SN
SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
APRIL 4, 2015

Face Time With Hominids

Milky Way's New Neighbors

Fateful Pull for Pangaea

Circadian Eating

Solo Voyagers

Planets without stars may be surprisingly common

We found our most important watch in a soldier's pocket

It's the summer of 1944 and a weathered U.S. sergeant is walking in Rome only days after the Allied Liberation. There is a joyous mood in the streets and this tough soldier wants to remember this day. He's only weeks away from returning home. He finds an interesting timepiece in a store just off the Via Veneto and he decides to splurge a little on this memento. He loved the way it felt in his hand, and the complex movement inside the case intrigued him. He really liked the hunter's back that opened to a secret compartment. He thought that he could squeeze a picture of his wife and new daughter in the case back. He wrote home that now he could count the hours until he returned to the States. This watch went on to survive some harrowing flights in a B-24 bomber and somehow made it back to the U.S. Besides the Purple Heart and the Bronze Star, my father cherished this watch because it was a reminder of the best part of the war for anysoldier—the homecoming.

He nicknamed the watch *Ritorno* for homecoming, and the rare heirloom is now valued at $42,000 according to *The Complete Guide to Watches*. But to our family, it is just a reminder that nothing is more beautiful than the smile of a healthy returning GI.

The hunter's back

The Ritorno watch back opens to reveal a special compartment for a keepsake picture or can be engraved.

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New approaches to categorizing stone tools are in the works. Their aim is to tell a story of hominid evolution that is closer to reality. *By Bruce Bower*

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COVER STORY Rogue planets may form as stars do but on a smaller scale, or they may become loners after planetary ping-pong. Either way, they are raising questions about what it means to be a planet. *By Ashley Yeager*

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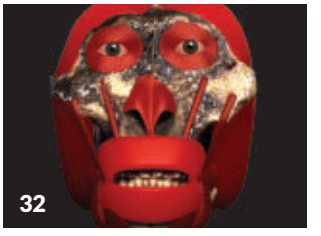

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SOCIETY UPDATE
Intel STS winners named

COVER Large planets may force others out of orbit and into a nomadic life. Researchers are seeking out these rogue planets. *Nicolle Rager Fuller*

CLOCKWISE FROM TOP: STONE: J. SHEA, JUSTIN PARGETER/STONY BROOK UNIV.; SWISS ARMY TOOLS: LJPAT/ISTOCKPHOTO. ADAPTED BY E. OTWELL; CÍCERO MORAES; SHER AFZAL KHAN/MPI FOR CHEMICAL ECOLOGY

What's in a name? In science, a lot

Sorting things into categories is one of the first scientific skills that children can learn. Categorizing, be it socks, rocks or plants, just seems to be an innate human urge. Categories help organize the world around us. Naming those categories allows us a simpler way to identify, compare and talk about them. Classification systems are essential to science; they act as the scaffolding that enables scientists to stand up close and get to know plants, rocks or anything else.

But any classification system, however useful, is ultimately simplistic. No such system perfectly describes reality and the wonderfully messy wonders of nature. And so classification systems get tweaked, revised, renovated or completely replaced to accommodate new discoveries. And, as we have reported before ("The name of the fungus," *SN: 5/3/14, p. 22*), and will again (Susan Milius is now at work on a story about the latest thinking on biological classification), scientists spend a good deal of time and energy arguing about such changes.

In this issue, two feature stories describe the questioning of existing classification schemes and proposals for new ones. In "Wandering worlds" (Page 22), Ashley Yeager focuses on how the discovery of rogue planets — those that don't orbit a star — is challenging the definition of a planet. So far, researchers have found dozens of untethered worlds, and some scientists suggest that there may be billions more. As astronomer Michael Liu says, the galaxy's contents are turning out to be much more complicated than current definitions allow.

Bruce Bower explores a very different way of knowing and naming in "Reading the stones" on Page 16. The system for categorizing tools used by human ancestors has outlived its usefulness, critics say. It may actually be impeding understanding of the development and evolution of ancient stone tools. Alternate schemes are proliferating, some involving the possible techniques used to make spearpoints, hand axes and other tools. Whatever the scheme, Bower writes, truly elucidating the mind-set of those who made the primitive tools may be out of reach. But developing effective categories is the surest bet for the greatest understanding possible.

As Confucius said, "The beginning of wisdom is to call things by their proper name." — *Eva Emerson, Editor in Chief*

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SANDY SCHAFFER

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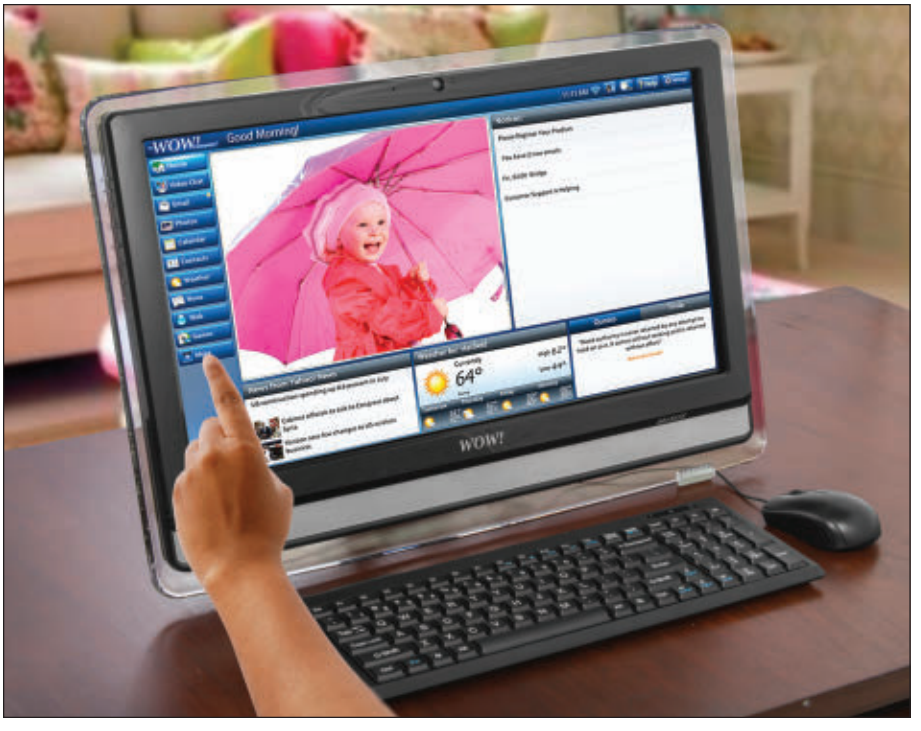

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"I love this computer! It is easy to read and to use! I get photo updates my children and grandchildren all the time."
– Janet F.

Have you ever said to yourself "I'd love to get a computer, if only I could figure out how to use it." Well, you're not alone. Computers were supposed to make our lives simpler, but they've gotten so complicated that they are not worth the trouble. With all of the "pointing and clicking" and "dragging and dropping" you're lucky if you can figure out where you are. Plus, you are constantly worrying about viruses and freeze-ups. If this sounds familiar, we have great news for you. There is finally a computer that's designed for simplicity and ease of use. It's the WOW Computer, and it was designed with you in mind. This computer is easy-to-use, worry-free and literally puts the world at your fingertips. From the moment you open the box, you'll realize how different the WOW Computer is. The components are all connected; all you do is plug it into an outlet and your high-speed Internet connection. Then you'll see the screen – it's now 22 inches. This is a completely new touch screen system, without the cluttered look of the normal computer screen. The "buttons" on the screen are easy to see and easy to understand. All you do is touch one of them, from the Web, Email, Calendar to Games– you name it… and a new screen opens up. It's so easy to use you won't have to ask your children or grandchildren for help. Until now, the very people who could benefit most from E-mail and the Internet are the ones that have had the hardest time accessing it. Now, thanks to the WOW Computer, countless older Americans are discovering the wonderful world of the Internet every day. Isn't it time you took part? Call now, and a patient, knowledgeable product expert will tell you how you can try it in your home for 30 days. If you are not totally satisfied, simply return it within 30 days for a refund of the product purchase price. Call today.

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Excerpt from the April 3, 1965, issue of *Science News Letter*

50 YEARS AGO

Atom-powered heart forecast by researcher

A reciprocating atomic steam engine, weighing 4 ½ pounds and measuring 6 by 3 inches, could be implanted in the abdominal cavity with a heat exchanger attached to the external iliac artery, reported Dr. Yukihiko Nose, Cleveland Clinic Foundation.... One capsule of atomic fuel would power the engine and its human carrier for as long as two years. A prototype of the nuclear-mechanical heart is now being built.

UPDATE: By 1977, scientists had abandoned the idea of a nuclear-powered artificial heart amid concerns over exposure to radiation, among others. In a 1985 *Pittsburgh Press* article, Nose recalled that researchers had also been "quite worried about terrorists killing the recipient, stealing the plutonium and contaminating the environment or making a bomb in the basement." Still, atomic-powered devices to regulate heart rate — rather than replace whole hearts — made it out of labs and into bodies. By some estimates, more than 3,000 patients received nuclear pacemakers during the 1970s and '80s.

IT'S ALIVE

Piggyback and other crocodile fun

"There is a lady who has a few pet crocodiles and they play tug-of-war," says Vladimir Dinets of the University of Tennessee in Knoxville. This is bath time merriment, with crocs pulling on towels.

That's just some of the fun Dinets has heard about since he published "Play behavior in crocodilians" in the February *Animal Behavior and Cognition*. He has encountered skepticism as well. "If you see a kitten playing with a ball, everybody will say it's play," he says. "If you see a crocodile doing the same thing, it's 'attacking the ball.' "

Dinets recognizes play based on criteria laid out by Tennessee colleague Gordon Burghardt. The behavior must, among other things, be spontaneous and look rewarding for its own sake. And it must be exaggerated, incomplete or out of context compared with, say, a real killer lunge.

Also, "crocodiles don't move unless they really want to," Dinets says. "If the crocodile is doing something for no obvious reason, it's probably something the crocodile enjoys."

He diagnosed spontaneous fun in a pair of Cuban crocodiles that routinely gave each other piggyback rides around their pool. Likewise for crocs of two species half a world apart, both of which tossed, nipped at and even gave nose rides to bougainvillea flowers; Dinets speculates that the animals might be drawn to small pink objects.

Or not-so-small objects. Dinets notes a report of a croc tossing around the carcass of a young hippo for about 25 minutes. Even crocs play with food.

Dinets has witnessed the daily play — his word — of a man and the crocodile he rescued. The two became a tourist attraction in Costa Rica. "They would kiss and hug, and the crocodile would make mock charges trying to scare the guy from behind," Dinets says. They romped for 20 years, and "the guy never got a scratch."

Dinets proposes 17 examples of crocodile play, a staggering leap in the annals of reptile recreation; Burghardt's 2005 tome on animal play had five. Burghardt proposes that animals with complex and flexible behavior (which of course crocodilians show) play a lot even if people don't notice. So Dinets would like to look elsewhere for overlooked funsters, he says. "For example, great white sharks." — *Susan Milius*

A male Cuban crocodile in a zoo gives his longtime female companion a piggyback ride (top) and a West African dwarf crocodile fiddles with a blossom for seemingly no good reason (bottom).

FROM TOP: V. DINETS; V. DINETS/*ANIMAL BEHAVIOR AND COGNITION* 2015

Watch a video of rollicking crocodiles at **bit.ly/SN_crocplay**

MYSTERY SOLVED

Why rain smells like that

A raindrop doesn't just go splat when it hits the ground. A fizz emanates from each drop, a new study published January 14 in *Nature Communications* reveals, transporting chemicals from the ground into the air. This mechanism may create the earthy aroma that arises after a rainstorm.

Using high-speed cameras on water droplets falling onto synthetic materials, MIT mechanical engineers Cullen Buie and Youngsoo Joung were surprised to see a cascade of tiny air bubbles that rose through each compressed droplet just after contact and then burst. Buie immediately thought of the smell after a quick rainstorm and wondered whether these little bubbles could carry that aroma. So Buie and Joung imaged droplets striking soil and, sure enough, observed the same fizz. Subsequent experiments demonstrated that when the air bubbles pop, they release chemicals from the soil.

A 1964 study proposed that the earthy smell following a storm, called petrichor, comes from chemicals in the soil. But to date, nobody had explained how those chemicals got released into the air. Buie and Joung are now exploring whether rain could spread soilborne microbes or pesticides. — *Andrew Grant*

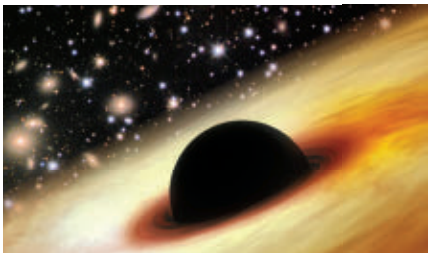
Soon after a water droplet hits the ground, tiny air bubbles form. The bubbles ascend through the squashed drop and pop, releasing jets of water and chemicals (yellow arrows) into the air.

THE -EST

Most massive black hole in early universe

When the universe was young, some black holes were terribly greedy. One of these black holes gobbled the mass of 12 billion suns by the time the universe was only about 860 million years old. This monster is the most massive known black hole in the early universe, clocking in at roughly six times as massive as other black holes from its time, researchers report in the Feb. 26 *Nature*.

To estimate the mass, Xue-Bing Wu, an astrophysicist at Peking University in Beijing, and colleagues measured the speed at which gas swirls around the black hole. Today, black holes this massive live only in the centers of galaxies containing several trillion stars. Since such galactic giants formed only relatively recently, the discovery suggests that some supermassive black holes grew much faster than the galaxies they inhabit. — *Christopher Crockett*



12
billion suns
Mass of newly discovered black hole

0.005
billion suns
Mass of black hole at the center of the Milky Way

INTRODUCING

A hummingbird that may get promoted

A flashy little hummingbird in the Bahamas could get upgraded to full species status, thanks to research that began with noise-making tail feathers.

The Inaguan lyretail, one of what are called bee hummingbirds because of their small size, was demoted to a subspecies in 1945. Its official name, *Calliphlox evelynae lyrura*, honored the (somewhat) lyrelike curve and length of the far left and right feathers in its tail.

In 2008, the feathers caught the interest of Christopher J. Clark of the University of California, Riverside, who has analyzed how male hummingbirds make their tails whine and whir as they flirtatiously dive-bomb females. The lyretail's feathers give a higher pitched sound than the feathers of the other subspecies.

More distinctive than the tail sounds are the lyretail's iridescent forehead and a tendency almost to whisper its distinctive songs, which sound like wet, squeaking shoes. Also, the birds' DNA suggests the lyretail set out on its own evolutionary path some 690,000 years ago, Clark and colleagues report in the January *Auk: Ornithological Advances*.

