Virus-Loaded Bats | A King's Final Chapter | Canine Cancer Clues

Science News

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MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ MARCH 9, 2013

Life Below Antarctic Ice

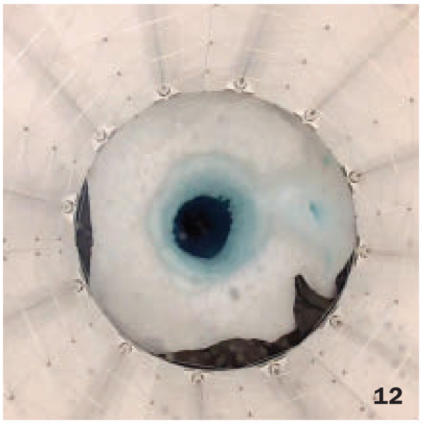
Gene for Ruffled Feathers

Stellar Death Throes

Made to MEASURE

3-D printing struts its stuff

MARCH 9, 2013 • VOL. 183 • NO. 5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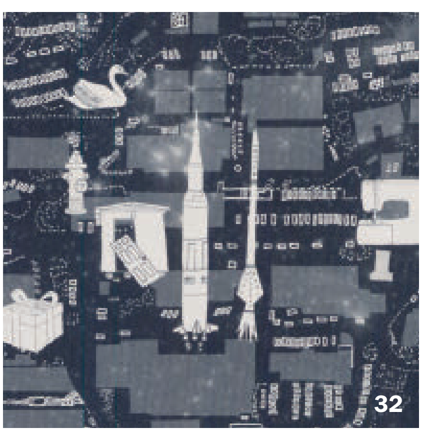
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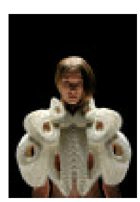
COVER A model walks the runway in an intricate top made with 3-D printing. The technology’s decreasing price makes it widely available to designers and hobbyists. *Gareth Cattermole/Getty Images*

ScienceNews
MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC

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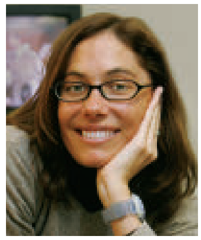
FROM THE EDITOR

3-D printing poised to hit the mainstream



Additive manufacturing, as 3-D printing is known to those in industry, is the stuff of science fiction. Imagine every homeowner being able to custom manufacture his or her own dishes, tools, toys, jewelry and holiday decorations. Imagine if doctors could print copies of cells, blood vessels and bone. Imagine a 3-D printer sophisticated enough to make a boat, an automobile or a flight-ready aircraft. Eventually, such a printer might make copies of itself in a life-mimicking act of reproduction.

As Rachel Ehrenberg reports on Page 20, 3-D printers have already done all of this and more. And while such feats are still relatively challenging, and in some cases expensive or limited to the research laboratory, the technology has progressed by leaps and bounds since it was first developed in the 1980s. Now, many in the field believe, additive manufacturing is finally growing cheap and powerful enough to revolutionize society. Some predict its impact will parallel that of computers, which in a relatively short time have changed how we do business, entertain ourselves and even socialize.

3-D printers may just be the next personal computer. Or they may not. Whether a technology is widely adopted is sometimes as much about economics and marketing as it is about the technology's usefulness. And while 3-D printing is currently attracting a lot of attention (garnering a mention by President Obama in his recent State of the Union address), it may remain of primary interest to researchers, specialty manufacturers and hobbyists. What's not in doubt is that the creativity allowed by the technology will inspire a new generation of digital do-it-yourselfers to make wonderful, futuristic things, à la the Jetsons.

3-D printing isn't science fiction, but it does remind me of the thrills I got as a child reading about seemingly magical technologies that made life easier. This and other stories in this issue also remind me that you don't need fiction to inspire your imagination. Read on Page 12, for example, about the recovery of living cells from an Antarctic lake buried 800 meters below a glacier and isolated for roughly 100,000 years. On Page 16, find out what stars do before they go supernova. Or, on Page 10, discover how common moles, which are blind, combine information coming from each nostril to better sniff their way to food. Now, that's pretty far out.

— Eva Emerson, Editor in Chief

PHILIP CHANNING

AMERICA'S LAST MORGAN SILVER DOLLAR

Saved from Destruction—Get yours before they're only a memory

The U.S. Morgan Silver Dollar was struck from 1878 until its final year in 1921. Back then, a hefty, gleaming Silver Dollar had real buying power—over 12 times more than today's paper dollar. In those days, a new car only cost you 325 silver dollars, and one silver dollar bought you nearly four gallons of gasoline!

SILVER TREASURES LOST TO THE MELTING POTS

When these massive, 90% Silver Dollars were struck, the price of silver was around 66 cents an ounce. Over the next nine decades, as silver prices shot to as much as $50 an ounce, untold millions of Morgan Silver Dollars have been lost to private and government melting pots. Today, as silver has reached as high as $48.70 an ounce recently, there is no telling exactly how many 1921 Morgan Silver Dollars—America's LAST Morgan Dollar —still survive in *any* condition!

AMERICAN SILVER WITH A RICH STORY TO TELL

Beautiful, historic, and brimming with pride, the U.S. Morgan Silver Dollar is more than a coin—it is a true American heirloom. Each 90% pure silver dollar is an impressive 38.1 mm in diameter, and has witnessed a lifetime of American history, trial, and triumph. Morgan Silver Dollars jingled in the pockets of gunslingers, riverboat gamblers, gangsters, prospectors, and pioneers. They were the storehouse of wealth for our fathers, grandfathers, and great-grandfathers.

A PRIVATE VAULT GIVES UP ITS SECRETS

Today, virtually all the surviving Morgan Silver Dollars are in private hoards. When we were recently guided into a wealthy owner's vault, we were thrilled to discover a hoard of nearly two thousand 1921 Morgan Silver Dollars. They were all in lustrous About Uncirculated (AU) condition, showing sharp detail and original luster. We wasted no time in securing the entire treasure trove into our own vaults. Now, this historic heirloom can become *your* family's own American silver legacy.

SAVE $30 OR MORE!

This same coin in the same About Uncirculated condition is offered elsewhere for $90. But today, you can secure the very last U.S. Morgan Silver Dollar for as low as $55.95 (*plus s/h*).

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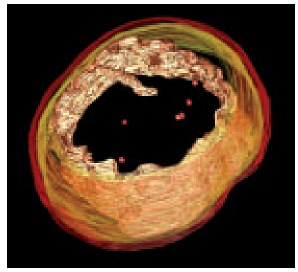
Say What?

