The Fight for Rice's Future | Protons Hang 10 on Shock Waves

Science News

MAGAZINE OF T… SEPTEMBER 25, 2021

The Human Story

Fossils and ancient DNA reveal secrets of our distant past

MUDD +YOU

Explore the possibilities



Visionary Leader

Priya Donti ’15, a joint computer science and mathematics alum, is among those “looking to the future of quantum computing, energy policy, robotics and more.” *MIT Technology Review* named her to its list of Innovators Under 35. Donti is a PhD student at Carnegie Mellon University working at the intersection of machine learning, electric power systems and climate change mitigation, with a focus on the world’s most vulnerable citizens.

First in Fellowships

For 2021, Harvey Mudd ranks first among all U.S. colleges and universities for the number of NSF Graduate Research Fellowships awarded on a per-student basis.

HARVEY MUDD COLLEGE

>>>> **Discover more hmc.edu/explore**

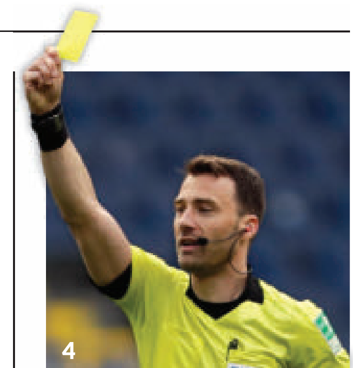
admission@hmc.edu | 909.621.8011

VOL. 200 | NO. 6

Science News

Features

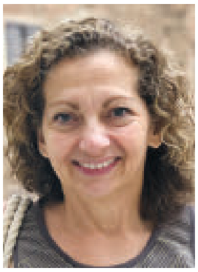
News



Departments

COVER The Taung Child fossil, discovered in 1924 in South Africa, is more than 2 million years old. *Patrick Landmann/Science Source*

FROM TOP: CALIFORNIA RICE COMMISSION, BRIAN BAER; MICHAEL PROBST/POOL VIA GETTY IMAGES; JILLIAN DITNER



A desire for knowledge on many science fronts

Our readers are newshounds with boundless curiosity, always eager to learn what's new, significant or surprising. With each issue, we try to feed that desire for credible, concise — even entertaining — news from many science fields. This issue, too, ranges far and wide. We cover new evidence that the coronavirus may be getting better at taking flight on tiny airborne particles (Page 6), as well as an experiment suggesting that protons can catch a shock wave (Page 7). And we had to share a story supporting what sports lovers already knew in their hearts: Home team advantage fades when the fans stay home (Page 5).

I'm also excited for you to read the latest feature in our Century of Science series. Each of these stories offers a deep dive into discoveries that *Science News* has covered over the last 100 years. This latest one is relevant to all of us: how our species, *Homo sapiens*, came to be (Page 20). Managing editor Erin Wayman was the perfect person to take on this project. With a graduate degree in biological anthropology, she has extensive knowledge of primate behavior and human evolution. As obsessed as she is with the topic (each table at her wedding had its own monkey theme), even she was surprised to learn how much has changed since her university days. Many of us take for granted that our ancient ancestors came from Africa, yet the search for human origins focused on Europe and Asia until the 1924 discovery of a skull in South Africa. Even in the mid-20th century, there were still doubts that Africa held the secrets of our beginnings.

As our species continues to evolve and grow in numbers, one of the biggest challenges we face is climate change. *Science News* intern Nikk Ogasa describes how climate change is imperiling one of the world's key food staples, rice (Page 16). Time for the big brains of *H. sapiens* to come through with bright ideas to rescue rice to feed the world.

— Cori Vanchieri, Features Editor

In the next few months, various *Science news* editors will share their thoughts in the Editor's Note.

Subscriber alert

Some *Science News* subscribers have recently received unauthorized "renewal notices." These deceptive notices have been sent by independent solicitation companies without the approval of *Science News* or its publisher, Society for Science. Their renewal rates are generally higher than our usual rates. Companies operate under numerous names but might include Publishers Partnership Services or Pacific Magazine Billing.

Any notice from *Science News* will always include our logo, refer to your account status and request that payments be made to our processing center in Kettering, Ohio. If you receive a notice that doesn't appear to be from *Science News* or an authorized agent, do not respond to it. If you have questions, call customer service at 800-552-4412 or e-mail subscriptions@sciencenews.org.

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

Subscriber services:
E-mail subscriptions@sciencenews.org
Phone (800) 552-4412 in the U.S. or (937) 610-0240 outside of the U.S.
Web www.sciencenews.org/join
For renewals, www.sciencenews.org/renew
Mail *Science News*, PO Box 292255, Kettering, OH 45429-0255

Alliance for Audited Media

Editorial/Letters: feedback@sciencenews.org
***Science News* in High Schools:** snhs@societyforscience.org
Advertising/Sponsor content: ads@societyforscience.org
Science News (ISSN 0036-8423) is published 22 times per year, bi-weekly except the first week only in May and October and the first and last weeks only in July by the Society for Science & the Public, 1719 N Street, NW, Washington, DC 20036.
Subscribe to *Science News*: Subscriptions include 22 issues of *Science News* and full access to www.sciencenews.org and cost $50 for one year (international rate of $68 includes extra shipping charge).
Subscribe www.sciencenews.org/subscription
Single copies are $3.99 (plus $1.01 shipping and handling). Preferred periodicals postage paid at Washington, D.C., and an additional mailing office.
Postmaster: Send address changes to *Science News*, PO Box 292255, Kettering, OH 45429-0255. Two to six weeks' notice is required. Old and new addresses, including zip codes, must be provided.

STACIE VANCHIERI

Excerpt from the October 2, 1971 issue of *Science News*

50 YEARS AGO

Aspirin and birth defects

Although aspirin has triggered defects in rat and mice fetuses, the evidence suggesting aspirin taken by women during pregnancy can harm their offspring has been circumstantial at best. Now, however ... [evidence shows] that aspirin can dramatically arrest the growth of human embryo cells.

UPDATE: Scientists are still sorting out how aspirin and other nonsteroidal anti-inflammatory drugs, collectively known as NSAIDs, affect pregnancy at every stage. Taking NSAIDs during the first trimester is known to increase the risk of miscarriage (*SN: 11/5/11, p. 14*). In 2020, the U.S. Food and Drug Administration warned that people who are 20 weeks or more into a pregnancy should avoid using NSAIDs altogether because the drugs can cause rare but serious kidney problems as well as heart problems for fetuses. However, exceptions can be made for pregnant people at risk of preeclampsia (*SN: 7/13/91, p. 22*), clotting and preterm delivery. In such cases, the FDA recommends that doctors prescribe the lowest effective dose of aspirin.

The wild flower *Triantha occidentalis*, which grows along North America's West Coast, has sticky hairs on its stem that the plant uses to trap and digest small insects.

HOW BIZARRE

Botanists uncover a flower's meaty secret

Gleaming, gluey, deathtrap hairs have betrayed the secret identity of a well-known wild flower: It's a carnivore.

A species of false asphodel (*Triantha occidentalis*) uses enzyme-secreting hairs on its flowering stem to snare and digest insects, researchers report in the Aug. 17 *Proceedings of the National Academy of Sciences*. Scientists have known about *T. occidentalis* since the 19th century, but the wild flower's taste for meat has gone undetected until now.

Sticky hairs by themselves aren't unusual — many non-carnivorous plants use such hairs to defend against pests. But *T. occidentalis* has qualities that some meat-eating plants share: a love of bright, boggy, nutrient-poor habitats and the absence of a gene that fine-tunes how plants get energy from light. Together, those features felt like pieces of a puzzle hinting at carnivory, says botanist Sean Graham of the University of British Columbia in Vancouver.

Sticky hairs (shown in this scanning electron microscope image) on the flowering stem of a species of false asphodel secrete an enzyme that many carnivorous plants use to digest prey.

To solve the puzzle, Graham and colleagues needed to know if the wild flower pulls nutrients from insect corpses. Luckily, *T. occidentalis* grows along North America's West Coast, from Alaska to California, and can be found on hikes near Vancouver. "They're right on our doorstep," Graham says.

The team attached fruit flies fed with nitrogen-15, an isotope that can be used to track changes in nitrogen levels, to the flowering stems of bog-dwelling *T. occidentalis* plants in British Columbia's Cypress Provincial Park. Over half of the nitrogen in wild flowers' leaves came from the fruit flies, the team found. Those levels are comparable to a known carnivorous plant. What's more, the wild flowers' sticky hairs oozed phosphatase, a digestive enzyme that many carnivorous plants secrete to consume prey.

In most of the world's roughly 800 meat-eating plant species, traps and flowers are kept far apart, possibly to avoid killing pollinating visitors. *T. occidentalis* bucks that trend. "Putting your traps close to your flowers is, on the surface, a really big conflict," Graham says. But the plant's hairs may be just sticky enough to catch small flies and beetles without entrapping bigger pollinators such as bees and butterflies.

T. occidentalis' sticky hairs might also hint at how some meat-eating plants evolved. In nutrient-poor soils, it may have been advantageous for some plants to co-opt hairs for carnivory, Graham says. "The insects are being trapped anyway, so might as well use them." — *Jaime Chambers*

FROM TOP: DANILO LIMA; QIANSHI LIN

THE EVERYDAY EXPLAINED

When fans are away, home teams lose their sway

Without fans, European soccer referees issue more fouls (shown) to home teams than when fans are in the stands, a study shows.

An analysis of crowdless "ghost games" during the 2019–2020 European soccer season adds to evidence that fans influence home team advantage, the phenomenon where athletes do better on their own turf. Home teams that played to vacant stadium seats due to COVID-19 restrictions won less, lost more and tied about the same compared with the season before the pandemic, researchers report August 19 in *Frontiers in Sports and Active Living*.

Scientists at the University of Salzburg in Austria compared the outcomes of 645 games from the 2018–2019 season with those of 641 ghost games from the 2019–2020 season. With stands empty or mostly empty, home team win rate decreased by 8.3 percentage points, from 48.1 percent to 39.8 percent. Meanwhile, loss rate increased by 8.4 percentage points, from 27.6 percent to 36 percent. The scientists then looked at how often referees issued foul calls. With fans largely absent, foul calls against home teams increased by about 26 percent. The findings suggest that referee bias tends to vanish when fans do, the scientists say. *—Nikk Ogasa*

THE –EST

'Big coral' embodies hope for Great Barrier Reef

A coral the size of a carousel is the widest known in the Great Barrier Reef. Found just off the coast of Goolboodi Island in northeast Australia, this reef-building *Porites* measures 10.4 meters in diameter — earning it the nickname Muga dhambi, or "big coral," from the Indigenous custodians of the island, the Manbarra people. Muga dhambi also stands a little over 5 meters tall, making it the sixth-tallest coral in the Great Barrier Reef, researchers report August 19 in *Scientific Reports.* Based on the coral's height and estimated growth rate, marine scientist Nathan Cook of the environmental consulting firm Reef Ecologic in Townsville, Australia, and colleagues calculate that Muga dhambi is about 421 to 438 years old. It predates European colonization of Australia and has survived as many as 80 cyclones and 99 coral bleaching events, the team says. That Muga dhambi has persisted for so long provides "a renewed sense of hope for the future" of the Great Barrier Reef, Cook says. *—Nikk Ogasa*

Researchers swim over the 10.4-meter-wide Muga dhambi, the widest known coral in the Great Barrier Reef.

FROM TOP: ANNA ZORA/FRÉGATE ISLAND FOUNDATION; MICHAEL PROBST/POOL VIA GETTY IMAGES; WOODY SPARK

A Seychelles giant tortoise lunges toward a noddy tern chick in the first documented instance of a tortoise hunting.

RETHINK

Tortoises may hunt prey

Justin Gerlach thought there must be some sort of misunderstanding. Tortoises don't hunt. These gentle herbivores spend their days munching on greenery, not stalking prey. His colleague's report must be mistaken.

But the video was indisputable. On a summer evening in 2020, a female Seychelles giant tortoise (*Aldabrachelys gigantea*) spent several minutes stalking a young noddy tern (*Anous tenuirostris*) that had fallen from its nest on Frégate Island off of East Africa. The tortoise forced the chick's retreat down a log, like a pirate walking the plank, until the bird had nowhere to go. Several slow, deliberate lunges later, the tortoise's yawning maw caught the bird, crushing its head. Eventually, the tortoise swallowed its prize whole. It's the first documented case of a tortoise hunting, researchers report in the Aug. 23 *Current Biology.*

Many herbivores will opportunistically scarf down carrion, says Gerlach, a biologist at the University of Cambridge. And every now and again, anecdotes surface of tortoises eating small birds that the reptiles have crushed, but it's unclear whether the crushing is intentional or accidental, he says.

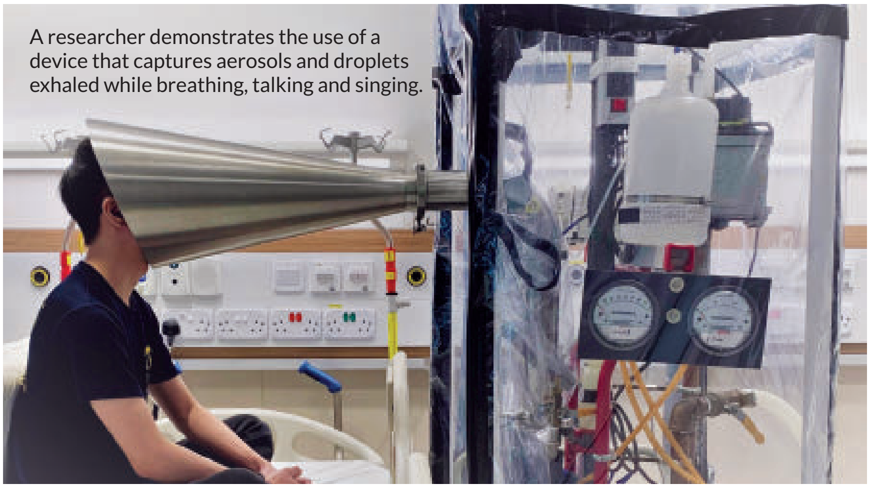
Gerlach suspects that this tortoise has hunted before, as its deliberate movements betray prior experience. He plans to investigate whether such hunting behavior occurs with any regularity, but the video has changed his view of these reptiles. "This shows there's an awful lot more to them." *—Jonathan Lambert*

Watch a tortoise hunt a bird at **bit.ly/SN_TortoiseHunt**

BODY & BRAIN

Lab tests find coronavirus in the air

Researchers provide evidence that the pathogen is airborne



A researcher demonstrates the use of a device that captures aerosols and droplets exhaled while breathing, talking and singing.

NATIONAL UNIV. OF SINGAPORE

BY TINA HESMAN SAEY

Small aerosol particles spewed while people breathe, talk and sing may contain more coronavirus than larger moisture droplets do. And the coronavirus may be evolving to spread more easily through the air, a new study suggests. But there is also good news: Masks can help.

About 85 percent of coronavirus RNA detected in COVID-19 patients' breath was found in fine aerosol particles 5 micrometers or smaller, researchers in Singapore report August 6 in *Clinical Infectious Diseases*. The finding is the latest evidence to suggest that COVID-19 is spread mainly through the air in fine droplets that may stay suspended for hours rather than in larger droplets that quickly fall to the ground and contaminate surfaces.

Similarly, infectious disease specialist Donald Milton of the University of Maryland in College Park and colleagues found that people who carried the alpha variant, which first emerged in the United Kingdom in 2020, had 18 times as much viral RNA in aerosols than people infected with earlier, less-contagious versions of the virus. That study, posted August 13 at medRxiv.org, has not yet been peer-reviewed.

