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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & DECEMBER 15, 2012

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MODERN FAMILY

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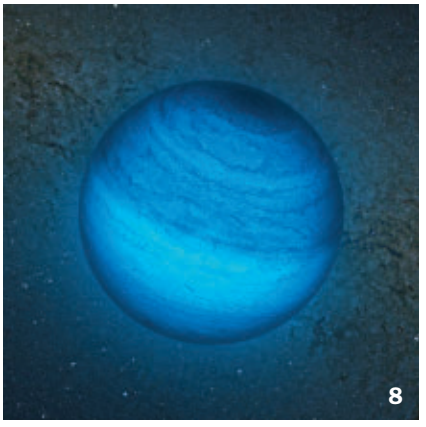

ScienceNews

In The News

Features

Departments

COVER Nontraditional families like the Moyas of Riverside, Calif., are inspiring social scientists to study how different living arrangements affect parents and children.
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FROM THE EDITOR

Decoding symbols: past, present and for the future

If I drew an →, you'd know to look to the right. Some symbols are human universals, no matter your language or culture. But the arrow, if you think about it, is easily interpreted only by beings with a deep hunter-gatherer past. Its meaning would probably not be so clear to extraterrestrials that had never developed bow-and-arrow technology. So, how do you communicate with beings that may or may not understand even the simplest symbols?

That's the question at the heart of the story by Sid Perkins on Page 26 of this issue. Perkins reports on how efforts to craft a message to E.T. — as well as successes in decoding texts from ancient Egyptians — are informing a more urgent communications task: alerting humans living in the distant future to hazardous nuclear waste sites. While scientists don't yet have all the answers, they have come up with a potential medium for their message. Transparent disks fabricated of industrial sapphire and engraved in platinum could survive for a million years and be read with a simple microscope.

At least one researcher — an Egyptologist who recently published a dictionary of a once-lost language — is optimistic about efforts to communicate with the future. After all, her job, like many scientists, is to reconstruct the distant past from the barest of clues. And though far from perfect, such methods have produced impressive results, including several reported in this issue. A few old teeth, for example, are shedding light on the preferred nibbles — grasses and sedges — of a 3-million-year-old member of the human evolutionary family (Page 14). Shooting replicas of 500,000-year-old spearpoints into springbok carcasses, scientists have been able to push back the date of the earliest known spear hunting (Page 5).

Of course, humans imbue symbols with meaning, and those meanings can shift. On Page 16, Bruce Bower reports on how the long-reigning symbol of the nuclear family is due for a revision. He describes declining marriage rates and rising numbers of unmarried couples and single moms. Gay couples are raising children together and legally marrying. People are remaking the institutions of marriage (and its many attendant symbols) and family into something to suit themselves.

Such shifts hint at the difficulty of communicating with distant generations. Who knows how many of our conventions are specific to this era. Firm answers may evade us, but the journey still fascinates. — *Eva Emerson, Editor in Chief*

PHILIP CHANNING

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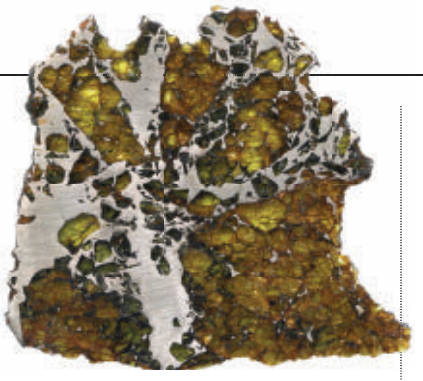

Pallasite *PAHL-leh-site*\ *n.*

A rare type of meteorite (shown, right) that contains chunks of the mineral olivine held together by a mix of nickel and iron. Scientists have long thought that pallasites were formed along the boundary between a planetary body's metal core and rocky mantle, where olivine, nickel and iron could come together. But after examining the magnetic properties of tiny metal grains trapped in olivine, a team led by University of Rochester geophysicists suggests a different theory. Pallasites may form when an asteroid collides with a protoplanet, injecting metal from the asteroid's core into the mantle of the bigger body, the team reports in the Nov. 16 *Science*. —*Allison Bohac*

Science Past | FROM THE ISSUE OF DECEMBER 15, 1962

NEW LASER USES LIQUID — A new way of producing the very intense light beam of lasers, which are promising for use in space and earth communications, was reported to the American Physical Society in New York. Organic liquid lasers give off light at wavelengths not previously available and are predicted to become important in the fundamental understanding of matter. The new kind of laser, or optical maser, operates on a principle never used before — stimulated "Raman" scattering. Although the Raman effect is well known to physicists it has not been involved in laser action. In the ordinary Raman effect, light is scattered from molecules. The outgoing, or scattered, light has different energy and wavelength than the incoming light, the energy difference having been converted to molecular vibrations.

Science Future

December 20

Join astronomers for the Winter Solstice and Telescope Party at the American Museum of Natural History in New York City. Jupiter and the full moon will be on view. See bit.ly/SFsolparty

January 13–15

Marine ecologist Enric Sala relates his ocean-exploring adventures at Seattle's Benaroya Hall. Learn more at bit.ly/SFsala

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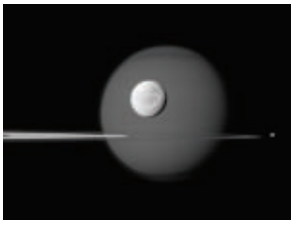
GENES & CELLS

Understanding inherited conditions is proving to be difficult. See "Rare genetic tweaks may not be behind common diseases."

ATOM & COSMOS

Titan and other moons may be crash debris. See "Violent birth proposed for Saturn's moon mishmash."



BODY & BRAIN

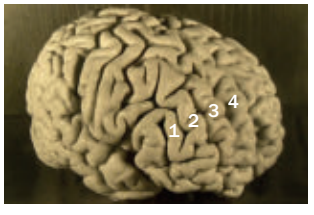
An invasive surgery works best for some. Read "Heart bypass surgery outperforms stents in diabetics."

EARTH

A deluge of freshwater may have triggered a cold spell 13,000 years ago. See "New pathway proposed for ancient flood."

How Bizarre | A MOST DISTINGUISHED BRAIN

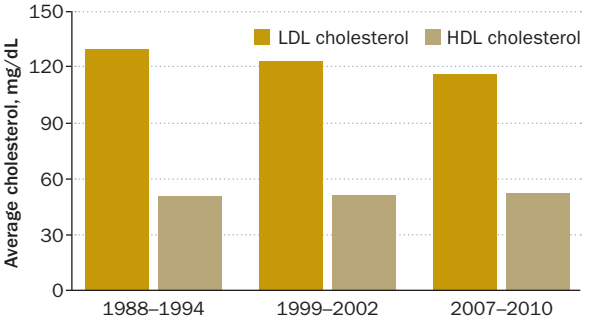
Newly available photographs of Albert Einstein's brain, taken just after his death, reveal some unusual features. Though it's impossible to say exactly how these quirks influenced Einstein's thinking, scientists have some guesses. For instance, Einstein's brain had a strange pattern of furrows in front, creating four bulges (shown) where typical brains have only three. This quirk and others nearby may have aided in thought experiments, since the prefrontal area of the brain is important for imagination and simulations, researchers propose. And a patch of tissue called the superior parietal lobule was larger on the right side of his brain than on the left. This area has been linked to spatial orientation and may play a role in doing mental arithmetic. — *Laura Sanders*



Science Stats | CHOLESTEROL DIP

Americans' cholesterol levels are on the decline, according to a study of U.S. adults from 1988 to 2010. Researchers say the drop is in LDL, or "bad" cholesterol, and is probably due to reduced consumption of trans fats and a rise in the use of lipid-lowering medications, not to improvements in physical activity or obesity levels. SOURCE: M.D. CARROLL *ET AL*/*JAMA* 2012

Cholesterol over time, U.S. men and women



CLOCKWISE FROM TOP: ARLENE SCHLAZER; JPL-CALTECH/NASA, SPACE SCIENCE INSTITUTE; NATIONAL MUSEUM OF HEALTH AND MEDICINE

“It seems as though once your telomeres get critically short, your risk of dying goes up.” —CATHERINE SCHAEFER, PAGE 13

In the News

STORY ONE

Earliest projectile weapons found

Common ancestor of people and Neandertals flung spears

By Bruce Bower

Scientists working in South Africa have unearthed the oldest known spear tips, apparently made by a common ancestor of people and Neandertals around 500,000 years ago.

About 13 percent of more than 200 stone points found at a site called Kathu Pan 1 display modifications and damage consistent with having been attached to spear handles and hurled at prey such as springbok, say Jayne Wilkins, an anthropologist at the University of Toronto, and her colleagues.

“These were close-range weapons, either thrusting spears or spears thrown from fairly short distances,” Wilkins says.

A description of the South African spearpoints appears in the Nov. 16 *Science*.

Human ancestors were regularly killing game by 780,000 years ago in the Middle East, as evidenced by remains of butchered deer carcasses. Until now, the earliest stone spear tips came from a Neandertal site in France dating to between 300,000 and 200,000 years ago. Wooden spears from 400,000 years ago have been found among the remains of butchered horses in Germany.

Wilkins’ team determined an approximate age for the Kathu Pan 1 points using a soil analysis method that estimates the time since artifacts were buried.

If the half-million-year-old age for the spear tips holds up, “the conclusion that Neandertals and *Homo sapiens* shared whatever mental abilities undergird hafted stone-tool technology seems reasonable,” says archaeologist John Shea of Stony Brook University in New York.

Wilkins’ investigation follows a report that humans at South Africa’s Pinnacle Point caves used spear-throwers or bows to launch projectiles tipped with tiny stone blades at least 71,000 years ago. The discovery of these apparent arrow tips predates the next oldest evidence

A common ancestor of modern humans and Neandertals made spearpoints (reproductions shown) for hunting African game 500,000 years ago.

COURTESY OF J. WILKINS

For the latest news, visit **www.sciencenews.org**

of arrow use by several thousand years.

Most of the blades — described in the Nov. 7 *Nature* by archaeologist Kyle Brown of the University of Cape Town in South Africa and his colleagues — were made from a type of stone called silcrete that had first been heated to make the rock easier to chip. The tips were found throughout cave sediments that spanned a period of 11,000 years, indicating that humans of the era could pass on complicated instructions to build multipart tools over hundreds of generations, the researchers report.

Together, the finds "document a two-step process of projectile weapon evolution that ultimately allowed modern humans to conquer the planet," says archaeologist Curtis Marean of Arizona State University in Tempe. Marean directs the Pinnacle Point excavations.

He suggests that a common ancestor of humans and Neandertals began heaving stone-tipped spears at animals about half a million years ago, but it wasn't until much later that Stone Age people figured out how to make devices such as spear-throwers that hurl weapons farther, harder and more accurately.

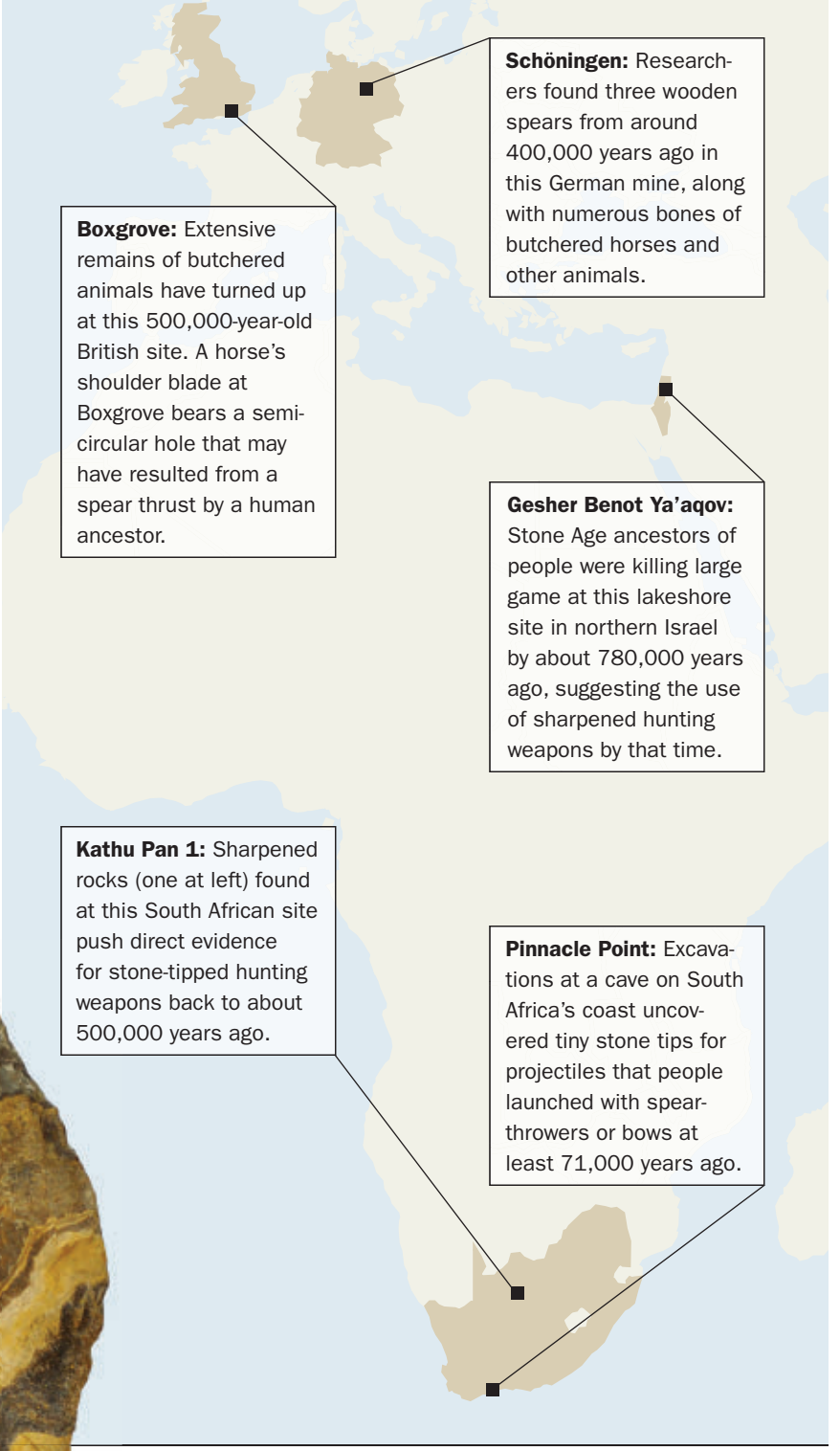
Fractures on the business ends of the Kathu Pan 1 stone points and intentional shaping of some of their bases indicate that these implements were spear tips. Wilkins' team made replicas of the stone artifacts and attached them to the ends of wooden dowels using acacia resin and animal sinews. Experimenters fired these makeshift spears into two springbok carcasses using a calibrated crossbow that simulated the force exerted by an adult thrower.