Anammox *AN-uh-mohx*\ *n.*



Short for anaerobic ammonium oxidation, anammox is the bacterial process of converting ammonium into nitrogen gas, a major component of Earth's atmosphere. Scientists were surprised to discover anammox bacteria in the 1990s because this conversion was thought to require oxygen, yet the bacteria carry it out in oxygen-free places. Only certain bacteria can do anammox, using a large internal compartment called an anammoxosome (shown, in *Kuenenia stuttgartiensis*). An international team reports January 6 in *Nature Geoscience* that hotspots of anammox activity in sediments and soil around China's Baiyangdian Lake are responsible for nearly 20 percent of annual nitrogen loss from the shore. This nitrogen loss may interrupt other bacterial processes that produce nitrous oxide, a potent greenhouse gas. *— Allison Bohac*

Science Past | FROM THE ISSUE OF MARCH 9, 1963

NEW AGE FOR ANCIENT MAN— It has taken longer than previously credited for the kind of people now on earth to rise to become what we know as modern man. Evidence

now is that man and his cultures extend beyond two million years into the past. Radioactive dating has given new time determinations for human ancestors and evolution in the dim anthropological past. The latest "clock" or dating method measures the amount of the chemical element argon in rocks to determine their age.... The date of the earliest skeletal remains, generally conceded "human," those of *Zinjanthropus* discovered in Olduvai Gorge, Tanganyika, was found to be 1,750,000 years.

Science Future

March 15

Learn about the 1989 "discovery" of cold fusion, later disproved, at a screening of the documentary film *The Believers* at Fermilab, near Chicago. A discussion with physicists and the directors follows. See bit.ly/SFbelievers

March 16 – 23

Try science activities, help clean up the coast and get teaching ideas at the San Diego Festival of Science and Engineering. See bit.ly/SFfestSD

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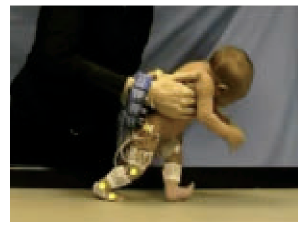
CULTURE BEAKER

Read Rachel Ehrenberg's column "In Hollywood, buzz beats star power when it comes to predicting box office take."

MIND & BRAIN

See a video showing a test of a baby's motor control (below) in "Newborn babies walk the walk."



EARTH

See video of the meteor that struck Russia on February 15 in "Meteor explodes over Russia."

EARTH IN ACTION

Alexandra Witze examines the perils of giving science-based advice in "Italian earthquake verdict exposes rifts between science and society."

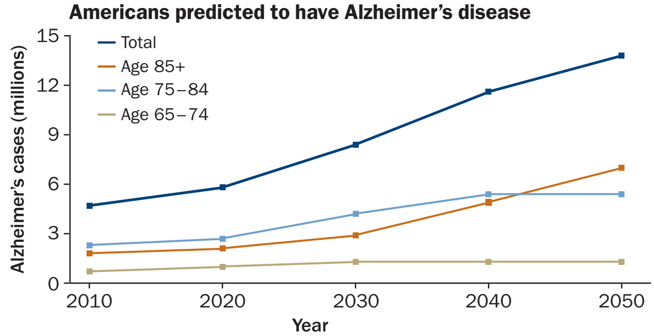
Introducing | TRAPDOOR SPIDERS FOR EVERYONE

Whatever else happens this term, at least Barack Obama can say he got a spider named after him. *Aptostichus barackobamai* (below) joins 32 other newly described species of trapdoor spider, a group known for building hinged doors to hide the entrances to their underground burrows. Jason Bond of Alabama's Auburn University Museum of Natural History describes the species — members of the *Aptostichus* genus that are found in Arizona, Nevada and California — December 19 in *ZooKeys*. Though most of the spiders are not much larger than a quarter, many have big namesakes: César Chávez, entertainer Penn Jillette and photographer Dorothea Lange all lend their names to new species. *— Allison Bohac*

Science Stats | ALZHEIMER'S ADVANCING

The number of Americans with Alzheimer's disease will triple by 2050, according to a new analysis that extrapolates from 2010 U.S. Census data. Cases will rise sharply as baby boomers enter their late 70s, and those who live past 85 will drive up numbers in that age group as 2050 approaches. SOURCE: L.E. HEBERT *ET AL*/*NEUROLOGY* 2013

Americans predicted to have Alzheimer's disease



CLOCKWISE FROM TOP LEFT: L. VAN NIFTRIK *ET AL*/*J. OF STRUCTURAL BIOLOGY* 2008; Y. IVANENKO *ET AL*/*J. OF NEUROSCIENCE* 2013; J.E. BOND/*ZOOKEYS* 2012

“This type of ejection could be a cosmic lamppost for a final explosion that’s about to happen.” —**ALEX FILIPPENKO, PAGE 16**

In the News

STORY ONE

Dinosaurs’ fall predated rise of most diverse mammal group

Roots of placental family tree found in genetic, fossil data

By Erin Wayman

Tyrannosaurus rex never would have had the chance to terrorize the most recent common ancestor of rodents, rabbits and primates. A new family tree using both anatomical and genetic data indicates that the lineages of modern placental mammals — those that give birth to well-developed young — arose after the dinosaurs went extinct 65 million years ago.

The new study, published in the Feb. 8 *Science,* adds to a debate over a diverse group that includes whales, cats, bats, horses and humans. Since the 1990s, some scientists have concluded from family trees based largely on molecular evidence that at least some lineages of modern placental mammals originated as early as 100 million years ago, during the Cretaceous period. But paleontologists have been skeptical because they have found no fossils resembling modern placental mammals that are older than 65 million years.

“What the [new] analyses do is vindicate the fossil record,” says Ken Rose, a paleontologist at the Johns Hopkins University School of Medicine.

But some molecular biologists aren’t as convinced. “This paper really doesn’t add anything new to the debate,” says Olaf Bininda-Emonds of the University of Oldenburg in Germany.

To build the family tree, paleontologist Maureen O’Leary of Stony Brook University in New York and colleagues began with 46 species of living mammals, including placental, marsupial and egg-laying mammals. The team also included 40 extinct species known from fossils. To determine how the species relate to one another, the researchers looked at differences in 27 genes in the living species.

Ukhaatherium nessovi **(fossil shown) was one of 40 extinct species that scientists used to construct a new mammal family tree. The tree indicates that modern placental mammals emerged after the dinosaurs went extinct 65 million years ago.**

COURTESY OF S. GOLDBERG AND M. NOVACEK/AMNH

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They also analyzed 4,541 physical traits related to bones, teeth and soft tissue in both the living and extinct mammals.