In one experiment, the Maryland team grew the virus from patients' air samples. Being able to grow infectious coronavirus from air samples could be evidence that may convince some reluctant experts to embrace the idea that the virus spreads mainly through the air.

The debate over aerosol transmission has been ongoing since the pandemic's early days. Last year, more than 200 scientists wrote a letter imploring the World Health Organization and other public health agencies to acknowledge aerosol spread of the virus. This April, the WHO upgraded its information on transmission to include aerosols. The U.S. Centers for Disease Control and Prevention had done so just weeks before.

Studies in monkeys have suggested that aerosols carry more coronavirus than large droplets do. But direct evidence that the virus spreads mainly through the air is lacking, some experts say.

"There's lots of indirect evidence that the airborne route — breathing it in — is dominant," says civil and environmental engineer Linsey Marr of Virginia Tech in Blacksburg. She studies viruses in the air and was among the scientists who signed the letter last year. Airborne infections require health care workers to isolate patients, wear protective gear and take other costly measures to stop disease spread. So infection control experts have been reluctant to call the coronavirus airborne without strong proof.

Most COVID-19 cases have been among close household contacts, and it can be hard to tease out whether such infections were passed on by large droplets or by breathing the same air. But for other situations, such as when patrons get infected while sitting across a restaurant from someone with COVID-19, aerosols are really the only explanation, Marr says.

Mechanical engineer Kwok Wai Tham of the National University of Singapore set out to sample how much virus COVID-19 patients produce when they breathe, talk or sing, in part, to address skeptics' concerns. "I'm doing this to convince some very close friends," he says.

Tham and colleagues had 22 patients stick their heads into a metal cone that was part of a mobile lab. The team collected both fine aerosols and larger droplets that the patients exhaled while breathing quietly for 30 minutes, repeating passages from the children's book *Green Eggs and Ham* for 15 minutes or singing tunes such as the "Happy Birthday" song for 15 minutes.

Only 13 patients spewed aerosols and droplets with detectable levels of viral RNA. In general, singing created the most virus-laden aerosols, but some people generated more while talking. That difference may be due to the volume at which patients sang, Tham says.

The overall amount of virus that people produced varied widely, and just one factor stood out as affecting how much virus was emitted: stage of infection. People who were earlier in the course of infection tended to produce more virus. That finding agrees with data from studies in lab animals and humans suggesting that people are most contagious in the first week after catching the coronavirus.

Tham's findings haven't convinced his skeptical virologist friends that aerosols are the main way that COVID-19 spreads. "They say, 'Show me a live virus that is retrieved from the air,' " he says.

The Maryland team's study may provide such evidence. Sixty-one people with asymptomatic or mild infections recited the ABCs, shouted "Go Terps!" (the Maryland mascot) or sang "Happy Birthday" into a device, once with a mask on and once with it off. Researchers were able to grow infectious virus from two of 66 fine-aerosol samples, both collected while people were wearing masks. Coarse aerosols did not yield infectious virus.

What's more, aerosols contained more alpha variant than earlier variants. That may suggest that the coronavirus is evolving toward more efficient airborne spread, the team proposes. The study concluded in April, before the delta variant began its surge in the United States.

Although the team found infectious virus in aerosols, it was still rare, says virologist Andrew Pekosz of Johns Hopkins Bloomberg School of Public Health. "It would be difficult to make the case that this was what is responsible for increased spread of alpha" relative to earlier variants.

Marr disagrees. The four participants who were infected with the alpha variant released more coronavirus than people infected with other variants. "These results combined with epidemiological observations about the spread of alpha, and now delta, support the idea that these variants are supercharged when it comes to aerosol transmission," she says.

Volunteers' masks were mostly loose-fitting and ranged from a single-layer homemade cloth mask to a KN95 mask. Wearing a mask reduced the amount of virus-laden fine aerosols released in the air by an average of 48 percent, though the reduction ranged from 3 percent to 72 percent. Masks performed equally well against the alpha variant as for other variants. The findings underscore previous research that has shown masks help reduce the amount of virus people give off (*SN: 3/13/21, p. 14*).

As new variants gain ground, increased attention to improved ventilation and the use of masks will be crucial for controlling the pandemic, the Maryland team says. That's especially important in places with low vaccination rates. ■

ATOM & COSMOS

Shock waves give protons a boost

In space, the particles may gain energy from similar swells

BY EMILY CONOVER

Protons can surf some truly gnarly waves.

A new experiment suggests that the subatomic particles can be accelerated by a process akin to surfers catching waves. The protons get a speed boost not from ocean swells, but from shock waves within plasma, a mixture of electrically charged particles. Such shock waves are sonic boom–like disturbances marked by an abrupt increase in density, temperature and pressure.

The research could help scientists better understand some of the high-energy particles that zip through the cosmos. Shock waves in space are thought to propel charged particles, but how the particles get their pep is still not fully understood (*SN: 11/7/20, p. 20*).

In the experiment, which mimicked certain types of cosmic shock waves, protons reached energies of up to 80,000 electron volts, researchers report August 19 in *Nature Physics*. In space, similar shock waves occur where the outflow of charged solar particles meets Earth's magnetic field and where those particles slow down as they approach the solar system's edge, at what's called the termination shock (*SN: 10/19/13, p. 19*).

Plasma physicist Julien Fuchs and colleagues used lasers to re-create the physics of such cosmic shock waves on a small scale. A laser blast vaporized a target, sending a burst of plasma careening into a hydrogen gas cloud. As the plasma plowed through the gas, a shock wave formed, and protons within the hydrogen sped up, measurements indicated.

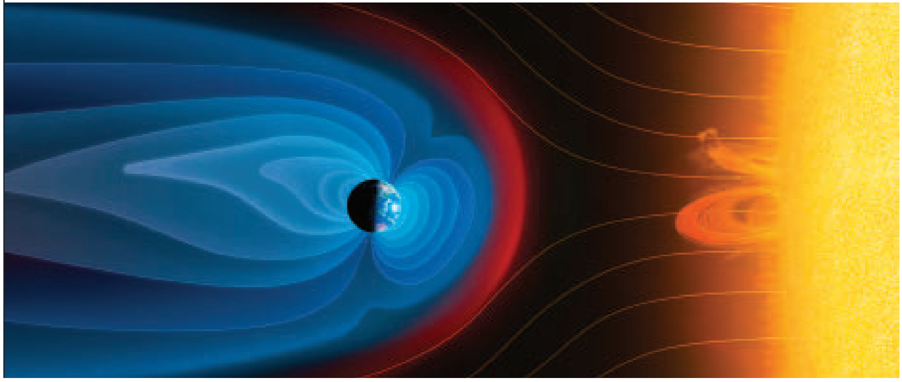
Scientists had predicted that protons could be accelerated by a process called the shock surfing acceleration, which happens in the presence of a magnetic field. While a shock wave's electric field pushes along a proton, the magnetic field helps the particle stay on course. If the proton strays from the shock wave, the magnetic field twists the particle's trajectory to return it to the wave, so the proton can surf again.

Of course, there's no such automatic return for human surfers, says Fuchs, of CNRS and the Laboratory for the Use of Intense Lasers in Palaiseau, France. It's too bad, he muses: "I think they would like that."

Still, the measurements alone didn't pinpoint if shock surfing was responsible for the protons' speedup. Comparing the data with computer simulations suggests that the protons were surfing the shock wave, the team says.

"This is definitely an exciting result," says Carolyn Kuranz, a plasma physicist at the University of Michigan in Ann Arbor. She says she hopes that further research will be able to uncover more direct evidence that doesn't rely on computer simulations. "It's very promising for future work." ■

A lab experiment hints that protons can gain energy by surfing shock waves in space such as the bow shock (illustrated, red), where the solar wind (orange lines) meets Earth's magnetic field (blue).



MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY IMAGES

NEWS

HUMANS & SOCIETY

Culture shapes humans' mental maps

Everyone arranges abstract ideas in space, but directions vary

BY SUJATA GUPTA

Consider a ruler, a timeline or even weights lined up in a gym. Why are the smaller values, the earlier times and the lighter weights typically on the left and the larger or later values on the right?

Since at least the early 1990s, researchers have debated whether these mental number lines, or the tendency to order spatially from small to large, are innate or learned. In more recent years, this debate has broadened from mental number lines to mental magnitude lines: the human tendency to map any abstract idea, such as numbers, time and even facial expressions, in three-dimensional space. Now, a study published August 11 in *Science Advances* comparing mostly adult Indigenous farmer-foragers in Bolivia with U.S. preschoolers and adults has fallen squarely on the learning or culture side, adding fresh fuel to the debate.

For the Tsimane people in Bolivia, "numbers increase in one direction. Time increases in one direction. Size increases in one direction. But any direction will do," says cognitive scientist Benjamin Pitt of the University of California, Berkeley. In other words, with little formal schooling telling them which way to position numbers in space, the Tsimane people do not care, in theory, if heavier dumbbells sit on the right or the left.

Understanding how humans map abstract ideas in space could provide clues about the development of spatial reasoning, researchers suspect. The thinking is that these maps "are a foundation upon which later mathematical and spatial abilities build," says cognitive scientist Kensy Cooperrider, who recently completed his postdoctoral work at the University of Chicago.

Pitt and colleagues first asked members of three groups — 96 Tsimane teens and adults, 31 U.S. children ages 3 to 5 and 18 U.S. adults — to arrange items on a horizontal board. All the participants lined up five wooden blocks covered in one to five dots or five blocks ranging in height from about 2.5 to 13 centimeters. While the U.S. adults all mapped the blocks from smallest on the left to largest on the right, the Tsimane adults and U.S. children were equally likely to map in either direction, the researchers found.

Then the team evaluated how a new group of 60 Tsimane young people and adults mapped information along the x, y and z (front to back) axes. Besides asking participants to order items by size and number, the researchers also tested to see whether the Tsimane people mapped time in space. In that trial, the team asked participants to order five sets of bananas ranging in color, or ripeness, from very green to almost black. Each participant completed three mapping tasks per axis for a total of nine tasks.

> For the Tsimane people, "numbers increase in one direction. Time increases in one direction. Size increases in one direction. But any direction will do."
>
> BENJAMIN PITT

Again, the Tsimane people showed little directional bias. An individual often ordered one concept one way on a given axis, such as the lower magnitude green bananas on the bottom of a y-axis, and another concept the other way, such as the higher magnitude of dots on the bottom. The researchers tallied when each participant placed all the items in the same direction on a given axis and when they did not. Averaging the scores across participants, the researchers found that the group mapped in the same direction only 42 percent of the time.

"This study casts doubt on the idea that many psychologists and cognitive neuroscientists have held that we have an innate system for spatializing numbers," says Cooperrider, who reached similar conclusions in a 2017 study testing mental number lines among the Yupno people of Papua New Guinea.

Members of an Indigenous Bolivian group line up bananas by color, but often in different directions, a study of mental mapping found.

B. PITT

The debate is far from closed, though, says cognitive scientist Stella Lourenco of Emory University in Atlanta. Tsimane participants did show some consistencies. For instance, any given individual ordered the size and number items the same way along the x, y and z axes about 80 percent of the time. "They look at these data and say there is inconsistency. I look at these data, and I say it looks pretty good to me in terms of consistency," Lourenco says. She suspects that people might be born with innate mental maps, as indicated by research on newborn babies, but life experience obscures those default tendencies.

Cognitive scientist Rosa Rugani of the University of Padua in Italy argues that a laser focus on directionality has obscured one of the most intriguing questions: Why do people across ages and cultures map abstract ideas in space at all? "We really need to return to the origins of this topic," she says. ■

ATOM & COSMOS

Scientists rethink the habitable zone

New ideas could extend or limit where to look for alien life

BY LISA GROSSMAN

When considering where to look for extraterrestrial life, astronomers have mostly stuck with what's familiar. The best candidates for habitable planets are considered the ones most like Earth: small, rocky, with breathable atmospheres and a clement amount of warmth from their parent stars.

But as more exoplanets have been discovered, astronomers have debated the usefulness of this definition. Some planets in a star's so-called habitable zone, where temperatures are right for liquid water, are probably not good for life at all. Others outside that designated area might be perfectly comfortable.

Now, two studies propose revising the concept of the habitable zone. One new definition brings more planets into the habitable fold; the other nudges some out.

"Both papers focus on questioning the classical idea of the habitable zone," says Penn State astronomer Noah Tuchow. "We should extend the range of places that we look, so we don't miss habitable planets."

Nikku Madhusudhan, an astrophysicist at the University of Cambridge, and colleagues propose a new category of possibly habitable planet that could be found at almost any distance from a wide range of star types. These hypothetical planets would have a global liquid-water ocean nestled under a thick, hydrogen-rich atmosphere. These "Hycean" planets (a mash-up of "hydrogen" and "ocean") could be up to 2.6 times the size of Earth and up to 10 times as massive, the researchers report in the Sept. 1 *Astrophysical Journal*. A thick atmosphere could keep temperatures right for liquid water even with minimal starlight, while the ocean could protect against crushing atmospheric pressure.

The odds of finding Hycean planets are good, Madhusudhan says. Though it's difficult to tell which worlds definitely have oceans and hydrogen atmospheres, there are many more known exoplanets in the mass and temperature ranges of Hycean planets than there are Earthlike planets. And because they would generally be larger and have thicker, more extended atmospheres than rocky planets, Hycean planets should be easier to probe for "biosignatures," molecular or chemical signs of life, Madhusudhan says. Detectable biosignatures on Hycean planets could include rare molecules associated with life on Earth like dimethyl sulfide and carbonyl sulfide. Such molecules tend to be too low in concentration to detect in thin Earthlike atmospheres.

Planned telescopes could soon detect such molecules. Madhusudhan plans to use NASA's James Webb Space Telescope, due to launch this year, to observe the water-rich planet K2 18b. Astronomers debated that planet's habitability when it was reported in 2019 (*SN: 10/12/19 & 10/26/19, p. 6*). Madhusudhan says 20 hours of observations should settle the debate. "Best-case scenario, we'll detect life on K2 18b," he says, though "I'm not holding my breath over it."

Astronomer Laura Kreidberg of the Max Planck Institute for Astronomy in Heidelberg, Germany, thinks it probably won't be that easy. Planets in the Hycean size range tend to have cloudy or hazy atmospheres, making biosignatures more difficult to detect. It's also not clear if Hycean planets actually exist. "It is a really fun idea," she says. "But … does it match up with reality? I think we absolutely don't know yet."

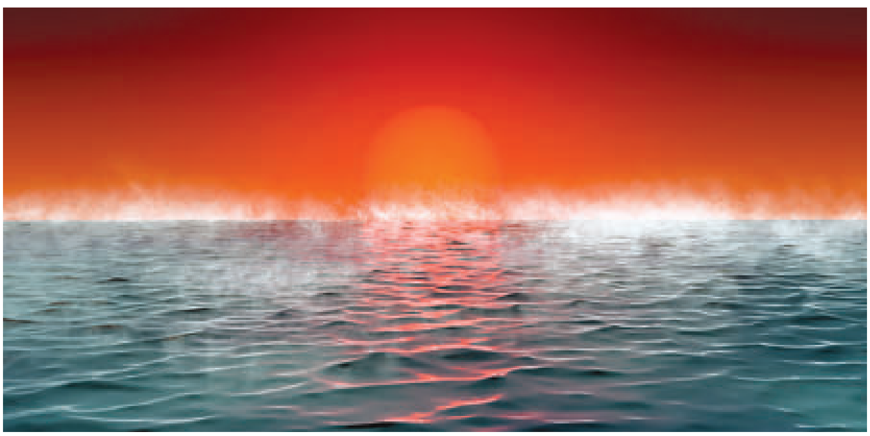
Rather than proposing a new way to bring exoplanets into the habitable family, Tuchow and Penn State astronomer Jason Wright are kicking some apparently habitable planets out. The pair realized that the region of clement temperatures around a star changes as the star evolves and changes brightness.