After repeated impacts, damage to the replicas looked much like that on Kathu Pan 1 stone points, Wilkins says. ■

With additional reporting by Erin Wayman

Back Story | SPEAR HUNTING'S SPREAD

Early advances in spear making occurred in Africa, the Middle East and Europe as people and now-extinct *Homo* species attempted to sate a taste for meat.



POINT: COURTESY OF J. WILKINS; MAP: GEOATLAS/GRAPHI-OGRE, ADAPTED BY E. FELICIANO

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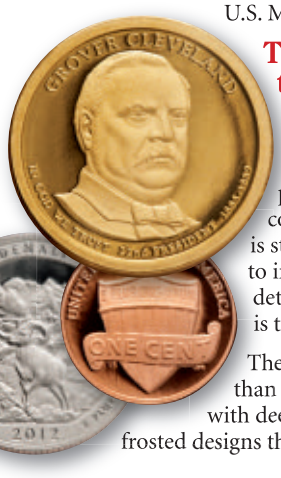

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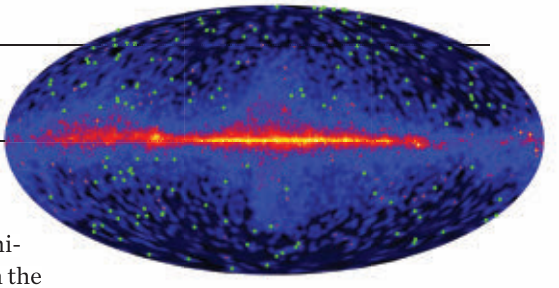
Atom & Cosmos



Astronomers used 150 bright galaxies called blazars (green dots) to detect photons from early stars. The map shows the sky in gamma rays, with the Milky Way in warm colors.

Light captured from early stars

High-energy radiation reveals founding stellar generations

By Nadia Drake

Light from the universe's very first stars still lingers in space. Now astronomers have a new way to catch it: distant, ultrabright galaxies that expose relict photons in a blaze of gamma rays.

But it's not just these earliest photons that are snared; light from every star that ever shined can be caught. "We now have constraints on the total number of stars that ever formed," astronomer Volker Bromm of the University of Texas at Austin says of the new way to see old light, described online November 1 in *Science*.

Studying these stellar fingerprints will help astronomers learn more about the universe's earliest years. Now roughly 13.7 billion years old, the universe is thought to have switched on the first stars about 400 million years after the Big Bang.

Astrophysicist Marco Ajello of Stanford and his colleagues used the orbiting Fermi Large Area Telescope to study distant blazars, a type of bright, active galaxy. Blazars are powered by supermassive black holes that shoot enormous jets toward Earth. The jets include gamma rays that can interact with photons from early stars.

Photons colliding with a blazar's gamma rays are converted into electrons and their antimatter particles, positrons. The transition produces a dimming effect, with the amount of dimming corresponding to the quantity of photons between Earth and the blazar.

Ajello and his colleagues used 150 blazars to parse early photons from the rest of the cosmic melee. So far, the researchers have managed to peer at the shimmering universe as it appeared when it was just 4 billion years old. The team plans to follow up with blazars at greater distances and earlier ages.

The new results suggest that early stars may have formed a bit more slowly than previously thought, were primarily made of hydrogen, and lived fast and died young. "The first stars were in general more massive — up to hundreds of times as massive as the sun — hotter, brighter and more short-lived," Ajello says.

Stray planet floats in cluster of stars

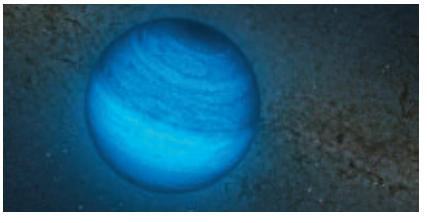
Orphan orb is closest known object of its kind to Earth

By Tanya Lewis

Not all planets are content to dutifully circle a star. A rogue planet has been spied roaming among a pack of young stars about 115 to 160 light-years from Earth. The free-floating planet is the closest to Earth yet discovered, scientists say.

It can't be a planet in the conventional sense because it doesn't orbit a star. But the rogue is between four and seven times the mass of Jupiter, well within planetary size range. The object appears to be a young, cold planet in a cluster of about 30 stars moving together called AB Doradus, astronomers report in the December *Astronomy & Astrophysics*.

"It's quite a nice discovery — probably the clearest example of a planetary mass object that's very young like this," says astrophysicist Philip Lucas of the University of Hertfordshire in England, who was not involved with the study.



The newly found object CFBDSIR2149 (illustrated) is the nearest known planetlike body not orbiting a star.

Other potential free-floating planets have been detected, but their ages weren't as well defined. Astronomers couldn't be sure the objects were planets and not brown dwarfs, failed stars too small to sustain fusion reactions in their cores.

The newfound object, CFBDSIR2149, lies in the southern constellation Dorado. Scientists estimate the planet is between 20 million and 200 million years old, based on the assumption that it was formed around the same time as the stars it accompanies. Compared with the sun, which is about 4.6 billion years old, "it's like a 1-year-old baby versus a 45-year-old man," says astrophysicist Philippe Delorme of the Institute of Planetology and Astrophysics of Grenoble in France, who led the research team. Knowing the planet's age helps pin down its approximate mass.

Delorme and his team were originally looking for brown dwarfs. Using the Canada France Hawaii Telescope on Mauna Kea, Hawaii, the scientists noticed a strange object with an unusual color and measured its spectrum of light — a rainbow of colors that reveals its chemical makeup — which gave the first hints it might be a planet. The team confirmed its observations using a European Southern Observatory telescope in Chile.

FROM TOP: NASA, DOE, FERMI LAT COLLABORATION; ESO, L. CALÇADA, P. DELORME, R. SAITO, VVV CONSORTIUM

Health & Illness

193 Average initial LDL level among volunteers in one study of AMG-145

99 Average LDL level among study volunteers given high doses of the drug for 12 weeks

Statin substitutes show promise

Injected antibody-based drugs reduce cholesterol in trials

By Nathan Seppa

People who can't take cholesterol-lowering drugs called statins may someday have an alternative that works about as well. Three new studies show that lab-produced antibodies that target specific proteins in cells can knock down LDL, the "bad" cholesterol, at a rate comparable to the highly successful statins.

The experimental drugs take a novel biological approach to clearing LDL from the blood, suggesting that they might replace statins (*SN: 5/5/12, p. 30*) in people who cannot abide those drugs' side effects, particularly muscle pain. The new drugs may even work in conjunction with statins for people who inherit extremely high cholesterol.

> "We have been bumping up against statin intolerance in patients."
>
> PETER WILSON

"We have been bumping up against statin intolerance in patients," often in people who have had a heart attack, said Peter Wilson, an endocrinologist at Emory University and the Atlanta Veterans Affairs Medical Center. Wilson, who wasn't part of these studies, estimates that 5 to 15 percent of people who need statins can't take them.

The new drugs, including AMG-145 and RN-316, are still in testing. But researchers offered early results November 5. Cardiologist Evan Stein of the Metabolic and Atherosclerosis Research Center in Cincinnati reported that people with very high LDL who got AMG-145 injections every four weeks experienced a 41 to 51 percent drop in LDL by 12 weeks, depending on dose. That study was also released online November 5 in the *Journal of the American Medical Association*.

Another AMG-145 study showed LDL reductions of 43 to 55 percent in people with inherited high cholesterol. Those findings also appear online in *Circulation*. The drug is made by Amgen.

RN-316, made by Pfizer, knocked down LDL by up to 75 percent in a 12-week trial, reported Barry Gumbiner, an endocrinologist at Pfizer in San Diego.

The drugs are antibodies that free up a protein on cells called the LDL receptor, which lowers LDL by pulling it out of circulation. The antibodies do this by targeting a troublesome protein called PCSK9 that binds to LDL receptors.

"Cholesterol is essential for the normal functioning of cells," said Frederick Raal, an endocrinologist at the University of the Witwatersrand in Johannesburg who presented the *Circulation* study. Even as LDL receptors remove LDL from the blood, the PCSK9 protein acts as a brake on that process, he said. Targeting PCSK9 allows the receptors to snag more LDL.

Besides helping people who cannot take statins, Raal said, the drugs may be added to therapy in those who can tolerate statins but who fail to benefit fully from those drugs even at high doses. That includes people with hereditary high cholesterol.

Only a few hundred people in the United States have an extreme form of this condition inherited from both parents, Wilson said. But about 500,000 have inherited the condition from one parent. Statins alone often don't get LDL levels into the safe range for those people.

PCSK9 was originally found because people who lack it have few heart problems, Gumbiner said. "Their LDL levels are much lower, and they live long, healthy lives," he said. "That was the genesis for looking at this as a drug target."

MEETING NOTES

Multivitamins don't guard against heart attack

A daily vitamin may have its benefits, but protecting against a cardiovascular crisis isn't one of them. That's the conclusion of researchers who randomly assigned more than 14,000 men age 50 and older to get a multivitamin or placebo. After a median of 11 years, both groups had a similar risk of a heart attack, stroke or of dying of a heart-related event. The study, presented November 5 by Howard Sesso, an epidemiologist at Harvard Medical School and Brigham and Women's Hospital in Boston, is the first long-term trial to assess whether multivitamins have a cardioprotective role. The study also appears in the Nov. 7 *Journal of the American Medical Association*. — *Nathan Seppa*

Designer tomatoes reduce artery clogging in mice

Genetically engineered tomatoes can limit artery plaque buildup in mice. Scientists fed tomatoes that make a compound called 6F that works like a key ingredient in "good" cholesterol, or HDL, to mice as part of a high-fat, high-calorie diet. Other mice got the diet without the engineered tomato. All mice lacked the ability to effectively clear LDL, the bad cholesterol. After 13 weeks, mice getting the genetically engineered tomatoes as 2.2 percent of their chow had half as much atherosclerotic plaque in the large artery leading out of the heart compared with those on unhealthy chow alone, said UCLA physician Alan Fogelman, who presented the data November 5. Treated mice also had lower triglyceride levels and less systemic inflammation. — *Nathan Seppa*

Mind & Brain

Early stress has lingering effects

Girls showed changes in brain regions involved in emotions

By Laura Sanders

The effects of a baby's rough start can linger. An early stressful environment during a girl's first year was associated with altered brain behavior and signs of anxiety in her late teens, scientists report online November 11 in *Nature Neuroscience*.

Studies in animals have pointed out how tough times in childhood can influence the brain and behavior later in life. But it's been hard to figure out how that process works in people, says Lawrence Price, a psychiatrist at Brown University in Providence, R.I. "One of the real advances of this paper is that it helps move us along on that pathway," he says.

The study, led by Cory Burghy of the University of Wisconsin–Madison, drew on a study that recruited pregnant women at prenatal visits. Three times during the first year of their babies' lives, the mothers reported whether they were experiencing stressful situations such as depression, marital conflict, money woes or parenting stress. Researchers assumed that having a mother with higher stress created a tougher situation for babies.

Four and a half years later, daughters whose moms reported higher stress had more of the stress hormone cortisol in their saliva. That observation suggests that the girls had trouble shutting down a hyperactive stress response. The same effect wasn't found in boys.

> "We have now a snapshot of what the brain is showing in response to early life stress."
>
> RASMUS BIRN

Fourteen years later, effects of that high cortisol appear to have turned up in the daughters' brains: The behavior of two brain regions involved in regulating emotions — the prefrontal cortex and the amygdala — was out of sync in women who had high cortisol levels as children, brain scans revealed.

Usually, the prefrontal cortex and the amygdala operate in tandem, a joint effort that seems to be involved in shutting down negative emotions. But in these women, the two brain areas had a reduced connection. The weaker this connection, the more likely a daughter was to have problems with anxiety.

"We have now a snapshot of what the brain is showing in response to early life stress," says study coauthor Rasmus Birn, also of the University of Wisconsin–Madison.

Linking cortisol changes in childhood to brain differences at age 18 is a key finding, Price says. "It provides this bridge between two large bodies of literature that haven't been able to connect with each other."

Brain works fast in speed dating

Two regions quickly gauge appeal of potential partners

By Laura Sanders

In the fraught, emotional world of speed dating, scientific calculations don't usually hold much sway. But the brain runs a complex series of computations to tally the allure of a prospective partner in just seconds. In a new study, the strength of these brain signals predicted which speed daters would go on to score a match. The work appears in the Nov. 7 *Journal of Neuroscience*.

"It's a gut feeling, but here, the paper dissects it for us and tells us, 'This is what we calculate,'" says neuroscientist Daniela Schiller of Mount Sinai School of Medicine in New York City.

Scientists led by Jeffrey Cooper, who conducted the work at Trinity College Dublin and Caltech, scanned the brains of single volunteers as they viewed photos of potential dating partners. Researchers had volunteers rate on a scale of 1 to 4 how much they'd like to go out with the person in the photograph.

