Washington, D.C. The competition interviews, for example, taught me to have the courage of my convictions. I had prepared myself to defend my project, but really the questions ranged well beyond that. It was a little painful, to be honest.

At some points the judges asked questions where I really did know the answer. One that's still fresh in my memory was about solar wind. I answered that it was charged particles from the sun, which was correct. They were very skeptical and pushed back, asking me "What are you talking about? It's photons." But I knew the answer because I knew about the importance of the magnetic field in the Earth to deflect the charged particles.

I realized at that point the judges were not only looking for knowledge of facts, but also the ability to explain why you were saying what you were saying, and as I said, to have the courage of those convictions. As you go on further in the sciences, you learn the art of argument. You learn to defend your positions. You learn to listen well because sometimes your positions are not correct. That was really the first experience I had in that way, so it was seminal for me.

The best part of the competition was the relationships that I developed with the other competitors. Under this pressure cooker, you make connections quickly and they were long lasting.

You are a national leader in the academic world. Can you tell us about that journey and how that path led to your current position as the president of Caltech?

I can't claim that it was any great planned path. I was a physics major in college and earned a Ph.D. in physics. I am an experimentalist and continue to do science. I still have a laboratory and graduate students. Along the way, you're asked to do certain things for the commonwealth to help your colleagues. It started for me with running the Materials Research Laboratory at the University of Chicago, where I joined the faculty straight out of grad school.

Then I was asked to do more serious administrative jobs, including being provost at the University of Chicago in 2007. I enjoyed interacting with really smart people who did completely different things. That part was fantastic, and I enjoyed those aspects of the job enormously. You have an excuse to talk to people that otherwise you might never learn from. I wasn't actually looking for a presidency, but when Caltech came up, I was encouraged to apply. I did and decided that maybe I could do something good and influence the direction of science in a place that really can change the world.

What has Caltech done recently to continue to provide a unique and productive environment for the training of future innovators, scientists and engineers?

I can pick out two aspects that I think are very important, and in a lot of ways describe my job. The first is maintaining a strong culture where people can come, dream big and do wonderful things. We provide the resources to let them do that. It's an attitude about what you can accomplish in science.

The second part is focus. Caltech is unusual in that we actually don't try to get bigger; we try to get better. We're constantly evaluating what the important scientific and technological problems are, and we take big bets. We try to operate in a way where we identify the most important issues, focus on them and invest broadly across disciplines in search of solutions to big problems.

CALTECH

You recently announced in 2018 a new visual culture program launching at Caltech. What role do you think the arts play on your campus as well as in a STEM education?

I firmly believe that the humanities and the arts are essential for forming well-rounded human beings who develop passions in life and can contribute to society broadly. We teach the arts, social sciences and humanities rigorously at Caltech. It's an important part of our curriculum. I would argue that it also makes you a better scientist because the arts allow you to step out of a particular subject and look at it from a different viewpoint.

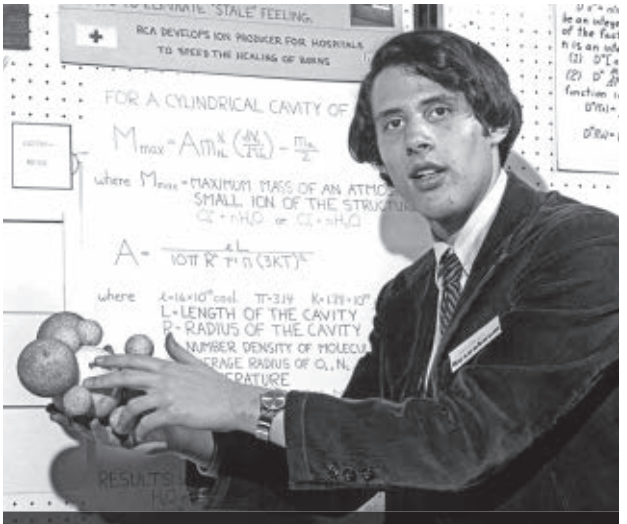
When you were inaugurated as Caltech's ninth president in 2014, you sent a command order to the Curiosity rover on Mars. What was that like?