Some previous family trees had combined molecular and anatomical evidence. But in such studies the large amounts of available DNA always overshadowed the sparser anatomical data, O'Leary says. Using new measurements and published findings about the mammals, she and colleagues created the largest dataset of mammalian physical traits ever amassed, containing 10 times as much anatomical data as previous family trees had used. (The resulting database is online at a website called MorphoBank.) This gave the genetic and anatomical data equal weight in constructing the tree, she says.

Once the tree took shape, the researchers used the ages of the fossil species and where they sit in the tree to date the origin of the tree branches. The oldest fossil that grouped with the living placental mammals dates to 64.85 million years ago. As little as 200,000 years later, the different groups of modern placentals began to diverge, the team reports.

The timing supports a view long held by many paleontologists — that the disappearance of the dinosaurs and changes in the postextinction ecosystem might have opened up opportunities for placental mammals, says Jaelyn Eberle, a vertebrate paleontologist at the University of Colorado Boulder. That runs counter to an idea favored by some molecular biologists that ties the rise of the different placental groups to the breakup of the supercontinent Gondwana. Gondwana — which consisted of Africa, Antarctica, Australia, South America, India and the Arabian Peninsula — began splitting up roughly 180 million years ago and continued rifting throughout the Cretaceous. As the continents drifted apart, the theory goes, newly isolated populations of mammals evolved into a variety of different species. The new work indicates that the explosion of placentals happened too long after the continental breakup for the two events to be related, Eberle says.

5,100

Approximate number of living placental species

But other researchers say the new study doesn't resolve fundamental issues of how to date the origins of placental mammals. Evolutionary biologist Mark Springer of the University of California, Riverside says using fossils to date a family tree is tricky because of convergent evolution: An extinct species, for example, might be inadvertently grouped wrongly with a living species not because it shares a common ancestor but because the two species independently evolved similar physical traits. "I don't think convergence has been effectively dealt with," he says.

Convergent evolution is less of a problem in trees that are based on genetic evidence, Springer says. Such trees use steady mutation rates to calculate when lineages diverged from each other. Yet this method also has its drawbacks, says J. David Archibald, an evolutionary biologist at San Diego State University. For example, he says, it assumes mutation rates are constant, but researchers have found that these rates may change with time and vary by gene.

Although the new study has provoked controversy, some critics are open to changing their opinions. "I think Cretaceous placentals are distinctly possible and out there to find," Bininda-Emonds says. "I'm also willing to say that if the paleontologists find nothing of the sort in the next 20 to 30 years and haven't left some big obvious clumps of rock unturned, then I'll switch camps and say we need to re-examine our [molecular] models." ■

COURTESY OF CARL BUELL

Back Story | HUMBLE ORIGINS

Researchers have reconstructed a hypothetical last common ancestor of all living placental mammals by working backward on the new family tree they constructed using both genetic and anatomical data. Maureen O'Leary of Stony Brook University in New York and colleagues determined which set of physical features would have been the simplest starting point for the evolution of the roughly 5,100 placental species alive today. The team concluded that the hypothetical creature probably weighed between 6 and 245 grams and had dark fur on its back with lighter hair on its belly. It also probably ate insects, climbed trees and gave birth to one offspring at a time. Its offspring was likely born hairless and with its eyes closed.

AAAS Meeting

For longer versions of these and other AAAS meeting stories, visit **www.sciencenews.org**

Speech, birdsong share wetware

Similar genes process human and bird communication

By Erin Wayman

"Birdbrain" may not be much of an insult: Humans and songbirds share changes in gene activity that affect parts of the brain related to singing and speaking, research shows. The finding may help scientists understand how human language evolved, as well as unravel the causes of speech impairments.

Neurobiologist Erich Jarvis of Duke University and colleagues identified roughly 80 genes that turn on and off similarly in the brains of humans and of songbirds such as zebra finches and parakeets. This activity, which occurs in regions involved in imitating sounds, speaking and singing, is not found in birds that can't learn songs or mimic sounds. Jarvis described the work February 15.

Songbirds are good models for language because, like human infants learning to speak, they have to observe and imitate others to pick up the tunes they croon as adults. The ancestors of humans and songbirds split some 300 million years ago, suggesting that the two groups independently acquired a similar capacity.

With the results and other recent research, Jarvis said, "I feel more comfortable that we can link structures in songbird brains to analogous structures in human brains."

Jarvis' team analyzed gene activity in the brains of three humans and compared those results with similar measurements from bird species that are capable of vocal imitation and song learning — such as songbirds, hummingbirds and parrots — as well as birds that aren't, such as doves and quails.

The vocal-learning birds and humans share a pattern of activity in roughly 40 genes in analogous regions that are involved in imitation: Area X in birds and the anterior striatum in humans.

The team also found similarities in a different set of about 40 genes in regions involved in speech and song production. For birds that was in the robust nucleus of the acropallium, and for humans, the laryngeal motor cortex. Previous studies have found connections between the laryngeal motor cortex, which is located in a part of the brain that controls voluntary movement, and brainstem nerve cells that control muscles of the larynx, the organ that produces sound. Similar connections have been found in the analogous regions of bird brains.

Jarvis plans to investigate how the activity of the 80 genes influences these connections and other brain circuitry related to speaking and singing.

It's "exciting stuff," said Simon Fisher of the Max Planck Institute for Psycholinguistics in the Netherlands, because scientists could combine data on gene activity in the brain with studies that have decoded the entire genetic instruction book of people with various speech disorders to pinpoint how these problems arise.

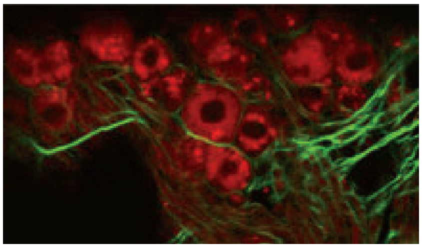
Inner ear damage comes clear

Two-photon microscopy shows noise-induced hair cell loss

By Rachel Ehrenberg

For the first time, researchers have snapped pictures of mouse inner ear cells using an approach that doesn't damage tissue or require elaborate dyes. The approach could offer a way to investigate hearing loss in people and may help guide the placement of cochlear implants or other devices.

Konstantina Stankovic of the Massachusetts Eye and Ear Infirmary in Boston and her colleagues imaged inner ear cells using two-photon microscopy (*SN: 9/22/12, p. 15*). The technique shoots photons at the target tissue, exciting particular molecules that then emit light. The researchers worked with mice exposed to 106 decibels of sound for two hours — levels comparable to the roaring buzz of a snowmobile or power tool. Then they removed the rodents' inner ears, which include the spiraled, snail-shaped cochlea and other organs. Instead of cutting into the cochlea, the researchers peered through the "round window" — a middle ear opening covered by a thin membrane that leads to the cochlea.