Later, the participants attended three actual speed-dating events loaded with many of the potential partners seen in the photos. Like a normal speed-dating scenario, volunteers' contact information was exchanged if both of the people wanted to follow up.

The team found that behavior in two parts of the brain's dorsomedial prefrontal cortex — a region near the front of the brain that sits above the eyes — could predict whether viewers would later pursue in real life the people seen in photographs.

One of these spots, the paracingulate cortex, appeared to gauge another person's attractiveness. This area "seems to be the one doing the heavy lifting in terms of sorting people you're going to say yes to and the people you're going to say no to," says Cooper, who is now an analyst in Glendale, Calif., for the Walt Disney Co.

The second brain region, a place a little closer to the eyes called the rostromedial prefrontal cortex, may be a more sophisticated matchmaker, focusing on personality instead of physical attractiveness. This part of the brain appeared to appraise, in a very idiosyncratic way, how likable a person appeared.

The rostromedial prefrontal cortex has been implicated in thinking about other people's mental states and comparing the self with others. On the dating scene, this region might be figuring out how similar a potential partner is to the observer, a calculation that's known to influence mate choice.

Life

"The beauty about the katydid ear is that it does the same job in a way that is much simpler." —DANIEL ROBERT

Elephant mimics Korean words

Trunk motion lets animal approximate human speech

By Susan Milius

An Asian elephant has learned to mimic five words in Korean, creating a human-like tone by sticking its trunk into its mouth.

This is the first systematically studied case of an elephant mimicking human speech, says bioacoustician Angela Stoeger at the University of Vienna. The male elephant, called Koshik and housed in a Korean zoo, makes sounds close in pitch to human language that remind Korean speakers of actual words, Stoeger and her colleagues report in the Nov. 20 *Current Biology*.

Studying the select group of animals that can imitate sounds they hear broadens the understanding of a skill crucial for human music and language, says Peter L. Tyack of the University of St. Andrews in Scotland. Other primates show "surprisingly little evidence" of learning to mimic sounds, says Tyack, who studies sound communication in marine mammals.

Intrigued by zookeepers' reports that Koshik was mimicking Korean, Stoeger visited him in South Korea's Everland Zoo. Koshik curls his trunk from the right side and puts the tip into his mouth before sounding off. It's impossible to see exactly what his trunk tip does, yet the resulting sounds approximate the pitch of tones in human speech.

Stoeger played recordings of Koshik's various utterances for 16 native Korean speakers, asking them to transcribe the sounds. Two thirds of listeners agreed on the vowel sounds of his vocalizations, but consonants weren't as close. About half of the listeners transcribed Koshik vocalizing *annyong*, which means hello in Korean. Almost half also heard *aniya*, Korean for no, which the zoo elephant had probably heard plenty of times. Listeners also agreed 15 percent or more on *nuo* (lie down), *anja* (sit down) and the vowel sounds in *choah* (good).

Koshik can respond appropriately to these words, but there's no evidence he uses the sounds with a sense of their meaning. "He didn't get upset if his keepers didn't sit down," Stoeger says.

For seven years Koshik was the only elephant in the zoo. He was clearly very motivated to engage in an interaction with his caretakers, says Vincent Janik at the University of St. Andrews. "Copying is a very effective way of addressing someone," he says. "If I copy everything you say shortly after you say it, you will turn towards me and pay attention, no matter what the actual content of your or my utterances are."

Other animals in captivity have appeared to mimic words, such as an orphan harbor seal named Hoover hand-raised in a bathtub before moving to Boston's aquarium and a white whale called NOC, whose occasional speech-like sounds confused a human diver in the whale's tank.

Stoeger and her colleagues are now studying whether elephants imitate the sounds of other elephants. ■

COURTESY OF D. ROBERT AND FERNANDO MONTEALEGRE-ZAPATA

A leg up on hearing

A rainforest katydid has ears like people's, the first three-stage hearing system known outside vertebrates. "The beauty about the katydid ear is that it does the same job in a way that is much simpler," says Daniel Robert of the University of Bristol in England.

When mammals hear a sound, first, airborne pressure waves thump against the eardrum. Then the drum jiggles tiny bones that translate large vibrations over the whole eardrum into smaller but intelligible sloshes in the third component, a liquid-filled chamber.

Copiphora gorgonensis katydids (one shown) don't need bones for translating because the eardrum does the job. Katydid ears sit below the knees with an eardrum on each side of the leg. An airborne pressure wave bends a large zone on each drum inward, and that motion forces a small translator plate on each drum outward. The plate vibration sends smaller ripples through a liquid-filled chamber inside the leg, Robert and colleagues report in the Nov. 16 *Science*. —*Susan Milius*

Genes & Cells

For longer versions of these and other Genes & Cells stories, visit **www.sciencenews.org**

Ebola virus may go airborne

Pigs can transmit virus to primates without contact

By Tina Hesman Saey

The Ebola virus can spread through the air from pigs to macaques, a new study suggests.

Transmission of the virus — which causes an often fatal hemorrhagic fever in people and other primates — was thought to require direct contact with body fluids from an infected animal or person. But in the new study, published online November 15 in *Scientific Reports*, piglets infected with Ebola passed the virus to macaques housed in the same room even though the animals never touched.

"The evidence that the virus got from a pig to a monkey through a respiratory route is good," says Glenn Marsh, a molecular virologist at the Commonwealth Scientific and Industrial Research Organization's Australian Animal Health Laboratory in Geelong.

Although pigs transmitted Ebola in the laboratory, there is still no evidence that anyone has been sickened from contact with infected pigs in Africa, where the virus occurs naturally, or that the virus passes through the air under normal conditions, says study coauthor Gary Kobinger, an infectious disease researcher at the University of Manitoba in Winnipeg, Canada. "It's definitely not an efficient route of transmission."

Working in a lab designed to contain the most dangerous pathogens, Kobinger and his colleagues infected piglets with the strain known as Zaire Ebola. The piglets were housed next to four cynomolgus macaques. A barrier prevented the animals from coming into direct contact with each other.

After about a week, two of the macaques fell ill with Ebola. Those two animals were in cages in the path of air flowing from the infected pigs' enclosure. After several more days, the other two macaques developed the disease.

While the finding could indicate that the virus spread through the air, the researchers can't rule out the possibility that the virus infected the macaques via water droplets scattered while cleaning the pig cage.

Mole rat is a natural cancer fighter

Underground rodents evolved a way to zap mutating tissue

By Tina Hesman Saey

Subterranean rodents with no eyes may show scientists a new way to beat cancer.

Blind mole rats — solitary, tunnel-dwelling cousins of rats and mice — live a long time and don't get cancer. Biologists thought the animals probably avoided the disease through the same strategy seen in naked mole rats, another long-lived subterranean rodent related to guinea pigs. In naked mole rats, a cell-suicide program called apoptosis turns on when cells get overcrowded, as might happen in a tumor.

But it turns out that blind mole rats have their own way of dealing with tumors, one that stems from adaptation to an underground lifestyle in which oxygen is scarce, researchers from the United States and Israel report in the Nov. 20 *Proceedings of the National Academy of Sciences*.

That both rodents have distinct ways of avoiding cancer is surprising, says Steven Austad of the University of Texas Health Science Center in San Antonio. "This is like finding two needles in a haystack," he says.

Blind mole rats ought to be susceptible to cancer because their cells can't kill themselves through apoptosis. Low-oxygen conditions, such as those common in blind mole rats' burrows, usually trigger cell suicide in other animals. To survive underground, the blind rodents had to evolve a countermeasure, a mutation in a cancer-fighting protein called p53. That mutation prevents cells from undergoing apoptosis, a process used to kill off cancer cells. Human cancer patients often have similar mutations that prevent tumor cells from dying.

Blind mole rats fight cancer by killing off cells in a messy type of cell death known as necrosis.

COURTESY OF ANDREI SELUANOV

But blind mole rat cells still find a way to off themselves. Growing cells in laboratory dishes, Vera Gorbunova of the University of Rochester in New York and colleagues found that the animals' cells die on cue after three days. The cells release a chemical called interferon-beta, which the immune system normally uses to fight viruses. In this case, the chemical caused blind mole rat cells to burst open in a violent death known as necrosis.

The researchers are now trying to determine what triggers cells to release the chemical and how necrosis heads off tumors without damaging healthy tissues.

Low-oxygen conditions may have inadvertently adapted mole rats, both blind and naked varieties, to avoid getting cancer, Austad says. But the fact that the two species do things differently "argues to me that there are probably many ways to prevent the out-of-control growth of cancer."

Telomere length linked to death risk

Association between chromosome caps and health studied

By Tina Hesman Saey

Nearly gnawed-off telomeres — the protective caps on the ends of chromosomes — may portend a higher risk of death, a new study suggests.

Telomeres prevent a chromosome's DNA from degrading. Previous studies have shown that telomeres shorten with age and have linked short telomeres with several diseases. What no one has yet been able to say is whether truncated telomeres cause health problems or are a side effect of aging and poor health.

To find out, researchers at Kaiser Permanente and the University of California, San Francisco measured telomere length in 110,266 people in northern California. The participants are part of an ongoing project that explores links between genetics and health. This study is the largest ever to examine telomeres' role in health.

> "It seems as though once your telomeres get critically short, your risk of dying goes up."
> CATHERINE SCHAEFER

The 10 percent of people with the shortest telomeres had more than a 20 percent higher risk of dying during the roughly three-year study period than people with longer telomeres, Catherine Schaefer reported November 8. "It seems as though once your telomeres get critically short, your risk of dying goes up," said Schaefer, an epidemiologist who directs the Kaiser Permanente Research Program on Genes, Environment and Health. The increased death risk is about the same as for people who drink 20 to 30 alcoholic beverages per week or smoke for 20 to 30 years. "It's a modest increase, but it's not nothing."

The researchers don't know the causes of death or the medical status of patients before they died.

Telomeres do get shorter with age, the study confirms, but men older than 75 and women over age 80 tended to have longer telomeres than their slightly younger counterparts. That result does not mean that telomeres start to grow in length once people reach a certain age, Schaefer said. Rather, the finding probably means that people with shorter telomeres died before they reached those ripe old ages and the survivors are those that carry longer telomeres.

African-Americans tended to have longer telomeres than European-Americans, Latinos or Asians, the researchers found. The reason for that difference is not clear. As expected, people who smoked or drank heavily were more likely to have shorter telomeres, and higher levels of education were associated with longer telomeres. Other studies have linked exercise with longer telomeres, but Schaefer and her colleagues found no such association.

One of the study's findings is rather puzzling, said anthropologist Dan Eisenberg of the University of Washington in Seattle, who studies telomeres' link to health. Higher body mass index, or BMI, was associated with longer telomeres. The discovery is counterintuitive, Eisenberg said, because higher BMIs — those associated with being overweight or obese — are linked to a variety of health problems including diabetes and heart disease. Eisenberg said he would have expected telomeres in people with higher BMIs to be shorter.

Schaefer agrees that the BMI link is a provocative finding. "We know that high BMI is not healthy," she said, but more work will be needed to understand the relationship between body size and telomere length. ■

MEETING NOTES

Genetic analysis ties Iceman to modern Sardinia

The genetic makeup of the 5,300-year-old mummy known as Ötzi suggests his modern-day relatives live in Sardinia, not near the border of Austria and Italy where his corpse was found. New analyses of DNA from present-day Europeans and remains of five other ancient people suggest he was probably part of a wave of migration of Middle Eastern farmers into Europe, Martin Sikora of Stanford University reported November 8. Ötzi shares a more similar genetic makeup with a 5,000-year-old Swedish farmer and a 2,500-year-old Bulgarian than he does with hunter-gatherers from Sweden and the Iberian Peninsula.

—Tina Hesman Saey

Genes link childhood growth and adult obesity

Some of the same genes that spark growth spurts in preschoolers predispose adults to obesity, a new study suggests. Marjo-Riitta Jarvelin of Imperial College London looked for genes associated with fast growth in more than 7,000 Finnish children and then repeated the search in more than 16,000 other children. Jarvelin reported November 9 that two genes are associated with how chubby babies are at 9 months old. One gene is involved in appetite control. The other gene, *PCSK1*, encodes an enzyme that helps make insulin. Three genes associated with early growth spurts and higher body mass index at about age 5 are also linked to obesity in adults, Jarvelin reported.

—Tina Hesman Saey

Humans

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Ancient Maya's fate tied to rainfall

Climate shifts help explain civilization's prosperity and decline

By Bruce Bower

Classic Maya civilization rose and fell with the rains.

This once majestic society, known for massive pyramids and hieroglyphic writing, expanded during an unusually rainy time and declined as the sky's spigots dried up and periodic droughts arrived, a new study suggests.

A stalagmite from Yok Balum Cave in Belize helped researchers reconstruct climate patterns during Classic Maya times. A rainy period allowed agriculture to prosper; war accompanied drought.

A 2,000-year climate record, gleaned from a stalagmite inside a Belize cave, highlights a central role for climate shifts in the ancient civilization's fortunes, say anthropologist Douglas Kennett of Penn State University and his colleagues.

A bounty of rain nurtured Maya agriculture and city building from the years 440 to 660, Kennett's team reports in the Nov. 9 *Science*. A drying trend and occasional droughts after 660 were accompanied by declining crop yields, increasing warfare among Maya city-states and shifting political centers northward into the Yucatán Peninsula, the researchers say. After the collapse of Maya political systems between 800 and 1000, a severe drought hit southern Belize from 1020 to 1100 and apparently motivated remaining Maya to leave the area.

"It looks like the Maya got lulled by a uniquely rainy period in the early Classic period into thinking that water would always be there," Kennett says.

His team analyzed a stalagmite that grew in Yok Balum Cave from 40 B.C. to A.D. 2006. Rainfall estimates for each year of rock formation were derived from measurements of a form of oxygen that accumulated in the stalagmite as runoff from rains entered the cave.