A committee standardizing bird species names is considering the researchers' proposal to boost the lyretail's status. — *Susan Milius*

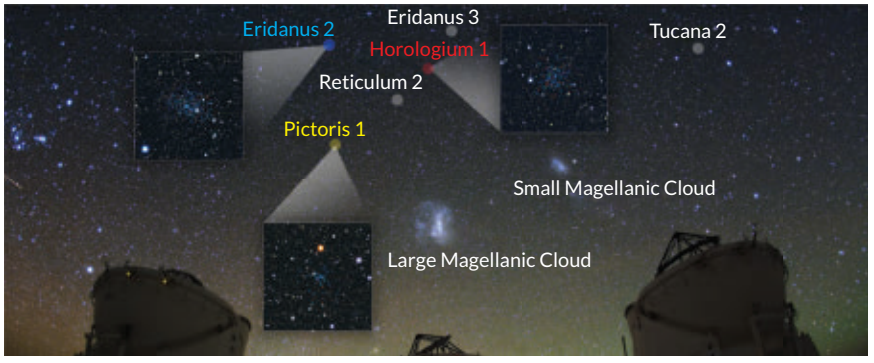
CLOCKWISE FROM TOP LEFT: COURTESY OF Y. JOUNG; ANAND VARMA/WWW.VARMAPHOTO.COM; ZHAOYU LI/SHANGHAI ASTRONOMICAL OBSERVATORY

Watch a slo-mo video of raindrops unleashing fizz at **bit.ly/SN_rainsmell**

ATOM & COSMOS

New Milky Way neighbors discovered

Finding dwarf galaxies boosts efforts to understand dark matter



Several newly discovered satellite galaxies of the Milky Way huddle near the direction of the Magellanic clouds. Six of the galaxies are shown in this picture of the sky above the Paranal Observatory in Chile.

BY CHRISTOPHER CROCKETT

The Milky Way's entourage of satellites just welcomed a few new members.

Two teams of astronomers independently discovered eight, or possibly nine, satellite galaxies that orbit the Milky Way, adding to the 27 previously known. These galaxies, despite being tiny, hold clues about the formation of the Milky Way, the birth of the first galaxies and the nature of dark matter, the elusive substance thought to hold galaxies together.

The galaxies were found near the Large Magellanic Cloud, the largest Milky Way satellite. The nearest galaxy sits about 100,000 light-years away in the constellation Reticulum. The farthest, in the constellation Eridanus, is just over 1 million light-years from Earth — roughly half the distance to the Andromeda galaxy. The findings appear in four papers published online March 9 at arXiv.org.

Most of these satellites contain about a few thousand stars, far fewer than the Milky Way's roughly 100 billion. But astronomers can see only several dozen of the brightest stars and have to infer the presence of the rest. "We literally run out of stars [in satellite galaxies] to study," says Marla Geha, an astronomer at Yale University. "That's why we're so delighted to find more."

Both groups found the satellites in images from the Dark Energy Survey, a five-year project at the Cerro Tololo Inter-American Observatory in Chile that is studying the accelerating expansion of the universe. Project scientists analyzed data from the first year of observations and turned up eight satellite candidates. At the same time, astronomer Sergey Koposov of the University of Cambridge and colleagues mined the survey's publicly available data and found the same eight objects, plus one more.

"It's exciting that there are two independent verifications of these objects," says Beth Willman, an astronomer at Haverford College in Pennsylvania.

The discovery of a wealth of satellites in a relatively small patch of sky "was really, really surprising," Koposov says. He suggests that these galaxies are traveling with the Magellanic clouds as part of a group that will eventually be gobbled up by the Milky Way. Researchers will have to wait until the Dark Energy Survey looks at more of the sky, however, before coming to any conclusions.

For more than a decade, astronomers have noted that they see far fewer satellite galaxies than predicted, which led some researchers to wonder if theories about the evolution of galaxies were accurate. An explosion of satellite discoveries around 2005 indicated that there should be hundreds more, yet subsequent searches turned up nothing until the latest finds. "The discovery of these objects puts people a little more at ease," says astrophysicist Alex Drlica-Wagner of the Fermi National Accelerator Laboratory in Batavia, Ill., who is part of the Dark Energy Survey.

Tiny galaxies are good probes of dark matter, Drlica-Wagner adds. Stars and gas make up only about 1 percent of the mass of these dwarf galaxies. The rest is dark matter. By measuring the speeds of stars within the satellites, he says, researchers can map out the dark matter, which could help them understand its role in forming galaxies.

To test ideas about the nature of dark matter, astronomers also can search the satellites for gamma rays, which some theories predict are created when dark matter particles collide. Astrophysicist Alex Geringer-Sameth of Carnegie Mellon University in Pittsburgh and colleagues claim that they see gamma rays coming from one of the newly discovered satellites. Geringer-Sameth and colleagues analyzed data from the Fermi space telescope to detect the gamma-ray signal, which they suggest comes from dark matter collisions. Researchers with the Dark Energy Survey, however, looked at the same data and report that they see no such signal.

Faint dwarf galaxies also give astronomers a peek at what the earliest galaxies were like. "These things turn out to be by far the oldest galaxies we know of," Geha says. They ceased forming stars roughly a billion years after the Big Bang, unlike spiral galaxies like the Milky Way, which form stars throughout their lifetimes. While images of very distant galaxies provide a snapshot of what the universe was like back then, satellite galaxies give astronomers a closer look. Researchers can probe the conditions under which the first galaxies formed by analyzing the chemical makeup of the stars in these satellites, Willman says. "Those are the fingerprints of the gas from which these stars formed 12 billion years ago." ■

OVERLAY: V. BELOKUROV AND S. KOPOSOV/IOA/CAMBRIDGE; PHOTO: Y. BELETSKY/CARNEGIE OBSERVATORIES

GENES & CELLS

For healthy eating, timing matters

Limiting mealtimes to 12-hour period per day helps flies' hearts

BY TINA HESMAN SAEY

When you eat may determine how long and how strong your heart beats.

Fruit flies that limited eating to 12-hour stints had steadier heartbeats in old age than flies that ate whenever they wanted, researchers report in the March 13 *Science*. The study adds to a growing body of evidence that the timing of meals may be as important for health as diet composition and calorie counts are.

The research also "suggests that the body clock is involved in cardiovascular function and risk," says Frank Scheer, a physiologist at Brigham and Women's Hospital in Boston and Harvard Medical School. Scheer was not involved in the fruit fly study, but he has shown that disrupting people's daily, or circadian, rhythms can damage their health.

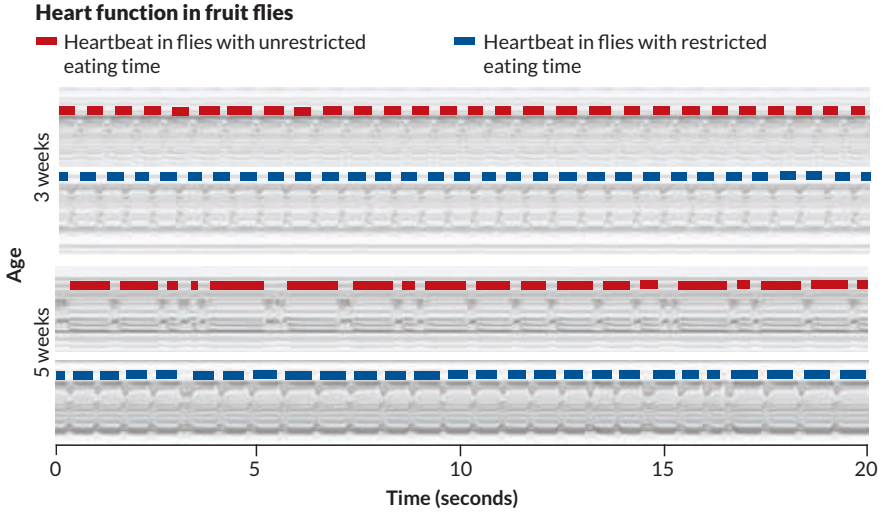
Circadian clocks work in nearly every cell in the body. They govern a wide variety of body rhythms, such as those associated with body temperature, blood pressure and sleep. The main timekeeper is located in the brain and is set by light, but other clocks synchronize themselves according to feeding time (*SN: 4/10/10, p. 22*).

Previous research in mice had suggested that limiting eating to 12 hours per day could protect rodents from obesity and other ravages of high-fat diets. Those studies couldn't address heart problems associated with poor diet because mice don't get heart disease the way people do, says Satchidananda Panda, a circadian biologist at the Salk Institute for Biological Studies in La Jolla, Calif.

Fruit flies, on the other hand, develop irregular heartbeats and other heart problems as they age. So Panda and his colleagues set out to test whether limiting the amount of time fruit flies eat, but not cutting back on calories, could affect the insects' heart health.

One group of flies ate a cornmeal diet around the clock; another group had access to the same food for only 12 hours each day. Both groups ate about the same amount overall, but the 24-hour group snacked at night.

The groups had similar amounts of activity. The flies with time-restricted feeding did most of their moving during the day, though, and slept better at night.



S. GILL ET AL/SCIENCE 2015

Keeping time Fruit flies that eat just 12 hours per day (blue) maintain steady heartbeats into middle age (5 weeks old), but the hearts of flies that eat around the clock (red) beat irregularly as they age. Each red or blue dash represents a heartbeat.

At 3 weeks old, flies in both groups had regular, healthy hearts. At 5 weeks — fruit fly middle age — the 12-hour eaters' hearts maintained a steady rhythm of roughly one beat per second. The hearts of the anytime eaters beat irregularly, sometimes skipping a beat and sometimes quivering. By 7 weeks, the anytimers had badly deteriorated heart function. Flies on a 12-hour schedule also lost a few beats over time, but their heart problems were not as severe.

Switching anytime flies to a 12-hour schedule at 5 weeks old improved some measures of heart function, but not all. In other experiments, restricting feeding time also staved off some of the negative heart effects of high-fat diets.

When the researchers disabled circadian clocks throughout some fruit flies' bodies, restricting eating times didn't help those flies' hearts, suggesting that functioning clocks are important for heart health.

The researchers also looked at timed eating's impact on gene activity. Many genes follow circadian rhythms, peaking in activity during certain times of day. In fruit flies with curtailed eating schedules, those peaks crescendoed right before breakfast and just before the last mouthful. Anytime eaters had several smaller peaks throughout the day. That finding suggests that timed feeding improves coordination of gene activity.

Panda likens the effect to getting a car tune-up. "The spark plugs need to fire in sequence," he says. "If you just fire randomly, you'll have a big problem and the head gasket will blow up." Similarly, tightly controlling gene activity may allow for more efficient energy use and prevent metabolic by-products from building up and damaging tissues, he says.

Improved sleep in the 12-hour eaters might account for some of the heart benefits, Scheer says. Lack of sleep is linked to a variety of diseases in people, including heart disease (*SN: 10/24/09, p. 28*). No one knows whether restricting mealtimes will improve human health, he says. ■

Watch a video of fruit fly heartbeats at **bit.ly/SN_fruitflies**

LIFE & EVOLUTION

Postmenopausal orcas guide hunts

By finding fish, older females may improve survival of kin

BY SUSAN MILIUS

A clue to the evolution of menopause may come from older female killer whales who often take the lead in salmon hunts.

Among the whales that feast on chinook along the coast of the Pacific Northwest, females past reproductive age often lead hunting parties, especially in fish-sparse years, says Lauren Brent of the University of Exeter in England.

Male killer whales rarely live longer than 50 years, Brent says. But females can live into their 90s. Sharing their long experience in these waters may give their kin an edge in finding food. And that advantage may help push the evolution of long life after menopause, Brent and her colleagues report in the March 16 *Current Biology*.

This salmon-hunting population of *Orcinus orca* whales is among only three kinds of mammals in which females live long after they stop having babies themselves. The other species with such extreme postreproductive lives among females are short-finned pilot whales (but not their long-finned relatives) and humans.

The new study gives the first evidence that information-sharing may be a way for old whales to boost the survival of their offspring, Brent says. Among these killer whales, both sons and daughters stick around mom even after they have grown up, an unusual closeness for a mammal. So if their postmenopausal mom's deep knowledge of local ecology helps them thrive and reproduce, evolution might favor longer life after menopause.

In 2012, a research paper on the same fish-hunter whale population reported that mothers seemed to enhance the survival of their adult offspring (*SN: 10/20/12, p. 16*). When a female beyond her reproductive years died, any sons older than 30 faced a 14-fold jump in the risk of disappearing (presumably by dying themselves) in their first year without mom, according to researchers led by Darren Croft, also of Exeter and senior author of the new work. Younger daughters faced a fivefold increase of death in the first year without their mothers.

Brent wondered how killer whale moms protect their adult offspring. She and colleagues matched up fishery data about salmon abundance in the area with 751 hours of video of traveling whale groups. With records from the Center for Whale Research in Friday Harbor, Wash., expert spotters used telltale healed wounds and color-patch quirks to identify the front whale,

HUMANS & SOCIETY

Fossil linked to origin of human genus

Classification of 2.8-million-year-old jaw sparks controversy

BY BRUCE BOWER

Researchers have discovered what they regard as the oldest known fossil from the human genus, *Homo*. But questions about the evolutionary status of the approximately 2.8-million-year-old lower jaw have already emerged.

Found in 2013 in Ethiopia's Ledi-Geraru research area, the jaw contains several signature *Homo* features, including small and symmetrically shaped teeth, say paleoanthropologist Brian Villmoare of the University of Nevada, Las Vegas and his colleagues.

A 2.8-million-year-old partial jaw found in Ethiopia may represent the earliest known member of the genus *Homo*.

KAYE REED

The jaw also has apelike traits, such as its large overall size, similar to those found in *Australopithecus afarensis*, a hominid that died out about 3 million years ago. *A. afarensis* fossils, unearthed at a nearby Ethiopian site called Hadar, include Lucy's famous partial skeleton. The similarities suggest that Lucy's species was an evolutionary precursor of the human genus, Villmoare's team proposes in the March 20 *Science*.

Until now, the oldest fossil attributed to the *Homo* genus was a 2.3-million-year-old upper jaw from Hadar.

Some researchers question the classification of the new find. A partial jaw with a handful of teeth "may be too incomplete to recognize a fossil as *Homo*," remarks Chris Stringer of the Natural History Museum in London. Additional evidence for a large brain, long legs, regular toolmaking and meat-eating, or some combination of these traits, may be needed to define the human genus, Stringer says.

Without a more complete skeleton, there's no way to know whether the jaw is the earliest representative of *Homo* "or just another australopithecine," adds paleoanthropologist Christoph Zollikofer of the University of Zurich.

Study coauthor William Kimbel thinks it's most likely that the jaw comes from an early *Homo* species that split into two evolutionary lines."The new jaw from Ledi-Geraru likely represents a transitional population between a Lucy-like *Australopithecus* ancestor and later *Homo* populations," says Kimbel, director of Arizona State University's Institute of Human Origins in Tempe.

One lineage, he says, included the 2.3-million-year-old Hadar jaw, which has a wide, deep palate and small, *Homo*-like teeth. The second line included

presumably the leader, and the followers in each hunting group. Out of 102 known individuals in these filmed journeys, the postreproductive females scored higher in leadership, increasingly so in years when salmon runs were sparse.

Males were especially likely to follow their mothers, the researchers found. This tendency might explain why the loss of older mothers has a big impact on male mortality, Brent suggests.

Anthropologist Sarah Blaffer Hrdy of the University of California, Davis points out that the data are not so much about menopause per se as about an advantage for female whales to live long afterward. There's a difference, she notes, in ways of framing the discussion of how menopause evolved. It could be a matter of females stopping reproduction early, or — and she finds this more likely — it could be about the evolutionary advantage of females extending their life spans after their reproductive years have already ended. ■

Homo habilis, known from a 1.8-million-year-old jaw, braincase and hand fossils.

Evolutionary anatomist Fred Spoor agrees with Kimbel. In Spoor's view, differences in jaw shape indicate that at least three *Homo* species lived between 2.1 million and 1.6 million years ago: *H. habilis*, *Homo erectus* and *Homo rudolfensis*.