Some planets are born in the habitable zone and stay there. But some, possibly most, are born outside of it and enter later as a star ages. In the August *Research Notes of the American Astronomical Society*, Tuchow and Wright suggest calling those worlds "belatedly habitable planets."

Whether such planets can ever become habitable is an open question, Tuchow says. If the planet started out too close to a star, it could have lost all its water to a greenhouse effect, like Venus did. Moving Venus to the position of Earth won't give it its water back.

On the other hand, a planet born far from its star could be covered in glaciers, which reflect sunlight. The glaciers may never melt, even when the star brightens. Worse, the water could go straight from frozen to evaporated. That scenario would leave the planet no time with a cozy wet puddle for life to get started in.

Both types of planets are "still in the habitable zone," Tuchow says. "But it adds questions about whether or not being in the habitable zone actually means habitable." ■



AMANDA SMITH/UNIV. OF CAMBRIDGE

A planet with a global ocean under a hydrogen atmosphere, like the world shown in this artist's illustration, might be a good place to search for life, researchers say.

LIFE & EVOLUTION

Baby bats babble to learn songs

Like human infants, the pups need to practice vocalizations

BY JONATHAN LAMBERT

Many millions of years of evolution separate humans and greater sac-winged bats, but these two mammals share a key feature of learning how to speak: babbling.

Just as human infants babble their way from "da-da-da-da" to "dad," wild bat pups learn the mating and territorial songs of adults by first babbling out the fundamental syllables of the vocalizations, researchers report in the Aug. 20 *Science*. These bats now join humans as the only clear examples of mammals that learn to make complex vocalizations through babbling.

"This is a hugely important step forward in the study of vocal learning," says Tecumseh Fitch, an evolutionary biologist at the University of Vienna who was not involved in the discovery. "These findings suggest that there are deep parallels between how humans and young bats learn to control their vocal apparatus," he says. The work could enable future studies that allow researchers to peer deeper into the brain activity that underpins vocal learning.


Greater sac-winged bats, like this pup in Costa Rica, and humans are the only clear examples of mammals that learn complex adult vocalizations through babbling.

Before complex vocalizations can be spoken or sung, vocalizers must learn to articulate the syllables that make up a species's vocabulary, says animal behavior biologist Ahana Fernandez of Museum für Naturkunde in Berlin. "Babbling is a way of practicing" and honing those vocalizations, she says.

The rhythmic, repetitive "ba-ba-ba's" and "ga-ga-ga's" of human infants may sound like gibberish, but they are necessary exploratory steps toward learning how to talk. Seeing whether babbling is required for any animal that learns complex vocalizations necessitates looking in other species.

Many songbirds babble to learn their songs. Some marmosets, a type of monkey, babble too, but only to solicit care, for example, not to learn a complex vocal repertoire, Fernandez says. Another mammal, the greater sac-winged bat (*Saccopteryx bilineata*), had been heard making babbling-like sounds. Males of this highly social species combine 25 different syllable types into songs used to defend territories and attract mates, but the babbling behavior wasn't formally studied. Fernandez sought to change that by getting up close and personal with the bats.

At bat colonies in Panama and Costa Rica, Fernandez spent a couple of weeks slowly inching closer to adult animals before they had their pups, habituating the bats to her presence. By the time the pups arrived and started babbling, she could spend all day camped just meters from the bats.

She observed and recorded the sounds of 20 pups as the bats developed their vocal repertoire by imitating male tutors. All told, she and her colleagues captured and analyzed 55,056 syllables from 216 bouts of babbling.

"Bat pup babbling is defined by the same characteristics as human infant babbling," Fernandez says. Like humans, the behavior starts early in development, a little over two weeks after the bats' birth. Protosyllables (akin to human "ba's" or "ga's") were the most prevalent sound made and exhibited lots of variability. These seemingly playful experimentations might help pups shape their vocalizations to match adults, Fernandez explains. Syllables were repeated and were rhythmic, two common features of babbling.

Both male and female pups babbled, even though female bats don't sing as adults. That is different from most songbirds, where only the males are known to both babble and sing.

"Females might use [their babbling experience] as a template" for making mating decisions as adults about which bats are better singers, Fernandez says.

The bats may not babble exactly like other known babblers, says Pralle Kriengwatana, a behavioral biologist at the University of Glasgow in Scotland who wasn't involved in the study. Compared with some songbirds, "this ability to produce adultlike syllables seems to happen much quicker in bats," she says, noting an abrupt rise in the number of adultlike syllables early in babbling. That rapid expansion might mean that practice through babbling is less important for certain bat syllables than growing the neurological and physiological capacity through normal development, she says.

"Obviously, the bats are babbling," says Ofer Tchernichovski, an ethologist at the City University of New York's Hunter College. But he hopes the babbling behavior will be confirmed in a more controlled laboratory setting.

More generally, he says he's glad to have another animal through which to study vocal learning. "Songbirds are nice, but they're very far from us." By investigating another mammal, this research "opens the door," he says, for studying the neural underpinnings of language's fundamental building blocks. ■

MICHAEL STIFTER

Listen to baby bat songs at **bit.ly/SN_BabblingBats**

Female white-necked jacobins (one illustrated at far left) typically have olive green heads and backs, and mottled throats. But about 30 percent of females sport shiny blue heads and throats and look similar to adult males (center) and juveniles of both sexes (right).

JILLIAN DITNER

LIFE & EVOLUTION

Female hummingbirds go undercover

Plumage common in males helps the birds dodge harassment

BY CAROLYN WILKE

Some female hummingbirds don flashy feathers to avoid being bothered by other hummingbirds, a new study suggests.

Male white-necked jacobin hummingbirds (*Florisuga mellivora*) have bright blue heads and throats. Females tend to have more drab hues, but some sport the blue coloring too. Appearing fit and fine to impress potential mates can often explain animals' vibrant colors. But mate choice doesn't seem to drive these females' pretty plumage since males don't appear to prefer the blue females. Instead, bright colors may help the females blend in with the guys, and as a result, feed for longer without harassment from other hummingbirds, researchers report August 26 in *Current Biology*.

Beyond vying for mates, animals often also compete for territory, parental attention, social rank and food (*SN: 4/16/16, p. 4*). Mating choices don't capture all those interactions and can't always explain animals' looks, says evolutionary biologist Jay Falk of the University of Washington in Seattle.

To investigate why some female jacobins have colorful blue plumage, Falk and colleagues captured and released more than 400 of the birds in Gamboa, Panama, using genetics to determine each bird's sex. Most females had drab colors — olive green heads and backs and mottled throats. But about 30 percent of females had the shimmery blue noggins that all juveniles have and that are characteristic of adult males.

White-necked jacobin hummingbirds develop the bright colors in their adolescence, when the birds aren't yet looking for mates. Most females lose the bright colors, but for some females, the colors persist into adulthood. If these bright colors in females were driven by mate choice, then this is "the exact opposite of what you would expect," says Falk, who did the work while at the Cornell Lab of Ornithology and the Smithsonian Tropical Research Institute in Gamboa.

In another experiment, the team set a taxidermy bird that was either a drab female, a blue-headed female or a male each at a pair of hummingbird feeders and compared how live birds reacted to the stuffed dummies. Male birds seemed to prefer drab-looking females, sometimes performing swooping courtship dives. Visitors to the feeders attempted to mate first with green female body doubles before attempting to mate with stuffed males or blue-colored females.

Generally, white-necked jacobins can be quite aggressive, Falk says. They are "the show-off jocks of the hummingbird world." At the feeders, preserved females with dull green hues more frequently endured attacks when the feeder next door featured a stuffed male or blue-colored female. Harassment came not only from jacobins, but also from other hummingbird species. That finding suggests that bright colors provide an even greater benefit. "It's really cool that these other species are paying attention to the differences between males and females," Falk says.

The researchers next implanted small tracking devices into wild birds, which let the team tally the amount of time that the birds spent at feeders. Brightly colored females made more visits to feeders, particularly ones with more sugary nectar, and spent more time there than their muted counterparts, the team found.

Being able to fly under the radar and eat in peace more frequently may make the brighter female birds more fit than other females. Hummingbirds have the highest metabolic rate of any vertebrate on Earth, which means the birds have to eat a lot of food relative to their body size, says evolutionary biologist Ola Fincke of the University of Oklahoma in Norman. Greater access to nutrient-dense food could make blue-headed females healthier, Fincke says, but the study looked only at hummingbird feeders. Whether the same trend would apply to foraging from flowers in the wild remains an open question.

Though it's not yet clear what drives such feather finery — whether genetics, hormones or something else — this is an "exciting example" of an evolved trait that helps females blend in with males to avoid harassment, says evolutionary biologist Sara Lipshutz of Loyola University Chicago.

The study also helps put the focus on female birds, which haven't garnered as much research attention as males. For a long time, Lipshutz says, scientists "have been ignoring females — 50 percent of vertebrate animals." ■

The Entomological Society of America seeks public input on a new common name for the moth *Lymantria dispar* after retiring the name “gypsy moth,” which contained a pejorative for the ethnic group known as Roma.

SCIENCE & SOCIETY

Racist legacies lurk in common names

In the scientific community, support grows for renaming animals

BY JAIME CHAMBERS

With lemon and black plumage, the Scott’s oriole flashes in the desert like a flame. But the bird’s name holds a violent history that Stephen Hampton can’t forget. Hampton used to see the orioles often when he lived in California. Now that he lives in Washington State, which is outside the bird’s range, “I’m kind of relieved,” he says.

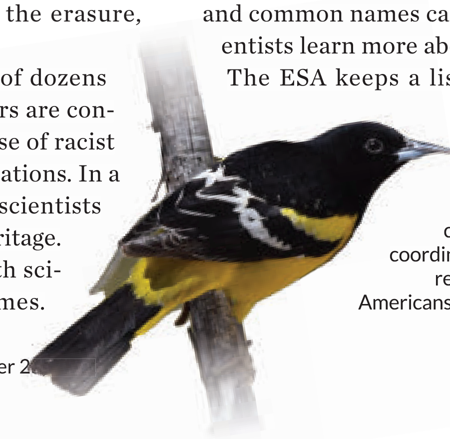
Hampton is a birder and registered citizen of the Cherokee Nation. The person the bird is named for, U.S. military commander Winfield Scott, drove Hampton’s ancestors and other Native Americans from their land in the 1800s during a series of forced marches known as the Trail of Tears. The journey killed over 4,000 Cherokee, displacing as many as 100,000 people in the end.

“So much of the Trail of Tears is already erased,” Hampton says. A few historical sites exist, “but you’d have to be an archaeologist to figure out where the actual stockades were.” Tying Scott’s legacy to a bird adds to the erasure, he says.

The oriole is just one of dozens of species that researchers are considering renaming because of racist or other offensive connotations. In a groundswell of revision, scientists are wrestling with this heritage.

Racist relics infuse both scientific and common names. But in contrast to scientific names, which are internationally standardized in Latin, common names live in the vernacular. They vary by language and region, and have a smaller scope than scientific names’ international reach, making common names arguably simpler to change. Some become immortalized in field guides and formally recognized by scientific societies. These common names provide a useful shared language for scientists and the public, but the names can also enshrine harmful legacies. Advocates for change see some names as barriers to inclusion and distractions from the organisms themselves. But those advocates also see opportunities in renaming.

“We can choose language that reflects our shared values,” says Jessica Ware, an entomologist at the American Museum of Natural History in New York City and president-elect of the Entomological Society of America, or ESA. Name changes are nothing new; scientific and common names can shift as scientists learn more about a species. The ESA keeps a list of English common names for insects, which is updated regularly.



The Scott’s oriole is named for a U.S. military commander who coordinated the forced removal of Native Americans from their land.

In July, the ESA removed the pejorative term “gypsy,” what many consider to be a slur for Roma people, from its common name list for two insects, the moth *Lymantria dispar* and the ant *Aphaenogaster araneoides*. The ESA has invited new name suggestions from the public. In the meantime, the insects will go by their scientific names.

“This is a moral, necessary and long-overdue change,” says Roma rights activist and scholar Margareta Matache of Harvard University. It’s a “small yet historic” step to rectify portrayals where “Roma have been denied humanity or depicted as less than human,” she says.

With the Better Common Names Project, the ESA now discourages names perpetuating negative stereotypes and welcomes public input about which names to change next. More than 80 insensitive names have been identified so far, Ware says, and over 100 name ideas for *L. dispar* have streamed in. With a “bottom-up swelling of names” to choose from, “everybody is included,” she says.

Racist legacies still lurk elsewhere. Some birds, fishes and flowers are known by the label Hottentot, a term of abuse for Indigenous Khoikhoi people in southern Africa. The Digger pine tree bears a pejorative for Native American groups including the Paiute people, once derisively called diggers by white settlers in the western United States.

The bird world, in particular, has been reckoning with such legacies. The practice of naming birds for people proliferated in the 19th century. Today, 142 North American bird names endure as verbal monuments to people. Names such as Bachman’s sparrow, for Lutheran minister and naturalist John Bachman, venerate people who defended slavery. Others such as Scott’s oriole, chosen by naturalist and U.S. military officer Darius Nash Couch, lionize

FROM TOP: HEATHER BROCCARD-BELL/E+/GETTY IMAGES; ANDY REAGO & CHRISSY MCCLARREN/FLICKR (CC BY 2.0) people who participated in genocide. "Native Americans would have always been opposed to these names," Hampton says.

Since 2020, supporters of the grassroots campaign Bird Names for Birds have advocated for replacing all eponymous bird names with descriptive ones. "It's not a be-all-end-all solution" to removing barriers to birding for minority communities, says evolutionary biologist Robert Driver of East Carolina University in Greenville, N.C. But it's one gesture of "consideration for everyone who's out there with binoculars."

The American Ornithological Society initially rejected Driver's proposal to revise the name of a brownish-gray bird called McCown's longspur, named after Confederate general John P. McCown. Then the 2020 murder of George Floyd sparked nationwide reflection on systemic racism, and some Confederate monuments were removed. The ornithology society subsequently changed its policies to consider a namesake's role in "reprehensible events" as grounds for revision. Now, the bird is known as the thick-billed longspur. Driver wants Scott's oriole to be next. But for now, common name changes have paused while the society considers a new name-changing process.

Removing harmful terms offers stability in common names, Ware says. With thoughtful criteria, scientists and others can craft names built to last. "It might be uncomfortable now," Ware says. "But hopefully, that only happens once."

As for Hampton, though he no longer sees Scott's orioles, he still can't escape these types of names. While birding, he'll sometimes spy a Townsend's solitaire — a bird that favors juniper berries. It's named after American naturalist John Kirk Townsend, who collected Indigenous people's skulls in the 1830s for cranial measurements that were used to justify pseudoscientific racial hierarchies. Every time Hampton sees one of the birds, he thinks: "That should be juniper solitaire." In his mind's eye, Scott's oriole is the yucca oriole. "I can't wait for those to be changed." ■

ATOM & COSMOS

Cool red dwarfs have a limit

Temperature cutoff separates stellar winners from losers

BY KEN CROSWELL

If you want to be a successful star while making the minimum possible effort, aim for a surface temperature about a quarter of the sun's. This is the temperature that separates red dwarf stars, which shine for a long time, from failed stars known as brown dwarfs, researchers report July 5 at arXiv.org.