Researchers have argued for decades about whether the Classic Maya collapse stemmed more from droughts or from warfare and weakened political systems. Intermittent droughts after 660 probably increased political pressure on already weakened Maya rulers as well as undermined the power of kings, Kennett says. Both situations would have upped the chances of wars breaking out.

Kennett's team has produced a "groundbreaking" rainfall history for southern Belize, says anthropologist Diane Chase of the University of Central Florida in Orlando.

But further work needs to establish whether the new climate record also applies to Classic Maya sites in Guatemala and the Yucatán, says anthropologist Vernon Scarborough of the University of Cincinnati. Droughts could have affected some parts of Classic Maya territory more than others, he says.

Early hominid had unusual diet

Eating grasses, sedges goes back at least 3 million years

By Bruce Bower

A mysterious, 3-million-year-old member of the human evolutionary family had a maverick taste for grasses and flowering plants called sedges, a chemical analysis of the creature's teeth suggests.

Central Africa's *Australopithecus bahrelghazali* was apparently not a devotee of leaves, fruit and other standard fare of early hominids based in forested areas. Instead, it fed mainly on underground parts of grasses and sedges growing in a savanna landscape, archaeologist Julia Lee-Thorp of the University of Oxford and her colleagues report online November 12 in the *Proceedings of the National Academy of Sciences*.

The only known remains of *A. bahrelghazali* are a partial lower jaw holding seven teeth, as well as teeth from other individuals unearthed in 1993 at Koro Toro in Chad. Researchers concluded that the hominid species lived between 3.6 million and 3 million years ago.

Chemical analyses of a tooth from this fossil jaw and of two other teeth indicate that their owners ate a lot of grasses and sedges.

Lee-Thorp's team measured two forms of carbon in teeth from three *A. bahrelghazali* individuals and in fossil teeth of various animals found at Koro Toro. One form of carbon comes mostly from grasses and sedges, and the other mainly from shrubs and trees.

More fossil teeth will be needed before researchers can flesh out all *A. bahrelghazali*'s eating habits, says anthropologist Peter Ungar of the University of Arkansas in Fayetteville.

"The puzzle of early hominid food choices looks more and more complicated as we add pieces to it," Ungar says.

FROM TOP: D. KENNETT/PENN STATE; M. BRUNET

Molecules

"These muscles are extraordinarily simple, but they have extraordinarily high performance." —RAY BAUGHMAN

Tiny muscles pull a big punch

Coated carbon nanotubes form smart new material

By Rachel Ehrenberg

Beefing up some muscles doesn't take steroids or exercise — paraffin wax will do. Incorporating wax into musclelike threads spun from carbon nanotubes gives them superior flexing power, a discovery that could lead to smart materials such as fabrics that respond to environmental changes.

The artificial muscles, about twice the diameter of a human hair, can lift 175,000 times their weight, outperforming mammalian muscles and all previously made artificial muscles (*SN: 12/4/10, p. 20*), a team reports in the Nov. 16 *Science*.

"This is a new kind of smart material, different from all the rest," says Mark Schulz, a mechanical engineer at the University of Cincinnati.

Scientists grew slender carbon nanotubes — each about 9 nanometers across, or nine billionths of a meter — and drew them out into a sheet. Then the researchers slathered it with a material such as wax and spun it into a yarn, or vice versa. Anchoring the ends of a length of yarn and twisting it into a tight coil made the muscles ready to spring, akin to the twisted rubber band that powers a balsa wood model airplane.

Next the scientists used a battery or a flash of light to apply heat to the muscles, slightly melting the wax, which swelled. The yarn expanded in diameter while contracting in length, essentially flexing the yarn. Experiments with an attached paddle found the torque created was better than that of a good-sized electric motor, says Ray Baughman of the University of Texas at Dallas, who led the research.

Yarn spun from carbon nanotubes coated with wax (scanning electron microscope image shown) creates lightweight, exceedingly strong muscles.

The yarns can also be embedded with materials that expand in response to factors other than heat. Nanotubes coated with palladium, for example, flex when they absorb hydrogen gas.

The artificial muscles might help operate cameras, toys or small robots. They might also prove useful as environmental sensors.

"These muscles are extraordinarily simple," Baughman says, "but they have extraordinarily high performance." ■

COURTESY OF *SCIENCE*/AAAS

Families in flux

As household arrangements take new directions, scientists attempt to sort out the social effects

By Bruce Bower

It's enough to send chills down Ozzie's and Harriet's happily married, two-kids-and-a-backyard, 1950s-sitcom spines.

Census and survey data for 2010 show that only half of U.S. adults age 18 or older are married, a proportion that has steadily declined from 72 percent in 1960. Marriage rates have plummeted most dramatically among 18- to 24-year-olds and among adults without college degrees, mostly from lower- and middle-class households. With marriage in retreat, other living arrangements — unmarried adults cohabiting with or without children, single people living alone, single parents raising children, to name a few — are on the rise.

At the same time, couples that do commit for the long haul come to their unions with new motives and expectations, and a determination to generate their own definitions of what constitutes wedded bliss. Most notable, marriage is now becoming an option for some gay partners, with same-sex marriage currently legal in nine states and the District of Columbia.

"Traditional heterosexual marriage has already been destroyed," says social historian Stephanie Coontz of the Evergreen State College in Olympia, Wash. "People now decide for themselves who and when and whether to marry, and whether to have children and how to divide household tasks."

In today's charged atmosphere, social science is under intense pressure to determine how well different types of new families work. Politicians, scholars and special interest groups impatiently await studies that can be exploited or criticized, depending on the findings. The social scientists, a generally liberal crowd, want to get an empirical grip on the effects of new arrangements, to inform issues ranging from the legalization of same-sex marriage to the allocation of funds for preschool interventions. While investigators aren't yet declaring winners in this divisive debate, new research is providing provocative, albeit preliminary, takes on the strengths and weaknesses of various family types.

Consider these findings: Living with an unmarried partner may provide all the physical and emotional health benefits of being married. Public commitment vows help relationships last longer, whether partners are married or living together, straight or gay. Behavioral problems are escalating in children of both sexes, a trend that has been linked to an increase in single motherhood. Most controversial, some research shows that young adults

FROM LEFT: FRAME: © MIKE IRWIN/SHUTTERSTOCK; PHOTO: GARY JOHN NORMAN/GETTY IMAGES; FRAME: © KUZNETCOV_KONSTANTIN/SHUTTERSTOCK; PHOTO: © CULTURA CREATIVE/ALAMY; FRAME: © KUZNETCOV_KONSTANTIN/SHUTTERSTOCK; PHOTO: PHOTO_ALTO/ISTOCKPHOTO

who have opposite-sex parents display better emotional health than peers with gay mothers.

The results cover a lot of social territory, and investigators caution that it will take decades to fully untangle the consequences of the shifts occurring today.

But research efforts have long been aimed at keeping up with fluxes in family life. Roughly four decades ago in the United States, for example, states began adopting no-fault divorce laws that made it easier to untie the knot. Though the move was originally criticized as a legislated death knell for marriage, only recently has it become apparent how the no-fault divorce revolution panned out, says economist Douglas Allen of Simon Fraser University in Burnaby, Canada.

Divorce rates indeed rose by as much as 20 percent in the 20 years after no-fault divorce first appeared, Allen says. By the 1980s, half of all first marriages in the United States went kaput. Since then, though, the trend has reversed. Today, roughly one-third of first marriages end in divorce.

Likewise, the effects of today's declining marriage rates and other changes may play out over many years.

Vow power

For those willing to take the plunge, research has long suggested that marriage is a happiness-making, health-promoting institution, at least on average. New evidence shows that the same may hold for what Ozzie and Harriet would have referred to as "living in sin," which researchers call cohabiting.

The number of cohabiting heterosexual couples in the United States shot up from 500,000 in 1970 to more than 7.5 million in 2010, whereas the total U.S. population grew by about half.

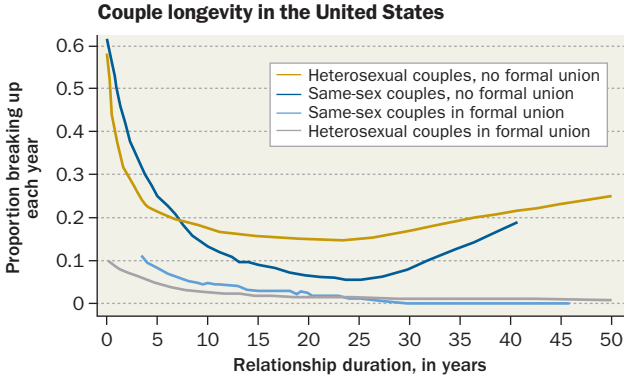
Married and cohabiting folks do comparably well emotionally and physically, say sociologists Kelly Musick of Cornell University and Larry Bumpass of the University of Wisconsin–Madison. The scientists analyzed interviews of more than 2,200 randomly chosen adults who had been contacted from 1987 to 1988 and again from 1992 to 1994, the most recent data available to the team.

Married couples fared slightly better than cohabiting partners in physical health, but cohabiting couples reported a slight edge over marrieds in happiness and self-esteem, Musick and Bumpass reported in the February *Journal of Marriage and Family*. After getting married or moving in together, both brands of partners cut down on social activities to spend more time with each other. These results held after accounting for cohabiting couples' inclination to call it quits

Making it last

A two-year study surveying thousands of people living in the United States found that couples in formal unions have lower annual breakup rates than couples who do not declare a commitment. This trend held for heterosexual and same-sex couples.

SOURCE: M. ROSENFELD AND R. THOMAS/*HOW COUPLES MEET AND STAY TOGETHER* 2011



more often than married partners do.

Be they husband and wife or not, partners who pledge their love in public stay together longer. New work suggests that a commitment to one another in front of family and friends, even when it is not legally recognized, may boost a relationship's life span.

"Commitment vows are very powerful, even in a cynical era when people aren't afraid of getting divorced," says Stanford University sociologist Michael Rosenfeld.

Heterosexual and gay couples who make public vows — either in marriage ceremonies, upon forming legal domestic partnerships or on their own initiative — report low breakup rates that fall to near zero among couples who have lived together for at least 20 years, Rosenfeld finds. Couples that don't make public commitments to their relationships split at much higher rates.

Rosenfeld's results come from a representative sample of 3,009 people living in the United States who completed annual Internet surveys from 2009 to 2011.

Breakup rates over the two-year period reached 46 percent for unmarried heterosexual couples who didn't live together or formalize their relationship, and ascended to 61 percent for their gay counterparts. Even after 40 years together, about 20 percent of same- and opposite-sex partners who skipped the vows went their separate ways, Rosenfeld reported in August in Denver at the annual meeting of the American Sociological Association.

In contrast, just under 3 percent of married, heterosexual couples broke up during the study. Gay men who were married or in domestic partnerships split at about the same 3 percent rate as married heterosexuals. Marriages and domestic partnerships among gay women dissolved at a 9 percent clip. Reasons for more breakups among gay female partners than gay male partners remain unclear. Women tend to have higher standards for what counts as a satisfying relationship than men do, Coontz suggests, perhaps making the female couples a bit less stable.

Opposite-sex domestic partnerships fared slightly worse, with a 16 percent breakup rate. And about one-quarter of opposite-sex cohabiting couples parted ways over the two-year stretch. But that's still better than those showing no sign of commitment.

Rosenfeld's study unveils the power of an openly declared commitment, Coontz says. Public ceremonies encourage relatives and close comrades to provide moral and financial support to couples, but that is especially true for those who wed. "Marriage doesn't create commitment, but it can reinforce commitment," she says.

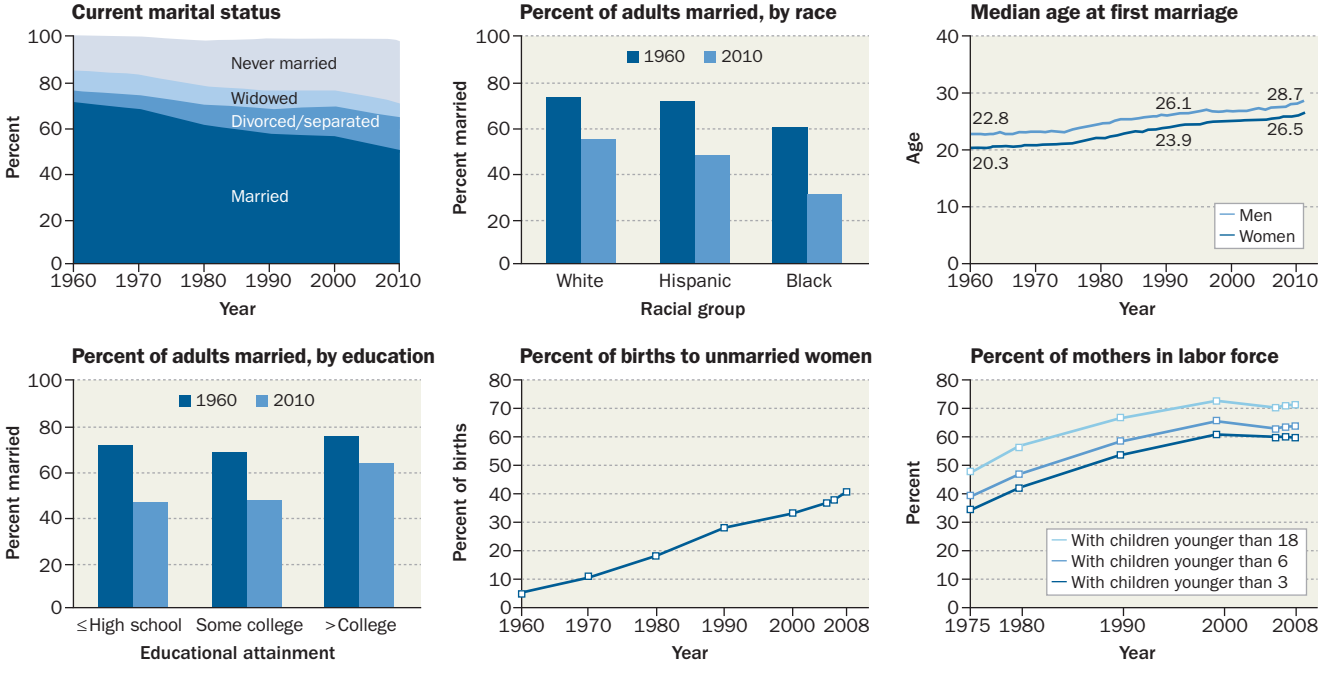
After the altar

Even the most steadfast same-sex relationships ignite controversy when kids enter the picture. About 100,000 gay couples in the United States are raising children amid a fierce national debate about what effects, if any, such family arrangements have on child development.