As you know, Caltech runs the Jet Propulsion Laboratory for NASA. On the morning of my inauguration, I went out to JPL, and I gave a talk there. At the end of the ceremonies, this robot comes rolling across the stage toward me, and it's holding an iPad. In the middle of the iPad is this big red button. It stops in front of me, and now I have the decision, do I push this red button? Who knows what's going to happen?

Having faith in my colleagues, I pushed the red button. They told me that I sent commands to the Curiosity rover that day, telling it where to move, where to take photos and so on and so forth. Fortunately, nothing went wrong that day, so I could fully enjoy the experience.

What character traits do you look for in prospective students and faculty at Caltech?

We look for fearlessness: individuals who are unafraid to try hard things. We look for people who will reinvent themselves. That is, if they find a problem that's important, even if it doesn't match their skill set at present, they will master the right background, talk to the right people and reinvent what they can do. We look for that flexibility of mind and purpose. I do want to emphasize there's no one answer. The wonderful thing about environments at places like Caltech and our peers is that you meet colleagues and students who have very different ways of approaching problems. Sharing those approaches, those different backgrounds and the diverse perspectives that come with them is what leads to progress.



Thomas Rosenbaum with his 1973 Science Talent Search project, "The Structure of Atmospheric Small Ions."

SSP

At Society for Science & the Public, we want every student to have the opportunity to be a scientist or engineer if that's what they choose. Do you think the United States is doing enough to foster the next generation of STEM leaders?

I think the role of the Society is exactly right. But I think we need to do more to make the case about the excitement for science. There are lots of stereotypes about science that just aren't right. There's this notion that science is a solitary life, that you wear a white coat, go into a basement lab, work for years and occasionally you come out to see the light and be dusted off. It is in fact a remarkably interactive experience to be a scientist. You basically run a small business if you run a laboratory. You intersect with colleagues around the world. You speak the same language that cuts across international boundaries. You ask questions that are compelling and obsessing.

What advice would you give to young people just starting higher education or an early professional career?

I would say enjoy it. You can do anything. But you should note that the path can be meandering, so you shouldn't worry if you're not going straight from point A to B. In fact, the detours are sometimes more influential than the endpoints.

What books are you reading right now?

I just read Hanna Holborn Gray's memoir, *An Academic Life*. It is a remarkable story of generations of European academics leaving Nazi Germany and reinventing their lives here in the United States. She also writes a lot about the role universities can play in societies, the importance of seeking truth, of academic freedom, of creating community, of the importance of immigration and the way it can transform societies for the better. On my nightstand there's always a stack of *New Yorker* magazines. I am never up-to-date, but I am trying.

The world faces so many challenges today. What keeps you up at night?

The free movement of people and ideas has been the secret to scientific progress. It has, I would argue, been a competitive advantage for the United States that really smart and creative people from around the world have chosen to come here and contribute to society. We're going through a period now where we're seeing a curtailment of these possibilities. I think it's bad for science and it's bad for the United States. The other one, of course, is climate change. I won't be very original here, but I really do worry about what kind of world we're leaving for our children and our grandchildren. It's a hard problem because we have to act now for effects that will not show up completely, or in their worst form, for decades. Society is not very good at addressing such problems. ◆

FEBRUARY 16, 2019

Robot revolution?

Educational robots could help students learn new skills and good study habits. But researchers still have a lot to learn about the potential risks involved when young kids keep close company with such robots, ***Maria Temming*** *reported in "Study buddies"* (SN: 2/16/19, p. 16).

The story reminded reader **A. Bogart** of Isaac Asimov's novel *The Naked Sun*, in which robots and humans live side by side. Asimov "raised the specter of some of the same issues with which scientists are now grappling," **Bogart** wrote. Although Asimov had a positive view of science and innovation, all inventions are force multipliers, **Bogart** noted. "That means they can be used to multiply the effects of good *and* evil," **Bogart** wrote. "Even at this early stage, it is well to think about negative impacts as well as positive ones."

Dogged questions

Bone fragments of dogs and other animals unearthed from Shubayqa 6, the site of an ancient settlement in Jordan, suggest that dogs may have helped humans devise new ways of hunting small game around 11,500 years ago, ***Bruce Bower*** *reported in "Early dogs helped hunt small game"* (SN: 2/16/19, p. 13).