But Zollikofer says that the shape differences between those proposed species are not that substantial. He suspects the *Homo* genus initially evolved as one species (*SN: 11/16/13, p. 6*).

Finding evidence that *Homo* emerged 2.8 million years ago in East Africa shows that *Australopithecus sediba* — a 1.98-million-year-old hominid from South Africa with some humanlike traits — was not an evolutionary bridge to *Homo*, Kimbel contends. The discoverers of *A. sediba*, however, view that species as a possible *Homo* ancestor (*SN: 8/10/13, p. 26*).

Stringer proposes that East African and South African *Homo* species evolved from different *Australopithecus* ancestors. If so, that would put *A. sediba* in the thick of *Homo* evolution. ■

The Dawn spacecraft (illustrated) has arrived at Ceres and will soon start to map the dwarf planet.

JPL-CALTECH/NASA

ATOM & COSMOS

Dawn spacecraft reaches destination

Survey of dwarf planet should yield clues to solar system's birth

BY CHRISTOPHER CROCKETT

The Dawn spacecraft has arrived at the dwarf planet Ceres.

After 7½ years trekking across the solar system — including a stopover at the asteroid Vesta — Dawn pulled up alongside Ceres March 6 and let the dwarf planet's gravity take over, pulling the probe in for a closer look. In late April, Dawn will be close enough to Ceres to begin its 14-month mission to map the dwarf planet in a quest for clues about the formation of the solar system.

Dawn is about "going back in time and visiting the basic remnants of objects that came together to form our planets," Jim Green, director of NASA's Planetary Science Division, said March 2 at a news conference.

Researchers think that Ceres is an intact protoplanet, a fossil from the beginning of the solar system. About 2.8 times as far from the sun as Earth is, Ceres is roughly as wide as France, making it the largest body in the asteroid belt between Mars and Jupiter. Starting in late April, Dawn will make detailed maps of Ceres, studying its size, shape and composition.

Unlike other solar system missions (*SN: 9/6/14, p. 8*), Dawn's arrival is a bit anticlimactic. "There's literally nothing to watch at the time it happens," said Robert Mase, project manager for the Dawn mission at the Jet Propulsion Laboratory in Pasadena, Calif. The spacecraft is approaching Ceres from the nightside and won't take any images until after it loops over the north pole in late April. "Then the floodgates are really going to open," Mase said.

Dawn has already turned up some surprises. A bright spot first reported in 2005 from Hubble Space Telescope images is actually two spots nestled inside a crater (*SN Online: 2/26/15*). These spots "have been puzzling to the team," said Carol Raymond, deputy project scientist at JPL. "Their apparent brightness is off the scale." The spots are probably patches of ice either excavated by asteroid impacts or blown out of cryovolcanoes. But the team won't know more until Dawn gets closer in.

"It seems to be off to a really good start," says Peter Thomas, a planetary scientist at Cornell University who is not a member of the Dawn team. "The more fun thing is trying to figure out what's on the inside [of Ceres] and what the role of water has been." Researchers suspect that a global ice sheet lurks beneath the rocky crust, possibly a remnant of a subsurface ocean (*SN Online: 1/22/14*). Dawn will look for evidence of surface material that originated in interactions between liquid water and rock.

The seas of Ceres might have even once been habitable, Raymond said.

This is the second stop for Dawn, which spent 14 months in 2011 and 2012 orbiting the asteroid Vesta (*SN: 4/21/12, p. 9*). Dawn found dark patches loaded with carbon-rich elements, Raymond said, which the team suspects arrived via water-rich asteroids that were similar to Ceres. If these asteroids delivered water and other goodies to Vesta, they also probably delivered material to the inner rocky planets, providing a possible link between Ceres, Vesta and Earth's oceans.

"We'll get some answers right away," Green said, "but it will take years to figure out the puzzle of how Ceres and Vesta fit into the building blocks of our solar system." ■

EARTH & ENVIRONMENT

Doubts grow over BPA replacement

Bisphenol S poses the same health risks, researchers suggest

BY BETH MOLE

Chemical tweaks aren't enough to tame a possibly dangerous component of plastics, two new studies suggest.

Bisphenol S has the same toxic, hormone-disrupting effects in cells and in animals as its relative bisphenol A. The findings are the latest to raise doubts that BPS — or perhaps any other bisphenol — is a safer alternative to BPA, which is a key ingredient in durable plastics and epoxies. The studies also suggest that products labeled "BPA-free," such as baby bottles, are not as free of health risks as consumers might expect.

In a study published online February 26 in *Environmental Health Perspectives*, researchers found that BPS, like BPA, can boost heart rates and spur irregular heartbeats in female rats. In the Feb. 3 *Proceedings of the National Academy of Sciences*, researchers reported that BPS, like BPA, can alter brain development and behavior in zebrafish. The findings follow previous reports that BPS and BPA can mimic estrogen in humans and other animals.

The potential human health hazards of BPS's estrogen-mimicking remain unknown. But researchers have linked BPA to obesity, cardiovascular disease, cancer, infertility, neurological problems and asthma.

"Based on the [chemical] structural similarity, you'd expect that they'd be similar," says environmental chemist Kurunthachalam Kannan. BPA consists of two identical ring structures linked by a carbon atom attached to two methyl groups. BPS has the same structure, except its rings are linked by a sulfur atom attached to two oxygen atoms.

Kannan, of the New York State Department of Health, reported in 2012 that BPS was a common replacement for BPA in paper products, such as in the coating on receipts (*SN Online: 6/20/12*); if BPS was present, BPA usually wasn't. In another 2012 study, Kannan and colleagues reported that 81 percent of 315 people tested had BPS in their urine, indicating widespread exposure to the chemical.

At the time, though, researchers had little data on what exposure means for health. "The study of BPS has only recently started," says pharmacologist Hong-Sheng Wang of the University of Cincinnati, who led the study that looked at the chemical's effects on rat hearts. So far, Wang says, he's amazed by how similar the effects of BPS are to those of BPA. "They are nearly indistinguishable, if not identical," he says.

In Wang's study, both chemicals altered how female rats' heart cells generated the electrical pulses that power beating, causing the rats' hearts to beat faster. When the researchers added a chemical that simulates the effect of stress on the heart, both BPA and BPS caused irregular heartbeats. If BPS acts similarly in humans, it might cause heart damage over time or put people with preexisting heart conditions or stressful lives at higher risk of heart disease.

The effects were seen only in female rats. Both BPA and BPS act like estrogen, Wang explains. The heart cells of male rats block certain estrogen signals. It's unclear if that would hold true in humans.

In the zebrafish study, researchers led by neuroscientist Cassandra Kinch of the University of Calgary in Canada exposed embryonic fish to low levels of BPS, similar to levels of BPA reported in nearby waterways.

The low doses spurred early development of nerve cells in a part of the brain called the hypothalamus, which is responsive to estrogen. Such premature development could cause sweeping changes in brain function because development is a precisely timed, well-orchestrated process, Kinch says. When the fish grew up, they were hyperactive, zooming around their tanks in circles, she says. In humans, BPA exposure has also been linked to behavioral changes, including hyperactivity.

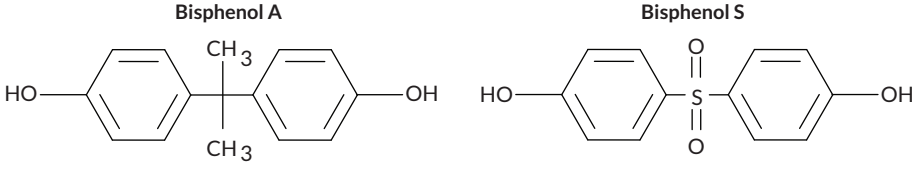
Despite the damaging data on BPA, it is still widely used. In 2012, the U.S. Food and Drug Administration banned the use of BPA in baby bottles, but few other restrictions are in place in the United States. Likewise, the use of BPS and many other bisphenols is not restricted.

More animal studies are needed and quickly, says toxicologist Daniel Zalko of the French National Institute for Agricultural Research in Toulouse. It took years to collect data on BPA, he says, adding that he hopes it doesn't take that long for BPS. ■

Manufacturers are replacing the potentially toxic chemical bisphenol A used in common products such as receipts and plastic bottles with bisphenol S. New studies suggest that BPS is as toxic as BPA.

FROM TOP: STOKKETE/SHUTTERSTOCK; C.D. KINCH *ET AL/PNAS* 2015

Family resemblance Bisphenol A and bisphenol S, often used as an alternative to BPA in plastics and other products, have similar chemical structures (shown below). That similarity explains why both chemicals have the same hormone-disrupting effects on animal cells.



MATTER & ENERGY

Message lingers after light leaves

If photons pass you by, just snatch signal from vacuum

BY ANDREW GRANT

Light may travel at the speed of light, but the information it carries doesn't have to. Three physicists have proposed a way to receive light-based messages even when the light itself has already flown by.

The communication technique, presented March 2 and in a paper to be published in *Physical Review Letters*, relies on measuring electromagnetic echoes that arise upon the generation of light. The method offers an intriguing exception to the idea that sharing information via light requires one party to send photons and the other to absorb them. Eventually, the technique could enable astronomers to glean details on distant stars and galaxies without directly measuring their light.

Light and other forms of electromagnetic communication — such as radio — consist of photons that travel at the speed of light. Your clock radio absorbs photon energy and translates the signal into sound. There is supposedly no way to recover that information after the photon passes by.

Theoretical physicists Robert Jonsson, Eduardo Martín-Martínez and Achim Kempf of the University of Waterloo in Canada discovered otherwise. They knew that photons leave a mark on their surroundings, even in a vacuum. That's because the vacuum is not truly empty — it is full of fleeting electromagnetic waves (*SN Online: 3/2/15*).

The three physicists mathematically demonstrated that when a message sender generates photons, the photons produce an afterglow discernible by measuring quantum fluctuations — ephemeral electromagnetic waves — in the vacuum. So a person can still recover information even if the photon carrying that information whizzed by long ago.

This technique is novel because the sender never directly transmits energy to the receiver, says Jorma Louko, a theoretical physicist at the University of Nottingham in England who was not involved in the research. Instead, the receiver has to expend energy to measure the electromagnetic waves in the vacuum disturbed by the long-gone photon. "The receiver has to actively do something to see something," he says. That means that a sender can transmit one photon and have multiple receivers tap into the vacuum to obtain the information.

Detecting these quantum fluctuations would require both parties to have antennas that consist of atoms specially prepared in a delicate quantum state. For now, that kind of technology is attainable only in physics labs. ■

MATTER & ENERGY

Superconductivity record could fall

Hydrogen-sulfur compound loses resistance at high temperature

BY ANDREW GRANT

Superconductors are finally heating up. A recent experiment is raising hopes that, for the first time in two decades, physicists have set a record high temperature at which a material can transport electrical current with no resistance.

The material, a compound of hydrogen and sulfur, must be compressed at extreme pressures to become superconducting. And the temperature at which it works is still very low: 190 kelvins (–83° Celsius). But confirming the finding, first reported online in December at arXiv.org, would bring physicists closer to a long-term goal: finding a material that exhibits superconductivity at room temperature (roughly 300 kelvins). It would also redirect the efforts of many physicists who have been focusing on copper-based superconducting compounds called cuprates, discovered in 1986.

For over a century, physicists have dreamed of room-temperature superconductors that could, among other things, help propel high-speed magnetically levitated trains. But until now, the highest-temperature superconducting material was a cuprate that had to be cooled to 164 kelvins.

Some theorists had suggested that compressed hydrogen-rich materials could become superconducting at relatively high temperatures. So Mikhail Eremets, a high-pressure physicist at the Max Planck Institute for Chemistry in Mainz, Germany, and colleagues cooled the noxious gas hydrogen sulfide until it liquefied, and then squeezed it between two diamonds.

At pressures over 150 billion pascals, or 1.5 million times standard atmospheric pressure, electrical resistance plummeted even when the sample was well above 100 kelvins. Other measurements confirmed that the compound remained superconductive at about 190 kelvins.

"It is the most exciting development in superconductivity since the discovery of the cuprate superconductors," says James Schilling, a high-pressure physicist at Washington University in St. Louis.

At a presentation March 2, Eremets said that about 15 theoretical papers have already come out supporting his team's results. But Ivan Božović, a condensed matter physicist at Brookhaven National Laboratory in Upton, N.Y., notes that many extraordinary superconductivity claims have failed to hold up. Many physicists say they would like to know whether the compound expels magnetic fields, a distinguishing trait of superconductors. Eremets said he recently built an instrument to perform that measurement under high pressure.

Crushing a superconductor to get it working isn't practical, but it might be possible to boost the temperature and cut the pressure required by doping similar compounds with other elements. ■

–83°
Celsius
New temperature high reported for superconductivity

BODY & BRAIN

Brain cells predict rival's move in game

Monkey experiment could offer clues to autism, schizophrenia

BY TINA HESMAN SAEY

Newly discovered brain cells in monkeys can predict another monkey's actions in a cooperation game. If such brain cells also exist in humans, they may be important in social interactions that require calculating another person's intentions.

The brain cells were found in rhesus macaques playing a game called the prisoner's dilemma. The cells keep track of how another monkey behaved in previous rounds of the game and predict the other monkey's next move, researchers report online February 26 in *Cell*.

Neuroscientists Keren Haroush and Ziv Williams of Harvard Medical School made the discovery while recording electrical activity of nerve cells, or neurons, in a part of the brain known to be involved in social interactions. That region, the anterior cingulate cortex, is also thought to be involved in autism spectrum disorders, schizophrenia and other maladies that impair people's ability to judge what others are thinking. Learning how these cells work may help researchers understand these disorders and improve treatments, the scientists say.

Haroush and Williams found the cells by implanting electrodes into the back part of the anterior cingulate cortex in four male macaques and then teaching the monkeys to play the game.

Two monkeys played the game sitting side by side. Using a joystick, the monkeys selected a symbol on a video screen that indicated whether or not they were willing to cooperate with their opponent to win a juice reward. If both monkeys cooperated, they would each win four drops of juice. If one chose to cooperate but the other opted out, the uncooperative monkey would get six drops while the obliging monkey got only one. If both got greedy and chose not to cooperate, they both got two drops of juice.

Some neurons in the anterior cingulate cortex became more active just before the monkeys made their choices. Haroush and Williams compared the activity patterns of these neurons with the outcome of the game. One set of neurons fired off electrical signals more rapidly if the other monkey ended up cooperating. Another group of neurons fired if the other monkey ended up defecting. Together, the cells' activity correctly predicted the other monkey's choices 79.4 percent of the time. Neuron activity also matched the other monkey's choice in the previous round of the game, indicating that the cells were keeping track of the other animal's actions, Williams says.

Activity of a different set of neurons in the same part of the brain foreshadowed the monkey's own future choices, but with less accuracy. These neurons correctly picked the monkey's own choice only 54.7 percent of the time because other parts of the brain also weigh in on the monkey's own decisions, Haroush says.

Pulses of electricity that disrupt the anterior cingulate cortex's function impaired the monkeys' ability to cooperate. That finding indicates that performance in the game depends on neurons in that brain region.