It's often difficult to distinguish between red and brown dwarfs. When young, brown dwarfs look like red dwarfs: red and dim. But only red dwarfs are born with enough mass to sustain nuclear reactions that power stars like the sun. In contrast, newborn brown dwarfs glow red primarily from the heat of their birth, but their nuclear activity sputters out, causing the objects to cool and fade. Now, by exploiting how red and brown dwarfs move through space, astrophysicists Dino Hsu and Adam Burgasser of the University of California, San Diego and their colleagues have discerned the dividing line between the two types.

When a star is born in the Milky Way, the star revolves around the galaxy's center on a fairly circular orbit. Over time, gravitational tugs from other stars, giant gas clouds and spiral arms toss the newborns to and fro. These perturbations make the dwarfs' orbits around the galactic center more elliptical. That means the orbital paths of the objects can reveal their approximate ages.

Most red dwarfs are fairly old; they are predicted to live far longer than the current age of the universe, which is about 13.8 billion years. Because brown dwarfs cool and fade, any that are warm are young. Thus, on average, red dwarfs should follow more elliptical orbits around the galaxy than young brown dwarfs do.

Hsu, Burgasser and colleagues analyzed 172 red and brown dwarfs of different spectral types — classifications based on objects' light broken into its component colors that correlate with the objects' surface temperatures.

A sharp break in orbital motions separates warmer objects from cooler ones, the researchers found. On average, the warmer objects have more elliptical orbits and are older while the cooler ones have more circular orbits and are younger. This break appears at a spectral type that corresponds to a surface temperature of about 1200° to 1400° Celsius, the team found. That's a fraction of the sun's surface temperature of about 5500° C.

A new study may make it easier to tell a brown dwarf (illustrated) from a red dwarf.

JPL-CALTECH/NASA

Above this newfound temperature boundary, objects are a mix of long-lived red dwarfs and young brown dwarfs. Below the boundary, "it's all brown dwarfs," Hsu says. The team's findings will appear in the *Astrophysical Journal Supplement Series*.

The team's method for detecting the temperature boundary between red and brown dwarfs is intriguing, but the result is tentative, says astronomer Trent Dupuy of the University of Edinburgh. "It's right around where you would expect," he says. Additional red and brown dwarfs at the purported boundary should be observed to verify the finding, Dupuy says.

Hsu agrees. "We need a more complete sample," he says. Though red dwarfs outnumber all other types of stars put together and brown dwarfs are also common, expanding the sample will take more effort. Red and brown dwarfs are faint, which makes measuring their Doppler shift — the change in the wavelength of an object's light as the object moves toward or away from Earth — a challenge. This measurement is essential for calculating red and brown dwarfs' orbital paths around the galaxy. ■

LIFE & EVOLUTION

Big-headed pterosaurs may have preferred walking to flying

In 2013, a police raid at Santos Harbor in Brazil recovered about 3,000 smuggled fossils, including the most intact specimen of a type of big-headed pterosaur ever found. An analysis of the fossil provides new insight into the flying reptile's foraging style, flight capability and anatomy, scientists report August 25 in *PLOS ONE*.

Identified as *Tupandactylus navigans*, the fossil was a tapejarid, a type of pterosaur known for its oversized, crested skull. Tapejarids lived during the early Cretaceous Period, which lasted from about 145 million to 100 million years ago.

Until now, tapejarid anatomy hadn't been fully described. "This is the first time we have the full skull and the full [body]," says Victor Beccari, a paleontologist at the NOVA School of Science & Technology in Caparica, Portugal.

When Beccari's team received the fossil in 2016, the limestone containing it had already been cut into six blocks. The team fit the pieces inside a CT scanner and used the scans to produce a 3-D model of the pterosaur's skeleton that revealed parts still buried inside rock.

Previous studies suggested that tapejarids had a short, stout neck to support the large head during flight. But the new work shows that the neck accounted for over half of the spine's length, which could have made sustained flight difficult. Long hind legs and relatively short arms hint that *T. navigans* could have been comfortable walking.

These observations suggest that this pterosaur may have behaved like a peacock, Beccari says. Its crest probably attracted mates, and *T. navigans* may have flown to treetops to look for food or escape from predators, he says. "But it spent most of its time walking on the ground." *— Nikk Ogasa*

The long neck and oversized head of a crested pterosaur called *Tupandactylus navigans* (illustrated) may have made sustained flight difficult for this reptile of the early Cretaceous Period.

V. BECCARI

BODY & BRAIN

Personalized brain organoids could help demystify disorders

Clumps of brain cells grown from the stem cells of two people with a neurological syndrome show signs of the disorder. The results, published August 23 in *Nature Neuroscience*, suggest that personalized brain organoids could be powerful tools to understand complex disorders.

Researchers grew two kinds of brain organoids. One kind, grown from healthy people's stem cells, produced complex electrical activity that echoed the brain waves a full-sized brain makes. These waves, created by the coordinated firing of many nerve cells, are part of how the brain keeps information moving.

The researchers also grew organoids using cells from a woman and a child with Rett syndrome, a developmental disorder marked by seizures, autism and developmental lags. Rett syndrome is thought to be caused by changes in a gene called *MECP2*, mutations that the lab-grown organoids carried as well.

These organoids looked like those grown from healthy people but behaved differently. Nerve cells fired off signals that were too synchronized and less varied. And some of the brain waves were reminiscent of a brain having a seizure, in which a burst of electrical activity scrambles normal brain business.

With organoids carrying Rett syndrome mutations, scientists can better understand the syndrome and even begin to test possible treatments. *— Laura Sanders*

LIFE & EVOLUTION

Some wasp nests glow green under ultraviolet light

Beam a black light into some Vietnamese forests at night, and green bulbs may glow in the trees. These eerie lanterns are the nests of Asian paper wasps, and the gleam comes from silk fibers in the nests that fluoresce when struck by ultraviolet light, researchers report in the August *Journal of the Royal Society Interface.*

Chemist Bernd Schöllhorn of the University of Paris and CNRS and colleagues came across the nests while searching for fluorescent insects using powerful UV torches. After analyzing the fluorescence of the nests of some Asian paper wasps (*Polistes* spp.) in the lab, the researchers found that silk threads in the nests glow more brilliantly than other documented fluorescent biomaterials. Nests of one species emitted about one-third as much light as they absorbed. And in some cases, the nests were visible by the naked eye from up to 20 meters away.

The fluorescence must benefit the wasps somehow, the researchers say. One hypothesis is that the nests protect larvae inside from UV radiation by absorbing some of the harmful energy and dissipating it as visible light, Schöllhorn says. Or, as the sun casts its last UV light at the end of the day, the nests might shine bright enough amid the darkening foliage to help wayward wasps find home, like beacons at twilight. *— Nikk Ogasa*


YOU PROVIDE THE VISION.
WE PROVIDE THE CONNECTIONS.
LINDE PACKMAN LAB FOR BIOSCIENCES INNOVATION and the PULVER SCHOLARS PROGRAM
FUNDED research, internships, and global experiences
PREPARE FOR CAREERS IN biotechnology, biomedicine, ocean sciences, genomics, and bioinformatics
colby.edu/admission/pulver-science-scholars
Colby

In a severe drought, rice farmers in California's Sacramento Valley have to leave some of their fields unplanted (upper left).

Rice in Trouble

Drought and floods threaten this worldwide food staple

By Nikk Ogasa

Under a midday summer sun in California's Sacramento Valley, rice farmer Peter Rystrom walks across a dusty, barren plot of land, parched soil crunching beneath each step.

In a typical year, he'd be sloshing through inches of water amid lush, green rice plants. But today the soil lies naked and baking in the 35° Celsius (95° Fahrenheit) heat during a devastating drought that has hit most of the western United States. The drought started in early 2020, and conditions have become progressively drier.

Low water levels in reservoirs and rivers have forced farmers like Rystrom, whose family has been growing rice on this land for four generations, to slash their water use.

Rystrom stops and looks around. "We've had to cut back between 25 and 50 percent." He's relatively lucky. In some parts of the Sacramento Valley, depending on water rights, he says, farmers received no water this season.

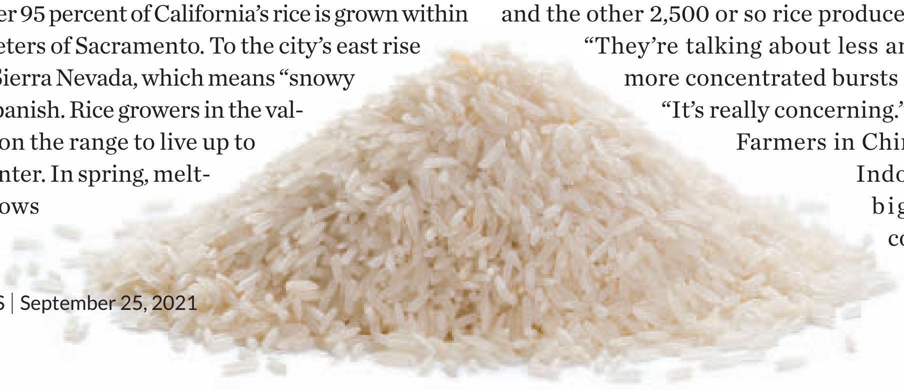
California is the second-largest U.S. producer of rice, after Arkansas, and over 95 percent of California's rice is grown within about 160 kilometers of Sacramento. To the city's east rise the peaks of the Sierra Nevada, which means "snowy mountains" in Spanish. Rice growers in the valley below count on the range to live up to its name each winter. In spring, melting snowpack flows into rivers and reservoirs, and then through an intricate network of canals and drainages to rice fields that farmers irrigate in a shallow inundation from April or May to September or October.

If too little snow falls in those mountains, farmers like Rystrom are forced to leave fields unplanted. On April 1 this year, the date when California's snowpack is usually at its deepest, it held about 40 percent less water than average, according to the California Department of Water Resources. On August 4, Lake Oroville, which supplies Rystrom and other local rice farmers with irrigation water, was at its lowest level on record.

Not too long ago, the opposite — too much rain — stopped Rystrom and others from planting. "In 2017 and 2019, we were leaving ground out because of flood. We couldn't plant," he says. Tractors couldn't move through the muddy, clay-rich soil to prepare the fields for seeding.

Climate change is expected to worsen the state's extreme swings in precipitation, researchers reported in 2018 in *Nature Climate Change*. This "climate whiplash" looms over Rystrom and the other 2,500 or so rice producers in the Golden State. "They're talking about less and less snowpack, and more concentrated bursts of rain," Rystrom says. "It's really concerning."

Farmers in China, India, Bangladesh, Indonesia, Vietnam — the biggest rice-growing countries — as well as in



FROM TOP: CALIFORNIA RICE COMMISSION, BRIAN BAER; EELNOSIVA/ISTOCK/GETTY IMAGES PLUS

Nigeria, Africa's largest rice producer — also worry about the damage climate change will do to rice production. More than 3.5 billion people get 20 percent or more of their calories from the fluffy grains. And demand is increasing in Asia, Latin America and especially in Africa.

Fourth-generation rice farmer Peter Rystrom (left) stands with his grandfather Don Rystrom (middle) and his father Steve Rystrom (right).

To save and even boost production, rice growers, engineers and researchers have turned to water-saving irrigation routines and rice gene banks that store hundreds of thousands of varieties ready to be distributed or bred into new, climate-resilient forms. With climate change accelerating, and researchers raising the alarm about related threats, such as arsenic contamination and bacterial diseases, the demand for innovation grows.

"If we lose our rice crop, we're not going to be eating," says plant geneticist Pamela Ronald of the University of California, Davis. Climate change is already threatening rice-growing regions around the world, says Ronald, who identifies genes in rice that help the plant withstand disease and floods. "This is not a future problem. This is happening now."

Saltwater woes

Most rice plants are grown in fields, or paddies, that are typically filled with around 10 centimeters of water. This constant, shallow inundation helps stave off weeds and pests. But if water levels suddenly get too high, such as during a flash flood, the rice plants can die.

Striking the right balance between too much and too little water can be a struggle for many rice farmers, especially in Asia, where over 90 percent of the world's rice is produced. Large river deltas in South and Southeast Asia, such as the Mekong River Delta in Vietnam, offer flat, fertile land that is ideal for farming rice. But these low-lying areas are sensitive to swings in the water cycle. And because deltas sit on the coast, drought brings another threat: salt.

Salt's impact is glaringly apparent in the Mekong River Delta. When the river runs low, saltwater from the South China Sea encroaches upstream into the delta, where it can creep into the soils and irrigation canals of the delta's rice fields.

"If you irrigate rice with water that's too salty, especially at certain [growing] stages, you are at risk of losing 100 percent of the crop," says Bjoern Sander, a climate change specialist at the International Rice Research Institute, or IRRI, who is based in Vietnam.

In a 2015 and 2016 drought, saltwater reached up to 90 kilometers inland, destroying 405,000 hectares of rice paddies. In 2019 and 2020, drought and saltwater intrusion returned, damaging 58,000 hectares of rice. With regional temperatures on the rise, these conditions in Southeast Asia are expected to intensify and become more widespread, according to a 2020 report by the Economic and Social Commission for Asia and the Pacific.

Then comes the whiplash: Each year from around April to October, the summer monsoon turns on the faucet over swaths of South and Southeast Asia. About 80 percent of South Asia's rainfall is dumped during this season and can cause destructive flash floods.

Bangladesh is one of the most flood-prone rice producers in the region, as it sits at the mouths of the Ganges, Brahmaputra and Meghna rivers. In June 2020, monsoon rains flooded about 37 percent of the country, damaging about 83,000 hectares of rice fields, according to Bangladesh's Ministry of Agriculture. And the future holds little relief; South Asia's monsoon rainfall is expected to intensify with climate change, researchers reported June 4 in *Science Advances*.

A hot mess

Water highs and lows aren't the entire story. Rice generally grows best in places with hot days and cooler nights. But in many rice-growing regions, temperatures are getting too hot. Rice plants become most vulnerable to heat stress during the middle phase of their growth, before they begin building up the meat in their grains. Extreme heat, above 35° C, can diminish grain counts in just weeks, or even days. In April in Bangladesh, two consecutive days of 36° C destroyed thousands of hectares of rice.

In South and Southeast Asia, such extreme heat events are expected to become common with climate change, researchers reported in July in *Earth's Future*. And there are other, less obvious consequences for rice in a warming world.

One of the greatest threats is bacterial blight, a fatal plant disease caused by the bacterium *Xanthomonas oryzae pv. oryzae*. The disease, most prevalent in Southeast Asia and rising

In Vietnam's Mekong River Delta, farmers pull dead rice plants from a paddy that was contaminated by saltwater intrusion from the South China Sea, which can happen during a drought.

FROM TOP: CALIFORNIA RICE COMMISSION, BRIAN BAER; HOANG DINH NAM/AFP VIA GETTY IMAGES in Africa, has been reported to have cut rice yields by up to 70 percent in a single season.

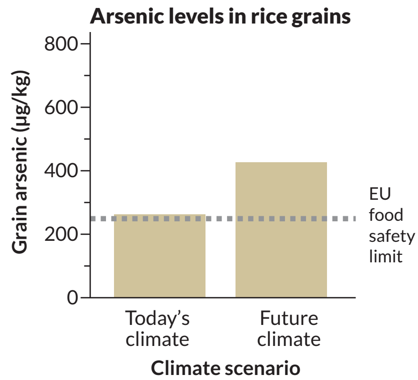
"We know that with higher temperature, the disease becomes worse," says Jan Leach, a plant pathologist at Colorado State University in Fort Collins. Most of the genes that help rice combat bacterial blight seem to become less effective when temperatures rise, she explains.

And as the world warms, new frontiers may open for rice pathogens. An August study in *Nature Climate Change* suggests that as global temperatures rise, rice plants (and many other crops) at northern latitudes, such as those in China and the United States, will be at higher risk of pathogen infection.