Reader **Eric Hobday** took issue with the researchers' conclusion that dogs assisted with hunting. "I will accept as fact that the bones in Shubayqa show signs of having passed through a dog's digestive system. However, this in no way indicates that the dog in Shubayqa was any more involved in hunting the animal than my dog was," **Hobday** wrote. He suggested that the dogs could have been feral and scavenged villagers' leftovers. "No evidence of domestication was presented, yet the article says the findings offer new insights into domestication," **Hobday** wrote. "Really?"

By comparing bones of modern Afghan hounds, greyhounds, gray wolves and golden jackals, researchers have determined that the Shubayqa 6 bones likely came from domesticated dogs, **Bower** says. "As pointed out in the story, the presence of numerous dogs at the site fits with observations of modern foragers who use dogs to locate small prey during hunts," he says. "Reconstructions of ancient behavior are always provisional."

Soil science

High demand for sparkling wine may be depleting 400 million kilograms of soil every year from northeastern Italy's vineyards, ***Cassie Martin*** *reported in "Prosecco production takes a toll on Italy's soil"* (SN: 2/16/19, p. 5).

"The best wine grows in poor soil conditions," reader **Jonathan Quint** wrote. "Is erosion even a concern for a vineyard?"

Soil erosion isn't necessarily a bad thing. It can help generate new soils to keep an ecosystem healthy. But such a high rate of soil erosion in Italy is a big concern, says **Jesús Rodrigo Comino**, a geographer at the University of Málaga's Institute of Geomorphology and Soils in Spain. The current rate is unsustainable and could actually harm vineyards there. A few simple changes, like leaving grass between rows of vines as well as planting hedges around vineyards and vegetation along rivers and streams, might help prosecco vineyards reduce their soil loss, scientists suggest.

On the rise

Deaths involving a type of antianxiety medication rose 830 percent from 1999 to 2017 in U.S. women ages 30 to 64, ***Aimee Cunningham*** *reported in "Benzodiazepines fuel overdose deaths"* (SN: 2/16/19, p. 12).

Reader **Dan Furtado** asked if benzodiazepines alone cause overdose deaths. He thought that the drugs, such as Xanax and Valium, could cause an overdose only if a person had additional medical issues or combined the drugs with opioids or similar substances.

"An overdose of benzodiazepines alone can cause death," **Cunningham** says. "The drugs depress the central nervous system, so a person who overdoses can stop breathing. But overdose deaths are more likely to happen when benzodiazepines are taken with opioids or alcohol," she says.

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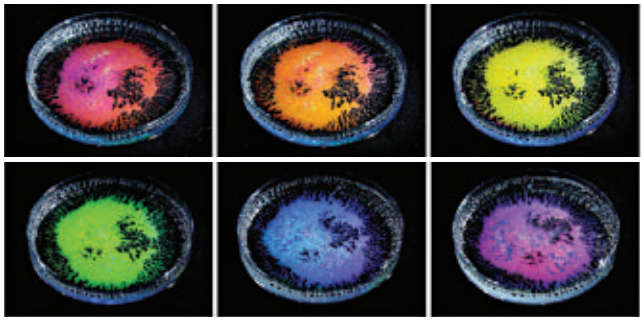
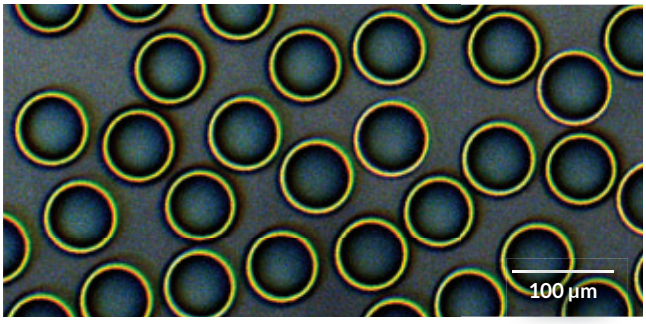
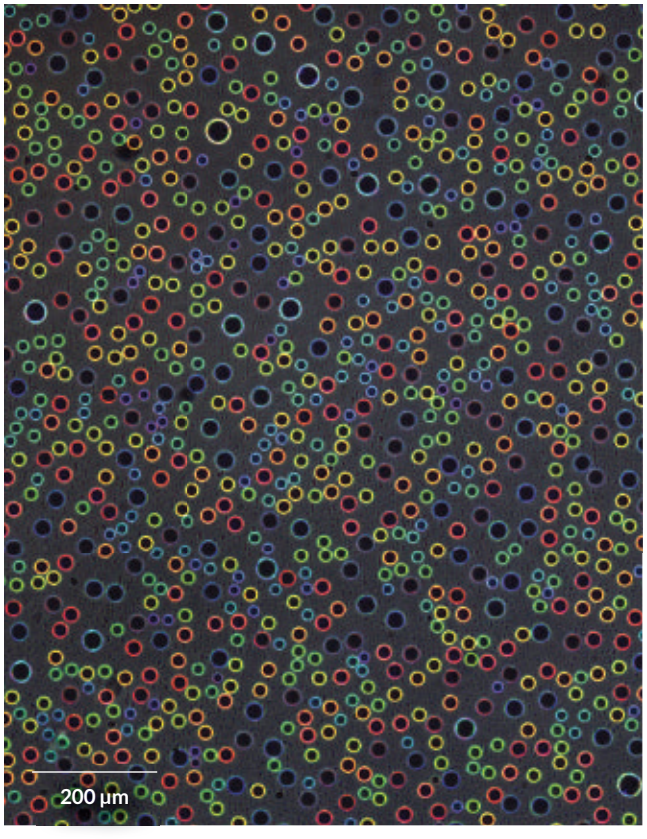
Droplet viewing angle alters color