A 2005 brief issued by the American Psychological Association concluded that children raised by same-sex parents do just as well socially and emotionally as kids with a mom and a dad at home.

But the 59 studies referenced in the brief contain too many flaws to say

Half-century shifts Though scientists are still struggling to understand the effects of changes in the American family, some recent trends are clear: Fewer people are getting married, and those who do are tying the knot later in life. Declining marriage rates are more pronounced among those with little education. More unmarried women are having children, and more mothers are working outside the home. SOURCE: PEW RESEARCH CENTER



anything about same-sex parenthood, concluded family studies professor Loren Marks of Louisiana State University in Baton Rouge in the July *Social Science Research*. Most of the research cited by the APA consisted of small numbers of affluent, self-selected gay parents who weren't compared with heterosexual parents of similar backgrounds, he says. Among other problems, measures of children's well-being varied from one study to another and few investigations tracked kids beyond childhood.

A study aimed at providing a clearer look at the adjustment of kids with same-sex parents, appearing in the same issue of *Social Science Research*, set off its own wave of disputes. Sociologist Mark Regnerus of the University of Texas at Austin analyzed data from a nationally representative sample of nearly 3,000 people, ages 18 to 39, surveyed in 2011 and early 2012.

Regnerus compared 163 individuals who reported that their mothers had a past or current gay partner with 919 participants who grew up with a biological mother and a father. Those from families headed by a gay mother displayed poorer mental and physical health, were more often unemployed and reported more problems in their current romantic relationships. A separate group of 73 participants had gay fathers, but that was too few to make any confident assertions.

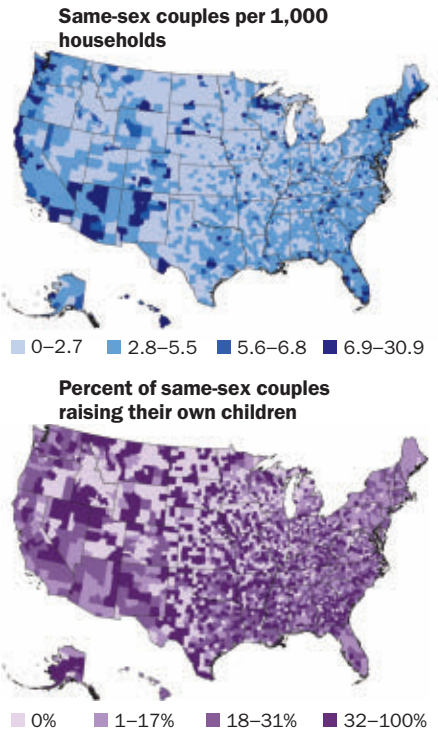
Regnerus acknowledges that the results do not show that a gay mother's sexual orientation or sexual behavior causes emotional and social problems in her children. The findings could reflect the fact that many gay mothers had previously been married to men and gotten divorced, so their children had contended with parental breakups while kids with opposite-sex parents often had divorce-free upbringings.

What's more, social stigma about gay parenthood might have made the wonder years even tougher for kids with lesbian mothers.

Regnerus' study swiftly came under attack. A letter published in the November *Social Science Research*, signed by 200 social scientists and scholars, criticized the work as muddled and misleading. Aside from the apples-and-oranges comparison of people with previously divorced gay parents and offspring of never-divorced heterosexual parents, Regnerus didn't confirm parents' sexual orientation, the letter asserts. As a result, it is unknown how many parents in Regnerus' same- and opposite-sex households were bisexual and whether that has made a difference for the children.

Better investigations are in the works, says Allen, of Simon Fraser. Small numbers of same-sex parents and the many paths that bring children into families with two men or two women as parents present big research challenges. Allen is currently analyzing census data on Canadian families, including about 1,400 with same-sex parents.

"We've got a long way to go before we can say whether children are better off, the same or worse off in same-sex families compared to intact biological families," Allen says.



Same-sex stats More than 600,000 couples identified themselves as same-sex in the 2010 U.S. census, more than five per 1,000 households. About 17 percent of these couples were raising children belonging to one of the spouses (by birth, marriage or adoption).

GARY GATES AND ABIGAIL COOKE/THE WILLIAMS INSTITUTE/UCLA

Bad girls, worse boys

Evidence is much clearer that children generally do better in families with two parents rather than one. An upsurge in single-mother families over the last 20 years helps explain the unsettling growth of behavior problems among young boys and girls, says Jayanti Owens, a sociology graduate student at Princeton University.

Owens consulted data from national samples of children born in the 1980s and the early 2000s who had been tracked by other researchers from birth until at least kindergarten. Unsurprising to Owens, boys from this cross section of U.S. families lost their tempers, got in fights, talked out of turn and otherwise misbehaved more than girls.

After controlling for mothers' incomes, children's early scores on mental tests and a variety of other factors, Owens calculated that an expansion of single motherhood substantially contributed to the two-decade rise of kids' misbehavior. Jumps in childhood physical problems such as low birth weight and asthma also stoked the troubling trend.

In single-mother families, boys are more likely than girls to veer into misconduct, Owens' analysis suggests. Increasing numbers of girls are behaving badly, but boys' rates of unruliness have escalated even faster, from a higher level to begin with.

"Girls are now at the level of behavior problems displayed by boys 20 years ago," Owens says. "It's an open question whether rates of behavior problems will continue to rise."

In her national samples, the proportion of 4-year-old boys raised by single mothers in the mid-2000s was around 33 percent and the proportion of 4-year-old girls was 35 percent, both up from the late 1980s.

Family instability may help explain Owens' finding. Recent work by sociologist Carey Cooper of Arizona State University in Tempe finds that boys whose family arrangements changed more often showed increased conduct problems and language difficulties up to age 5. The steadier the family situation,

the more young boys' misbehavior was held in check.

Unstable families in the study, reported last year in *Sociology of Education*, included but were not limited to families where a mother started out married, got divorced, lived with another man and then struck out on her own.

Boys' disruptive lead over girls has long-term consequences. It may, for example, help explain why young women have become more likely than young men to graduate from high school and attend and graduate from college, especially in the middle- and lower-income households where single mothers are most common, Owens said at the sociology meeting.

Family unknowns

Such findings only scratch at the surface of some vital questions about the social effects of modern family life. Owens' results, for instance, may ultimately speak to what some researchers consider to be an overall cultural decline of males.

Though the idea is debated, there are investigators who argue that, in a knowledge-based economy, girls' overall advantages over boys in concentration, self-control and goal-setting may translate into greater educational success and better-paying jobs. If current childhood misconduct trends continue, male and female achievement may decline to different extents over the next few generations, Owens says, though she notes that there is no way to know if that scenario will play out.

Other head-scratchers concern whether today's partner-defined commitments will increasingly skew who decides to get and stay hitched. "We're seeing a major class divide emerge in who gets married," Coontz says, with well-off, college-educated couples most apt to walk down the aisle and negotiate successful marriages. It's hard to predict whether 20 or 50 years from now, marriage will have become an exclusive luxury of the affluent.

Low-income couples who do get married and then split up, unlike affluent couples, increasingly forgo divorce for indefinite separations, Dmitry Tumin, a graduate student in sociology at Ohio State University, reported at the sociology meeting. "Marital separation is becoming an alternative to divorce among the poor," he said.

Most divorces these days follow separations of a few years. But more than 10 percent of separations now last for at least 10 years, Tumin said. Poor couples, who are least able to pay for a divorce and who may still need one another's help for child care, frequently opted for extended separations.

Ozzie and Harriet certainly wouldn't have lived apart for a decade, much less hired a divorce lawyer. If the Nelsons argued, they resolved the tiff in 30 minutes, with time for commercials.

Today's real-life families are headed in a variety of directions, though, with strengths and weaknesses yet to be determined. Ozzie and Harriet, among the first sitcom couples to share a bed, would be as eager as anyone to see how all the changes shake out. ■

Explore more

- Michael Rosenfeld's website: www.stanford.edu/~mrosenfe
- More info on social trends from the Pew Research Center: pewresearch.org/topics/socialtrends

Matchmaking through time

In the networked world of human evolution, love took a backseat to parental matchmaking.

Arranged unions of men and women have been the norm since humans first left Africa between 60,000 and 70,000 years ago, says anthropologist Robert Walker of the University of Missouri in Columbia. In a 2011 paper, Walker and his colleagues combined mitochondrial DNA patterns and mating practices from a worldwide sample of hunter-gatherer groups to reconstruct likely ways in which eligible guys and gals partnered up in the distant past.

No one can say for sure what social life was like in the Stone Age. But by looking at the mating behavior of modern hunter-gatherers with the most ancient genetic roots, the researchers estimate that Stone Age men and women usually formed monogamous relationships arranged by their parents. Families of marriage partners typically exchanged goods or labor to seal a union, a practice still common today. Courtship might still have characterized a minority of Stone Age groups, as it does a small number of present-day hunter-gatherer societies, Walker says.

His findings are consistent with an idea, developed by anthropologist Bernard Chapais of the University of Montreal, that arranged marriages of men and women from neighboring foraging groups opened the door to complex human societies. Networks of in-laws enabled cultural innovations to spread rapidly and united bands into larger social units (*SN: 4/9/11, p. 13*).

Ancient civilizations may have carried matchmaking even further. Historical accounts from 16 societies going back more than 4,000 years to ancient Egypt consistently describe marriages controlled by parents, especially fathers, to promote favorable family alliances, evolutionary psychologist Menelaos Apostolou of the University of Nicosia in Cyprus reported this year in *Evolutionary Psychology*. Sexes were strictly segregated to prevent illicit love affairs.

In Northwest Europe and North America, the Industrial Revolution of the early 1800s allowed young adults for the first time to make a living on their own, outside family farms and parental control, says demographic historian Steven Ruggles of the University of Minnesota in Minneapolis. That shift laid the groundwork for love matches and other family shake-ups, he says.
—Bruce Bower

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Into the fold

Flat structures pop into 3-D forms, yielding miniature robots and tools

By Susan Gaidos

As a graduate student, roboticist Robert Wood became fascinated with the idea of developing a life-size, flying bee machine. Able to soar above trees or maneuver around obstacles, such a robot, Wood figured, could gather secret information for military missions or monitor hazardous environments without risking human lives.

Later, when he set up his own lab at Harvard University, Wood developed a system to cut materials into well-defined shapes and fold them into insect-sized parts. Creases and pleats gave the structures their three-dimensional forms.

Still, creating a tiny robot proved difficult. Because the structures were so small, the scientists had to use microscopes and tweezers to introduce a ridge or crimp an edge. "Assembly by folding gives you the ability to create all sorts of mechanisms and structures," Wood says. "But the folding part was tremendously difficult and not very precise."

One evening while reading to his young son, Wood had a eureka moment: Why not get the bees to fold themselves? Inspired by the intricate engineering found in pop-up books, where structures go from flat to 3-D with the turn of a page, he began investigating ways to get the pieces to swing into place on their own.

Inspired by the folding methods in pop-up books for children, researchers developed this self-assembling robobee.

Wood's group has since developed a number of prototypes, combining layers of rigid materials and electronics that, when prompted, self-fold into miniature aerial machines.

His approach, and others like it, may one day lead to all kinds of structures that are hard to create using current manufacturing methods. Applications for the research go far beyond flying machines. Scientists are now seeking ways to use self-folding to add surgical robots to the ends of catheters in order to peer into the darkest recesses of the human body, remove polyps or cauterize tumors. Self-folding also holds promise for delivering drugs and other therapies

THE HARVARD MICROROBOTICS LAB

into the human body, says David Gracias, a chemical and biomolecular engineer at Johns Hopkins University, who outlined the idea in the March *Trends in Biotechnology*. In addition, antennas and solar cells that unfold automatically may even make their way onto satellites of the future.

Self-folding offers the potential to revolutionize many areas of medicine and electronics, Gracias says. But figuring out how to go about doing it is another thing. Most applications are years away from real-world use, awaiting solutions to several challenging obstacles.

For starters, scientists need to develop materials that can be rolled, folded or molded into various shapes. Another challenge is figuring out where and how to embed the instructions for folding. Ultimately, researchers will have to find ways to guide self-folded devices once they achieve their final form, for example powering the miniature machines so that they can fly on their own. A variety of approaches, many borrowed from the manufacture of printed circuit boards, are at the experimental stage.

Buckle up

A lot of the three-dimensional structures found in nature fold and unfold into well-defined forms. Leaves, for example, unfurl in a predictable pattern from a small, oval bud. Proteins, which start out as formless strings of amino acids, fold and unfold depending on molecular signals provided by their local environment.

Scientists and engineers are working to emulate this type of self-folding to create complex objects too tiny to be assembled by existing machines. The problem, Wood says, is that traditional manufacturing methods fall into two categories. Some methods are designed to assemble large-scale, three-dimensional objects such as cars or refrigerators part by part. Others very precisely etch shrunken components onto two-dimensional surfaces such as computer chips. Neither approach is adequate for assembling the fine-scaled three-dimensional features needed to make a flying robot the size of a bumblebee.

Before developing its "pop-up" technique, Wood's team had to build each individual robobee manually, adding pieces one at a time. The process was time-consuming, requiring a high level of training and a steady hand. Even then, the results were uneven: Only a small percentage of the bees built in this painstaking fashion worked properly.