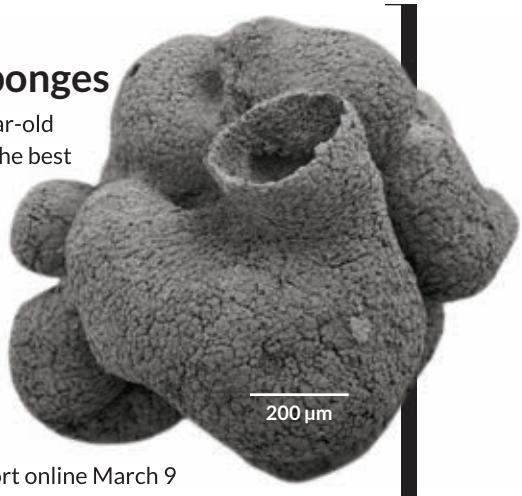
The neurons became active when the monkeys were hanging out together playing video games, but fewer fired when the animals played in separate rooms or against a computer. The result suggests that the neurons are sensitive to social situations, Haroush says.

Other researchers aren't completely sold that the neurons really forecast the next move by keeping track of previous plays. Marco Iacoboni, a neuroscientist at UCLA, says other social cues, such as body language, may be tipping the monkeys off to their opponents' moves. How well the monkeys know each other and their position in the social group may also affect their game play, he suggests. ■

LIFE & EVOLUTION

Possible ancestor of sponges

A beautifully preserved 600-million-year-old fossil that reveals the details of cells is the best candidate yet for an ancestor of sponge animals, researchers propose.



Z. YIN ET AL/PNAS 2015

Discovered in China, the new find, named *Eocyathispongia qiania*, is just a single fossil (shown), barely as big as a pinhead. Yet its three tubular chambers arising from a base and its visible cells resemble those of sponges, Zongjun Yin of the Chinese Academy of Sciences in Nanjing and colleagues report online March 9 in the *Proceedings of the National Academy of Sciences*.

Using X-rays and scanning electron microscopy, the team saw cells that look similar to modern sponges' flat outer cells called pinacocytes. Among these cells are signs of pores, like those in living sponges. And a patch inside one of the tubes has pits encircled by raised collars, resembling cells called choanocytes that move water through sponges.

The search for fossils from such ancient times, 60 million years before the Cambrian period and its burst of multicellular evolution, has yielded tantalizing bits but nothing with details like this specimen. The fossil "is the oldest and best" of the sponge ancestor candidates so far, says study coauthor Maoyan Zhu, also of the Chinese Academy of Sciences. — *Susan Milius*

Shrinking sea cited in Pangaea demise

Explanation of supercontinent's fragmentation reconsidered

BY THOMAS SUMNER

Pangaea's breakup may have been an outside job.

A reexamination of tectonic movements 200 million years ago suggests that the supercontinent was pulled apart by the shrinking of the precursor to the modern Indian Ocean. The new work, presented online February 27 in *Geology*, signals that scientists may have to rethink Pangaea's demise, says geologist Stephen Johnston of the University of Victoria in Canada, who was not involved with the research.

"Everything we think we know about Pangaea is up in the air now," says Johnston.

Roughly 300 million years ago, all the major landmasses squashed together to form Pangaea (*SN Online: 6/18/12*). Around 100 million years later, the supercontinent began breaking apart. Scientists have traditionally blamed the breakup on material from Earth's interior that sprung up along the boundary between North America and Africa and pushed the continents apart, creating the Atlantic Ocean.

Because the planet's surface area and volume don't change, the creation of new crust at the bottom of the Atlantic had to be compensated for by the destruction of crust elsewhere at a subduction zone, where surface material plunges into Earth's interior.

Scientists have proposed two sites for where this subduction might have occurred: the ancestors of the modern Indian and Pacific oceans. The forerunner of the Indian Ocean, called the Tethys Ocean, shrank around this time as the early African and Eurasian continents drifted together. To the east, the western edge of North America may have steamrolled over the Paleo-Pacific Ocean.

Determining which ocean accommodated the crust formation is challenging because of the planet's shape, says earth scientist Fraser Keppie of Nova Scotia's Department of Energy in Halifax. Flat maps with fixed geographic poles distort which areas are parallel to one another and are therefore conducive to forming a conveyor belt between emerging and sinking crust. Because the continents move in a circular motion, Keppie created a circular map centered on a fixed point near Southern Europe, around which the continents rotated like the swinging hands on a clock.

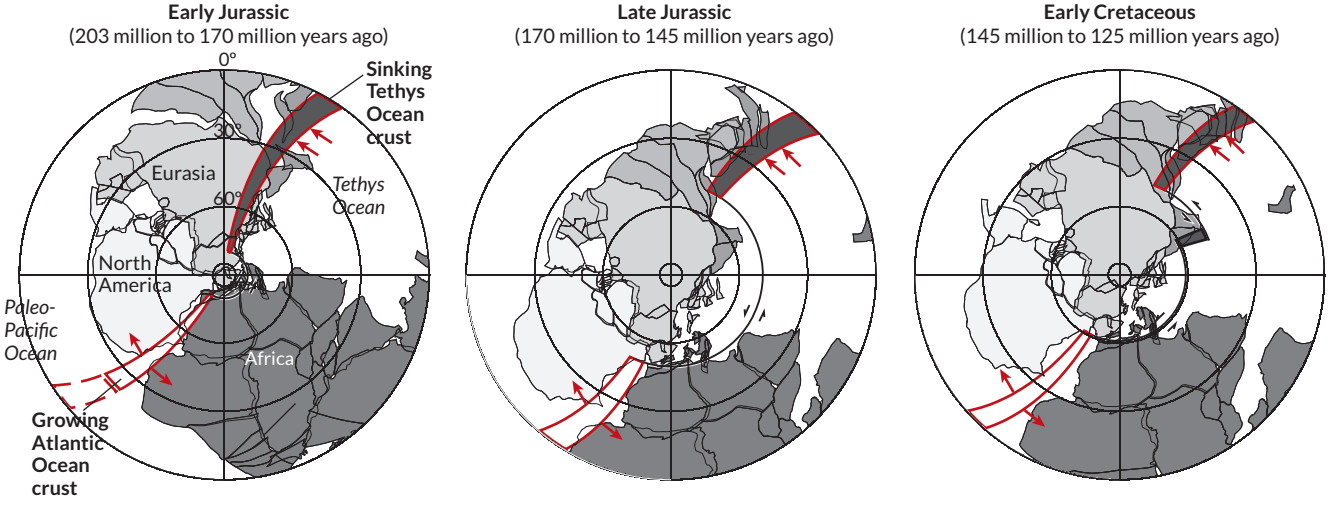
Keppie saw that both the boundary where the Tethys crust sank and the rift where Atlantic crust formed extended outward from the circle's center. The Paleo-Pacific's edge, on the other hand, sat along the circle's rim, perpendicular to the other two regions. This arrangement establishes that as the continents rotated around the fixed central point, the Atlantic's growth connected to the dwindling Tethys, not the Paleo-Pacific, Keppie says.

Keppie proposes that the Tethys didn't just accommodate Pangaea's breakup — it was the driving force behind the fragmentation. Instead of material from the interior pushing apart the supercontinent, Keppie suggests Pangaea was pulled apart. As gravity pulled the Tethys crust into the subduction zone, the crust yanked on Pangaea's Eurasian edge. If strong enough, this tug could have ripped the continent apart between Africa and North America, a weak point left over from where two landmasses had stitched together to form Pangaea.

This pulling hypothesis makes more sense, Keppie says, because the prevailing idea posits a big coincidence that the new material just happened to bubble up along one of Pangaea's seams.

Keppie's work isn't the final say, notes Johnston. But it does make predictions that geologists can test, such as looking for an ancient fault in the Pacific where two plates scraped together. ■

Circular reasoning Shrinking of the Tethys Ocean fueled Pangaea's breakup, a scientist proposes. Visualizing the continents' motion around a fixed point revealed that the Atlantic's opening was parallel to the Tethys' closing. The Tethys shrank to accommodate new crust under the Atlantic.



D.F. KEPPIE/GEOLOGY 2015

SHER AFZAL KHAN/MPI FOR CHEMICAL ECOLOGY

LIFE & EVOLUTION

Beetle RNA makes crops a noxious meal

To keep pests at bay, try giving them a taste of their own genes. Hungry beetles spurn crops bearing the insects' genetic material, scientists report in the Feb. 27 *Science*. When Colorado potato beetles (one shown) munched the engineered plants, beetle RNA in the leaves switched off key genes in the bugs. Researchers had transplanted fragments of beetle genes into potato plants. The team housed the genes in machinery in plant cells called plastids. A chloroplast, which performs photosynthesis, is a type of plastid. When laced with insect gene fragments, the potato plants produced double-stranded RNA that if eat eaten was able to disable certain genes in the beetles. The RNA blocked the beetle genes from being converted into proteins. Soon after the bugs devoured the modified plants, the insects' guts started to break down, says study coauthor Jiang Zhang of the Max Planck Institute of Molecular Plant Physiology in Potsdam, Germany. Within three days, nearly all adult beetles had stopped feeding. After four days, larvae that had feasted on potato plants were dead. Because plastids have their own DNA that doesn't make it into pollen, the beetle genes can't spread to plants pollinated by the engineered crops. — *Kate Baggaley*

BODY & BRAIN

Food additive tied to gut inflammation

Food additives may keep snacks fresh but they can wreak havoc on the gut. Additives called emulsifiers disrupt the intestine's protection from bacteria and boost inflammation in mice, scientists report in the March 5 *Nature*. Emulsifiers are added to many foods, including ice cream, bread and salad dressing. To see whether these additives play a role in inflammatory conditions, researchers fed mice an emulsifier, either polysorbate 80 or carboxymethylcellulose, for 12 weeks. The mice put on weight and made proteins that signal inflammation. More inflammation-causing microbes also showed up in the bacterial communities in the mice's guts. Mice engineered to lack gut bacteria experienced none of these effects. But when the researchers transplanted bacteria from the first group of mice into the second group, the microbe-free mice developed the same symptoms. Tests showed that bacteria had penetrated the layer of mucus that normally protects the cells lining the gut. This mucus layer also became thinner. Emulsifiers may make the mucus layer more permeable, allowing certain bacteria to penetrate and cause inflammation, says study coauthor Andrew Gewirtz of Georgia State University in Atlanta. Bacteria are thought to infiltrate the mucus layer in inflammatory conditions such as Crohn's disease and metabolic syndrome, a collection of symptoms that predispose people to diabetes and heart disease. — *Kate Baggaley*

EARTH & ENVIRONMENT

Scientists confirm amassing carbon dioxide heats Earth's surface

For the first time, scientists have witnessed a direct connection between rising levels of atmospheric carbon dioxide and an increase in the amount of thermal radiation striking Earth's surface. The work affirms a cornerstone of the theory that humans have contributed to worldwide warming, the researchers report online February 25 in *Nature*. Carbon dioxide, like other greenhouse gases, can absorb and reradiate infrared light back to Earth. This process traps thermal energy that would otherwise escape into space. To uncover how large an effect recent CO_2 increases have had on Earth's energy balance, Daniel Feldman of the Lawrence Berkeley National Laboratory in California and colleagues monitored the thermal radiation hitting two sites in Alaska and Oklahoma on cloudless days. Because CO_2 emits light within a signature range of wavelengths, the researchers could differentiate between energy balance changes caused by CO_2 and by other factors, such as water vapor. Over 10 years of near-daily observations, the team found that a rise in CO_2 concentrations of 22 parts per million boosted the amount of incoming thermal radiation by 0.2 watts per square meter, an increase of about 10 percent. The researchers say their results agree with the theoretical predictions of CO_2-driven warming used in climate simulations. — *Thomas Sumner*

ATOM & COSMOS

Ganymede home to subsurface ocean

Jupiter's largest moon, Ganymede, has solidified its membership in the growing cadre of solar system locales where liquid water flows beneath the surface. The ocean showed itself not with plumes or pools but via subtle changes in Ganymede's aurora, the moon's version of the Northern Lights. Jupiter's magnetic field should interfere with Ganymede's magnetic field, causing the moon's aurora to rock back and forth by about 6 degrees. Observations with the Hubble Space Telescope, however, showed that the aurora shifted by only about 2 degrees, researchers report online March 12 in *Journal of Geophysical Research: Space Physics*. Joachim Saur of the University of Cologne in Germany and colleagues deduced that an electrically conductive fluid beneath the surface — a saltwater ocean, for example — would create a secondary magnetic field that counteracted Jupiter's interference. Observations with the Galileo probe, which orbited Jupiter from 1995 to 2003, hinted at Ganymede's ocean (*SN: 12/23/00, p. 404*), but the flybys were too brief to provide unambiguous evidence. Jupiter's moon Europa and Saturn's moon Enceladus also hide subsurface oceans (*SN: 5/3/14, p. 11*). And researchers suspect that there may be water within Jupiter's moon Callisto and the dwarf planet Ceres (see story on Page 9). — *Christopher Crockett*

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Hand axes, such as this Acheulean tool, were made as early as 1.7 million years ago. They probably had multiple uses, much like a Swiss army knife.

Reading the Stones

There is more than one way to tell the story of hominid evolution via ancient tools

By Bruce Bower

Imagine if tens of thousands of years from now, archaeologists were to dig up a pile of wrecked, 20th century cars and try to figure out what people did with the strange-looking things.

After measuring soil-encrusted automobile shells and scattered engine innards, the researchers might well announce the discovery of ancient religious altars. Support for their interpretation would come from fragments of 20th century texts describing widespread car worship. Eminent scientists might propose that basic altars were made in a city called Detroit before being modified by their owners into objects suitable for worship. A flood of publications would sort the artifacts into categories of altars based on the presence or absence of tail fins and roof racks.

Archaeologist Harold Dibble of the University of Pennsylvania in Philadelphia likes to tell this futuristic farce when he gives lectures about the modern study of ancient stone tools. His point: Long-held assumptions about how human ancestors made and used stone tools are probably way off. It is easy to generate plausible explanations of behavior from way, way back. But rigorously testing those accounts is hard.

When scientists find stones that appear to have been pounded or chipped, they sort them into what they call "tool industries" based on the general shape and age of their finds. The various tool industries are thought to define particular ancient cultures or populations. Researchers also evaluate stone tools based on how they were made, breaking down the steps probably used to make tools for, say, chopping plants or slicing meat from animal carcasses. Taken together, this evidence is used to reconstruct how hominids, such as *Homo sapiens* and Neandertals, interacted and moved across Africa, Asia and Europe.

Current evolutionary scenarios based on that evidence inspire about as much confidence as calling a Ford Pinto a holy relic, Dibble says. Researchers unearth stone objects that, for the most part, were discarded by ancient individuals. No one can say for sure whether those items were final versions of tools that had specific uses, partly completed or worn out tools, or garbage produced during toolmaking. Even stone artifacts that show signs of extra sharpening may not be stellar examples of a finished, ready-to-use stone tool, as

STONE: J. SHEA, JUSTIN PARGETER/STONY BROOK UNIV.; SWISS ARMY TOOLS: LJPAT/ISTOCKPHOTO, ADAPTED BY E. OTWELL

archaeologists have long assumed, Dibble holds.

And there's no reason to conclude (as many in the field do) that stone tool industries define particular ancient cultures or populations, such as Neandertals, he adds. Worse, many pounded and sharpened stones discovered at archaeological sites are ignored because they don't fit neatly into any of the traditional named tool industries.

Armed with only this partial view of the past, it becomes easy to assume, for instance, that a single tool industry monopolized Western Europe, South Asia, the Arabian Peninsula and North Africa between 200,000 and 40,000 years ago. But don't bet on it.