Two-photon microscopy reveals mouse inner ear nerve fibers (green) and cells (red). This technique could help scientists better understand hearing loss.

K. STANKOVIC

The approach yielded clear images of the hair cells, tiny structures that detect sound vibrations. Whole sections of hair cells were wiped out in the noise-exposed mice, Stankovic reported February 17.

The imaging approach might help guide the placement of an experimental device that extracts energy from the inner ear, acting as a tiny battery. The new device, developed by Stankovic and colleagues, could act as a sensor, monitoring for infections or sensing drug levels.

Such devices might prove useful for monitoring all sorts of physiological responses, said biomedical engineer Philippe Renaud of Swiss Federal Institute of Technology in Lausanne.

“There is no way that you could possibly expect to measure BPA in human blood.” —JUSTIN TEEGUARDEN

Blood levels of BPA controversial

Values reported for humans appear high, study charges

By Janet Raloff

The ubiquity of the compound bisphenol A in many plastic products, food-can linings, cash-register receipts and dental resins means that everyone is exposed to it. But new data raise red flags over the accuracy of previously reported human blood concentrations of BPA — amounts described over the years as being representative of the general population.

Those values appear to be roughly 1,000 times higher than most people actually encounter, toxicologist Justin Teeguarden of the Pacific Northwest National Laboratory in Richland, Wash., reported February 16.

Animal and human studies have linked exposures to BPA, a hormone mimic, with cardiovascular changes, altered behavior in children, prediabetic symptoms and reproductive impairments. So getting estimates of typical exposure right, Teeguarden said, is crucial to defining what intake levels should now be probed intensively by toxicity testing.

Toxicologist K. Barry Delclos of the National Center for Toxicological Research in Jefferson, Ark., described experiments in which rodents received seven doses of BPA daily from conception through birth and on into early adulthood. Amounts ranged from very low (2.5 micrograms per kilogram of body weight, in the range of probable human exposure) to a dose more than 100 times higher.

“We did not see clear adverse effects in the low-dose range,” Delclos said. And although most animals were receiving hefty doses of BPA, his team detected none of the active form of the chemical in animals receiving less than 80 micrograms per kilogram of body weight per day. Blood levels were below the limits of detection.

His colleague Daniel Doerge shared preliminary data from studies in rodents and monkeys showing rapid breakdown of ingested BPA into inactive substances. Infants, however, proved far less effective than adults at breaking down BPA.

Such studies at NCTR and elsewhere have mapped the relationship between BPA consumption and amounts of the biologically active chemical that subsequently show up in blood and urine. Based on those studies, “there is no way that you could possibly expect to measure BPA in human blood,” Teeguarden said.

He described performing four different analyses of BPA levels in urine from 28,765 people. Each analysis indicated that corresponding blood values in these people should be in the parts per trillion range or lower. Values would have to be 1,000 times higher to be picked up by currently available analytical techniques.

This finding raises suspicions, he argued, that previous studies finding measurable blood levels of BPA must reflect either “a very high, unusual exposure” or contamination — if not in the laboratory then during sampling.

Parts-per-trillion quantities of biologically active BPA are also one one-thousandth or less of the concentration that triggers endocrine action by any of several hormones, Teeguarden showed.

Developmental biologist Laura Vandenberg, a BPA researcher at Tufts University in Medford, Mass., expressed skepticism about this assessment. More than 25 studies have measured BPA in human blood, she said; Teeguarden appears to be arguing “that because his calculations say BPA shouldn’t be there, then all of the measured blood values must be wrong.”

Not necessarily, Teeguarden said. Reported blood values may be real, just not typical of most people.

MEETING NOTES

Warmer oceans may muscle out mussels

Warming waters make it harder for mussels to get a grip. The tough, fibrous threads that anchor the bay mussel *Mytilus trossulus* to its rocky intertidal digs are 60 percent weaker in 25° Celsius waters compared with their strength at 18° C, reported Emily Carrington of the University of Washington Friday Harbor Laboratories. Mussels are constantly replenishing these fibers, which last about two months in winter and up to a month in summer. As the oceans warm, the ranges of mussel species may shift, or perhaps competitors will muscle in on them, Carrington said February 16. —*Rachel Ehrenberg*

Finger ridges may help primates climb trees

Detectives who use fingerprints to find criminals should be thankful that humans descended from tree-dwelling ancestors. The fine ridges that mark the skin of primates’ hands and feet might have evolved because they helped the animals grip tree branches, anthropologist Nate Dominy of Dartmouth College reported February 16. Dominy and colleagues dragged tree bark across an artificial silicone finger etched with skinlike ridges and measured the friction. When the bark’s ridges were rubbed perpendicular to the finger’s, friction increased by 50 percent compared with tests with the bark and finger ridges parallel. Dominy suggests the enhanced friction would have allowed early primates to more efficiently climb up and down trees. —*Erin Wayman*

Life

For more Life stories, visit **www.sciencenews.org**

Mole sniffs the world in stereo

Nostrils of unlovely mammal can track direction to odors

By Tina Hesman Saey

The common mole may be homely, but its nose is a wonder to behold.

The eastern American mole, also known as the common mole, tracks down an earthworm treat by recognizing the slightly different odor cues entering each nostril, neurobiologist Kenneth Catania of Vanderbilt University in Nashville reports online February 5 in *Nature Communications*.

The finding suggests that even though mole nostrils are separated by only a fraction of a centimeter, each gets its own scent information that can guide an animal's actions. "It's an elegant demonstration of what many people suspected," says Peter Brunjes, a neuroscientist at the University of Virginia. Previous experiments with people and rats had reached contradictory conclusions regarding whether smell, like sight and hearing, is a bilateral sense.

Catania never expected the common mole, *Scalopus aquaticus*, to have uncommon abilities. "I've described it as the unlucky, stupid cousin of the star-nosed mole," he says. Star-nosed moles, *Condylura cristata*, have an incredible sense of touch in their tentacled schnozzes and are among the world's fastest foragers. But compared with other mole species, the eastern American mole has a poor sense of touch. The animals also can't see. Catania turned to common moles because he thought they would have a hard time finding food and could be tested against star-nosed moles in future experiments.

K. CATANIA

The common mole is blind and has a relatively poor sense of touch. But each of its nostrils picks up a slightly differing scent cue that the animal uses to navigate toward food.

But when he placed a common mole in a semicircular arena with a chopped-up bit of earthworm as bait, he says, "it would wiggle its nose around and go in a beeline toward the food."