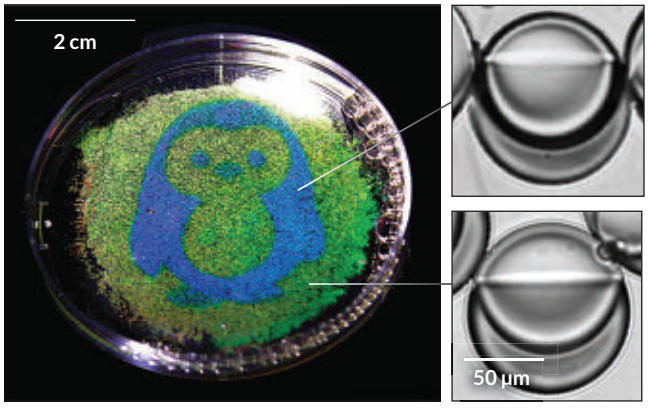




Droplet diameter alters color



Droplet curvature alters color



How droplets of oil or water can glow vibrant rainbow colors

Oil and water may not mix, but the two have now revealed a new example of structural color, in which an object's hue arises from its shape.

Studying droplets made of two layers of clear oil, researchers discovered that the tiny blobs glowed vibrant colors under white light. In a petri dish, same-sized droplets changed color as the dish was rotated (top, left). The same phenomenon, described in the Feb. 28 *Nature*, occurred with tiny water droplets that collected on the underside of a petri dish's lid.

Materials chemist Lauren Zarzar of Penn State and her colleagues found that the iridescent hues appear when light strikes a bowl-shaped boundary between two substances. In this case, that was the water-air barrier on the underside of the water droplets hanging off the flat surface, or the basin-shaped divide between the two layers of oil. Light that enters near a droplet's edge bounces along the concave surface multiple times before being reflected and exiting near the opposite edge.

Under a microscope, that reflected light creates an iridescent ring whose apparent color depends on the viewer's perspective. That's because light waves can take many different ricocheting routes through the droplet on their way from the light source to an observer. When waves of a specific wavelength — for instance, yellow light — line up, they reinforce each other and produce a bright color (yellow example shown above, right). But light rays of other wavelengths taking these same routes may get misaligned and wash each other out. Changing the viewing angle changes which pathways a viewer sees, and therefore the perceived color.

The team also found that changing the diameter of a droplet altered its color, even when viewed from the same angle (middle left). So did changing a droplet's curvature. A surface covered with two differently curved kinds of oil droplets (gray images, bottom, near left) produced a two-color picture of a penguin (bottom, far left).