"Archaeologists have built evolutionary stories on a foundation of sand," Dibble says.

Unhappy with the stone tool status quo, Dibble and others are experimenting with new ways of squeezing insights about hominid evolution out of pieces of rock. They are looking for hidden clues to how ancient folk worked stone into tools, adapted those methods as they traveled in and out of Africa, and passed toolmaking knowledge from one group to another.

> "Archaeologists have built evolutionary stories on a foundation of sand."
>
> **HAROLD DIBBLE**

Some archaeologists doubt that all this fuss will clarify hominid evolution or generate testable predictions about a largely unknowable past. Others say stone tool industries still provide valuable insights when applied to large numbers of artifacts found in relatively limited areas.

If any of the new approaches pans out, it could reveal previously overlooked ties between toolmakers in different regions and dramatically change ideas about how and when humans left Africa and settled the globe. With a revamped understanding of how stone tools relate to hominid evolution, for example, evolutionary geneticists, who study ancient DNA, would have a framework for interpreting their latest molecular discoveries.

Banish the NASTIES

Purveyors of new methods for analyzing stone artifacts are bucking longstanding tradition in archaeology. Stone tool industries were formulated in the late 19th and early 20th centuries to describe discoveries at single European and African sites. Because there is no formal process for adding new industries or retiring tired ones, those categories have become bloated over time, says John Shea, an archaeologist at Stony Brook University in New York. As a result, each industry encompasses artifacts found across massive geographical expanses where two or more hominid species once lived at the same time.

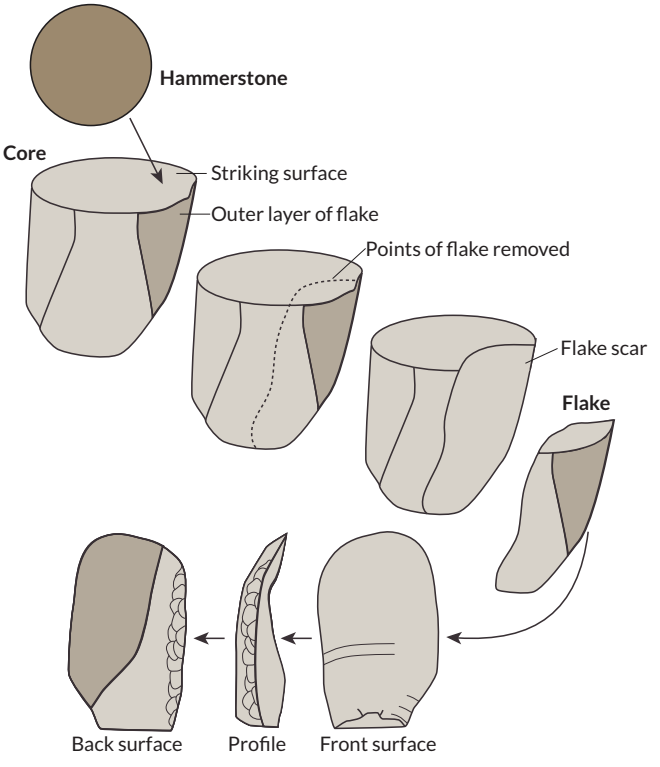
Researchers are left wondering, for example, whether triangular stones with sharp points made between around 200,000 and 40,000 years ago and found at various Middle Eastern sites were shaped by *H. sapiens* or Neandertals. Or maybe each species invented the same tool on its own. If all the Middle Eastern finds are lumped into one category of tool industry, the question doesn't even arise.

Shea has a pet name for the "named stone tool industries." He calls them NASTIES because, in his view, they hide more than they reveal about the makers of ancient artifacts. Mobile hunter-gatherers probably made different kinds of tools as they traveled from, say, savannas to forests. NASTIES may lump together the tools of different hominids adapting to similar habitats in the same way.

NASTIES also don't account for ingenuity among Stone Age humans, who devised up to a dozen different ways of making teardrop-shaped hand axes and chiseling lumps of rock into cores from which sharp flakes could be removed, Shea argues.

"NASTIES are like archaeologists' family heirlooms," Shea says. "We don't know what to do with them, but we don't want to throw them away."

One archaeological heirloom deserves an immediate heave-ho, Shea says. In the November 2014 *Quaternary International*, he calls for discarding the influential Mousterian stone tool industry. Named in 1883 for finds at France's Le Moustier Cave, Mousterian artifacts are exemplified by triangular stone points and lumps of rock from which toolmakers pounded off sharp implements. Mousterian tools have since been found in sites across Europe, West Asia, the Arabian Peninsula, India and North Africa. Those discoveries date to between 200,000 and 40,000 years ago, when both *H. sapiens* and Neandertals occupied many of those regions.



Freeing the stone From upper left to lower left, drawings depict the process of using a hammerstone to pound a lump of stone with a prepared surface, called a core, to release a sharp flake that can be used as a tool.

But the Mousterian label has been stretched so thin over the last 130 years that the term has become meaningless, Shea contends. Consider that Middle Eastern Mousterian artifacts commonly include cores shaped like a tortoise shell, known as Levallois cores, and triangular flakes with reworked edges. French Mousterian tools, on the other hand, feature oval flakes with reworked edges and large, double-edged hand axes.

Middle Eastern Mousterian tools, which are generally divided into two or three types, have been unearthed at sites that have yielded Neandertal and ancient human fossils. Disagreement reigns about whether one hominid borrowed toolmaking techniques from the other or each species operated on its own.

Attempts to unravel hominid relationships in the Middle East with Mousterian tool types "are quite a mess," says archaeologist Lawrence Straus of the University of New Mexico in Albuquerque.

Shea also gives the boot to the oldest tool industry, the 2.6-million-year-old Oldowan. And he shoots down the Acheulean industry, best known for teardrop-shaped stone hand axes dating to as early as 1.7 million years ago. In a college textbook to be published in 2016, he suggests a new system based on identifying core toolmaking techniques rather than looking for similarities in artifacts' shapes or reconstructing steps presumed to have been needed to make tools. Stone tool use, he proposes, developed from 2.6 million years ago onward based on nine ways in which rock can be fractured and ground into tools. One example consists of cores and flakes that have been placed on hard surfaces and pounded with another stone to detach smaller pieces of rock.

Analyzing stone artifacts from more than 50 ancient sites using this approach, Shea concludes that new ways of making stone tools were added over time, but few were permanently abandoned. As *Homo* species evolved an upright stance capable of long-distance travel after 1.6 million years ago, tools got lighter and were made for easy transport and multitasking, much like Swiss army knives.

If old toolmaking methods hung on as new techniques emerged, then the influential idea that humans progressed from "primitive" to "modern" behavior, as reflected in their stone tool industries, is wrong. That idea has led some researchers to contend that *H. sapiens* didn't evolve brains capable of "fully modern" behavior until around 50,000 years ago.

Humans and Neandertals made Mousterian tools (left) more than 40,000 years ago. Later tools included Aurignacian blades (bottom right) and smaller implements called microliths (top right).

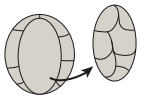
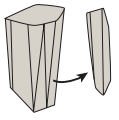
Nonsense, says Shea. Specialized tools didn't require specialized brains. Unlike previous hominids, early *H. sapiens* devised tools that were increasingly tailored to survival, including grinding stones and arrowheads. These innovations added to what was already known about toolmaking in populations that were expanding in size and becoming better able to transmit knowledge quickly. "The easiest way to be wrong [in evolutionary research] is to underestimate our ancestors' abilities," Shea says.

Reconstructionists

Our ancestors' knack for learning and sharing toolmaking techniques has been underexplored and underestimated, says anthropologist Gilbert Tostevin of the University of Minnesota in Minneapolis. Influences of Stone Age Middle Easterners on Central Europeans' toolmaking practices are starting to come to light thanks to a new way of studying stone artifacts, he asserts.

Like Shea, Tostevin rejects stone tool industries. Instead, he proposes a new way of organizing artifacts that might help reveal more about the transmission of one tool manufacturing style from one group to another. Over the last 50 years, researchers, especially in Europe, have sought to reconstruct how stone tools found at different sites were made. After defining what they regard as the steps involved in transforming a piece of rock to a finished tool — known as an operational chain or reduction sequence — these investigators lump artifacts into general toolmaking categories. Like NASTIES, those

Old school Researchers have traditionally sorted stone artifacts into stone tool industries, which increase in number after around 40,000 years ago. Some archaeologists contend that these categories don't reveal much about ancient population movements and interactions. Age ranges below can vary in different parts of the world.

					
Stone tool industry	Oldowan	Acheulean	Mousterian	Aurignacian and others	Various
Age (in years)	2.6 million–1.7 million	1.7 million–200,000	200,000–40,000	40,000–12,000	12,000–7,000
Signature artifacts	Chopping tools	Large cutting tools	Flakes struck from cores	Rectangular flakes	Small, geometric flakes

PHOTOS: J. SHEA, J. PARGETER; ILLUSTRATIONS: USED WITH PERMISSION BY J. SHEA/COPYRIGHT RESERVED, ADAPTED BY E. OTWELL

categories say nothing about how toolmaking practices spread from one ancient population to another, Tostevin says.

As an avid flintknapper, or maker of stone tools, Tostevin consulted his own and others' studies on how people today pound and chip rocks into spearpoints and other objects. Tostevin got his first flintknapping lesson as a Harvard graduate student from Shea, an experienced flintknapper who was hired to show Tostevin's class the basics of stone toolmaking.

Tostevin divides the toolmaking process into five types of behaviors. Importantly for reconstructing the transmission of such methods in ancient times, these behaviors can be learned by someone standing near enough to watch and then practice the actions. Each action leaves telltale marks on stone artifacts, Tostevin says.

To create a spearpoint or any other stone tool, a seasoned flintknapper first orients a piece of stone, or core, in a desired direction and trims it in specific ways. Second, the toolmaker decides how to deliver a blow with a hammerstone — including the angle of the blow and the spot to strike — to remove a suitably shaped chunk. Third, a flintknapper determines the direction from which to remove a desired chunk from a core. One possibility: Strike from the center outward. Fourth, steps are taken to shape a detached chunk, or flake, to make it thinner or rectangular, for example. Finally, edges, points and other tool features are further shaped and sharpened.

In a 2012 book titled *Seeing Lithics*, Tostevin described how he measured and compared markers of such learnable toolmaking actions among stone artifacts from 18 sites in Central Europe, Eastern Europe and the Middle East. Finds dated to between 60,000 and 30,000 years ago, a period during which Neandertals gave way to *H. sapiens*.

Unexpectedly, Tostevin found stark differences in how Middle Eastern tools from early and later stages of that time period were made. Researchers have traditionally regarded those tools as part of a single stone tool industry.

Instead, Tostevin concludes, a common cluster of toolmaking techniques unites Middle Eastern artifacts from around 47,000 years ago with those made in Central Europe 41,000 years ago and in Eastern Europe 38,000 years ago. These similarities, seen in triangularly shaped stones with sharp points and other tools, could have arisen only by direct contact between Middle Eastern and European toolmakers, Tostevin holds.

After 38,000 years ago, those Middle Eastern–inspired tools appear to have hit a dead end in Europe. Around that time, rectangular flakes that received extra sharpening became the popular tool among European *H. sapiens*. For more than a century, archaeologists have placed these finds in the Aurignacian tool industry.

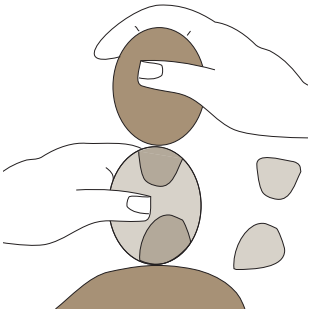
Based on further analyses presented in Honolulu at the 2013 annual meeting of the Paleoanthropology Society, Tostevin suspects Middle Eastern humans or Neandertals made triangular stone darts for spear-throwers that for some reason later got replaced by rectangular Aurignacian stone darts. "We need to figure out why only the Aurignacian industry went viral in Europe," he says.

Across North Africa

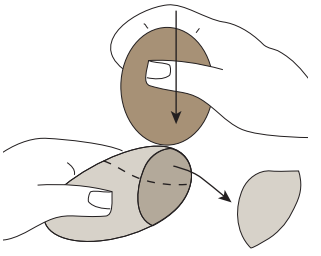
Tostevin's division of stone toolmaking into learnable parts has inspired a new take on one of the most controversial issues in evolutionary studies — how and when humans spread out of Africa.

Various *H. sapiens* populations moved east across North Africa and into the Arabian Peninsula between 130,000 and 75,000 years ago, says archaeologist Eleanor Scerri of the University of Bordeaux in France. After analyzing ancient temperature and rainfall data, she and her colleagues found that four east-west corridors containing lakes and vegetation ran through North Africa's vast Sahara Desert at that time.

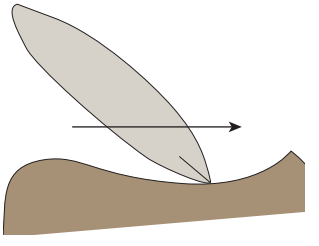
New school John Shea's approach to studying stone tools focuses on technique. Categories are based on nine toolmaking operations. Three are shown below. This proposed approach would replace the longstanding practice of sorting finds into stone tool industries.



Bipolar core
Marks on the top and bottom of a rock show where flakes were removed with a hammerstone.



Pebble core
A large flake was struck off the top of this stone with naturally rounded edges.



Abraded-edge tool
A piece of rock detached from a larger stone contains a polished edge.

PHOTOS: J. SHEA, J. PARGETER; ILLUSTRATIONS: USED WITH PERMISSION BY J. SHEA/COPYRIGHT RESERVED. ADAPTED BY E. OTWELL

Comparisons of 4,700 stone artifacts from 17 ancient North African sites, based on measures of Tostevin's five learnable toolmaking behaviors, indicate that related ways of modifying rock spread eastward through each of those geographic corridors, Scerri and her colleagues reported in last October's *Quaternary Science Reviews*. Migrants slightly modified how they made tools as they trekked from one habitable part of North Africa to the next, she says.

Humans fanning out across North Africa eventually left the continent, Scerri suspects. Stone artifacts excavated by her team at six sites on the Arabian Peninsula, all dating to at least 75,000 years ago, were manufactured much like those found in North Africa.

North African tools from that time usually get sorted into any of three stone tool industries: the Aterian, the Mousterian and the Nubian Complex. But the three industries lump together too many artifacts to detect distinct clusters of tools associated with the continent's ancient geographic corridors, Scerri says. In her view, Tostevin's approach combined with models of ancient climate and habitat change can track the spread of toolmaking techniques, and therefore, populations, across great distances.

Her evidence challenges a 2013 proposal, published in the *Proceedings of the National Academy of Sciences*, that humans first left Africa in a big way around 60,000 years ago, via a coastal route from East Africa to Arabia and then South Asia. A team led by archaeologist Paul Mellars of the University of Cambridge found similarities linking stone tool industries in those regions.

"One migration out of Africa 60,000 years ago is an appealing story, but human dispersals were more complicated than that," Scerri says. Instead, her linkage of ancient wet zones to particular stone tools suggests that more than 75,000 years ago human groups shuttled back and forth across habitable parts of North Africa and Arabia, adjusting toolmaking styles along the way.