Since the moles' other senses are so bad, Catania wondered whether the animals locate their food by smell. He first plugged one of a mole's nostrils with a short piece of plastic tubing. That caused the mole to veer off course in the direction of the open nostril. Next, Catania stuck small tubes into both nostrils and crossed the tubes so that the right nostril sniffed odors from the left side of the mole's face and vice versa. The moles behaved as if they had gotten reversed directions to the food — searching right when they should have gone left — and often missed the earthworm treat entirely.

Catania's discovery that crossing the nostrils' inputs confuses the animals is strong evidence that moles, and probably other mammals, engage in bi-nostril smelling, Brunjes says. If moles simply sniffed their way toward an ever-stronger scent, then crossing the tubes wouldn't make a difference. "It's kind of the perfect proof," he says.

Moles may have evolved to follow a scent trail with precision because they have to dig for their food. "Being off by half an inch could be hugely energetically expensive," Catania says.

He is interested in studying whether star-nosed moles traded their sense of smell for better touch. He also wants to know how scent information is wired into the brains of common moles. ■

A bat beats a rat as top virus host

Flying mammals a rich source of germs that infect humans

By Susan Milius

A bat may be more likely than a rodent to carry viruses that can jump from animals to people.

Per species, bats also harbor more known viruses in total than rodents do, including wildlife-only infections as well as those that also infect people, says Angela Luis of Colorado State University in Fort Collins. And a bat virus on average can infect a greater number of species, Luis and her colleagues report February 1 in the *Proceedings of the Royal Society B*.

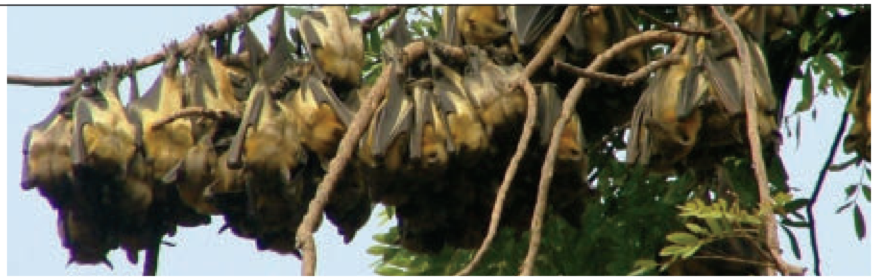
Recent years have brought headlines about scary viruses jumping from bats to people. The virus that caused the global SARS outbreak in 2003 and South Asia's emerging Nipah virus have been traced to bats. Rodents, in the meantime, spread other emerging diseases such as hantavirus pulmonary syndrome and Lassa hemorrhagic fever.

The possibility that gruesome outbreaks may arise from bat viruses feeds worries about bats. "The public — and scientists — often suffer from saliency bias, where we remember dramatic events and believe they occur more frequently than other, less-dramatic ones," says veterinary epidemiologist Jonathan Epstein of EcoHealth Alliance, an environmental health nonprofit in New York City. So he welcomes the new study for starting to quantify comparisons of virus richness.

Luis and her colleagues analyzed scientific papers on viruses among the world's 1,000-plus bat species and the roughly 2,000 rodent species. Even though more studies have been published on rodent viruses, bats ended up with more documented viruses per

1.48 Average number of human-infecting viruses per rodent species

1.79 Average number of human-infecting viruses per bat species



Bats like these straw-colored fruit bats (*Eidolon helvum*) live together in large groups. When many individuals intermingle in a roost, they may share viruses.

D. HAYMAN/COLORADO STATE UNIV.

species. On average, a species of bat has 1.79 viruses known to infect people and a rodent has 1.48.

The researchers also found that among bats, species that live in the same geographic region with many other kinds of bats were more likely to carry higher numbers of viruses than were isolated species. The same effect was not nearly as strong in rodents. Many bat species mingle in roosts, Luis notes, but "there's not a place where rodents hang out together in the millions."

That link between overlapping habitats and virus numbers suggests that people watching for emerging diseases might pay special attention to places with high levels of mammal diversity, suggests Kevin Olival, also with EcoHealth.

Also, Olival points out, there are other animal groups to consider. There is no doubt that bats host many viruses that humans can catch, he says. "But I think many people would say the jury is still out on whether or not they are the most important group of mammals."

Epstein cautions that biologists still don't understand very much about bat physiology and immune systems. An important question that remains unanswered, he says, is whether bats are somehow more capable than rodents of carrying species-jumping viruses.

Regardless, Luis says, bats are "doing really important things" for ecosystems — and for people, such as saving farmers several billion dollars a year in pest-control costs by eating insects. Bats also pollinate plants.

The problem is not bats but people. When the fast-growing human population crowds into what were once wildlife-only domains, viruses have more chances to jump between species, notes David Hayman, a colleague and coauthor of Luis'. "Putting some distance between people and bats may be good for both." ■

Earth

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Life found deep below Antarctic ice

U.S. team finds microbial cells in subglacial Lake Whillans

By Janet Raloff

Cells containing DNA have emerged as the first evidence of life in a subglacial lake. On January 28, a U.S. drilling team retrieved water and sediment from Lake Whillans in West Antarctica after penetrating 800 meters of ice. The water hosted a surprising bounty of living cells.

The scientists collected three 10-liter water samples from the lake. Preliminary tests conducted in mobile labs show that the cells are actively using oxygen. It may take months for biologists to identify the microbes present.

The microbes have been sealed off below the ice for at least 100,000 years.

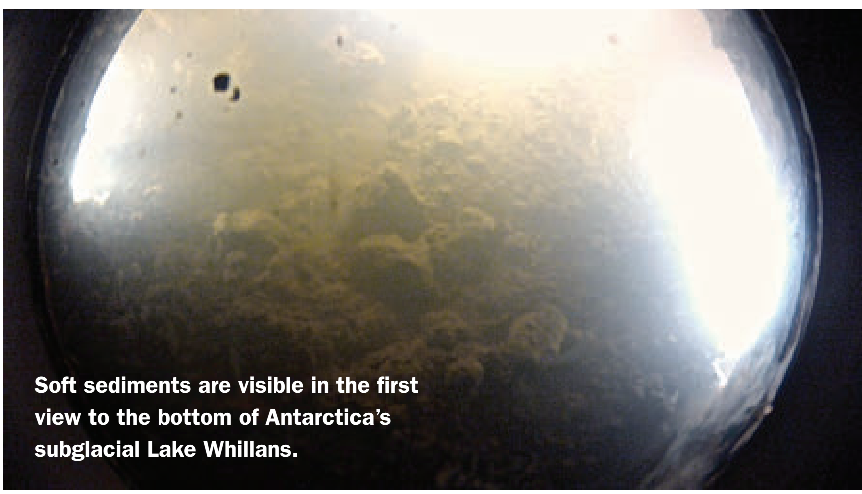
Ruling out contamination as a source of the cells was a challenge, says microbiologist Brent Christner of Louisiana State University in Baton Rouge, reached by satellite phone at the drill site. Even glacial ice harbors low concentrations of microbes, "or their corpses," so the researchers were concerned that cells in the lake samples could actually have come from the ice, Christner says.