The effect also worked with clear polymer bumps on a surface. Such research could help make color-changing materials that could be used in cosmetics, camouflage or other products. — *Maria Temming*

TOP RIGHT: A.E. GOODLING *ET AL*/*NATURE* 2019; ALL OTHERS: ZARZAR LAB/PENN STATE

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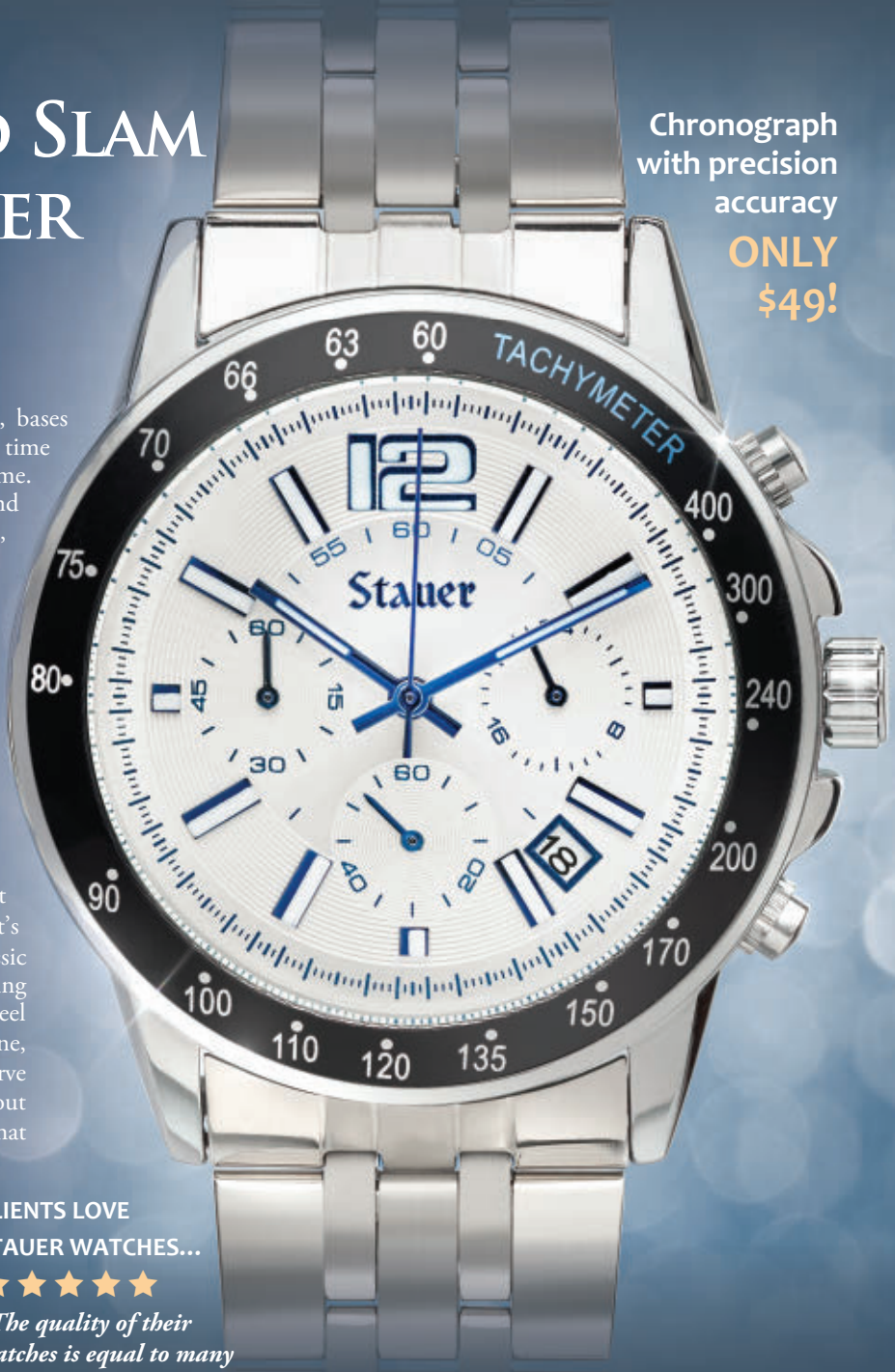

It was the bottom of the ninth. Two outs, bases loaded. A glance at my watch told me it was time to go. If I'm late to the Met, my wife will kill me. Then the bat cracks out its victory cry— Grand Slam. Ecstatic I got to see my team win. But, now it really is go time.

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