On those journeys across sparsely populated landscapes, mating between different human groups would have been sporadic, Scerri contends. If so, restricted breeding among spread-out groups dampened genetic diversity. That's something for paleogeneticists to keep in mind, she adds, since minimal differences in ancient Africans' DNA could mistakenly be read as a sign of a dramatic population decline. Ancient DNA can illuminate evolutionary connections between populations but not the history of each population's travels and encounters with outsiders, Scerri says. That's where a revitalized archaeology comes in.

"One migration out of Africa 60,000 years ago is an appealing story, but human dispersals were more complicated than that."

ELEANOR SCERRI

Alien tools

Like Scerri and her colleagues, Pennsylvania's Dibble would love to see improvements in how archaeologists analyze stone tools. But he's skeptical of both new and traditional approaches. People today have no idea what ancient humans or other hominids considered proper toolmaking techniques or finished tools, Dibble contends.

"The alien nature of stone artifacts makes them difficult to study," he says.

Shaped rocks from Western European Neandertal sites provide a case in point. Analyses of these finds and their points of origin indicate that Neandertals carried resharpened triangular points, irregularly shaped lumps of rock and various other artifacts across distances sometimes exceeding 100 kilometers. A team led by archaeologist Alain Turq of France's National Museum of Prehistory reported the finding in 2013 in the *Journal of Human Evolution*. The team used microscopic evidence to trace artifacts from 27 Neandertal sites, mostly in France, to more than 1,000 rock sources in the general area.

Many of those items are not regarded as tools by archaeologists, the scientists found. Neandertals often transported small, irregularly shaped flakes that attract little scientific attention, as well as the hand axes and large, symmetrically shaped flakes long cherished by investigators.

Turq's group also found that traveling Neandertals picked up naturally broken pieces of flint that display evidence of having been used for cutting and scraping. These close relatives of *H. sapiens* had no hard-and-fast rules for how stone tools were supposed to look, the researchers concluded.

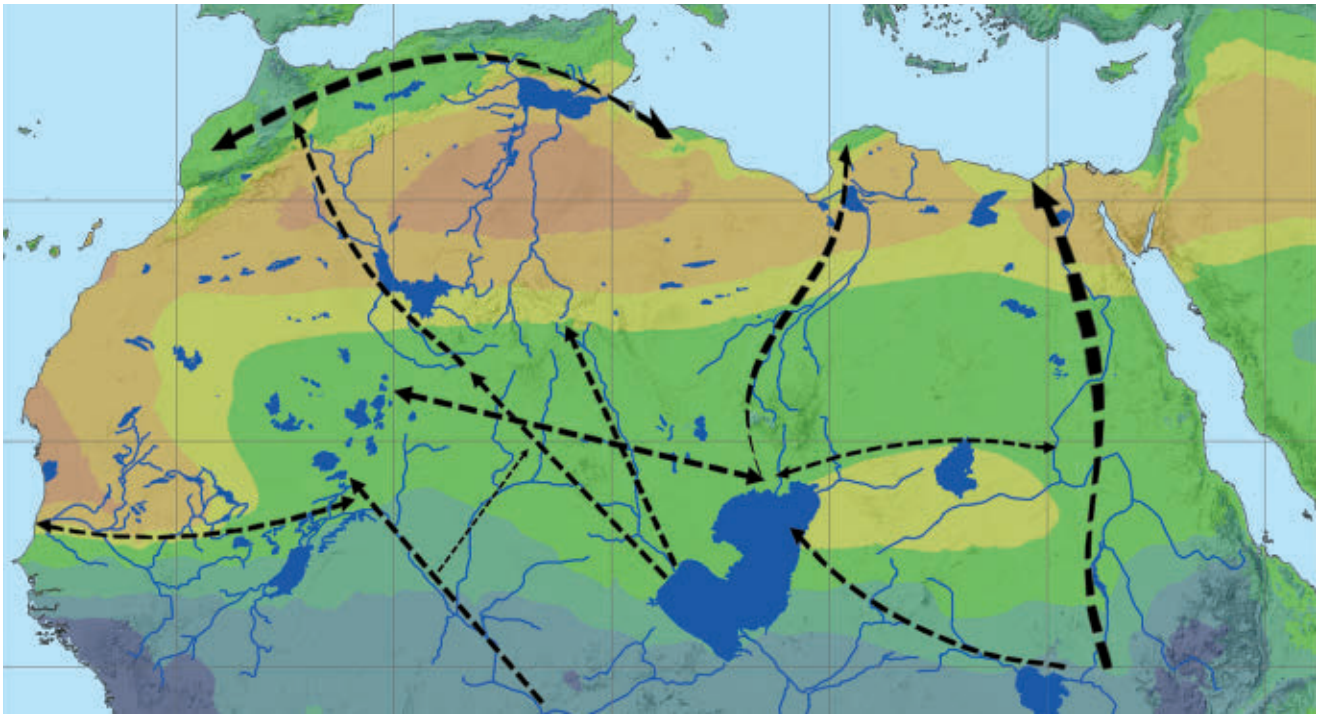
To further complicate matters, laboratory experiments led by Dibble over the last two decades demonstrate that there are many ways to make the same stone tool. Making a tool the easy way might represent an advance over making it the hard way, in line with Shea's argument that there was no inevitable progression toward mental complexity in human evolution.

Dibble's team attaches hammers made of synthetic bone and other material to a pneumatic cylinder. This device thrusts hammers into molded pieces of rocklike glass to detach flakes. The researchers can control for many factors that influence what a flake looks like, including core shape and the speed and angle of hammer strikes.

Dibble's group finds that thin, elongated flakes — thought by some researchers to reflect surges in human intelligence and toolmaking skills starting about 50,000 years ago — can be produced fairly simply by adjusting the angle of a platform on which a core rests and striking the core with a relatively soft bone hammer. Those results appeared in the June *Journal of Archaeological Science*.

Present-day flintknappers have worked out a number of possible ways in which hand axes, cores and other artifacts can be made. But ancient toolmakers probably employed strategies that people today can't intuitively re-create, says Dibble, himself an experienced flintknapper.

"Flintknappers want good-quality rock and a good-looking product," he says. "Ancient hominids made tools as quickly and as easily as possible to get the job done."



Back and forth Humans crossed North Africa where rivers and lakes had formed more than 75,000 years ago, Eleanor Scerri's team suggests. Dashed lines denote movements of groups that made similar stone tools at various locations along those corridors. Arrows on both ends of dotted lines represent movements in both directions.

COURTESY OF E. SCERRI *ET AL*

Industry standards

Despite getting hammered by critics, traditional stone tool industries still find favor among some researchers.

When large numbers of artifacts with characteristic shapes are found in a restricted area, it makes sense to place those finds in a tool industry, says archaeologist Jeffrey Rose.

Rose, of the Ronin Institute in Montclair, N.J., and archaeologist Anthony Marks of Southern Methodist University in Dallas have identified five previously defined tool industries made by *H. sapiens* groups that intermittently occupied the Arabian Peninsula between about 106,000 and 50,000 years ago. Signature methods of working stone into long points and other objects appear among tens of thousands of artifacts excavated at more than 250 sites, the researchers conclude in the 2014 *Quartär*, an annual German archaeological journal.

The oldest Arabian artifacts resemble comparably ancient tools manufactured by hunter-gatherers in North Africa's Nile Valley, Rose says. Echoing Scerri's argument, Rose and Marks suspect nomadic human groups moved back and forth across Africa and Arabia for at least 50,000 years, as geographic corridors dotted with lakes and ponds expanded and receded in response to climate fluctuations.

Even the much maligned Mousterian industry can't be dismissed, contends Stanford University anthropologist Richard Klein. No formula exists for determining whether similar tools from different sites were made by separate or intermingling populations, Klein says. A handful of Mousterian stone tool types defined 50 years ago have limitations, but, in his view, researchers such as Shea and Tostevin haven't come up with anything better.

Meaningful ways of connecting stone tools to hominid evolution are desperately needed, says archaeologist Daniel Adler of the University of Connecticut in Storrs. Adler and his colleagues have found that hominids in West Asia as well as Africa added carefully prepared stone flakes to their toolmaking repertoire around 330,000 years ago (*SN: 11/1/14, p. 8*). If West Asian and African populations independently learned this Mousterian technique while still producing Acheulean hand axes in a process dating back 1.7 million years, then traditional stone tool categories and their presumed links to specific hominid species "are kind of meaningless," Adler says.

With these questions at play, understanding of prehistoric life is still beyond reach. That doesn't bode well for future researchers who will confront artifacts far more complex than pounded pieces of rock. It makes Dibble's tale of archaeology's future less far-fetched. Perhaps tens of thousands of years from now, archaeologists will assign excavated 20th century cars to religious-altar industries with names such as Chevrolettian and Toyotaterian. ■

Explore more

■ Gilbert Tostevin. *Seeing Lithics.* Oxbow Books. 2012.

WANDERING WORLDS

Discoveries of starless orbs may complicate views about stars and planets

By Ashley Yeager

Out among the stars, toward the constellation Capricornus, a red sphere floats freely through space. It doesn't have enough mass to fuse atoms for fuel, as stars do, and it's too small to be a failed star. In nearly every way, this drifter, known as PSO J318.5-22, is like a planet. Except it fails one key test for planethood: It does not orbit a star.

PSO J318.5-22 is homeless. With no parent star to give it heat or light, it drifts in eternal darkness, a rogue of the Milky Way.

Computer simulations in the 1970s gave planetary scientists their first hints that rogue planets might exist. As planets formed around a star, some planetary material would have been scattered into far-flung orbits. A few miniplanets may have been tossed far enough to be ejected completely from the star's gravitational grasp.

Later estimates suggested that every planetary system in the galaxy booted at least one planet into interstellar space. With billions of planetary systems in the Milky Way, there may be billions, maybe even hundreds of billions, of rogue planets in the galaxy, says planetary scientist Sara Seager of MIT.

The first actual observations of what appeared to be free-floating planets came in 2000, suggesting that the simulations were on to something. In the last 15 years, astronomers have stumbled upon about 50 of these planetlike worlds. Some have all the characteristics of planets, minus a parent star. Others raise questions about how stars and planets can form. They all appear to challenge the standard definition of a planet.

It's time to go beyond serendipitous discoveries, says Michael Liu of the University of Hawaii in Honolulu. He would like to see a systematic search for other untethered worlds.

"A census of rogues," Liu says, "is the only way we are going to fully understand the extent of what's out there in the Milky Way."

Isolated giants

Liu and his colleagues first spotted PSO J318.5-22 in 2010; they confirmed and reported the finding in 2013 (*SN Online: 10/9/13*).

The researchers detected the planet in images taken with the Maui-based Pan-STARRS 1 telescope. The team had been looking for failed stars called brown dwarfs, which appear to start their lives in the same way stars do: A clump of gas breaks free from a cloud of cold, dense gas and collapses, pulling material inward into a swirling disk around it. At the center of this disk is a baby star or, depending on the size of the original gas clump, a brown dwarf.

Two traits distinguish a star from a brown dwarf and to an extent, from a planet: mass and the presence or absence of nuclear fusion. Stars, even small ones, are at least 80 times the mass of Jupiter, which at 318 times the mass of Earth is the

A disk of gas and dust swirls around OTS 44, a rogue planet shown in this artist's illustration. It may have formed the same way stars are made.

A. M. QUETZ/MPIA

most massive planet in the solar system — and is often used by astronomers to gauge the size of other gaseous objects. According to theoretical calculations about how stars work, objects must be 80 Jupiter masses or more to fuse hydrogen nuclei (protons) into helium. This process liberates energy, which is how stars burn bright, speckling the night sky.

Brown dwarfs are smaller, anywhere between 13 and 80 Jupiter masses. They are not dense enough to fuse hydrogen. But they may have been big and hot enough to fuse deuterium nuclei (a proton plus a neutron) with protons or other nuclei, which means they once generated energy but no longer do.

Any sphere less than about 13 Jupiter masses is not large or dense enough to fuse any kind of atomic nuclei. As a result, some astronomers define orbs with less than roughly 13 Jupiter masses — even untethered ones — as planets.

This has been a point of contention in the astronomy community. When astronomers started reporting free-floating planetary mass objects in 2000, they dubbed them "isolated giant planets." That simple description set off a heated debate about whether the free-floaters should be bestowed planethood. In 2003, the International Astronomical Union — the same organization that demoted Pluto to a dwarf planet — weighed in. The IAU said planets orbit the sun. Period. Planets that orbit other stars are extrasolar planets, or exoplanets, and rogues with planetary masses that do not orbit a star are not planets; they are sub–brown dwarfs.

The IAU's definitions drew a clear dividing line between stars, brown dwarfs, sub–brown dwarfs and planets. But in reality, Liu says, the galaxy's contents are much more complicated.

Around the time of the IAU announcement, Liu joined the hunt for brown dwarfs and exoplanets. In fact, when he and his team first spotted PSO J318.5-22, they thought it might be a brown dwarf. But it was "like nothing we'd seen before," he says. It was dim and extremely red, redder than any brown dwarf. A closer inspection with larger telescopes confirmed that the object was more like a planet. PSO J318.5-22 is about 6.5 times the mass of Jupiter — well within the size range of a planet. Its color, brightness, atmosphere and mass are also similar to those of the young, dusty exoplanets that orbit the nearby star HR 8799 (*SN: 4/6/13, p. 5*), the team reported in 2013 in the *Astrophysical Journal Letters*.

Rogues are hard to see for two reasons: their lack of a parent star and their size. Planets in orbit tug on their parent star or block its light, which gives clues that the planet exists. This is how the Kepler space telescope and others find far-off worlds. And because rogues are small, they don't give off a lot of heat and light compared with stars, which makes them faint and easy to miss with infrared and optical telescopes.

Despite these challenges, Liu and other astronomers have found about 40 planetlike rogues using infrared and optical telescopes. These instruments are pretty good at spotting larger rogues, but they tend to miss smaller, Earth-sized ones. That's where gravitational microlensing comes in. A massive object can act as a gravitational magnifying glass, bending and brightening the light of a background star that happens to lie directly behind it as seen from Earth. About a dozen rogues have been identified with microlensing.

Violent and messy

Mass isn't everything when determining whether an object is a star or a planet. What really matters, says Kevin Luhman of Penn State, is how the rogue was created.

Based on computer simulations, astronomers suggest two scenarios for how rogues are made: They either got kicked out of a planetary system

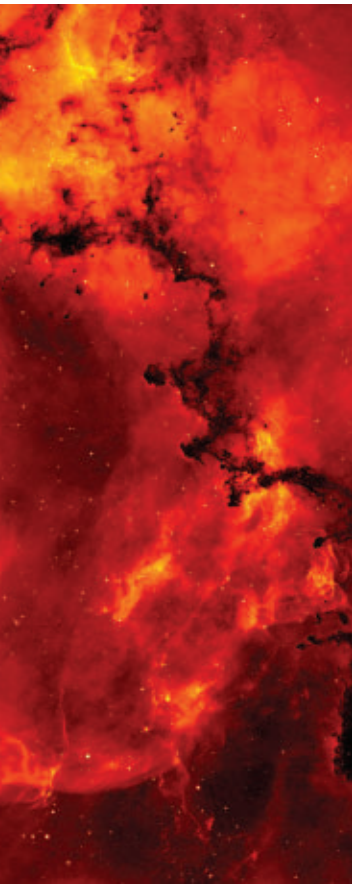
"A census of rogues is the only way we are going to fully understand the extent of what's out there in the Milky Way."