He argues that the cells do come from the lake. First, cell concentrations in water retrieved from the lake were on the order of 10,000 per milliliter, which is about 100 times higher than the cell count in meltwater from the drill hole. Second, glacial meltwater is roughly comparable chemically to distilled water. In contrast, mineral levels in the team's samples are 100 times higher.

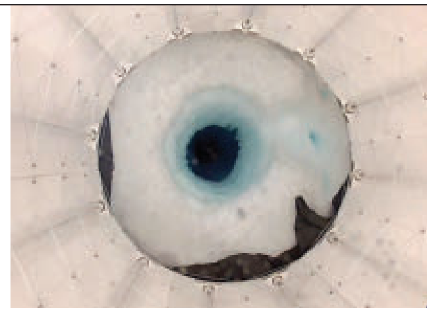
"This is a big deal — and exciting," says glaciologist Martin Siegert of the University of Bristol in England. The U.S. team's drilling endeavor marks "the first clean access to a subglacial lake system." Acquiring clean samples is imperative, he adds, to inspire confidence that any microbial finds truly come from the buried lakes.

Lake Whillans sits in a shallow cavity at the downstream end of a slow-moving ice sheet. The deep liquid streams that feed this and more than 340 other subglacial lakes across Antarctica also lubricate the ice above. Geothermal energy, along with friction and a heavy, insulating blanket of ice, keeps the water liquid in this frigid land.

Excitement at the prospect of exploring the lakes erupted in 1996, Siegert recalls. That's when an international research team he was part of realized the massive extent of Lake Vostok, a subglacial lake discovered decades earlier. At once, Siegert says, microbiologists began proposing that this buried lake — and possibly others — might host ecosystems



Soft sediments are visible in the first view to the bottom of Antarctica's subglacial Lake Whillans.



A borehole leads to Antarctica's Lake Whillans, 800 meters below the ice surface. A collar around the edge of the hole kills germs with ultraviolet light to prevent contamination.

that had been cut off from the surface for a very long time.

Precisely how long remains unknown, says Slawek Tulaczyk, a glaciologist from the University of California, Santa Cruz and a team leader on the Antarctic drill program. At Lake Whillans, "a good guess for a minimum is about 100,000 years." That's the last time the ice sheet may have shrunk back enough to expose the lake, he explains.

The new drilling project uncovered a second revelation: The lake is surprisingly shallow. Two years ago, a team conducted seismic experiments by detonating explosives; researchers used the resulting sound waves to map what lies beneath the ice. These seismic data indicated Lake Whillans was about 10 meters deep, Tulaczyk says. But instruments his team sent down the borehole now peg the lake's depth at closer to 2 meters.

The most likely explanation for the discrepancy, Tulaczyk says, rests on a third surprise that emerged from the drilled borehole: The lake sediment contains a substantial amount of water. That unexpected mixing, he says, may have confused the earlier seismic readings.

Early last year, a Russian team pierced Lake Vostok but has to date found no evidence of life. In December, technical difficulties convinced Siegert and his colleagues on a British team to suspend their efforts for the year to reach subglacial Lake Ellsworth. (*SN: 1/26/13, p. 9*) ■

BOTH: ALBERTO BEHAR/ASU

Humans

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King Richard III's bones bear witness to his life and death. His remains show that severe scoliosis curved his spine; either of two wounds evident on his skull could have killed him.

UNIV. OF LEICESTER

A notorious king's life and death, revealed by his mortal remains

Skeleton of Richard III reflects a violent and chaotic end

By Rachel Ehrenberg

History and literature have painted England's King Richard III as a scoundrel who met a violent death in battle and was unceremoniously buried. Now that researchers have revealed some conclusions from a fast-paced scientific investigation of a skeleton and its DNA found under a parking lot in Leicester, England, that end seems all the more gruesome. The results announced February 4 by a team from the University of Leicester paint a picture that is remarkably consistent with both historical and fictional accounts.

The search for the king's body began in August 2012 in the parking lot of a Leicester city council building. An excavation there uncovered walls and other structures of Grey Friars church, where Richard III was buried after his ignominious death on August 22, 1485, in the Battle of Bosworth. Beneath the spot where the church stood, the researchers found a skeleton stuffed into what appears to have been a hastily dug grave, too small for the body it contained.

History says Richard III's final moments were brutal; Shakespeare portrays the king frantically calling for a new horse to carry him back into battle after being knocked off his mount, only to be killed by Henry, Earl of Richmond, who then takes the throne.

Though the bones can't reveal the king's final words, 10 wounds confirm a violent and chaotic end. A gaping wound in the back of his head suggests the death blow was delivered by a halberd, a bladed pole weapon favored in the 15th century. A second blade wound that would have been fatal on its own penetrated the base of the skull. Carefully examining the skull's interior revealed a mark opposite this entry point, suggesting the blade penetrated 10.5 centimeters.

Then there are the humiliation wounds. In battles throughout history, combatants have rushed to plunge weapons into the dead or mortally wounded bodies of enemy leaders. Cuts deep enough to penetrate bone litter the skeleton's skull, marring its jaw and right cheek. Richard's ribs bear signs of further attacks, Leicester osteoarchaeologist Jo Appleby reported. His pelvis was nicked, indicating that a knife or dagger was plunged into his right buttock. Many of these wounds would have been prevented if Richard III had been wearing a protective helmet and armor, leading the team to speculate that these injuries were inflicted after his death.

Historical accounts report that after his death in the final major battle of the Wars of the Roses, Richard III's body was tied up, thrown naked over the back of a horse and brought to Leicester for public viewing. The body was then buried unceremoniously in Grey Friars church. The arrangement of the skeleton's hands suggests they were still tied at burial.

"The last thing the victors wanted was to give him a nice tomb in Westminster Abbey and have people put pretty flowers on it," says Cornell's Paul Hyams, a specialist in conflicts and disputes of the Middle Ages.

Grey Friars church was demolished sometime after 1538. In the early 17th century, a mayor of Leicester lived in a mansion on the site. In the 19th century, excavations for a brick outhouse apparently severed the feet from the rest of the skeleton and came close to destroying the grave.