Self-folding provided a way to create diminutive structures, on scales of micrometers to centimeters, without having to do a lot of complex assembly, Wood says. By patterning flat structures and then getting them to curl or fold, scientists can produce 3-D forms with the precision of 2-D techniques. Wood's fully functional robobees, for example, have a wingspan of about 3 centimeters — a little wider than the diameter of a U.S. quarter, and comparable to the wingspan of some bumblebees.

Material matters

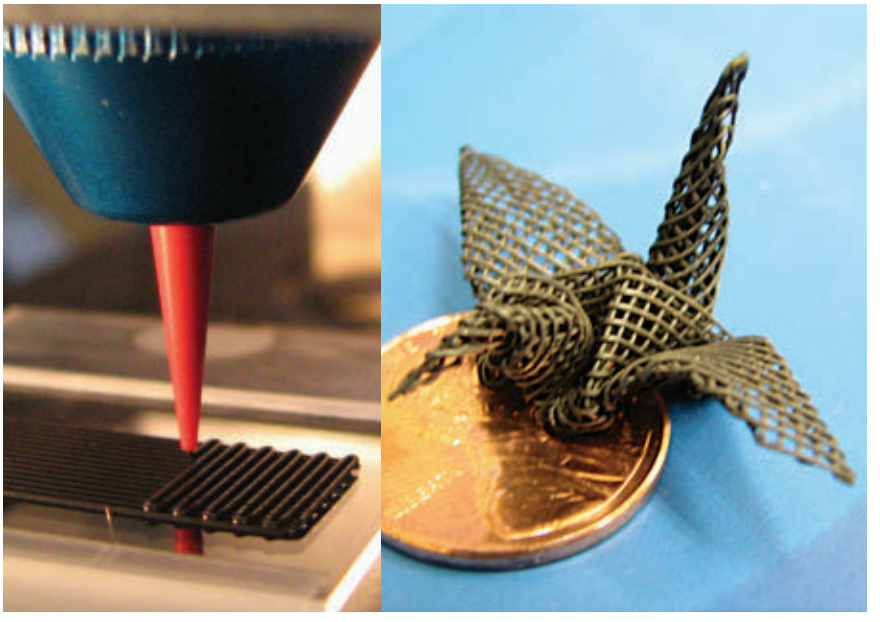
While Wood's robobee assembly relies on a scaffold to trigger the folding of rigid, hinged parts, other approaches demand more bendable materials. So scientists are also in search of substances that can be programmed to achieve a specific shape and then transform into another. Such materials might be used to create the ultimate reconfigurable robot — one that can turn into absolutely anything.

But many of the materials used in manufacturing today don't easily bend or fold. Some, such as metals and ceramics, are downright brittle and thus prone to cracking. Scientists who want to take full advantage of self-folding's potential will need to make these materials pliable, or create new ones with built-in flexibility.

That's what Jennifer Lewis, a materials engineer at the University of Illinois at Urbana-Champaign, is doing. Drawing on a technique used in paper origami, in which artists moisten the paper to make it more malleable, she has found ways to create materials that can be handled and folded without cracking.

Lewis' fabrication technique depends on direct-write assembly, in which a small nozzle deposits ink containing metal or ceramic particles directly onto a substrate. By mixing solvents with the ink, her team creates sheets that dry only partially. As long as the ink has some solvent, the material remains plasticlike; it can be folded, unfolded and refolded again and again.

Lewis says the approach, outlined in



To create a 3-D structure, researchers in Illinois start by printing slow-drying ink of metal or ceramic particles into flat sheets (left). Such sheets can be folded and refolded into 3-D shapes (crane, right) as long as the ink doesn't dry completely.

BOTH: BOK YEOP AHN *ET AL*/*ADVANCED MATERIALS* 2010

2010 in *Advanced Materials*, can be modified to lengthen the material's window of foldability. Solvents with a high boiling point remain stable at room temperature and barely evaporate at all. Such solvents might allow a material to retain its bendability for months or years.

To date, all of the structures created in Lewis' lab have been folded by hand. Now the trick is to find ways to make the materials curl up on their own.

One way to go about that would be with "shape-memory" polymers and alloys, materials capable of undergoing phase transformations in response to stimuli such as heat. As the materials transition from one phase to another, they contract, which could drive a folding action.

Such materials were recently used by scientists at North Carolina State University in Raleigh to create self-folding, box-like structures. A group led by Jan Genzer and Michael Dickey showed how sheets of stretched material called Shrinky Dinks could be programmed to fold into a desired shape with the simple addition of lines printed in black ink. When exposed to a high-heat lamp, the ink absorbed the heat, causing the sheet to shrink down along the lines to its original size. This shrinking created creases that triggered the folding.

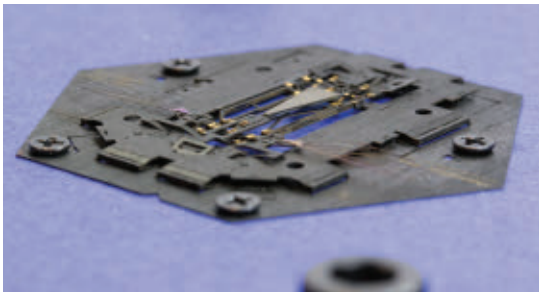
A new wrinkle

Whether working with rigid or bendable materials, getting the final product right means making sure the angles of the folds are correct. That requires precision in positioning hinges or creases, Gracias says.

Gracias and his group are strategically placing tiny hinges on polymer films and other materials so that they fold into capsules, similar to the way viruses construct their shells. The goal is to make dust-sized devices, such as drug-carrying containers that can circulate through the bloodstream to deliver medicine only where needed. The researchers envision a hollow shell — a simplified geodesic dome of sorts — with a precisely patterned surface that is not only porous, but also capable of flexing to control the release of medication over long periods of time.

Last year, the group got a good start, creating a self-assembling 12-sided polyhedron with faces angled at 116.6 degrees.

To figure out what folding pattern would turn a flat sheet into a desired shape, Gracias joined efforts with mathematician Govind Menon of Brown University. Using a computer program, the scientists first "cut" a virtual version of the desired shape apart along its faces and flattened it to find all the possible 2-D arrangements, called "nets," that might work. A single 3-D shape may have thousands of different nets that could re-create it when folded. After sifting through the possibilities, the scientists selected a handful to try, fabricating those versions in the lab. Through trial and error, the researchers found that the more compact nets — those with faces that linked up in more places — were better at self-folding. The compact nature forced a net to fold in a particular way, decreasing the chance of misfolding, Menon says.



To get the hinges to lift, the scientists deposited solder along the edges of each piece. When heated, the solder melted and balled up, causing the faces to fold upward. The edges pulled together to fuse the structure shut.

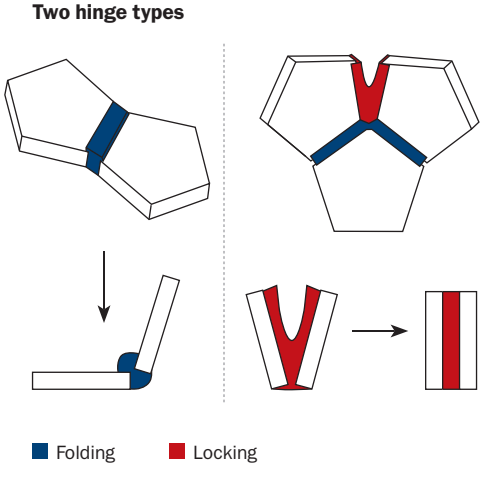
"That these structures fold is not all that interesting, but that they fold only into a specific shape with such precision is fascinating, because that is the meaning of self-assembly," Gracias says. Details of the study were reported last year in the *Proceedings of the National Academy of Sciences*.

Gracias and Menon are now studying ways to generate more complicated structures. One effort aims to create self-assembling buckyball-type structures that contain 50 to 60 faces each, as opposed to 12.

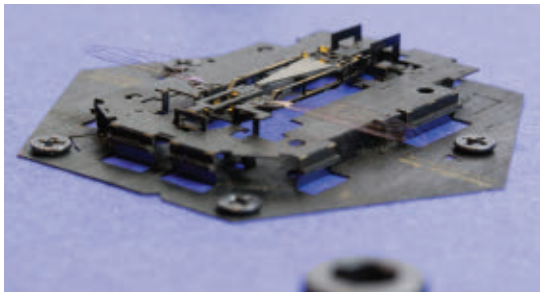
"We're beginning to uncover the rules of folding," Gracias says.

Gracias' group is also designing hinged structures that open and close, acting as microsurgery tools that, once swallowed or injected, could cut away damaged tissue or excise a tumor. In lab experiments, the researchers have used a microgripper guided by a magnet to retrieve animal

Hinge selection With the help of hinges, researchers can design flat structures that self-assemble into hollow three-dimensional capsules (left). But deciding how to arrange the faces, and thus the two types of hinges (below, left), can be a challenge. Many different arrangements can fold into dodecahedrons (below, right), but more compact versions do so more reliably.
SOURCE: C. RANDALL *ET AL*/*TRENDS IN BIOTECHNOLOGY* 2011



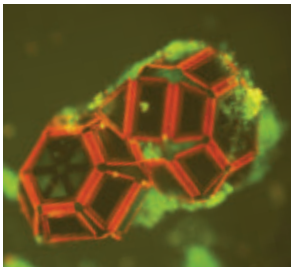
FROM TOP: THE HARVARD MICROROBOTICS LAB; S. PANDEY *ET AL*/*PNAS* 2011; STEPHEN EGTS



A robotic bee designed by Harvard researchers relies on a flat scaffold and more than 100 hinges. When the layers of the scaffold pop up, the bee takes shape and can be removed from its base.

cells placed in a glass tube. Recently, the team successfully performed a biopsy-like procedure with the microtool, gathering cells from the bile duct of a live pig. Results were reported online October 9 in *Advanced Materials*.

But hurdles, such as finding ways to include biocompatible materials in the self-folding structures, stand in the way of such devices becoming commonplace. Many of the manufacturing methods designed to create small structures were developed for the microelectronics industry, Gracias says, and simply aren't suitable for working with biological materials.



Self-folding devices that grip cells on command (shown) may one day be used for biopsies and other medical procedures.

Layers of complexity

While some groups figure out the best routes for folding by studying a single flattened structure, this approach doesn't always deliver on a desired function.

"Having multiple layers gives us a huge range of design options," Wood says. Wood's robotic bee, for example, starts as a stack of 18 sheets of strong but lightweight material sandwiched together. This structure allows researchers to add or etch electrical components onto the layers while the device is flat, using the same techniques chip companies rely on to make circuit boards.

To date, most of the bee's individual electronic components — such as vision and horizon-detection sensors that help the bees maintain stability while in flight — have been added manually. But the researchers are working on ways to integrate the components into the 2-D form by including "circuit layers."

Such additions make placing the folds a more challenging question. Each of the 18 sheets — carbon fiber for the body, titanium and polymer films for wings, and plastic for the joints — is cut to a certain pattern by a laser and aligned appropriately in the stacked sandwich. As the structure pops into shape, flexor hinges in the design push out, allowing the bee's wings and other tiny parts to join into a body. Later, the hinges allow the parts to bend and flex.

Figuring out where and how to place the more than 100 hinges that will create the pop-up bee continues to be grueling. Currently done by "paper and pen," the process requires months of work. That's because the hinges must be laid out through multiple layers of thickness. An incorrect arrangement might result in a configuration that cannot self-assemble or that causes the robot to freeze in action.

To tackle this challenge, Wood and his group have turned to Erik Demaine of the Massachusetts Institute of Technology. Demaine has long been fascinated by the mathematical problems that develop naturally in origami, and is an expert in a branch of science called origami mathematics. His studies include efforts to discern how the thickness of material — whether paper, polymer or metal — affects the ability to create different shapes by folding.

Wood is drawing upon such insights to develop a computer-based program that can help cut through the folding process. The new software will automate many aspects of the layout, showing where and how key mechanisms must be placed.

After developing shortcuts for making the intricate structures and electronics for their bee-sized robots, the scientists hope to tackle other challenges associated with the flying machines.

Currently, the prototype bees run on electricity transmitted through thin wiring from high-voltage amplifiers. Wood aims to add an onboard power source, such as a built-in battery. A thin battery could be included as an additional layer, or a micro–fuel cell could be glued to one of the existing layers during manufacturing.

Eventually, Wood says, he hopes to design a crew of fully functional robobees that act as a group, communicating and working together to explore places that are dangerous or hard to reach.

But it may be a decade or so before swarms of the bees are flying about. Before that time, other self-folding robots could find real-world applications.

Wood's team is experimenting with a 20-legged centipede-inspired robot to perform search-and-rescue operations. And Gracias' group is designing a wide array of self-folding devices — developing wireless, reconfigurable surgical tools that respond to light, pH, enzymes and temperature. Such abilities may allow the devices to reconfigure themselves in response to specific disease markers or conditions in the body.

One thing is certain: It will be fun to watch the developments unfold. ■

Explore more

- To watch video of the pop-up bee, visit micro.seas.harvard.edu

FROM TOP: BOTH: THE HARVARD MICROROBOTICS LAB; T.G. LEONG *ET AL*/*SMALL* 2010

Dear Future Earthlings

A message in a bottle won't be enough to communicate with distant generations

By Sid Perkins

When Geoffrey Chaucer wrote *The Canterbury Tales*, he probably didn't think much about the students who would painstakingly slog through the text hundreds of years later. This literary classic is loaded with references and expressions specific to its author's time — part of what makes it so difficult to read, even with CliffsNotes to serve as a decoder ring.

Likewise, people of the future will no doubt face tremendous challenges interpreting the texts of today. Far enough forward in time, it won't just be an issue of literary style. To be understandable tens of thousands of years from now, ideas must be expressed in a language that lasts and stored in a form that can survive millennia.