MICHAEL LIU

Spotting floaters In the last few years, astronomers have stumbled upon rogue objects not too far from Earth that have roughly the right mass to be called planets. SOURCES: JOERGENS *ET AL*/ARXIV.ORG 2014; LIU *ET AL*/*APJ LETTERS* 2013; LUHMAN *ET AL*/*APJ LETTERS* 2014; DELORME *ET AL*/*A&A* 2012; BENNETT *ET AL*/ARXIV.ORG 2013.

Rogue planet name	Mass relative to Jupiter's	Distance in light-years from Earth	Constellation	First reported	Method used for detection
OTS 44	~ 12	522	Chamaeleon	1999	Direct imaging
CFBDSIR 2149-0403	4–7	101	Dorado	2012	Direct imaging
PSO J318.5-22	6.5	80	Pictor	2013	Direct imaging
MOA-2011-BLG-262*	3.2	1,827	Sagittarius	2013	Microlensing
WISE 0855-0714	3–10	7.5	Hydra	2014	Direct imaging

*This object may be a rogue planet of 3.2 Jupiter masses plus a small moon that's half the mass of Earth, or it could be a small star or large brown dwarf alongside a planet roughly the mass of Neptune.



About 5,200 light-years from Earth, a cloud of gas and dust called the Rosette nebula (shown here) is churning out newborn stars. It may also be giving birth to rogue planets, some scientists say.

NICK WRIGHT/IPHAS

early on, or they formed just like stars but on a smaller scale.

The formation of planetary systems is extremely chaotic. It starts with a glob of gas and dust that breaks away from a much larger cloud containing material to support the start-up of many stars. As the glob pulls away, gravity forces everything toward its center. The center becomes more and more compressed, gets hotter and becomes the beginnings of a newborn star. Chunks of rock, ice and dust start to swirl around this stellar kernel. The chunks stick together to form boulders and then continue to grow bigger into planets. These planets can get pulled in toward the star and then pushed farther out.

As the planets jockey for position, they play a violent and messy game of ping-pong with others around them. In the end, there's not enough gravity to keep all the planets circling the parent star. One or more get knocked into space, according to this scenario, and rogue planets are born.

There's evidence of this kind of roughhousing even within our own solar system (*SN: 3/21/15, p. 14*), Seager says.

The first hint of these shenanigans came from the Oort cloud, a swarm of trillions of ice chunks tethered to the sun by gravity (*SN: 10/19/13, p. 19*). The Oort cloud, which extends to the farthest edges of the solar system, forms a bubble of debris around the sun and its planets. It is probably made of rubble that was thrown out of the inner solar system as the planets took their places about 4 billion years ago, Seager says.

In order for Jupiter, Saturn, Uranus and Neptune to be orbiting where they are today, some simulations suggest, there was probably a fifth planet bouncing around with them at some point (*SN: 5/5/12, p. 24*). Jupiter eventually booted the hypothetical planet, with a mass similar to Neptune's, into interstellar space, researchers from the Southwest Research Institute reported in 2011.

Not what, but how

Planetary ping-pong may not be the only way rogues are made, says astronomer Gösta Gahm of Stockholm University. He argues that planets may form without parent stars. Perhaps they form exactly the way stars do in the same regions of space, only on a much smaller scale. In stellar nurseries, big globs of gas and dust become stars. In Gahm's theory, a glob of gas and dust, which can be just a few times the mass of Jupiter, can collapse and condense into a planet — a free-floating planet rather than a star or brown dwarf.

Gahm has detected hundreds of potential planet-forming gas and dust globs, called globulettes, in the Carina nebula, he and Tiia Grenman of Luleå University of Technology in Sweden reported in *Astronomy & Astrophysics* in May 2014. Gahm and colleagues also found some in the Rosette nebula, as reported in the same journal in 2013. Rosette, 5,200 light-years away in the Monoceros constellation, is a low-density cloud of gas at the center of a larger cloud of gas and dust where stars and planetary systems are taking shape. The Rosette nebula contains globulettes that are just starting to break away from larger gas clouds.

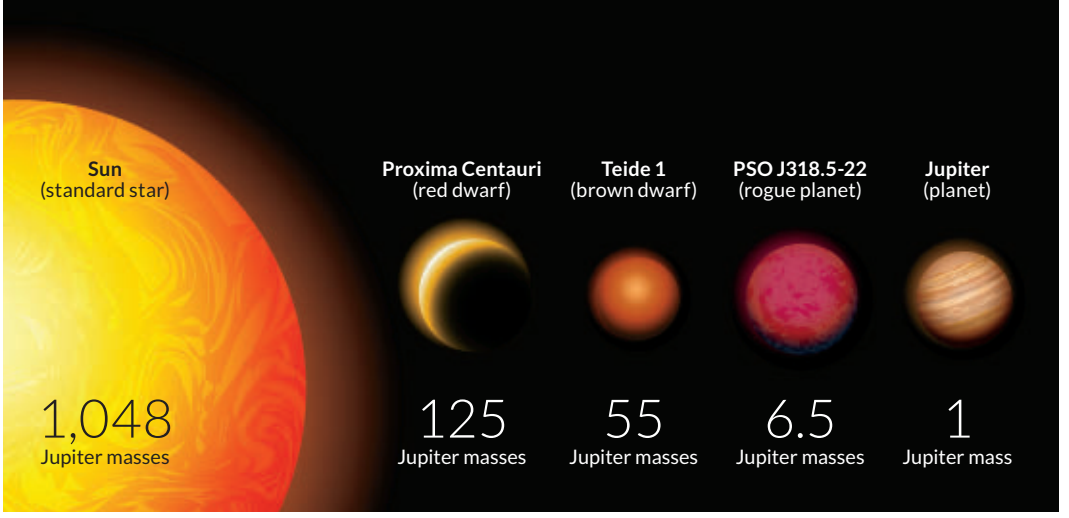
The Carina nebula, which sits about 7,500 light-years away in the constellation Carina, is one of the largest star-forming regions in the sky. It's a diffuse cloud where stars are forming at a fast pace and where there are a lot of globulettes, some smaller than the mass of Jupiter. These tiny gas globs are smaller and denser than what's been observed in other nebula, so they are possibly farther along in their path toward becoming free-floating planets, Gahm argues.

Thomas Haworth, an astrophysicist at the University of Cambridge, is delving deeper into how globulettes might transition from extremely tiny gas clouds to full-fledged free-floaters. His simulations show that the tiny globs of gas don't necessarily have enough gravity to collapse in on themselves and condense to form stars. Gahm argues that external pressure from hot gas from nearby new stars or some other turbulence could force the globulettes to condense. But when Haworth includes this type of turbulence in simulations, it's still not enough to turn globulettes into planets. He and colleagues reported the findings in the January *Monthly Notices of the Royal Astronomical Society*.

That doesn't mean the scenario is wrong, Haworth says. Globulettes could hit the boundary of a cloud where stars are forming, and, with the right amount of oomph, get squashed and collapse into a planet or brown dwarf, he says. He is working on simulations of this scenario and a few others.

"Globulettes are very numerous," he says. "Even if only a small fraction can be made to collapse, they could make a significant contribution to the population of free-floating planets."

One directly imaged free-floater, a rogue called OTS 44, appears to support Gahm's globulette theory. Astronomers estimate that OTS 44's mass is right around 12 Jupiter masses, at the high end of the mass of a planet. And it's about 2 million years old — a newborn in the cosmic sense. OTS 44 also



Measuring up
Small stars, brown dwarfs and rogue planets can be similar in diameter but have different masses. Mass is one characteristic used to distinguish the objects. However, for classification purposes, astronomers may need to look beyond mass to consider how an orb formed and what elements it's made of.

has a ring of gas and dust around it, and like a star, the gassy rogue is pulling on this disk of material to build itself up. Astronomers have seen this kind of accretion disk around planets that orbit small stars, but it has never been found around a free-floater before, researchers reported last year at a workshop on cool stars and the sun. The nomad appears to be in an advanced stage along Gahm's globulette-based path to planethood.

That finding blurs the line that the IAU and others say separates stars and planets.

Luhman argues, however, that the formation process of a star is very different from the formation process of a small body within the gas and dust around a much larger object. "It is much more meaningful to distinguish between planets and brown dwarfs based on how they formed," he says.

No interference

For all the problems they pose for scientists, rogue planets do have some benefits. "One of the best things about rogue planets is that they don't have a blinding parent star to wash out their atmospheres," Liu says. "Rogues have given us an incredible view of planet composition, and they can tell us about planets that *do* orbit stars."

Comparing the atmospheres of rogue planets with those of brown dwarfs and stars could be the best way to distinguish the types of spheres from each other. Such comparisons could reveal how different free-floaters formed and lend credence to Luhman's argument that if it formed like a star, it's a star, and if it formed like a planet, it's a planet. That kind of detail could require a new definition of the word *planet*, one that may need to include rogues.

Sifting through the rogues' atmospheres could also reveal whether they have signs of life. David Stevenson, a planetary scientist at Caltech, was among the first to argue (in *Nature* in 1999) that if free-floaters retained their hydrogen atmospheres, they could stay warm enough to have water oceans and possibly harbor life. Others have invoked dark matter to explain how rogues could support life without energy from a nearby star.

In this far-out scenario, dark matter, in the form of weakly interacting massive particles, comes in contact with atomic nuclei, loses momentum and gets pulled in by a planet's gravity. The dark matter particles build up in the planet's interior, where they bang into and annihilate each other. This interaction creates energetic particles that get absorbed by surrounding material, providing heat to the planet. It could happen at high enough rates to heat the planet to a temperature that keeps liquid water on its surface, even without the help of a parent star's light, scientists argued in a 2012 paper in the *Journal of Cosmology and Astroparticle Physics*.

Seager agrees that it may be possible for rogues to have the right surface conditions for life.

Finding evidence to support the idea, however, will require a more complete census of rogues, both big and small. PSO J318.5-22's extreme redness appears to be a signature that astronomers can use to find more, at least the bigger ones. Liu has tried it and may have hit on four or five more free-floaters already, he says. As for the small ones, some may have been spotted indirectly. But taking images of these smaller ones and exploring their atmospheres to look for signs of life is going to require much more powerful telescopes, a few of which are slated to come online in a decade or so.

"We're trying to understand the full range of planet systems," Seager says. Bigger telescopes will help astronomers understand what's still in a planetary system, what's been forced out and what else is out there.

Astronomers may just find that our galaxy is swarming with wandering worlds. ■

Explore more

■ Viki Joergens *et al.* "The coolest 'stars' are free-floating planets." arXiv.org. July 29, 2014.

JUT13/ISTOCKPHOTO; NASA; SEGRANSAN *ET AL/A&A* 2008; LEECH *ET AL/ASP CONFERENCE SERIES* 2000; LIU *ET AL/APJ LETTERS* 2013

Intel STS 2015 winners (left to right) Noah Golowich, Andrew Jin and Michael Winer.

CHRIS AYERS PHOTOGRAPHY/SSP

FAIR REPORT

Teens win big at Intel Science Talent Search

WASHINGTON — Studies of pattern-finding, genetic variation and sound have earned three teens the top prizes in the 2015 Intel Science Talent Search. The three first-place finishers each received $150,000 and were feted at a gala celebration in the nation's capital on March 10.

Run by the nonprofit Society for Science & the Public since 1942, the Science Talent Search is America's oldest and most prestigious science competition for high school students. Intel Corp. of Santa Clara, Calif., has sponsored the competition since 1998.

Each year, Intel STS brings 40 accomplished finalists to Washington, D.C., for a week of scientific presentations, judging, fun — and the chance to vie for a total of more than $1 million in awards. This was the first year that judges selected three top prizes: one for basic research, one for global good and another for innovation. Previously, Intel granted a single first-place prize of $100,000.

Speaking of the 2015 finalists, Maya Ajmera said: "These students serve as shining examples of the incredible work being accomplished in STEM fields by young people." Ajmera, president and chief executive officer of SSP and the publisher of *Science News*, is herself an alumna of STS. "We are proud to recognize and reward these stellar young researchers," she said.

Corporations and new companies will need employees with "a solid foundation in science, technology, engineering and math ... to drive their business and contribute to economic development," said Renée James, president of Intel Corp., who addressed the gala audience. "We hope this program will encourage other young people to become the next generation of scientists, inventors and engineers."

Kip Thorne, a physicist at Caltech and the science adviser for the movie *Interstellar*, had high hopes for the finalists. "You, the finalists in this talent search, represent the future of our nation's science [and] the future of the world's science," he said in a keynote speech at the gala. "You have the opportunity to have a huge impact on humanity."

Noah Golowich, 17, of Lexington, Mass., received the first place medal for basic research. He developed a proof in a field of mathematics known as Ramsey theory. It focuses on finding patterns in large and complicated systems.

Andrew Jin, 17, of San Jose, Calif., won the first place medal for global good. He developed an original algorithm to comb through genetic data and identify tiny changes in a person's complete set of genetic instructions. Such mutations can play a role in disease. Identifying the genetic contributions to disease could lead to better diagnostics and treatments.

Michael Winer, 18, of North Bethesda, Md., took home the first place medal for innovation. He studied phonons, the fundamental units of sound. Sound results from the vibration of particles. Winer studied how phonons interact with electrons. His research showed how electrons absorb and emit phonons when bombarded by sound waves.

Winer's work could be applied to complex atomic structures. One example: superconductors. These are materials that can carry electric currents without resistance. Previously, he won a silver medal at the 2014 International Physics Olympiad. During that competition, he was the highest scoring student from the United States on the theoretical exam.

Three second-place winners each received cash awards of $75,000: Brice Huang, 17, of Princeton Junction, N.J.; Kalia D. Firester, 17, of New York, N.Y.; and Saranesh Prembabu, 17, of San Ramon, Calif.

Three third-place winners each picked up prizes of $35,000: Shashwat Kishore, 18, of West Chester, Pa.; Anvita Gupta, 17, of Scottsdale, Ariz.; and Catherine J. Li, 18, of Orlando, Fla. — *Andrew Bridges*

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EXHIBIT

The expressive face of human history on display

One bust depicts a gaunt-faced man with a beaked nose and angular chin. Nearby, another has rounded cheeks and a softer nose and chin. But the two faces were both created based on the skull of one man, St. Anthony of Padua.

The gaunt face, a reconstruction made 20 years ago, is closer to how St. Anthony appears in religious artwork. The rounder face was created in late 2013 by a team of archaeologists and 3-D modelers from Italy and Brazil. The group, called Arc-Team, used updated computer modeling techniques and drew on forensic data from organizations such as the FBI about how muscles fit to human skulls.

Based on skulls, a computer modeler built 27 reconstructions of faces of humans and ancient hominids. They include the celebrity hominid Lucy (top left).

The two busts form part of the exhibit "Faces: The Many Visages of Human History" at the University of Padua in Italy. The exhibit showcases how facial reconstruction sharpens anthropologists' image of humanity's past. Arc-Team created St. Anthony's face without knowing whose skull they were working on, says curator Nicola Carrara, a physical anthropologist at the University of Padua. Unlike the creator of the older bust, the Arc-Team modeler "was not conditioned by the icons connected to St. Anthony," Carrara says.

The exhibit's reconstructions travel deep into human history. In a long corridor, Arc-Team's rebuilt faces of human ancestors squint, stare and sneer beside replicas of the skulls they are based on. The corridor's faces include the famous 3.2-million-year-old apelike hominid Lucy and early *Homo sapiens*.