While it suffered minor damage from being buried for 500 years, the skeleton is well preserved, Appleby says. It shows Richard III was a slight man whose spine curved like a question mark — characteristics consistent with historical accounts. While Richard III was not "the foul bunch-backed toad" that Shakespeare made him out to be, his skeleton indicates he had scoliosis that developed sometime after about age 10. The condition would have reduced his height, caused one shoulder to stand higher than the other and may have caused him pain. Contrary to another Shakespearean description, neither of Richard's arms was withered.

Surviving portraits of Richard III depict him with a prominent chin and nose. Those features emerged when facial reconstruction experts added layers of muscle and skin to a digital scan of the skull, says Caroline Wilkinson of the University of Dundee in Scotland, who led the reconstruction team.

While the bones tell much of the story, genetic data bolster the case that the skeleton is Richard's. The researchers examined DNA from mitochondria, cellular energy factories that contain genetic material, that were extracted from the skeleton's teeth and right femur. Unlike nuclear DNA, half of which comes from each parent, mitochondrial DNA passes down only from mother to child. Previous research by historian John Ashdown-Hill had traced an all-female line through 17 generations from Anne of York, Richard's sister, to Michael Ibsen, a cabinetmaker from Canada. He agreed to have his DNA tested. The genetic work also included another individual in the maternal line who wanted to remain anonymous.

> **"The last thing the victors wanted was to give him a nice tomb in Westminster Abbey and have people put pretty flowers on it."**
> PAUL HYAMS

Ibsen's mitochondrial DNA and that of the anonymous donor matched the DNA extracted from the skeleton, says Turi King, who led the genetic work. Unlike nuclear DNA, mitochondrial DNA is not usually unique to individuals. But it is far more prevalent in the body and more likely to be found when remains are very old, or not much is left; hence it finds frequent use in forensic investigations. The DNA signature that the skeleton, Ibsen and the third individual shared, called haplotype J1c2c, is quite rare, says King, making the match a solid argument for relatedness. Only a small percentage of Europeans carry it.

"They've built a strong forensic case," says anthropologist John Hawks of the University of Wisconsin–Madison. The analyses of the remains have not yet appeared in a peer-reviewed journal, he notes. But none of the presented evidence calls into question the notion that the skeleton is indeed Richard's.

Genetic data from the Y chromosome, which passes from father to son, will provide more definitive evidence. Several male descendants of Edward III, Richard III's great-great-grandfather, have agreed to share their genetic data. (Richard III himself had only one legitimate son, who died as a child in 1484 without any descendants). The team plans to compare the skeleton's DNA with that from the descendants. Richard's Y chromosome is being analyzed now, says King.

"I'm dying to get on with it," she says.

Atom & Cosmos

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

Survey snags impending supernova

Archival images show activity in weeks before star's demise

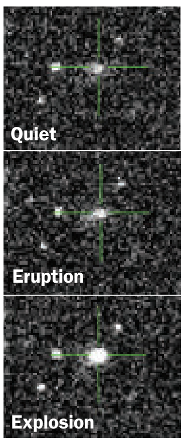
By Andrew Grant

Just before a giant star blew up in a spectacular supernova explosion, it gave hints to its imminent demise. The pre-explosion activity of this star, detailed in the Feb. 7 *Nature*, could enable astronomers to predict a coming supernova and then watch it in real time.

"It's a very fascinating study," says Jon Mauerhan, an astronomer at the University of Arizona who was not involved in the research. Astronomers have only rarely witnessed the activity of a massive star before its explosion, he adds.

The star came to astronomers' attention thanks to a computer program. The program scans sky survey images from a 48-inch telescope at the Palomar Observatory in Southern California and flags regions that show sudden brightening, which astronomers take as potential signs of supernovas. In August 2010, researchers followed up on one such brightening 500 million light-years away and confirmed that it was a type 2 supernova, an explosion of a massive star whose core runs out of fuel and collapses. Then they looked at images of the same star from the prior weeks and months for signs that it was about to blow.

The researchers spotted a slight brightening of the star 40 days before its supernova peaked and determined that the s tar had expelled a shell of gas equivalent to about one one-hundredth the mass of the sun hurtling into space at some 2,000 kilometers per second.



Burst of light Images from the Palomar Observatory in California show a giant star exploding (bottom). Sixty days before the supernova (top), the star showed no unusual activity. But 40 days before the supernova, it erupted (middle), brightening slightly.

"The star was making a little burp," says Alex Filippenko, an astronomer at the University of California, Berkeley who was on the team that made the discovery. When the star finally exploded, it ejected material that spread so quickly that it took just three weeks to overtake the previous outburst.

That stars shed mass before exploding is not surprising, Filippenko says, but this is the first time astronomers have spotted an ejection so shortly before a star's demise. The tight time frame suggested to the team that these cosmic burps are more than 100 times more likely to occur just before a supernova than at any other point in a star's lifetime.

"This type of ejection could be a cosmic lamppost for a final explosion that's about to happen," Filippenko says.

Further work will help scientists distinguish between ejections that presage supernovas and more routine eruptions. Other massive stars have burped material into space and lived on. The most famous example is Eta Carinae, a star 7,500 light-years from Earth which, for a brief time in the mid-1800s, unleashed into space a shell of gas 10 times the mass of the sun and became the second-brightest star in the night sky. Since then it has quieted down, and astronomers have no idea whether it will explode in 100 days or 100,000 years.

Astronomers certainly have the tools to explore these questions. Automated sky surveys like the Palomar project have popped up worldwide, and by the end of the decade the 8.4-meter Large Synoptic Survey Telescope in Chile will scan the entire sky every few nights with its 3,200-megapixel camera.

MANSI KASLIWAL/CARNEGIE INSTITUTION FOR SCIENCE

Atom sheds light on neutron stars

Heavy zinc hints at makeup of dense stellar remnants

By Andrew Grant

The precise measurement of an exotic atom in the laboratory has refined scientists' understanding of neutron stars, which contain some of the most densely packed matter in the cosmos. The study, published in the Jan. 25 *Physical Review Letters*, could help determine whether the crusts of neutron stars serve as the source of dozens of heavy elements such as zinc, silver and gold.

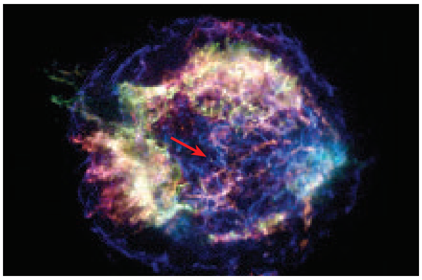
"One of the universe's overriding mysteries is where heavy elements originate," says James Lattimer, an astrophysicist at Stony Brook University in New York who was not involved in the study. "These mass measurements allow us to tune our equations."