Meanwhile, rising temperatures may bring a double-edged arsenic problem. In a 2019 study in *Nature Communications*, E. Marie Muehe, a biogeochemist at the Helmholtz Centre for Environmental Research in Leipzig, Germany, who was then at Stanford University, showed that under future climate conditions, more arsenic will infiltrate rice plants. High arsenic levels boost the health risk of eating the rice and impair plant growth.

Arsenic naturally occurs in soils, though in most regions the toxic element is present at very low levels. Rice, however, is particularly susceptible to arsenic contamination, because it is grown in flooded conditions. Paddy soils lack oxygen, and the microbes that thrive in this anoxic environment liberate arsenic from the soil. Once the arsenic is in the water, rice plants can draw it in through their roots. From there, the element is distributed throughout the plants' tissues and grains.

Muehe and her team grew a Californian variety of rice in a local low-arsenic soil inside climate-controlled greenhouses. Increasing the temperature and carbon dioxide levels to match



Leaching in When grown in a greenhouse at 5 degrees Celsius above preindustrial temperatures with elevated carbon dioxide levels (representing a future climate), California rice varieties absorbed more of a type of highly toxic arsenic from the soil, raising the rice's arsenic levels above European Union safety thresholds.

SOURCE: E.M. MUEHE *ET AL/NATURE COMM.* 2019

future climate scenarios enhanced the activity of the microbes living in the rice paddy soils and increased the amount of arsenic in the grains, Muehe says. And importantly, rice yields diminished. In the low-arsenic Californian soil under future climate conditions, rice yield dropped 16 percent.

According to the researchers, models that forecast the future production of rice don't account for the impact of arsenic on harvest yields. What that means, Muehe says, is that current projections are overestimating how much rice will be produced in the future.

Managing rice's thirst

From atop an embankment that edges one of his fields, Rystrom watches water gush from a pipe, flooding a paddy packed with rice plants. "On a year like this, we decided to pump," he says.

Able to tap into groundwater, Rystrom left only about 10 percent of his fields unplanted this growing season. "If everybody was pumping from the ground to farm rice every

To keep rice bowls around the world full, researchers breed new varieties of rice that can endure stresses like drought, floods and salt.

Sahbhagi Dhan Traditional rice varieties take 120 to 150 days to harvest and require four irrigations. Sahbhagi Dhan is a drought-tolerant variety harvested after 105 days and just two irrigations. In normal conditions, it produces about twice as much rice (four to five metric tons per hectare) as other local varieties in India. Under drought conditions, it produces one to two metric tons per hectare; local varieties produce none.

Scuba rice *Sub1*, a submergence-tolerance gene, has been bred into scuba rice varieties. Rice normally dies after three to four days of total submergence — many varieties will exhaust themselves to death trying to quickly grow to the water's surface. *Sub1* varieties (shown), however, refrain from this frenzied growth spurt, and can withstand over two weeks underwater, able to survive the sudden floods of the summer monsoon.

Salt-tolerant rice Made by inserting an area of the genome called Saltol, salt-tolerant rice varieties are better able to regulate the amount of sodium ions, toxic in high amounts, in their tissues. Saltol has been incorporated into high-yield varieties throughout the world. — *Nikk Ogasa* year," he admits, it would be unsustainable.

One widely studied, drought-friendly method is "alternate wetting and drying," or intermittent flooding, which involves flooding and draining rice paddies on one- to 10-day cycles, as opposed to maintaining a constant inundation. This practice can cut water use by up to 38 percent without sacrificing yields. It also stabilizes the soil for harvesting and lowers arsenic levels in rice by bringing more oxygen into the soils, disrupting the arsenic-releasing microbes. If tuned just right, it may even slightly improve crop yields.

But the water-saving benefits of this method are greatest when it is used on highly permeable soils, such as those in Arkansas and other parts of the U.S. South, which normally require lots of water to keep flooded, says Bruce Linquist, a rice specialist at the University of California Cooperative Extension. The Sacramento Valley's clay-rich soils don't drain well, so the water savings where Rystrom farms are minimal; he doesn't use the method.

Building embankments, canal systems and reservoirs can also help farmers dampen the volatility of the water cycle. But for some, the solution to rice's climate-related problems lies in enhancing the plant itself.

Better breeds

The world's largest collection of rice is stored near the southern rim of Laguna de Bay in the Philippines, in the city of Los Baños. There, the International Rice Genebank, managed by IRRI, holds over 132,000 varieties of rice seeds from farms around the globe.

Upon arrival in Los Baños, those seeds are dried and processed, placed in paper bags and moved into two storage facilities — one cooled to 2° to 4° C from which seeds can be readily withdrawn, and another chilled to –20° C for long-term storage. To be extra safe, backup seeds are kept at the National Center for Genetic Resources Preservation in Fort Collins, Colo., and the Svalbard Global Seed Vault tucked inside a mountain in Norway.

All this is done to protect the biodiversity of rice and amass a trove of genetic material that can be used to breed future generations of rice. Farmers no longer use many of the stored varieties, instead opting for new higher-yield or sturdier breeds. Nevertheless, solutions to climate-related problems may be hidden in the DNA of those older strains. "Scientists are always looking through that collection to see if genes can be discovered that aren't being used right now," says Ronald, of UC Davis. "That's how *Sub1* was discovered."

The *Sub1* gene enables rice plants to endure prolonged periods completely submerged underwater. It was discovered in 1996 in a traditional variety of rice grown in the Indian state of Orissa, and through breeding has been incorporated into varieties cultivated in flood-prone regions of South and Southeast Asia. *Sub1*-wielding varieties, called "scuba rice," can survive for over two weeks entirely submerged, a boon for farmers whose fields are vulnerable to flash floods.

Over 132,000 varieties of rice seeds fill the shelves of the climate-controlled International Rice Genebank. Breeders from around the world can use the seeds to develop new climate-resilient rice strains.

Some researchers are looking beyond the genetic variability preserved in rice gene banks, searching instead for useful genes from other species, including plants and bacteria. But inserting genes from one species into another, or genetic modification, remains controversial. The most famous example of genetically modified rice is Golden Rice, which was intended as a partial solution to childhood malnutrition. Golden Rice grains are enriched in beta-carotene, a precursor to vitamin A. To create the rice, researchers spliced a gene from a daffodil and another from a bacterium into an Asian variety of rice.

Three decades have passed since its initial development, and only a handful of countries have deemed Golden Rice safe for consumption. On July 23, the Philippines became the first country to approve the commercial production of Golden Rice. Abdelbagi Ismail, principal scientist at IRRI, blames the slow acceptance on public perception and commercial interests opposed to genetically modified organisms, or GMOs (*SN: 2/6/16, p. 22*).

Looking ahead, it will be crucial for countries to embrace GM rice, Ismail says. Developing nations, particularly those in Africa that are becoming more dependent on the crop, would benefit greatly from the technology, which could produce new varieties faster than breeding and may allow researchers to incorporate traits into rice plants that conventional breeding cannot. If Golden Rice were to gain worldwide acceptance, it could open the door for new genetically modified climate- and disease-resilient varieties, Ismail says. "It will take time," he says. "But it will happen."

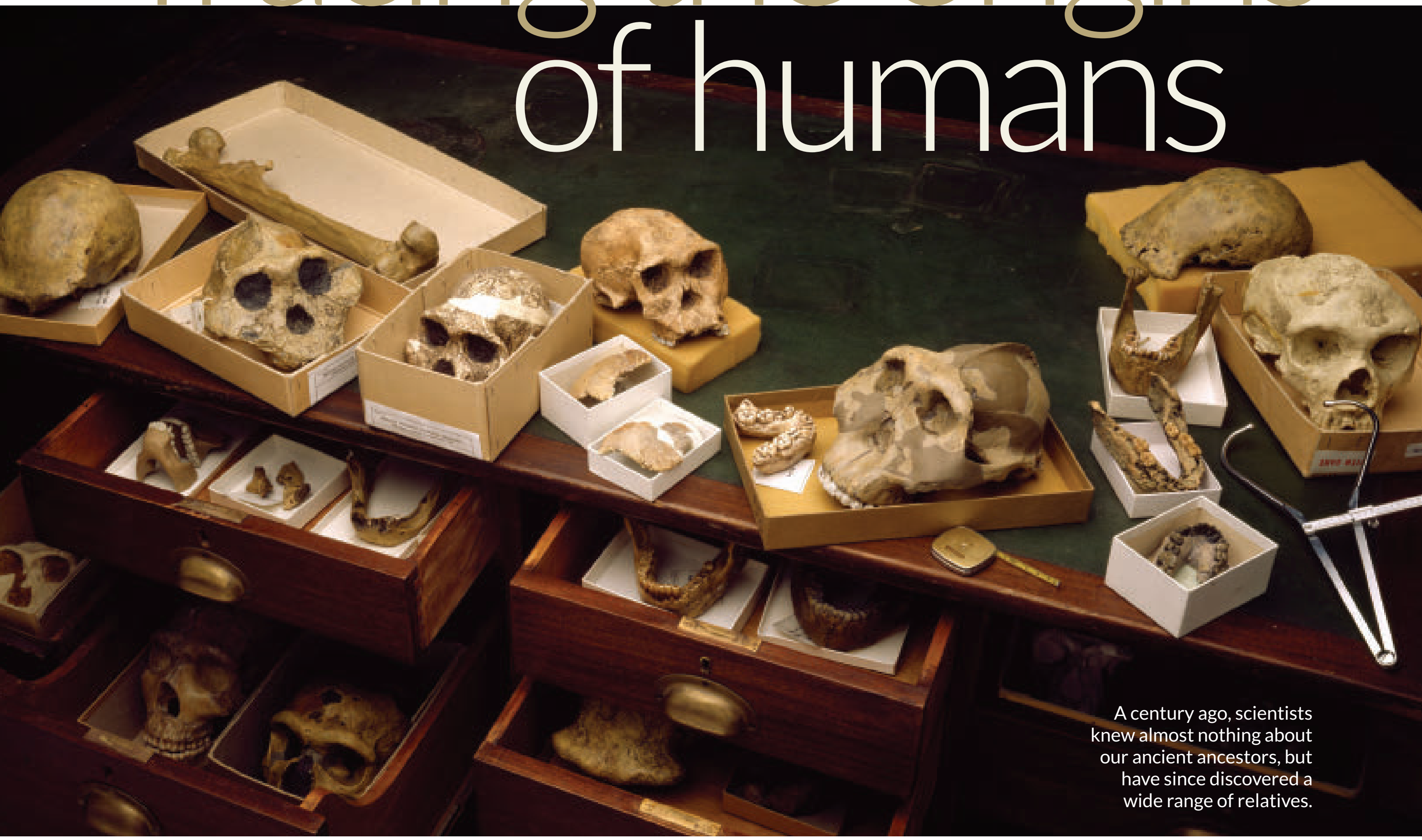
Climate change is a many-headed beast, and each rice-growing region will face its own particular set of problems. Solving those problems will require collaboration between local farmers, government officials and the international community of researchers.

"I want my kids to be able to have a shot at this," Rystrom says. "You have to do a lot more than just farm rice. You have to think generations ahead." ■

Explore more

■ E. Marie Muehe *et al.* "Rice production threatened by coupled stresses of climate and soil arsenic." *Nature Communications.* November 1, 2019.

Tracing the origins of humans



A century ago, scientists knew almost nothing about our ancient ancestors, but have since discovered a wide range of relatives.

THE NATURAL HISTORY MUSEUM/ALAMY STOCK PHOTO

A century of science has begun to piece together where we came from

By Erin Wayman

In *The Descent of Man*, published in 1871, Charles Darwin hypothesized that our ancestors came from Africa. He pointed out that among all animals, the African apes — gorillas and chimpanzees — were the most similar to humans. But he had little fossil evidence. The few known human fossils had been found in Europe, and those that trickled in over the next 50 years came from Europe and from Asia.

Had Darwin picked the wrong continent?

Finally, in 1924, a fortuitous find supported Darwin's speculation. Among the debris at a limestone quarry in South Africa, miners recovered the fossilized skull of a toddler. Based on the child's blend of humanlike and apelike features, an anatomist determined that the fossil was what was then popularly known as a "missing link." It was the most apelike fossil yet found of a hominid — that is, a member of the family Hominidae, which includes modern humans and all our close, extinct relatives.

That fossil wasn't enough to confirm Africa as our homeland. Since that discovery, paleoanthropologists have amassed many thousands of fossils, and the evidence over and over again has pointed to Africa as our place of origin. Genetic studies reinforce that story. African apes are indeed our closest living relatives, with chimpanzees more closely related to us than to gorillas. In fact, many scientists now include great apes in the hominid family, using the narrower term "hominin" to refer to humans and our extinct cousins.

In a field with a reputation for bitter feuds and rivalries, the notion of humankind's African origins unifies human evolution

ScienceNews 100

To celebrate our 100th anniversary, we're highlighting some of the biggest advances in science over the last century. To see an expanded version of this story and more from the series, visit the Century of Science site at www.sciencenews.org/century researchers. "I think everybody agrees and understands that Africa was very pivotal in the evolution of our species," says Charles Musiba, a paleoanthropologist at the University of Colorado Denver.

Paleoanthropologists have sketched a rough timeline of how that evolution played out. Sometime between 9 million and 6 million years ago, the first hominins evolved. Walking upright on two legs distinguished our ancestors from other apes; our ancestors also had smaller canine teeth, perhaps a sign of less aggression and a change in social interactions. Between about 3.5 million and 3 million years ago, humankind's forerunners ventured beyond wooded areas. Africa was growing drier, and grasslands spread across the continent. Hominins were also crafting stone tools by this time. The human genus, *Homo*, arrived between 2.5 million and 2 million years ago, maybe earlier, with larger brains than their predecessors. By at least 2 million years ago, *Homo* members started traveling from Africa to Eurasia. By about 300,000 years ago, *Homo sapiens*, our species, emerged.

But human evolution was not a gradual, linear process, as it appeared to be in the 1940s and '50s. It did not consist of a nearly unbroken chain, one hominin evolving into the next through time. Fossil discoveries in the '60s and '70s revealed a bushier family tree, with many dead-end branches. By some counts, more than 20 hominin species have been identified in the fossil record. Experts disagree on how to classify all of these forms — "Fossil species are mental constructs," a paleoanthropologist once told *Science News* — but clearly, hominins were diverse, with some species overlapping in both time and place.

Even our species wasn't always alone. Just 50,000 years ago, the diminutive, 1-meter-tall *Homo floresiensis*, nicknamed the hobbit, lived on the Indonesian island of Flores. And 300,000 years ago, *Homo naledi* was a neighbor in South Africa.

Finding such "primitive" species — both had relatively small brains — living at the same time as *H. sapiens* was a big surprise, says Bernard Wood, a paleoanthropologist at George Washington University in Washington, D.C. Those discoveries, made within the last two decades, were reminders of how much is left to learn.

It's premature to pen a comprehensive explanation of human evolution with so much ground — in Africa and elsewhere — to explore, Wood says. Our origin story is still a work in progress.

Eyes on Africa

Raymond Dart had a wedding to host.

It was a November afternoon in 1924, and the Australian-born anatomist was partially dressed in formal wear when he was distracted by fossils. Rocks containing the finds had just been brought to his home in Johannesburg, South Africa, from a mine near the town of Taung.

Imprinted on a knobby rock about as big as an orange were the folds, furrows and even blood vessels of a brain. It fit perfectly inside another rock that had a bit of jaw peeking out.

The groom pressed Dart to get back on track. "My god, Ray," he said. "You've got to finish dressing immediately — or I'll have to find another best man."