To make the reconstructions, scientists pinpointed the spots where muscles connected to the skull. The researchers also estimated the depth of flesh using small pegs on the skull surface, and combined that information with forensic data from modern skulls to derive the thickness, position and length of the deepest-set muscles in the face. The modelers then used the same methods to place progressively shallower muscles until the outermost muscles gave shape to a human or prehuman face. For the rest — skin tone, hair and eye color — scientists and artists made educated guesses. (For more on the process, see Page 32.)

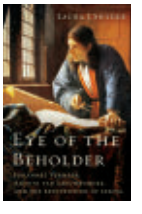
Faces: The Many Visages of Human History
THROUGH JUNE 14, 2015
University of Padua, Italy

Deriving the shapes of faces of extinct species can be especially tricky because scientists have no examples of fleshy faces to turn to. So the modelers used a new computational technique that had passed the test of approximating one ape's face (a gorilla's) from another's skull (a chimpanzee's). Arc-Team used the method on four roughly 1.8-million-year-old *Homo georgicus* skulls, and their strikingly individual faces greet museum visitors.

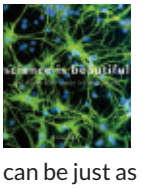
The exhibit extends beyond facial reconstruction. It showcases tools from anthropology's history of trying to justify dividing humankind into races. It also offers a glance at the discredited ideas of phrenology. The exhibit is an homage to people's fascination with faces themselves, even if — like St. Anthony's visage — our view of those faces changes over time. — *Sean Treacy*

BOOKSHELF

Jonas Salk
Charlotte DeCroes Jacobs
A comprehensive biography of the discoverer of the first polio vaccine takes readers from Salk's childhood in New York City all the way to his work on AIDS. *Oxford Univ., $34.95*



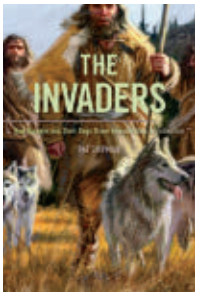
Eye of the Beholder
Laura J. Snyder
The invention of optical instruments is told through the stories of artist Johannes Vermeer and scientist Antonie van Leeuwenhoek.
W.W. Norton & Co., $27.95



Science Is Beautiful
Colin Salter
A glorious coffee table book shows that microscope images can be just as beautiful as paintings.
Sterling Publishing, $35

TOP: UNIV. OF PADUA, ARC-TEAM; BOTTOM LEFT, BOTH: MASSIMO PISTORE

For more on the reconstructed visages, visit **bit.ly/SN_faces**



The Invaders
Pat Shipman
HARVARD UNIV., $29.95

BOOKSHELF

‘The Invaders’ sees dogs as key to modern humans’ success

Ancient humans drove Neandertals to extinction around 40,000 years ago with the help of dogs soon after canines diverged from their wolf ancestors, anthropologist Pat Shipman proposes in her new book, *The Invaders*. Using fossil and genetic studies to build her case, Shipman argues that European *Homo sapiens* used the first dogs to track and corral big game for spear-wielding hunters. Unable to compete, Neandertals and several other meat-eating animals died out.

Shipman knows that Neandertals have inspired intense scientific debates for more than a century. Her proposed explanation of our evolutionary cousins’ demise won’t put those arguments to rest. But she raises an intriguing hypothesis to keep in mind as researchers learn more about interactions between Neandertals and Stone Age people and about the timing of dog domestication.

Shipman regards humans as the planet’s most accomplished invasive predators, having exploited one new habitat after another over the last 200,000 years. Successful invasive predators spell hard times or worse for native predators.

Starting around 42,000 years ago, only a few thousand years after humans reached Europe, Neandertal territory and hunting activity declined, archaeological finds suggest. Genetic evidence indicates that Neandertals’ numbers fell around that time, and other European predators, such as cave bears, similarly started a slide toward extinction 40,000 years ago.

European sites where mammoths were butchered as early as 36,000 years ago have yielded remains of wolflike creatures that some researchers regard as the first dogs. If humans domesticated wolves shortly after entering Europe, canine hunting assistants could have enabled much greater access to fat-rich mammoth meat, Shipman says.

The author acknowledges that holes exist in what might be called the Fido Scenario of human evolution. An ongoing debate concerns whether the fossil skulls that Shipman attributes to ancient dogs actually belonged to wolves. Also, some investigators suspect that large numbers of migrating humans genetically swamped sparse Neandertal groups rather than outhunting them.

Still, Shipman offers a nice rundown of much recent research on Neandertal and human evolution. In a particularly enjoyable chapter, she vividly describes wolves’ role as invasive predators in Yellowstone National Park. But it’s too early to tell if the Fido Scenario is barking up the right tree. — *Bruce Bower*

Rust
Jonathan Waldman
SIMON & SCHUSTER, $26.95

BOOKSHELF

Chronicling humankind’s incessant battle with corrosion

The No. 1 threat to the U.S. Navy isn’t a foreign adversary. It’s corrosion. And many admirals say they’re losing the battle. What the Department of Defense spends dealing with corrosion each year would buy two brand new aircraft carriers or a few dozen fighter jets. The annual bill for the United States as a whole is an estimated $437 billion — about 3 percent of the nation’s gross domestic product. Corrosion’s cost is, in fact, higher than that of all natural disasters combined.

In *Rust*, science writer Jonathan Waldman relates noteworthy episodes from the war with corrosion — which, presumably, has plagued humankind since the Iron Age. Rust, to be precise, results from the oxidation of iron. Corrosion, a more general term (and the broader subject of this fascinating, but too-restrictively titled book), is oxidation that afflicts all but a handful of particularly rare metals.

There are precious few weapons that can fight corrosion, Waldman notes. Some include the selective electrification of an object’s components to counteract oxidation’s flow of electrons. Others consist of paint or other coatings on metal that keep oxygen out. Waldman suggests that some of the most precisely engineered objects on the planet are the billions of aluminum beverage cans whose liners must protect them from corrosive liquids, some of which have a pH approaching that of battery acid.

Waldman’s cast of characters includes people who developed stainless steel in the early 1900s, others who rehabbed the Statue of Liberty in the 1980s, and those who today search for corrosion inside the Trans-Alaska Pipeline using sensor-toting robots. He weaves a wonderfully diverse tapestry that honors the myriad scientists and engineers who have doggedly taken on one of nature’s most destructive forces.

Yet corrosion isn’t *always* a bad thing, Waldman notes. Iron and oxygen love each other so much that sachets full of the powdered metal are placed inside sealed time capsules. There, the iron scrubs the ruinous gas from the air, protecting the capsules’ artifacts. — *Sid Perkins*

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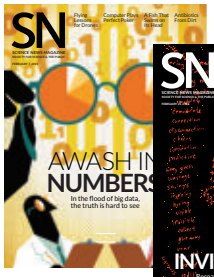

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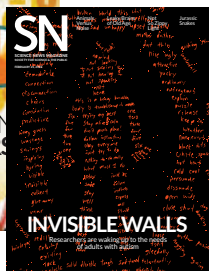
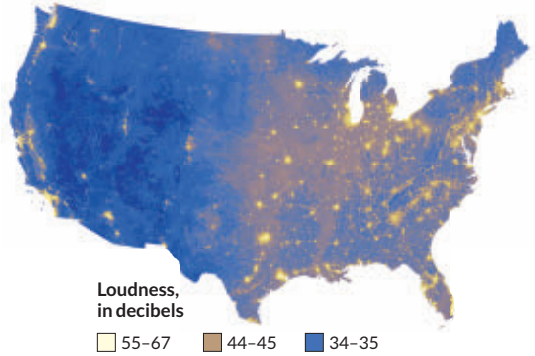


FEBRUARY 21, 2015

SOCIAL MEDIA

Lost in the noise

A map depicting the human-made racket across the United States (*SN: 2/21/15, p. 32*) had readers on Facebook reflecting on their experiences of sound — and silence.



Loudness, in decibels

55–67	44–45	34–35
53–54	42–43	32–33
51–52	41	30–31
49–50	39–40	27–29
48	37–38	21–26
46–47	36	<20

"See that bright spot in central Indiana? That's my son's room." **William Watkins**

"The most quiet experience for me was at night across Puget Sound off the coast of Washington state." **Betty Huber**

"Big Bend and Terlingua, Texas, in April have absolutely no noise. No crickets, cars, nothing." **Cate O'Connor**

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A failure to replicate

Tina Hesman Saey's two-part series, "Repeat Performance" (SN: 1/24/15, p. 20) and "Big data, big challenges" (SN: 2/7/15, p. 22), examined the serious problems scientists face in trying to reproduce research results.

Readers had lots of ideas about why it has been so hard to duplicate findings. "There is a big difference between laboratory studies where everything is controlled, down to the genetics of the test animals, and studies that are exposed to the real world," wrote **Vic Arnold**. On Facebook, **Dylan Lynch** put the responsibility on scientists, asserting that "the most important reason that research goes wrong is cherry-picking the data." Others pointed fingers at the "publish or perish" culture in academia, which, **Alison Moodie** said, "asks people to publish before they are ready and often with data that are insufficient for high statistical significance."

Solutions to the problem were in short supply. **Robert Smith** echoed the thoughts of many by declaring that "any new claims should be the subject of multiple retests at different labs using the described methodology." Conducting do-overs may sound like a good fix, but it's not that simple, argued **Janet Basu**: "Who gets glory by replicating somebody's research? What granting agency supports that endeavor? It's the weak link in the scientific method."

Autism over time

In "Disconnected" (SN: 2/21/15, p. 16), Siri Carpenter described growing efforts to help teenagers with autism transition to adulthood — a time when many services designed to support them disappear.

"It's encouraging to see research on the needs of young adults as they exit school systems," wrote **Cindy Fisher**. "As a transition teacher working with 18- to 21-year-olds, I witnessed students gaining in independence but who were not quite ready to be on their own. The supports available were counseling, support groups or tutoring at prearranged times. For individualized help in real time, in-person caregivers [were] paid by the hour. Neither of these options provides the just-in-time, natural supports that college-aged individuals need."

Chris Wood suggested that other people might benefit from the autism-focused research: "Why not make a program to help everyone transition from youth into adulthood, that recognizes the special needs of particular individuals, while providing a visible path from childhood dependence into self-sufficiency, that is available to all? Many people without an official diagnosis struggle with figuring out where they fit, as today's modern world can overwhelm anyone."

Rethinking light's speed

*Scientists can slow down a pulse of light by manipulating its structure. Even in a vacuum, the altered photons arrive a bit later than their unaltered counterparts do, as **Andrew Grant** reported in "Speed of light not so constant after all" (SN: 2/21/15, p. 7).*

"Does this cause concern when using light as a measure of distance?" asked commenter **ChazNCenTex**. Reader **Mack G.** had a similar concern: "The Andromeda galaxy is supposed to be 2.5 million light-years away from us. But now it seems like the physical distance could actually be quite different than we thought."

Study coauthor **Daniele Faccio** of Heriot-Watt University in Edinburgh says that his team's finding probably has little or no effect on the current understanding of the universe. Stars and galaxies emit light that more closely resembles ideal waves traveling at c, the speed of light constant, than the experiment's slower structured beams. He adds that typical astronomical measurements aren't precise enough for a slight adjustment in light's speed to be significant. The finding is most relevant for people who use the travel time of light to measure minute distances in the lab. In those cases, Faccio says, "the real speed of light should be carefully evaluated."

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Reconstructing a big-mouthed ancestor

Cícero Moraes is adding new portraits to the human family album. The 3-D designer based in Sinop, Brazil, has digitally reconstructed the faces of over 15 extinct hominid species, including *Paranthropus boisei*, a distant cousin to modern humans. The faces are on display at the University of Padua in Italy (see Page 28).

The odd anatomy of *P. boisei*, which lived in East Africa some 2.3 million to 1.2 million years ago, has long perplexed scientists. Anthropologists once thought the hominid used its colossal molars and heavy jaw to crack open nuts. Yet recent chemical analyses indicate it grazed on grass (*SN: 6/4/11, p. 8*).

Moraes began his reconstruction with some photos of a skull (top right). After creating a 3-D digital scan of the bones, Moraes approximated the facial musculature using CT scans of chimpanzees as a reference. From there, he used software to manually sculpt the hominid's facial features. Finally, he added hair and other cosmetic touches. Bringing *P. boisei* to life took about five days. — *Erin Wayman*

3-D: C. MORAES; SKULL PHOTO (TOP RIGHT): MOACIR ELIAS SANTOS

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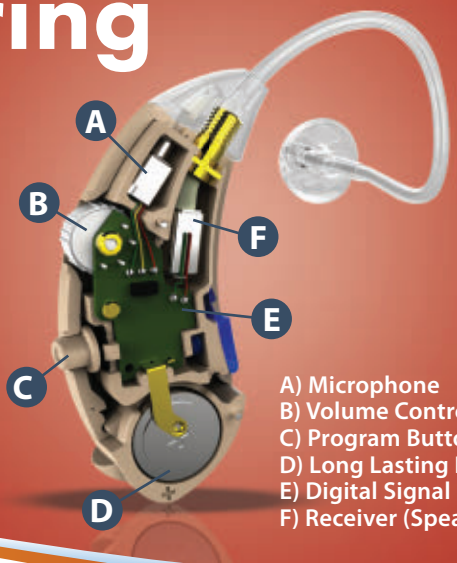

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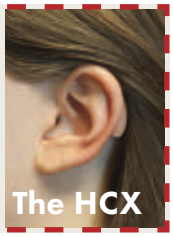

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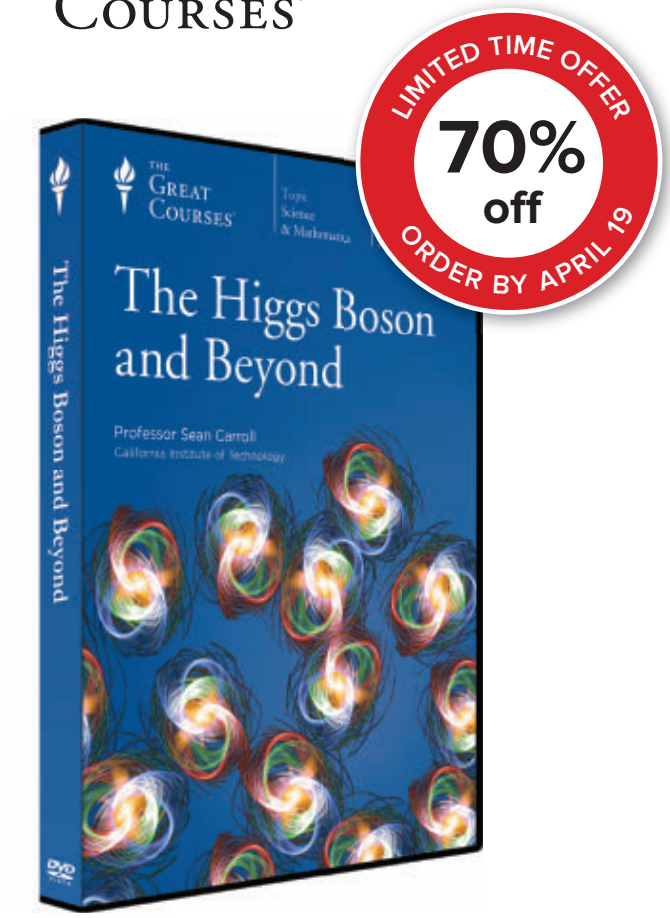

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