Storytellers may be willing to take their chances. But for others, leaving notes for the future is a task of great concern. Whether passing along a basic understanding of biology, documenting historical events or clueing future generations in to potential hazards, scholars believe some messages are imperative to convey. These forward thinkers have long been interested in designing messages that can be read and understood by people as unknowable to present-day generations as present-day generations would have been to Chaucer, or even the Neandertals.

New hardware for long-term message storage was reported earlier this year in Dublin at the Euroscience Open Forum, where archaeologists and nuclear scientists gathered to discuss how to warn future generations about buried nuclear waste. As for making the messages understandable, recent efforts by linguists and cultural anthropologists studying ancient Egypt's Rosetta Stone may suggest a trick. Anyone looking to communicate with the future could also take clues from astronomers attempting to get the attention of extraterrestrials; these efforts emphasize the importance of context.

Though some experts believe communicating with future humans may well be impossible, linguist Robert Millar of the University of Aberdeen in Scotland is optimistic. "They won't understand everything about the message," he says, "but they may be able to get pretty close."

Long-term storage

Books like those used in English class aren't suitable for holding messages destined for deep time, says Patrick Charton, a mechanical engineer at Andra, the French nuclear waste management agency, headquartered outside Paris.

Disks of industrial sapphire, printed with platinum and then sealed with a second disk, could preserve text and images for 1 million years.

FROM TOP: GREG801/ISTOCKPHOTO; ARNANO

Although some manuscripts from the Middle Ages survive today, paper typically lasts only a few centuries, even when stored under the right environmental conditions. Clay tablets like those excavated from archaeological digs throughout the Middle East are more durable, but they too have to be preserved properly. Prolonged exposure to moisture can turn these archives into mud.

Today's digital media devices may store vast amounts of data — somewhere around half a million books or about 2,000 hours of CD-quality audio can fit on a one-terabyte hard drive — but the lifetime of these devices is shorter than that of paper and clay tablets. Even if the equipment needed to read the hard drives sticks around, the devices themselves deteriorate within a few decades, if not sooner.

French researchers have come up with one solution: Engineers led by Alain Rey of Arnano, a company based in Grenoble, start with a thin, 20-centimeter-diameter disk of a form of aluminum oxide known as industrial sapphire. These transparent disks, which look like large CDs, are acid-resistant, scratch-resistant and more than five times as strong as tempered glass, Rey says.

The researchers engrave text or images into the surface of a disk and fill the etchings with platinum, which is more resistant to corrosion than gold. Finally, the team protects the information by fusing a second disk to the one containing the information. Charton, who oversees the French nuclear agency's program to develop long-lasting nuclear waste warnings, described the sapphire-and-platinum data sandwich in July at the Euroscience Open Forum.

Each disk can be etched with tiny images of tens of thousands of pages of information, Charton said, and acid tests suggest the disks could last as long as 1 million years. Another plus: People who discover the disks won't need an electronic device to read them, only a simple microscope.

Creating a data-storage method that could last as long as it takes for nuclear waste to become relatively harmless (*SN: 2/27/88, p. 139*) is only one hurdle in leaving warnings for far-distant generations. Scientists must also consider the language used to convey the message.

Death and evolution

When it comes to choosing which language to use to communicate with the future, there is good news and bad. The good news is that there are a multitude to choose from: Today, people on Earth speak somewhere between 6,000 and 7,000 languages. The bad news: By some estimates, one of those languages disappears every two weeks or so.

Rather than choose to encode a message in just one language, researchers might take a cue from the Rosetta Stone and choose several. The 760-kilogram chunk of black granite, discovered in Egypt in 1799, was inscribed with a decree issued by King Ptolemy V more than 2,200 years ago. Of great help to archaeologists, the message had been chiseled in three different scripts: Greek, Demotic Egyptian (a language used in Ptolemy's day for everyday communications and records) and hieroglyphs (most often seen on temples and used for sacred texts).

Demotic Egyptian disappeared as a language in the 5th century A.D., and hieroglyphs were similarly unintelligible, says Janet Johnson, an Egyptologist at the University of Chicago. But because Greek was a well-known language and the differences in the three texts were minor, the researchers could decipher the Demotic Egyptian language and the hieroglyphs. The messages written in those languages on the Rosetta Stone, in turn, have helped decode ancient documents throughout Egypt.

"The Rosetta Stone was the key," Johnson says. In August, she and her colleagues unveiled a dictionary of Demotic Egyptian, the culmination of a 37-year effort to give new life to a forgotten language.

Even when a language is rediscovered, though, much of a message can be lost to context, Millar says. "When a language is lost, there's also a loss of culture, a loss of the stories that were told in that language."

John Traphagan, a cultural anthropologist at the University of Texas at Austin, agrees, noting that a great depth of knowledge is needed to interpret even simple messages. "Even among humans today, languages and cultures can be different enough that communication is nearly impossible," he says. "And the pace of change today is so rapid, 500 years from now it will be a different world altogether."

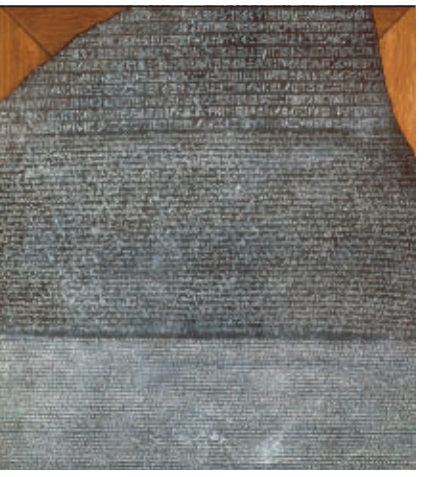
Humans sending messages into space, to connect with whoever — or whatever — is out there, have realized that context is everything. Anyone composing messages to future generations may have something to learn from attempts to communicate with alien civilizations.

Safe storage

Designing a device to hold messages for deep time means thinking ahead and recognizing possible data destroyers. Long-lasting devices should be:

- Made of nonradioactive, stable materials
- Resistant to fire
- Resistant to corrosion
- Insensitive to light
- Impossible to counterfeit
- Capable of being updated
- Indifferent to technological evolution
- Compact
- Maintenance-free

SOURCE: ARNANO



Ancient Egypt's Rosetta Stone has three different scripts, meaning it can act as a key for decoding other texts.

DE AGOSTINI/GETTY IMAGES

Lessons from E.T.

In the early 1970s, NASA's Pioneer 10 and Pioneer 11 missions were launched to the outer solar system. They swooped past Jupiter and got a gravitational boost toward interstellar space. Each craft carried a gold-coated plaque with a sketch of the probe and a crude map of the solar system and where it lies in relation to certain fast-rotating stars known as pulsars. The plaques also had several symbols meant to provide information about the origin of the craft.

One symbol easily understood by humans but possibly meaningless to aliens who might intercept the messages is the arrow depicting the route of the craft out of the solar system, says Traphagan. While a society with a hunter-gatherer heritage would know that the tip of an arrow points forward, aliens without that shared past might see a random symbol. "There's nothing specific about that that denotes direction," Traphagan says.

Another space-bound signal, dubbed the Arecibo message after the radio telescope that broadcast it in November 1974, consisted of 1,679 ones and zeros. If aliens arrange these data in a picture that consists of 23 columns and 73 rows — a purportedly obvious choice given that 1,679 is the product of these two primes — the message depicts the numbers one through 10, the chemical formulas for the major components of DNA, a stick figure sketch of a human and various other scientific data.

When other researchers saw the Arecibo message, designed by astronomer Frank Drake, many were befuddled. "They didn't automatically 'get it,'" Traphagan says. The portions providing information about DNA were particularly confusing.

Nevertheless, scientists say, the Arecibo message is a step in the right direction. "You can't just start with a complex message," says Yvan Dutil, an astrophysicist now at the University of Quebec in Montreal. "You have to do a lot of teaching before you can talk."

> "If you convey a message in multiple ways, the chances of it being interpreted correctly goes up."
> JOHN TRAPHAGAN

Dutil and colleague Stéphane Dumas have designed a longer and more sophisticated radio message for alien civilizations, dubbed the Interstellar Rosetta Stone. The message, described in the recent book *Communication with Extraterrestrial Intelligence*, starts out by introducing numbers, equations and other mathematical symbols and concepts. Then it builds the foundation for understanding physics, chemistry and biology. Finally, it delves into language, providing a vocabulary, a dictionary and grammatical rules.

Using these foundations, researchers can construct a meaningful message, Dutil says. "The first part of the message will be very boring," he says. But the boring parts will form the foundation, allowing for true communication.

Besides having many layers of information, Dutil says, messages sent into deep space — as well as those intended for generations deep in the future — should be incredibly redundant. Repeating information often ensures that the message can be reconstructed even if part of it becomes destroyed or garbled. Moreover, the message should be presented in many different ways: Text, images, symbols and even music and art are just a few possibilities.

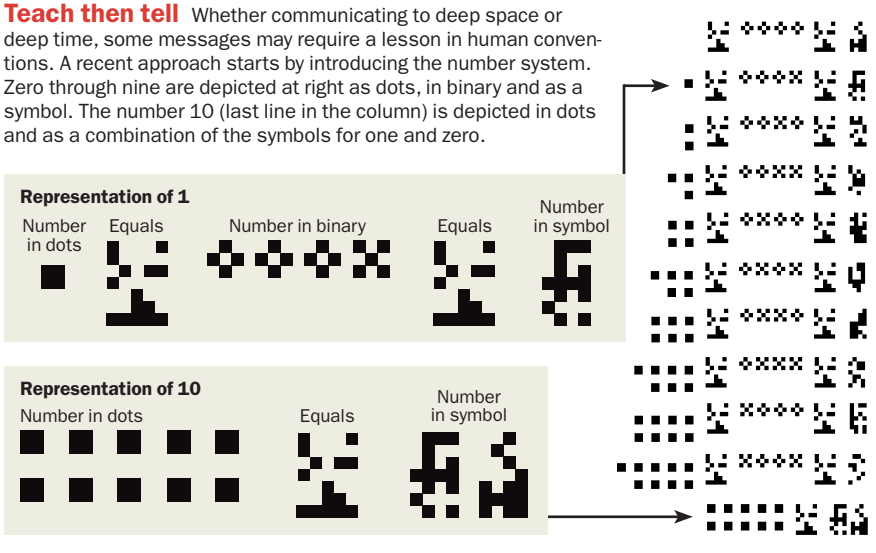
"If you convey a message in multiple ways, the chances of it being interpreted correctly goes up," says Traphagan. "You have to try a lot of different things, because you don't know what's going to work."

Though there aren't yet clear conclusions on how to leave long-lasting messages, gatherings such as the one at the Euroscience Open Forum bring people together to generate new considerations and possible solutions. Because no one can ever know what will work reliably, all that can be offered is a best attempt.

"In the coming millennia, cultures and languages will change in ways that we can't foresee," archaeologist Anders Högberg of Linnaeus University in Kalmar, Sweden, said at the meeting. "We will not be understood in the future the way we'd like to be understood."

But Egyptologist Johnson takes a more sunny view. "As long as you have some records, and as long as you have some interested human beings," she says, "there is always the hope of reconstructing a message." ■

Teach then tell Whether communicating to deep space or deep time, some messages may require a lesson in human conventions. A recent approach starts by introducing the number system. Zero through nine are depicted at right as dots, in binary and as a symbol. The number 10 (last line in the column) is depicted in dots and as a combination of the symbols for one and zero.



S. DUMAS AND Y. DUTIL, ADAPTED BY E. FELICIANO

Explore more

- Douglas A. Vakoch, ed. *Communication with Extraterrestrial Intelligence*. SUNY Press, 2011.

Sid Perkins is a freelance science writer based in Crossville, Tenn.

The invention of the year is great news for your ears

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New Personal Sound Amplification Product is an affordable alternative

Over the years, technology has made the way we live easier, safer and more convenient. In many cases, it's even made many products more affordable… (remember how much the first VCR used to cost?). Unfortunately, the cost of hearing aids never seemed to come down. Now, a new alternative has been invented… it's called Perfect Choice HD™.

"Reading glasses for your ears"

Perfect Choice HD is NOT a hearing aid. Hearing aids can only be sold by an audiologist or a licensed hearing instrument specialist. In order to get a hearing aid, you had to go to the doctor's office for a battery of tests and numerous fitting appointments. Once they had you tested and fitted, you would have to pay as much as $5000 for the product. Now, thanks to the efforts of the doctor who leads a renowned hearing institute, there is Perfect Choice HD. It's designed to accurately amplify sounds and deliver them to your ear. Because we've developed an efficient production process, we can make a great product at an affordable price. The unit has been designed to have an easily accessible battery, but it is small and lightweight enough to hide behind your ear… only you'll know you have it on. It's comfortable and won't make you feel like you have something stuck in your ear. It provides high quality audio so sounds and conversations will be easier to hear and understand.