As soon as the festivities ended, Dart, 31 years old at the time, started removing the jaw from its limestone casing, chipping away with knitting needles. A few weeks later, he had liberated not just a jaw but a partial skull preserving the face of a child.

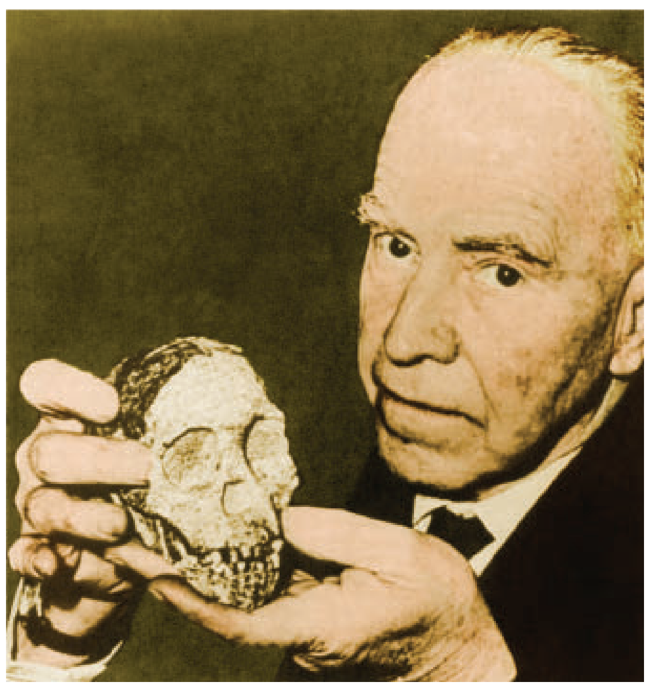
On February 7, 1925, in the journal *Nature*, Dart introduced the Taung Child to the world. He described the fossil as an ape like no other, one with some distinctly humanlike features, including a relatively flat face and fairly small canine teeth. The foramen magnum, the hole through which the spinal cord exits the head, was positioned directly under the skull, implying the child had an erect posture and walked on two legs.

Dart concluded that the Taung Child belonged to "an extinct race of apes *intermediate between living anthropoids and man*." His italicized text emphasized his judgment: The fossil was a so-called missing link between other primates and humans. He named it *Australopithecus africanus*, or southern ape of Africa.

The Taung Child was the second hominin fossil discovered in Africa, and much more primitive than the first. Dart argued that the find vindicated Darwin's belief that humans arose on that continent. "There seems to be little doubt," *Science News Letter*, the predecessor of *Science News*, reported, "that there has been discovered on the reputed 'dark' continent a most important step in the evolutionary history of man."

But Dart's claims were mostly met with skepticism. It would take more than two decades of new fossil finds and advances in geologic dating for Dart to be vindicated — and for Africa to become the epicenter of paleoanthropology.

Raymond Dart recognized that the Taung Child (shown with Dart decades after its 1924 discovery) had both apelike and humanlike qualities. The find sparked the search for more hominin fossils in Africa.



SCIENCE HISTORY IMAGES/ALAMY STOCK PHOTO

Against the establishment

Unlike Darwin, many evolutionists of the late 19th and early 20th centuries had theorized that the human family tree was rooted in Asia. Some argued that Asia's gibbons were our closest living relatives. Others reasoned that tectonic activity and climate change in Central Asia sparked human evolution. One naturalist even proposed that human origins traced back to a lost continent that had sunk in the Indian Ocean, forcing our ancestors to relocate to Southeast Asia.

And that's where the best contender for an early human ancestor had been found. In the 1890s, a crew led by Dutch physician-turned-anthropologist Eugène Dubois had uncovered a skullcap and thigh bone on the Indonesian island of Java. The thick skullcap had heavy brow ridges, but Dubois estimated it once held a brain that was about twice as big as an ape's and approaching the size of a human's. The thigh bone indicated that this Java Man, later named *Homo erectus*, walked upright.

Europe had its own tantalizing fossils. Neandertals had been known since the mid-19th century, but by the early 20th century, they were generally thought to be cousins that lived too recently to shed much light on our early evolution. A more relevant discovery seemed to come in 1912, when an amateur archaeologist had recovered humanlike bones from near Piltdown, England; the site also contained fossils of extinct creatures, suggesting Piltdown Man was of great antiquity. Skull bones hinted he had a human-sized brain, but his primitive jaw had a large, apelike canine tooth.

Some experts questioned whether the skull and jaw belonged together. But British scientists embraced the discovery — and not just because it implied England had a role in human origins. Piltdown Man's features fit with the British establishment's view of human evolution, in which a big brain was the first trait to distinguish human ancestors from other apes.

So when Dart announced that he had found a small-brained bipedal ape with humanlike teeth in the southern tip of Africa, scientists were primed to be skeptical, says Paige Madison, a historian of science at the Natural History Museum of Denmark in Copenhagen. Scientists were also skeptical of Dart. While a student in London, he had earned a reputation as a "scientific heretic, given to sweeping claims," according to a paper coauthored by a colleague.

But initial criticism focused mostly on practical concerns, says Madison, who has studied the skeptics' reactions. "I found what they were actually saying on paper to be quite reasonable."

A big problem: Dart's fossil was of a 3- or 4-year-old child. Critics pointed out that a young ape tends to resemble humans in some ways, but the similarities disappear as the ape matures. Critics also complained that Dart hadn't done proper comparative analyses with young chimps and gorillas, and he refused to send the fossil to England where such analyses could be done. This refusal irked the British old guard. "It was unpalatable to the scientists in England that the young colonial upstart had presumed to describe the skull himself," one of Dart's contemporaries later wrote, "instead of submitting it to his elders and betters."

In the 1930s and '40s, Robert Broom unearthed fossils in South African caves, including at Sterkfontein (shown), that helped convince skeptics that *Australopithecus* was a human ancestor.

It's hard not to wonder how the era's colonialist and racist attitudes shaped perceptions. The Taung Child came to light at a time when eugenics was still considered legitimate science, and much of anthropology was devoted to categorizing people into races and arranging them into hierarchies. On the one hand, Western researchers tended to maintain the perverse notion that Africans are more primitive than other people, even less evolved. On the other, they wanted to believe Europe or Asia is where humans originated.

How these views influenced reactions to the Taung Child is not clear-cut. Many skeptics didn't cite the fossil's location as a problem, and some acknowledged humans could have evolved in Africa. But deep-seated biases may have made it easier for some researchers to reject the Taung Child and accept Piltdown Man, even though fossil evidence for that claim was also scant, says Sheela Athreya, a paleoanthropologist at Texas A&M University in College Station.

Newspapers worldwide followed the Taung Child controversy. And while fans sent Dart poems and short stories casting the child as a national hero, he also received letters from disapproving creationists.

Amid it all, Dart had convinced at least one well-known scientist. Robert Broom, a Scottish-born physician living in South Africa and an authority on reptile evolution, recognized that fossils of fully grown *A. africanus* individuals would be needed to confirm that the Taung Child's humanlike qualities were retained in adulthood.

Broom began to find just that evidence in 1936 in caves not far from Johannesburg. Often taking the heavy-handed approach of detonating dynamite to free specimens, he

NATURAL HISTORY 1947, LINDA HALL LIBRARY amassed a collection of fossils representing both the young and the old. Limb, spine and hip bones confirmed South Africa was once home to a bipedal ape, and skull bones verified Dart's inferences about *A. africanus*' humanlike teeth.

Even the staunchest Dart doubters couldn't overlook this evidence. British anatomist Arthur Keith, who had once called Dart's assertions "preposterous," conceded. "I am now convinced," he wrote in a one-paragraph letter to *Nature* in 1947, "that Prof. Dart was right and that I was wrong; the Australopithecinae are in or near the line which culminated in the human form."

A few years later, in 1953, researchers exposed Piltdown Man to be a hoax — someone had planted a modern human skull alongside an orangutan jaw with its teeth filed down. Many experts outside of England had never been convinced by the find in the first place. "It was not a complete surprise when he was proved to be a fake," *Science News Letter* reported.

Still, Africa's role in human evolution was not cemented. From the time of the Taung Child's unearthing through World War II, discoveries of hominin fossils continued in Indonesia and at a cave site near Beijing called Zhoukoudian. These fossils kept the focus on Asia.

A series of surprises

It was ultimately a series of discoveries by the husband-wife paleoanthropologists Louis and Mary Leakey that shifted the focus. Louis, who had grown up in East Africa as the son of English missionaries, had long believed Africa was the human homeland. While Broom was scouring South Africa in the 1930s, the Leakeys began exploring Olduvai Gorge in what is now Tanzania.

Year after year, the pair failed to find hominin fossils. But they dug up stone tools, suggesting that hominins must have lived there. So they kept looking. One day in 1959, while an ill Louis stayed behind in camp, Mary discovered a skull with small canine teeth like *Australopithecus*. But the fossil's giant molar teeth, flaring cheekbones and bony crest running along the top of the skull where massive chewing muscles would have attached suggested something else. Nicknamed Nutcracker Man for its chompers, the species was dubbed *Zinjanthropus boisei* (it's now called *Paranthropus boisei* because it is clearly a close cousin of *P. robustus*, a South African species found by Broom).

Until the *Zinjanthropus* discovery, determining a hominin fossil's age was largely a guessing game because there was no good way to measure how long ago an ancient fossil had formed. But advances in nuclear physics in the early and mid-20th century led to radioactive dating techniques that allowed age calculations. Using potassium-argon dating, geologists reported in 1961 that *Zinjanthropus* came from a rock layer about 1.75 million years old. The fossil was three times older than the Leakeys initially suspected. (Later, *A. africanus* proved to be even older, living about 2 million to 3 million years ago.) The discovery vastly stretched the timescales on which researchers were mapping human evolution.

The surprises didn't end there. In the early 1960s, the Leakeys' team recovered fossils of a hominin that lived at roughly the same time as *Zinjanthropus* but had smaller, more humanlike teeth and a brain notably bigger than that of both *Zinjanthropus* and *Australopithecus*. Because of the elevated brain size and details of the hand, the Leakeys argued that this hominin was the one who made the tools at Olduvai Gorge; in 1964, Louis and colleagues placed it in the human genus with the name *Homo habilis*, or handy man.

Louis and Mary Leakey spent decades digging in East Africa's Olduvai Gorge (left) before finding hominin fossils. Their luck changed in 1959 when Mary found a skull belonging to an ancient human relative now known as *Paranthropus boisei*.

FROM LEFT: ACC. 90-105 - SCIENCE SERVICE, RECORDS, 1920S-1970S, SMITHSONIAN INSTITUTION ARCHIVES/FLICKR; HUMAN ORIGINS PROGRAM/NMNH/SMITHSONIAN INSTITUTION

Olduvai Gorge in Tanzania's eastern Serengeti Plains was home to a lake millions of years ago. Nearby volcanic eruptions helped preserve fossils at the site and enable dating of the finds.

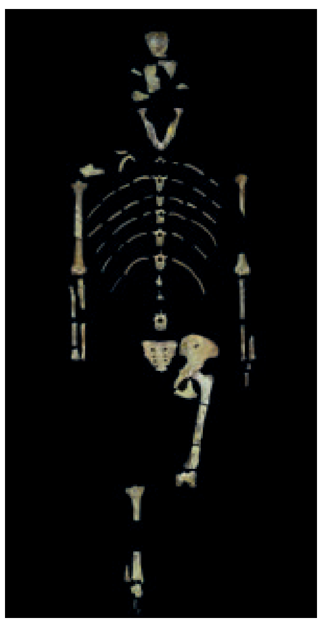
The *Homo* designation was controversial, and to this day paleoanthropologists debate how to classify these fossils. Still, the discoveries at Olduvai Gorge kicked off a paleoanthropological gold rush in Africa. A 1974 discovery in Ethiopia, for instance, once again expanded the timescale of human evolution. It was one of the most famous discoveries in all of human evolution: the nearly 40 percent complete skeleton of Lucy, known more formally as *Australopithecus afarensis,* who lived about 3.2 million years ago.

Since then, researchers have shown repeatedly that the hominin fossil record stretches farthest back in Africa. Today, the oldest purported hominins date back some 6 million or 7 million years — to around the time when the ancestors of humans and chimpanzees probably parted ways.

On the origin of our species

Even after it became clear that hominins originated in Africa, it was still uncertain where our species, *Homo sapiens*, began. By the 1980s, paleoanthropologists had largely settled into two camps. One side claimed that, like the earliest hominins, modern humans came from someplace in Africa. The other side championed a more diffuse start across Africa, Asia and Europe.

That same decade saw researchers increasingly relying on genetics to study human origins. Initially, scientists looked to modern people's DNA to make inferences about ancient populations. But by the late 1990s, geneticists pulled off a feat straight out of science fiction: decoding DNA preserved in hominin fossils.



The skeleton known as Lucy, discovered in Ethiopia in 1974, helped confirm that our ancient ancestors evolved upright walking long before big brains.

For paleoanthropologists, studying ancient DNA has been like astronomers getting a new telescope that sees into deep space with a new wavelength of light. It's revealing things no one even thought to look for, says paleoanthropologist John Hawks of the University of Wisconsin–Madison. "That is the most powerful thing that genetics has handed us."

And it's revealed a truly tangled tale.

A trellis or a candelabra

Long before the rise of genetics, or even the discovery of many hominin fossils, unraveling human origins was a quest to explain how the world's different races came to be. But after the horrors of World War II, anthropologists started to question the validity of race.

"This was a real moral hinge point in the science," Hawks says. "It was a realization that viewing things through the perspective of race was creating evils in the world." And it was scientifically dubious, as genetic evidence has shown that people are all so similar that race is more of a cultural concept than a biological phenomenon. Humans, in fact, are less genetically diverse than chimps.

As race was de-emphasized in the 1940s and '50s, anthropologists started to think more about the mechanisms of evolution and how populations change over time, a direct influence of the "modern synthesis" that had united Darwinian evolution and genetics.

One influential forerunner to this period was anatomist and anthropologist Franz Weidenreich. After leaving Nazi Germany in the 1930s, he ended up in China studying fossils known as Peking Man (now classified as *H. erectus*), who lived several hundred thousand years ago. Weidenreich noticed that

FROM TOP: NOEL FEANS/FLICKR (CC BY 2.0); JOHN KAPPELMAN/UNIV. OF TEXAS AT AUSTIN

Peking Man shared certain features, such as shovel-shaped incisor teeth, with some present-day East Asians.

From this observation of apparent regional continuity across time, he concluded there had never been just one real-life Garden of Eden. As he wrote in 1947, "Man has evolved in different parts of the old world."

Rather than picturing a family tree with one main trunk and branches, he envisioned human evolution as a trellis. Vertical lines represented groups of humans from different geographic regions, with the crisscrossing lines of the lattice representing mating between groups. Such gene flow enabled ancient forms across Africa, Asia and Europe to stay a unified species that gradually evolved into modern humans, with some regional variation maintained.

One consequence of all that mixing: "Pure" races never existed.

But a minority of researchers clung to the idea that race was central to understanding human evolution. In 1962, American anthropologist Carleton Coon transformed Weidenreich's trellis into a candelabra, trimming away the intersecting lines. He argued that modern races stemmed from a common ancestor, but different lines independently evolved into *H. sapiens*, with races crossing the "sapiens" boundary at different times. In his view, *Science News Letter* explained, "the Negro race is at least 200,000 years behind the white race on the ladder of evolution."

It's a deeply disturbing statement to type today, and it was rejected by many at the time. Coon published his claims during the height of the U.S. civil rights movement, less than a year before Martin Luther King Jr. stood on the steps of the Lincoln Memorial and shared his dream of racial equality. Advocates of segregation cited the supposed evidence of inferiority to justify their racist agenda. But many experts discounted Coon's views. It's an "extreme opinion," one anthropologist told *Science News Letter* in 1962, lacking "evidence of any nature to support it."

Still, Coon's claims tarnished Weidenreich's view of human evolution. And in the 1960s and '70s, interest shifted to much earlier stages of hominin history, many millions of years ago.

Hot spots This map marks locations of some of human evolution's biggest fossil discoveries. The search in Africa began in the 1920s. Yet there is still much of the continent left to explore, as paleoanthropologists have mostly focused on eastern and southern Africa. SOURCE: NATIONAL RESEARCH COUNCIL/*UNDERSTANDING CLIMATE'S INFLUENCE ON HUMAN EVOLUTION* 2010

A. The oldest known *Homo sapiens* fossils, dating to about 300,000 years ago, come from Jebel Irhoud in Morocco.

B. At the Toros-Menalla site in Chad, scientists found what may be the earliest known hominin, *Sahelanthropus tchadensis*.

C. Ethiopia's Afar region hosts numerous sites, some stretching back more than 5 million years. Major finds include the early hominin *Ardipithecus* and Lucy.

D. Southern Ethiopia and northern Kenya hold a long hominin history, including *Australopithecus* fossils, some of the oldest known stone tools, early *Homo* fossils and early *H. sapiens* fossils.

E. Louis and Mary Leakey put Tanzania's Olduvai Gorge on the map with discoveries of *Paranthropus boisei* and *Homo habilis*. The nearby Laetoli site preserves hominin footprints dating to 3.6 million years ago.

F. The Kabwe skull, the first hominin fossil found in Africa, came from a mine in Zambia in 1921.

G. South Africa's limestone caves have yielded *Australopithecus*, *Paranthropus* and *Homo* fossils.

H. Quarry workers near Taung, South Africa, recovered the first *Australopithecus* fossil ever found.

I. At caves along coastal South Africa, scientists have recovered a rich record of *H. sapiens* activity, including what may be the earliest known drawing and other signs of symbolic behavior.

ADAPTED BY E. OTWELL

Homo sapiens arrives, somehow

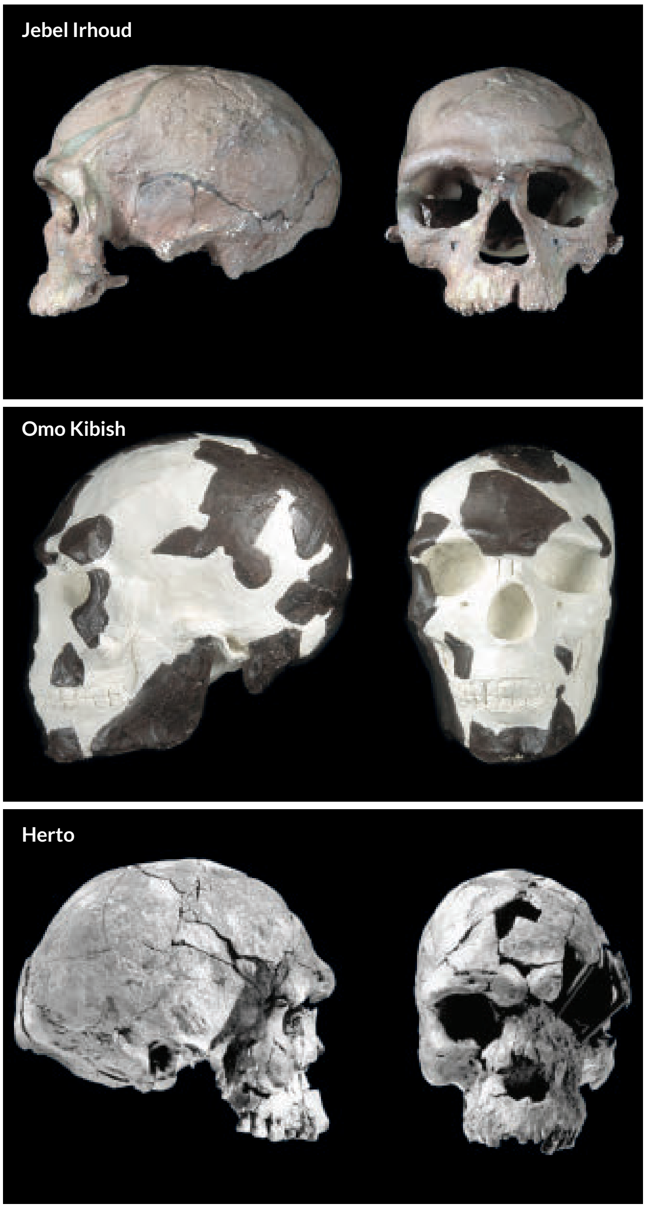
In the mid-1980s, anthropologists went back to disentangling the roots of *H. sapiens*. By then, a basic picture had emerged: Hominins arose in Africa, and *H. erectus* was the first to venture outside of it, by what we now know was nearly 2 million years ago. In some places, *H. erectus* persisted for a long time; elsewhere, new groups appeared, such as Neandertals (*H. neanderthalensis*) in Europe and Asia. At some point, somehow, *H. sapiens* arrived and its predecessors vanished.

That "somehow" became a matter of debate in the 1980s, '90s and into the 2000s.

Milford Wolpoff, a paleoanthropologist at the University of Michigan in Ann Arbor, and colleagues revived the latticework of Weidenreich's trellis model in the 1980s. Under this "multiregional" view, it was difficult to draw a clean line between the end of *H. erectus* and the beginning of *H. sapiens*. In fact, Wolpoff argued that *H. erectus* and other seemingly distinct groups should be folded into our species. Through intergroup mating these earlier "archaic" *H. sapiens* gradually evolved the features of "anatomically modern" humans.

Critics doubted there could have been enough intergroup mating back then to allow a small, globally scattered population to remain as one. Chris Stringer, a paleoanthropologist at the Natural History Museum in London, and colleagues proposed instead that *H. sapiens* originated in just one place — descending from *H. erectus* or a subsequent species — and then spread across the world. Along the way, these humans replaced other hominins, including Neandertals.

Both theories were difficult to test. For instance, the single-origin idea predicted that the oldest modern human fossils should all be found in just one region. But there weren't many well-dated fossils from the relevant time period. And seeing ourselves in the fossil record proved challenging. Researchers disagreed on what features defined modern humans. A globular head? A flat face? Something as banal as a chin? These disagreements meant researchers on both sides could often look at the same fossil data and claim support for their position.



Some of the oldest fossils classified as *Homo sapiens* still lack some features typical of people today. For instance, a roughly 300,000-year-old skull (top) from Jebel Irhoud in Morocco has a relatively long, flat braincase. Only later does a tall, rounded braincase appear to evolve, as seen in a 195,000-year-old skull (middle, white fills in missing pieces) from Omo Kibish and a 160,000-year-old skull (bottom) from Herto, both in Ethiopia.

TOP TWO: THE NATURAL HISTORY MUSEUM/ALAMY STOCK PHOTO; BOTTOM: T.D. WHITE *ET AL/NATURE* 2003

Genetic revolution

By the 1980s, DNA offered a new way to investigate the deep past. In 1987, one genetic study shifted momentum toward the single-origin theory, with Africa as the point of origin.

Researchers at the University of California, Berkeley analyzed mitochondrial DNA from people around the world. Because it's inherited from mother to child and undergoes no genetic reshuffling, mitochondrial DNA preserves a record of maternal ancestry. African populations showed the greatest genetic diversity. And when the team built a family tree using the genetic data, it had two main branches: One held only African lineages and the other contained lineages from all over the world, including Africa. This pattern suggested the "mother" lineage came from Africa. Based on the estimated rate at which mitochondrial DNA accumulates changes, the team calculated that this African Eve lived about 200,000 years ago.

"Thus," the team reported in *Nature*, "we propose that *Homo erectus* in Asia was replaced without much mixing with the invading *Homo sapiens* from Africa."

Like fossils, genetic evidence is open to interpretation. Proponents of multiregional evolution pointed out that the African diversity may not be indicative of greater antiquity but simply a sign that African populations were much larger than other ancient groups. Mitochondrial DNA also isn't a complete record of the past — given its unusual inheritance, lineages are easily lost over time.

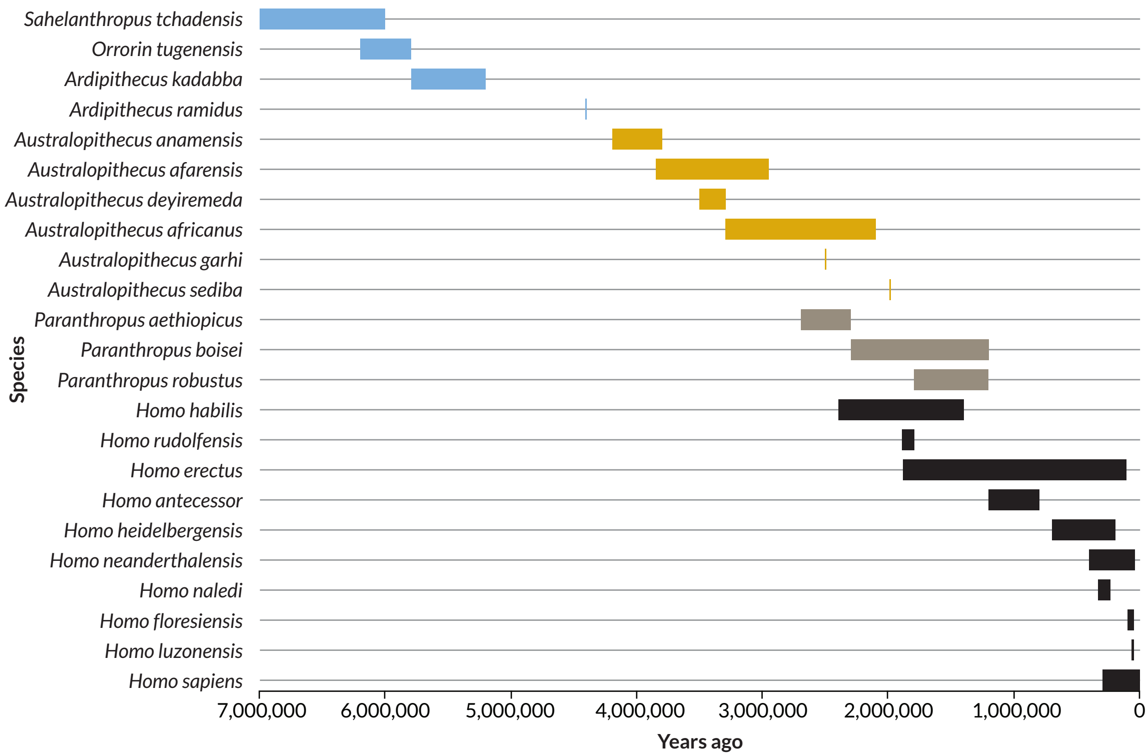
Even with those warnings, the "Out of Africa" model gained followers as genetic evidence piled up. And in the late 1980s, 1990s and early 2000s, new dating techniques and discoveries suggested the earliest *H. sapiens* fossils came from Africa, at sites in Ethiopia dating to between 195,000 and 160,000 years ago. More recently, scientists linked roughly 300,000-year-old Moroccan fossils to *H. sapiens*.

A new window into the past opened in 1997. A team led by Svante Pääbo, a geneticist now at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, recovered mitochondrial DNA from a Neandertal fossil. It was so different from any modern human's DNA that it suggested Neandertals must be a separate species. That was another blow to the multiregional model.

But paleoanthropology is like solving a jigsaw puzzle without all the pieces; any new piece can change the picture. That's what happened in 2010. When Pääbo and colleagues assembled the Neandertal's genetic blueprint, or genome, and compared it with modern human DNA, the team came to a startling conclusion: About 1 to 4 percent of DNA in non-Africans today came from Neandertals.

"We were naïve to think that humans just marched out of Africa, killed some Neandertals and populated the world," archaeologist John Shea of Stony Brook University in New York later told *Science News*.

That genetic data seemed to support a compromise model between Out of Africa and multiregionalism. Yes, modern



All in the family
Many hominin species, humans and our extinct cousins, have lived over the last 7 million years (dates for each species are based on fossils found so far), though researchers debate the validity of some of these classifications. The earliest purported hominins (blue) show some signs of upright walking, which became more routine with the rise of *Australopithecus* (yellow). *Paranthropus* (brown) was adapted for heavy chewing. Brain size began to increase in *Homo* (black).

SOURCES: SMITHSONIAN INSTITUTION'S HUMAN ORIGINS PROGRAM, Y. HAILE-SELASSIE *ET AL/NATURE* 2015, R. PICKERING *ET AL/SCIENCE* 2011, AUSTRALIAN MUSEUM, F. DÉTROIT *ET AL/NATURE* 2019

humans originated in Africa, the idea went, but once they expanded into new territories, they mated with other hominins. Hints of such hybridization had been reported in the late '90s, when some researchers claimed an ancient skeleton from Portugal had a mix of Neandertal and human features.

Interbreeding wasn't the only shock to come in 2010. Pääbo's group also analyzed DNA from a finger bone found at Siberia's Denisova Cave. Both Neandertals and modern humans had once lived there, but the DNA didn't match either group. For the first time, genetics had revealed a new hominin. These Denisovans are still mysterious, known from only a few bits of bone and teeth, but they too interbred with humans. For instance, Denisovan DNA accounts for about 2 to 4 percent of Melanesian people's genome.

It's complicated

Over the last decade, as genetic and fossil revelations have painted a more complex picture of human origins, paleoanthropologists have moved beyond both the multiregional and simple Out of Africa scenarios. Rather than a tree with separate branches or a trellis, human evolution was probably more like a braided stream, a concept traced to paleoanthropologist Xinzhi Wu of the Chinese Academy of Sciences in Beijing, who used a river metaphor to describe patterns of human evolution in China. Different human populations may have emerged, with some floating away and petering out and others connecting to varying degrees.

One emerging view suggests that much of early human evolution occurred in Africa, but there was not one place on the continent where *H. sapiens* was born. Starting at least 300,000 years ago, modern *H. sapiens* features start to show up in the fossil record. But these features didn't arise all together. Only through the mating of different populations across Africa did the suite of behavioral and biological traits that define us today crystallize, says Eleanor Scerri, an evolutionary archaeologist at the Max Planck Institute for the Science of Human History in Jena, Germany.

"Our origins lie in the interactions of these different populations," she says. Understanding those interactions is limited by how little of ancient Africa researchers have explored so far. Western, central and much of northern Africa are terra incognita.

There's still much to explore in other parts of the world too. A single, unifying explanation of human origins may not be possible, as different evolutionary processes probably shaped human history in different regions, says Athreya, of Texas A&M University.

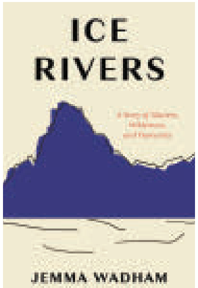
Making more progress on understanding those processes and our roots will come from new discoveries, technological advances and, importantly, new perspectives. For the last 100 years, our origin story has been told by mostly white, mostly male scientists. Welcoming a more diverse group of researchers into paleoanthropology, Athreya says, will reveal blind spots and biases as scientists add to and amend the tale.

This is, after all, everyone's story. ■

Explore more

■ Paige Madison and Bernard Wood. "Birth of *Australopithecus*." *Evolutionary Anthropology*, August 2, 2021.