Perfect Choice HD feature comparison

	Perfect Choice HD	Others
Lightweight and Inconspicuous	YES	Some
Easy Toggle Switch Adjustment	YES	Few
Tests and Fittings Required	NO	Most
Affordable	YES	as much as $5000
Friendly Return Policy	**YES**	**Rarely**

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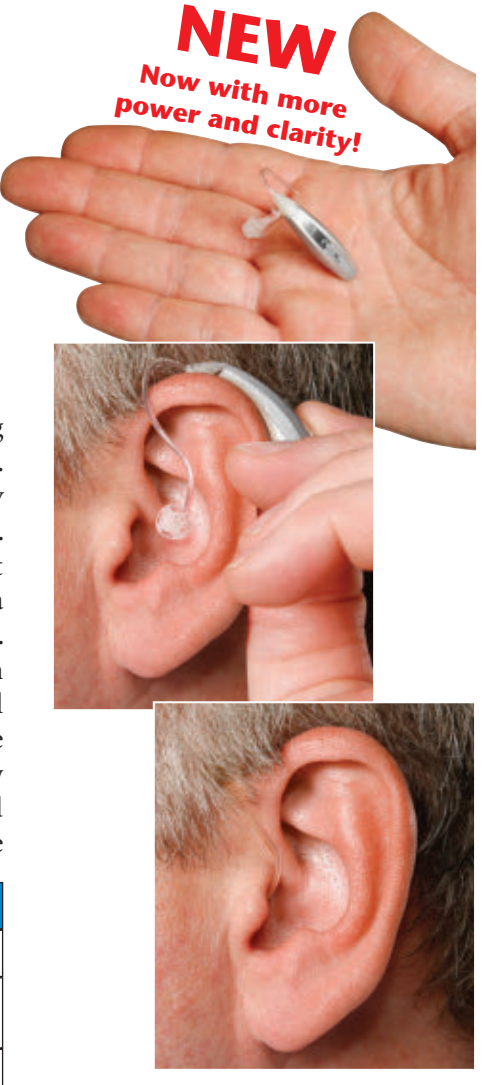

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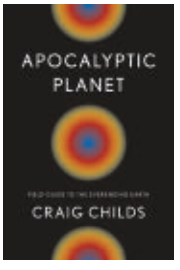
Apocalyptic Planet: Field Guide to the Everending Earth

Craig Childs

The world could end any number of ways — and in a sense it already has, many times, in mass extinctions that paved the way for new life.

Childs, a writer, recounts field trips to nine sites that today are suffering some of the same major environmental disruptions that afflicted Earth during those extinctions or that might trigger future die-offs — places that Childs describes as "the most desolate, phenomenal and downright strange parts of the world."

Fresh lava fields in Hawaii stand in for the landscape that probably existed after large asteroid strikes and during an interval that scientists aptly call the Late Heavy Bombardment, when an innumerable horde of such objects pummeled the planet billions of years ago. Arid salt flats in South America's Atacama Desert epitomize how Earth's surface may look once the sun expands and the planet's oceans boil away billions of years from now. And in the monoculture of Iowa's cornfields, Childs sees a modern-day version of the kind of species-poor world found in the wake of a mass extinction, at least five of which have slammed Earth in the last 540 million years.



In chapters packed with vivid descriptions and lyrical language, Childs tells tales not merely of droughts and ice ages, but of globe-swallowing deserts and planet-freezing cold spells during which equatorial oceans were awash with slush. Chronicling Childs' jaunts from Greenland to Mexico to a forbidding island in the middle of the Bering Sea, this thoroughly enjoyable book is a fascinating travelog of an excitable, seething and perilous planet where catastrophes are frequent, at least when measured on a geological timescale. — *Sid Perkins*

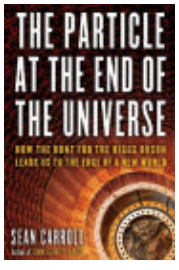
Pantheon Books, 2012, 343 p., $27.95

The Particle at the End of the Universe

Sean Carroll

There seems no end to the titles shoved on the unsuspecting Higgs boson. First it was the "God particle." Now it's the "particle at the end of the universe."

Carroll, a theoretical physicist at Caltech, doesn't mean this literally; the Higgs is not roaming out there at cosmological distances. It's at the explanatory end of the universe, the last piece in understanding how the matter that makes up our everyday world works.



Anyone paying attention to science knows by now that particle hunters at the CERN lab, in Switzerland, found the Higgs this summer in debris left behind by crashing protons together. Carroll seizes this moment to explore the scientific significance of the Higgs and what its discovery means from here.

There have been other excellent popular books about the Higgs, but Carroll's benefits by being able to include the recent discovery. He also serves as a superb armchair guide to the science. One warning: Theory discussions come fast and furious, punctuated by name after name of the eminent scientists who built the foundation for understanding the Higgs. Carroll then moves on to explore more broadly the symmetries of nature and the meaning of humankind's quest for pure discovery.

All this hard-core science is leavened by Carroll's chatty, conversational tone. This is surely the only book about the Higgs boson that also references the hip-hop duo Insane Clown Posse.

By the end, readers may even be inspired to come up with their own nickname for the Higgs.

— *Alexandra Witze*

Dutton, 2012, 352 p., $27.95

The Half-Life of Facts

Samuel Arbesman

Learning how knowledge changes over time, a mathematician contends, will help humans better make sense of their world. *Current, 2012, 242 p., $25.95*

The Miracle of Trees

Olavi Huikari

Packed with drawings and engravings, this pocket guide briefly covers the science of trees, from how they grow and reproduce to whether they feel pain. *Walker & Co., 2012, 58 p., $12*

Hunger, Thirst, Sex, & Sleep

John K. Young

A biologist delves into the varied roles of the hypothalamus, the command center in the brain that controls the most basic human drives. *Rowman & Littlefield, 2012, 161 p., $39.95*

Seduced by Logic

Robyn Arianrhod

The tales of two women — a French aristocrat and a Scottish commoner — intersect in an exploration of how the pair advanced Newton's ideas about the universe. *Oxford Univ., 2012, 338 p., $34.95*

Train Wreck

George Bibel

Investigations of 17 accidents help show why trains crash and what those incidents can teach. *Johns Hopkins Univ., 2012, 355 p., $29.95*

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Curiosity cleanup

In the article "Protecting the planet" (*SN: 11/3/12, p. 32*), the sidebar "Keeping Mars clean" gives the impression that Curiosity had not been contaminated, while the opposite is true. Apparently the sterilized craft was opened up and microbial contamination likely occurred. Curiosity's drill bits may be contaminated with Earth microbes. So now NASA is in the catch-22 position that if they do find water they cannot use the drill. The entire gist of the article is to give an erroneous impression that Curiosity was clean, when in fact Catharine Conley has been quoted saying that she knew Curiosity was contaminated.
Dennis Kuzara, Punta Gorda, Fla.

A box of sterilized drill bits meant for use on Mars was opened on Earth so one could be installed on the rover. While this handling was less than optimal, Conley says, after several reviews the Mars Science Laboratory (Curiosity) mission is still in compliance with NASA and international policy. As for the article in Science News*, "The statement is true that MSL is the cleanest spacecraft sent to Mars since the Viking [missions]," Conley says. Curiosity carries about the same total number of spores, but fewer spores per square centimeter, than the much smaller spacecraft that included the rovers Spirit, Opportunity and Pathfinder. The Viking landing craft initially had more spores than Curiosity, but prelaunch baking knocked down the number of viable spores to less than the number carried by Curiosity. —Tina Hesman Saey*

Face effects

The Thatcher effect described in "Face smarts" (*SN: 10/6/12, p. 20*), in which altered upside-down faces appear normal, fails in my household. My wife, an artist, spotted all the facial anomalies immediately, apparently because she is acutely aware of such details by her training and abilities. I, an amateur artist, spotted the anomalous eyes immediately but not the lips. Perhaps a larger picture with more detail would have had me equal my wife's performance.
Irwin Tyler, Spring Valley, N.Y.

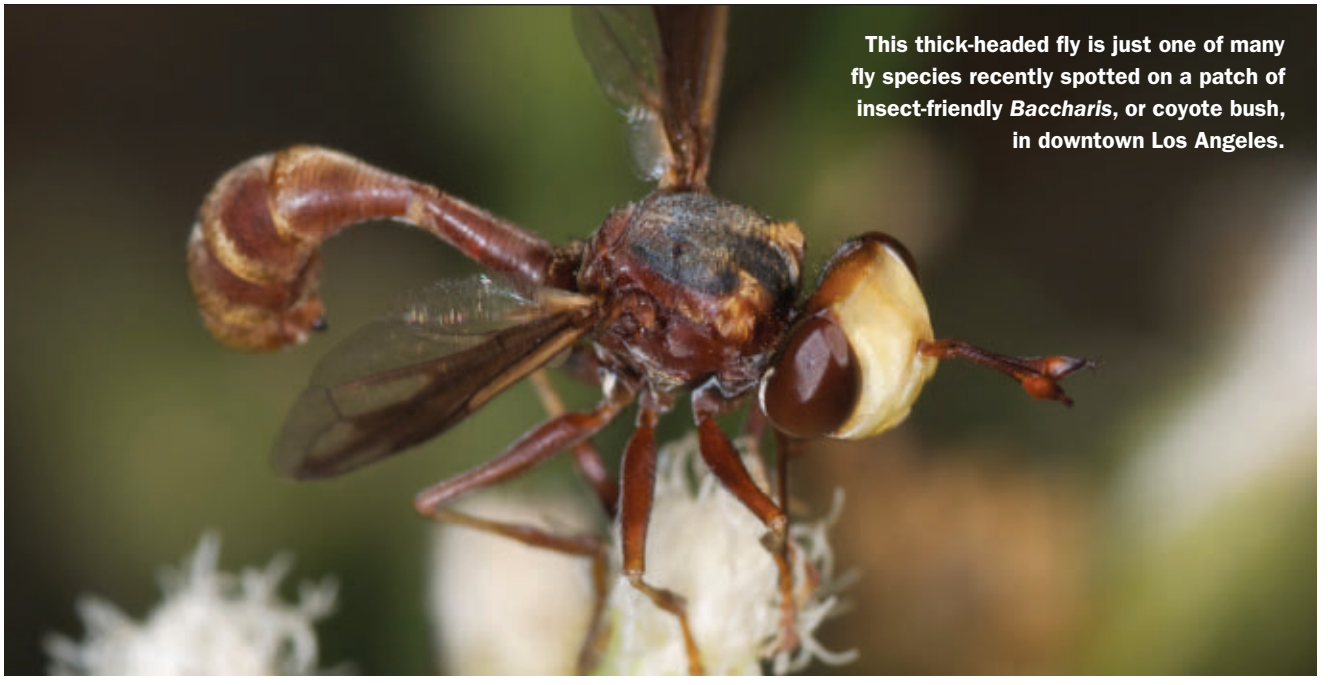
Earthlike bias

"Planetary peekaboo" (*SN: 9/22/12, p. 26*) appears to make a very common assumption: All life must be like Earth life. That is, it requires liquid water, among other things. But this is really Earth-chauvinism. Just because all life we know about requires liquid water doesn't mean that there can't be life that doesn't. When looking for life elsewhere in the universe, we shouldn't limit ourselves to Earthlike planets. We should keep an open mind.
Ted Grinthal, Berkeley Heights, N.J.

Send communications to: Editor, Science News, 1719 N Street, NW, Washington, D.C. 20036 or **editors@sciencenews.org**. Letters subject to editing.

The Science Life

Visit Brian Brown's dipterology blog at **www.flyobsession.net**



This thick-headed fly is just one of many fly species recently spotted on a patch of insect-friendly *Baccharis*, or coyote bush, in downtown Los Angeles.

Fly guy

Brian Brown can discover a new kind of fly anywhere. He often takes up the search in exotic locales such as New Zealand, Chile or Taiwan, but he's not picky. Once, he was challenged to find a new species in a Los Angeles backyard. After setting a trap and waiting, he pulled out a winner: "Turns out it was a new species, the first thing I pulled out of there," he says. And it wasn't a fluke. The second fly was a member of a species previously known only in Europe.

A self-described novophile, Brown says he and fellow fly lovers "are junkies for the new and different." So far, he has discovered about 500 new species. "Finding the new species isn't the problem; it's finding the time to describe them all," says Brown, an entomology curator at the Natural History Museum of Los Angeles County.

Brown (left) shares his dipterology exploits on his blog, called flyobsession, where his admiration is obvious. "Most people think flies are disgusting, horrible creatures that we should eradicate," he says. "I think they're incredible."

In his writings and research, Brown focuses on small humpbacked flies called phorids, classified in the Phoridae family, which by current counts includes about 4,000 species. The real number could be anywhere from 30,000 to 50,000 species, Brown writes on his blog. Now, he and other fly experts from around the world may boost the known number. A recent grant will support the researchers' effort to catalog every single fly species in a 100-by-200-meter patch of forest in Costa Rica, where thousands of new species may await.

One of Brown's recent adventures led him and his colleagues to the world's smallest fly — a phorid from Thailand that's smaller than a flake of pepper. The fly's only known close living relative decapitates ants, laying eggs that later hatch into larvae that feed on the ants' heads. This new fly may similarly target some of the world's smallest ants, Brown says, which goes to show that even tiny creatures can be a force to be reckoned with. — *Laura Sanders*

Compared with a common housefly (top left, shown larger than actual size), the world's smallest fly, *E. nanaknihali* (circled, right), is a mere speck. The tiny fly (magnified in illustration, bottom) is less than half the size of a flea.

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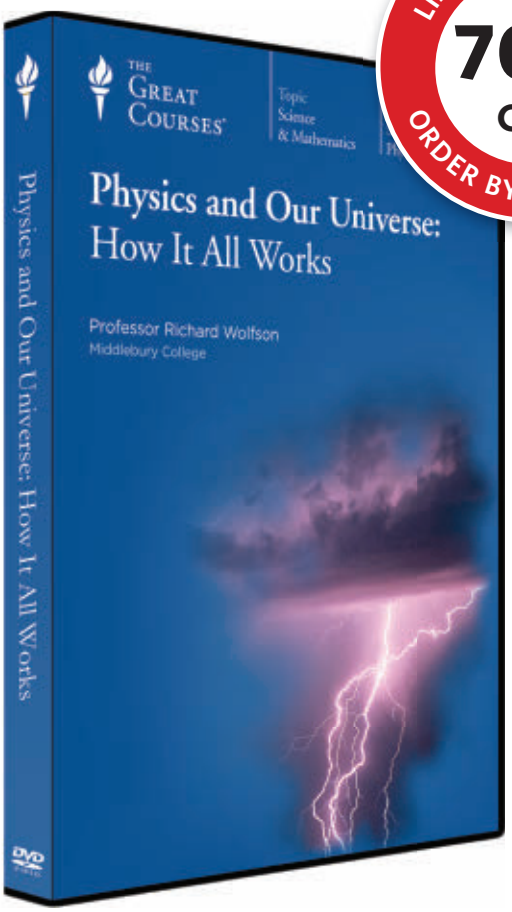

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