E. OTWELL



Ice Rivers
Jemma Wadham
PRINCETON UNIV., $26.95

BOOKSHELF

An icy tale invites you to care about glaciers

I've always been a sucker for glacier lingo, whimsical words for a harsh landscape gouged, smoothed and bulldozed by ice. Moulins, drumlins, eskers and moraines. Cirques and arêtes. Cold katabatic winds blowing down a mountain, huffed from a glacier's snout and said to be its spirit.

Jemma Wadham's *Ice Rivers: A Story of Glaciers, Wilderness, and Humanity* leans into this duality of whimsy and harshness, cheerfully pulling readers into this strange, icy world. Wadham, a glaciologist at the University of Bristol in England, confesses that her goal is to give readers a sense of connection to glaciers, which she knowingly anthropomorphizes: In her writing, glaciers have heavy bodies, dirty snouts and veins filled with water.

"When I'm with them, I feel like I'm among friends," she writes. "It is, in many ways, a love story." And knowing the glaciers, she reasons — perhaps coming to love them — is key to trying to save them.

Accordingly, the book's chapters are anchored by site, and each chapter documents a different field expedition or series of expeditions to a particular glacier. Wadham takes us from the Swiss Alps to Norway's Svalbard islands, from India's Himalayas to Antarctica's McMurdo Dry Valleys. It's a breezy read, with an eager party host vibe ("let me introduce to you my friend the glacier; I think you two will get along").

While describing each site, Wadham dives into an engaging mishmash of personal recollections about her fieldwork, snippets of accessible glacier and climate science (I now know that these rivers of ice have three different manners of flow), a dash of alpine and polar exploration history, and many bits of local color. Ötzi the 5,300-year-old iceman, Erik the Red, Svalbard's many polar bears and wild Patagonian horses all make an appearance, not to mention the mummified corpses of seals and penguins littering the Dry Valleys.

Glaciologist Jemma Wadham has studied glaciers all over the world, including Pastoruri Glacier (shown in 2010) in the Peruvian Andes.

An interesting thread winding through the book concerns how the focus of glaciology as a field has shifted through time. After several years of not winning grants that would allow her to continue working on Svalbard, in 2008 Wadham got the opportunity to go to Greenland instead. "Valley glaciers were no longer considered quite as cutting-edge to the research council funders," she writes. "Instead, glaciologists had become obsessed with the vast ice sheets," for the potential of their meltwaters to raise sea levels and alter ocean currents. Several years later, funders began to call for projects looking at melting glaciers' impacts on ocean life and the water cycle, opening up an opportunity for Wadham to study Patagonia's fast-changing glacial region.

Where the book really comes alive is in its vivid snapshots of a scientist's life in the field: making a bleary-eyed cup of coffee in Patagonia using a thin sock as a filter; fearfully skittering across fragile fjord ice on a Ski-Doo; consuming tins of bland *fiskeboller*, or fish balls, which were mostly used for food but sometimes for rifle practice; solo dancing away a gray mood on a pebbly beach on Svalbard, with a rifle ready to repel polar bears resting nearby on the stones.

These recollections are honest, funny and poignant, and reveal how the highs and lows of fieldwork are inextricably intertwined. Wadham writes, for example, of dreading the "hollow feeling caused by constant sleep deprivation" due to the midnight sun and the relentless roaring of winds and water, a feeling tempered by her fierce love for the open expanses of the wild and for pursuing a "big mission."

She also writes wistfully of the "communal mirth of field-camp life" where she had never laughed as much before and, less wistfully, of the heavy, claustrophobic atmosphere of an Antarctic research station with its supercharged heating system and extreme politeness over meals with strangers. Against the backdrop of Patagonia's swiftly shrinking glaciers, Wadham comes to grips with difficult personal losses, even as she wrestles with mysterious headaches. Months later, while recovering from emergency brain surgery, she secretly begins to write about her glaciers. Still more months pass before she finds her way back to the ice, this time in the Peruvian Andes.

"I quickly realized one key thing about fieldwork — if you think you are there to work, you're gravely mistaken," Wadham writes. "You're actually there to survive, and perform some research along the way — if you're lucky.... In some ways I found all this 'surviving' a grounding process."

Every glacier Wadham has studied has shrunk since she first set foot on the ice over a quarter century ago. But *Ice Rivers* isn't focused on mourning those glaciers so much as on celebrating the peace and purpose — the grounding line — Wadham found in them. It certainly makes me want to know them better. — *Carolyn Gramling*

Society for Science is proud to share our 2020 Annual Report

Society for Science, the nonprofit organization that publishes *Science News*, is thrilled to share the extraordinary work we accomplished despite the challenges brought by the coronavirus pandemic.

In this report, we detail a year in which we overcame incredible obstacles. From equipping our readers with accurate information about the virus, to providing educators with resources to captivate STEM students, to encouraging young people to conduct scientific research, our team engaged the wider public during a time when science could not have been more important.

BIG RESULTS

During a challenging year, Society for Science made an impact. We found new and creative ways to educate and inspire students, teachers and our readers.

7 virtual events reaching people around the world

7,844 STEM kits delivered to 373 teachers, impacting 15,500 students

21,000+ subscribers to *Science News'* Coronavirus Update newsletter

14,700,000 *Science News* coronavirus coverage page views

View the 2020 Annual Report at www.societyforscience.org/2020-annual-report

AUGUST 14, 2021

What makes a modern human?

Just 1.5 to 7 percent of human DNA is unique to modern humans, ***Tina Hesman Saey*** *reported in "Most human DNA is not unique to us"* (SN: 8/14/21, p. 7)*.* Reader **Mark Jenike** wondered how the new research squares with the well-known finding that we humans share more than 98 percent of our DNA with chimpanzees and bonobos. "Are these two statistics measuring different things?" **Jenike** asked.

That shared DNA was likely passed down from the most recent common ancestor of humans, chimpanzees and bonobos, **Saey** says, and is common among all modern and ancient humans. The question asked in the study, however, is how much of our DNA is found only in anatomically modern humans, and not in Neandertals, Denisovans or other extinct ancient human relatives, she says.

"It's important to remember that the 1.5 to 7 percent of DNA unique to modern humans consists of small genetic changes, and every single person today has them," **Saey** says. "Overall, humans' DNA still closely resembles that of other apes such as chimpanzees and bonobos."

Reader **Chuck Almdale** wondered why the phrase "uniquely human" was used in the story to exclude Neandertals and Denisovans. If the ancient hominids could interbreed and have fertile offspring with modern humans, wouldn't that make them the same species as us?

Drawing the line between species can sometimes be more of an art than a science, **Saey** says. Modern humans, Neandertals and Denisovans are genetically distinct groups, and while the groups were able to mate and reproduce with each other (*SN: 5/8/21 & 5/22/21, p. 7*), that doesn't necessarily make them the same species, she says.

Even scientists don't agree on whether these three groups really are separate species, **Saey** says. What's more, not all scientists use the term "human" the same way (see Page 20).

Martian rumblings

Analyses of seismic waves picked up by NASA's InSight lander suggest that Mars' core is at least partially liquid and somewhat larger than expected, ***Sid Perkins*** *reported in "Quakes offer a peek inside Mars"* (SN: 8/14/21, p. 9)*.*

Perkins wrote that volcanic activity in a region of Mars that's home to large volcanoes could trigger quakes or seismic waves. Reader **Jim Sanborn** pointed out that this statement seems to contradict another story in the same issue, "Mars lakes appear to be mirages" (*SN: 8/14/21, p. 8*). In that story, **Adam Mann** reported that it's unlikely that liquid lakes lurk under the Red Planet's southern polar ice cap. An underground magma pool would be needed to keep the lakes from freezing, but the planet appears to lack recent volcanic activity, he reported.

It's true that there haven't been signs of ongoing volcanic activity on Mars in recent times, **Perkins** says, although a study published in the Sept. 1 *Icarus* suggests that lava may have flowed from a fissure in the planet as recently as about 50,000 years ago. If any molten rock were to move within the planet, either underneath ancient volcanoes or elsewhere, it could potentially trigger marsquakes and seismic waves, he says.

Corrections

"How muscle cells keep otters warm" (*SN: 8/14/21, p. 13*) incorrectly described the effect of surface area on heat loss. Small bodies with less surface area don't lose heat faster; small bodies with greater surface area relative to their volume do.

"Roads to the good life" (*SN: 9/11/21, p. 24*) incorrectly stated the name of a journal in which research by psychologist Shigehiro Oishi of the University of Virginia and social psychologist Erin Westgate of the University of Florida appears. The study, which suggests that major life events can contribute to higher psychological richness, was published in *Psychological Review*, not *Psychological Science*.

Join the conversation

E-MAIL feedback@sciencenews.org

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

Connect with us

TOP: SANTIAGO R. RON; ALL OTHERS: N.G. CERVINO *ET AL/PROCEEDINGS OF THE ROYAL SOCIETY B* 2021

Forget stars in their eyes. These are the shapes of frog and toad pupils

Frog and toad pupils come in quite the array, from slits to circles. But overall, there are seven main shapes for these animals' peepholes, researchers report in the Aug. 25 *Proceedings of the Royal Society B*.

Eyes are "among the most charismatic features of frogs and toads," says herpetologist Julián Faivovich of the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" in Buenos Aires. People have long marveled at the animals' many iris colors and pupil shapes. Yet "there's almost nothing known about the anatomical basis of that diversity."

Faivovich and colleagues cataloged pupil shapes from photos of 3,261 species, representing 44 percent of known frogs and toads. The team identified seven main shapes: horizontal slits (an example shown in the large image above), vertical slits, diamonds, triangles, circles, fans and inverted fans (from left to right in the row above). The most common shape, horizontal slits, appeared in 78 percent of studied species.

By mapping pupil shapes onto a tree of evolutionary relationships among frogs and toads, the scientists inferred in what order the seven forms arose. Though uncommon in other vertebrates, horizontal pupils seem to have given rise to most of the other shapes in frogs and toads, the team found.

Pupils generally didn't correspond with animals' lifestyles or habitats. The scientists plan to continue investigating what drives pupil evolution in tree frogs, a smaller group with fewer types of shapes.

As the chytrid skin fungus continues to cause many presumed extinctions of frogs and toads around the world (*SN: 4/27/19, p. 5*), researchers may be losing their chance to solve this mystery. "When we are losing species," Faivovich says, "we're actually losing the opportunity of learning a lot about them." *— Carolyn Wilke*

NJIT INNOVATES FOR THE FUTURE.

A leader among the nation's 32 research polytechnic universities, NJIT excels with top quality, highly relevant academic programs. Whether you are interested in emerging tracks like **Data Science, FinTech, Cyberpsychology** and **Forensic Science**, or burgeoning fields like **Engineering Infrastructure with Sustainable Materials**, NJIT will prepare you for the exciting future that awaits you.

MAKE IT HAPPEN.

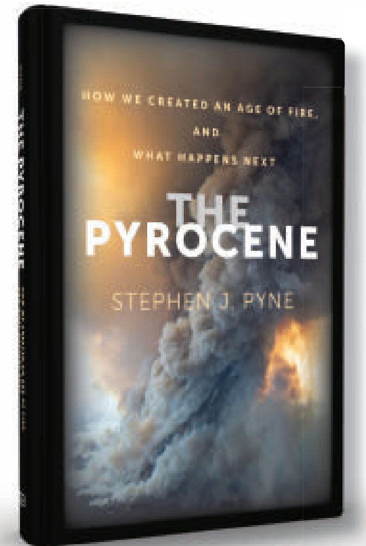
njit.edu/apply

R1	$160M+	135
research institution *- Carnegie Classification®*	of research NJIT conducts annually *FY2019*	research institutes, centers and labs

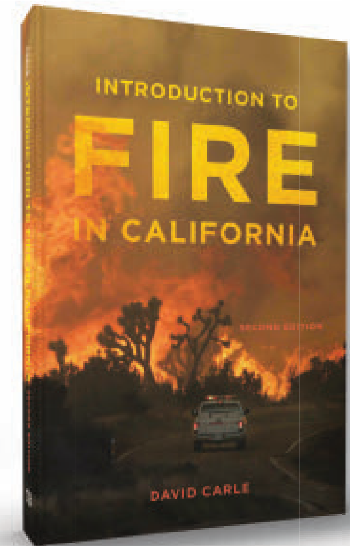
New Jersey Institute of Technology • University Heights • Newark, NJ 07102 • njit.edu

ON FIRE AND UNDER WATER

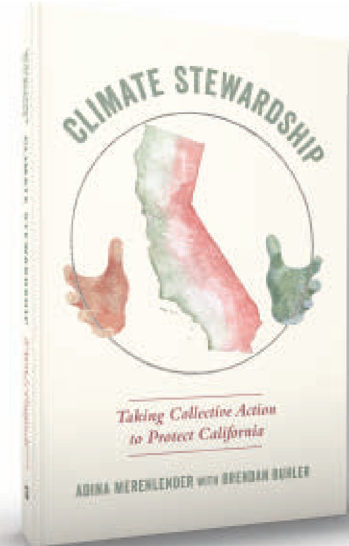
SOLUTIONS FOR OUR BURNING PLANET AND ITS RISING OCEANS



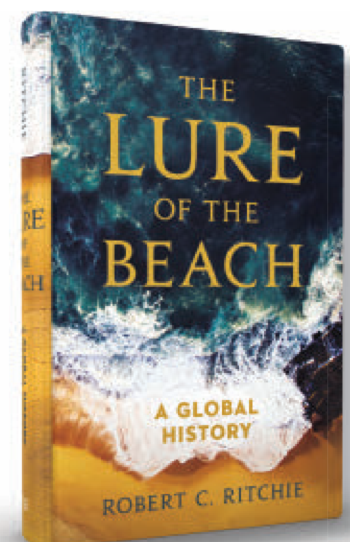
"The world is on fire, and no one sees that—or writes about it—better than Stephen Pyne. This is a brilliant guidebook to that future."
—David Wallace-Wells, author of *The Uninhabitable Earth*



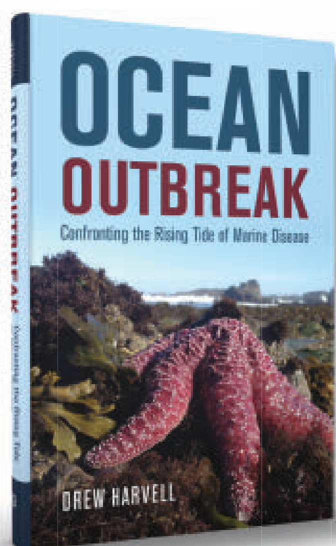
The essential guide to California's long relationship with fire, updated for the climate-change generation.



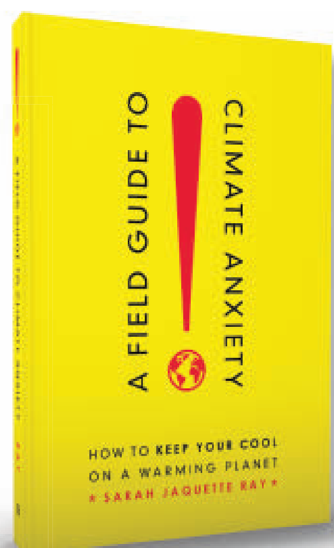
"This wonderful book reminds us of what we are capable of as individuals to improve the future of our planet and people."
—Kirkus Reviews



A history of our relationship—and responsibilities—to our beaches and their ecosystems.



"Manages to inspire both pragmatism and optimism, which likely stems from the immense number of people working . . . to better understand these issues."
—Forbes



"The book is carefully and clearly written, demonstrating the author's commitment to climate work . . . as well as the depth of her own knowledge as an environmentalist. Highly recommended."
—CHOICE

UNIVERSITY of CALIFORNIA PRESS

www.ucpress.edu