Neutron stars are not actually stars at all. After a massive star explodes in a supernova, the remnant is a hot, dense ball of protons, electrons and lots of neutrons that measures about 20 kilometers across and is more massive than the sun. These extreme conditions allow atomic nuclei that are normally unstable to exist in the neutron star's outer layers.

Neutron stars are too far away for astronomers to study their composition, and scientists cannot re-create their enormous pressures in the lab. But researchers can plug the measured properties of various neutron-rich atoms into computer simulations to predict neutron star composition.

Physicist Robert Wolf of the University of Greifswald in Germany and an international team were particularly interested in determining the mass of zinc-82, which some models predict should occur in the crusts of neutron stars. Zinc-82 has a nucleus consisting of 30 protons and 52 neutrons — many more than the

“One of the universe’s overriding mysteries is where heavy elements originate.” —JAMES LATTIMER



A newly formed neutron star (marked by arrow) sits in the center of the supernova remnant Cassiopeia A, about 11,000 light-years away.

NASA, CXC, UNAM, IOFFE, D. PAGE, P. SHTERNIN *ET AL*

34 neutrons in the most common form of zinc. The challenge was isolating and measuring the rare isotope, most of which would decay in less than a second.

At the CERN lab outside Geneva, Wolf’s team used the On-Line Isotope Mass Separator facility to measure the mass of a pure sample of zinc-82. The researchers compared this mass with predictions in various computer simulations and determined that zinc-82 is probably too light to be stable beneath a neutron star’s surface. That’s in line with the most well-supported prediction of neutron star composition.

Lattimer believes this aspect of the study is not its greatest contribution; previous experiments had already shown that the leading model was more accurate than others. Instead, he is most impressed by the technique’s potential to pin down the characteristics of other exotic nuclei that may exist in neutron stars.

Scientists want to create this compositional profile because neutron stars may be the source of many of the universe’s heavy elements. Fusion reactions in the cores of regular stars produce carbon, oxygen, nitrogen and other elements essential for life. But the heaviest element that fusion can construct is iron. Astrophysicists have long looked for another astronomical process with enough energy to forge heavier elements from protons and neutrons.

One potential explanation is that these elements form in the midst of the extreme heat and energy of supernovas — no neutron stars required. But simulations show that these explosions have an insufficient quantity of neutrons. That need for neutrons leads to a competing idea: that heavy elements form when two neutron stars collide and some of their crustal material escapes into space.

To evaluate this possibility, theorists need to improve models of neutron star composition. Mass measurements of heavy atoms like zinc-82, Wolf says, will help them do that. Then astronomers can survey the abundances of heavy elements in various stars and compare them with predictions of what would be produced in neutron star collisions.

Genes & Cells

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Just one gene for pigeon crests

Mutation arose once and then spread via breeding

By Tina Hesman Saey

Pigeons with crests, like the ones decorating this Old German owl pigeon (left) and Indian fantail pigeon (right), carry a mutation in a single gene that causes some feathers on the neck and head to grow in the opposite direction from normal.

FROM LEFT: COURTESY OF SYDNEY STRINGHAM; COURTESY OF M. SHAPIRO

A change in a single gene ruffles the feathers of all pigeons with collars and crests, a new study shows.

Many breeds of rock pigeons sport these crests, even though the birds come from different branches of the pigeon family tree. So it was a surprise that all the birds owe their fancy plumage to the same mutation in a gene called *EphB2*, Michael Shapiro of the University of Utah and colleagues report online January 31 in *Science*.

The researchers found that the mutation arose once and spread to many different varieties of pigeons through breeding programs. Scientists don't yet know whether the mutation arose in a wild ancestor of domesticated pigeons or if it sprang up only after domestication.

As different species evolve, the same traits can show up again and again. Scientists debate whether each occurrence comes from the same genetic mechanism, as in the pigeons, or from different mutations that produce the same result, says James Hanken, an evolutionary biologist at Harvard University.

The finding in pigeons may help answer the question in other bird species. Pinpointing the genes behind feather colors, ornamentation or other characteristics in pigeon breeds might give researchers clues about the causes of similar features in wild birds, says Scott Edwards, a Harvard University evolutionary biologist who specializes in birds.

Cardinals and blue jays also have crests, but no one knows whether those feathered cowlicks arise thanks to changes in the same gene as in pigeons. Tweaks in multiple genes may instead give those wild birds their distinctive styles.

"We still don't know whether the genetics of domestic species are simpler than those of wild species," Edwards says.

To make the discovery, Shapiro's colleagues in China and Denmark deciphered the genome of a male Danish tumbler pigeon. That bird's blueprint served as a reference for putting together the genomes of 40 other rock pigeons, all members of the species *Columba livia*, including individuals from 36 breeds and two feral pigeons.

Rock pigeons, which include more than 350 breeds including most familiar, garden-variety pigeons, are not native to North America. The wild pigeons in North America owe at least some of their heritage to escaped domesticated birds, especially to homing pigeons bred to race, the researchers discovered by comparing the DNA of feral pigeons to the domesticated breeds.

Shapiro, who is interested in genes that give rise to physical characteristics, decided to investigate feather crests because earlier studies had indicated that just one gene might be involved. But no one had delved deeply into pigeon genetics, so the researchers had no idea where to look for the crest gene.

"It must have been a very nerve-racking study," Edwards says. The researchers could have come up empty-handed.

To track down the gene, Shapiro's group pooled genetic data from pigeons that have crests and compared that information with data from breeds with smooth heads and necks. Just one part of the genome stood out as differing between the two groups.

Closer examination revealed that all of the birds with crests carried a single change in the *EphB2* gene. That mutation causes some feathers on the neck and head to grow in an unusual direction — upward toward the face, rather than downward toward the torso.

"This mutation that we found appears to be the on/off switch for crest development," Shapiro says. He doesn't yet know why the mutation affects feathers only on the head and neck.

Crests come in many shapes and sizes, and Shapiro thinks other genes play a role in determining how big and elaborate the ornaments grow. The researchers are trying to track down those modifying genes and to determine whether *EphB2* is involved in crest development in other bird species. ■

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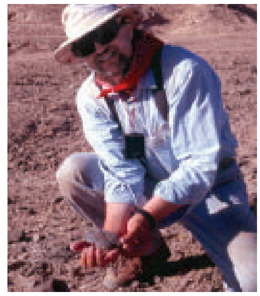
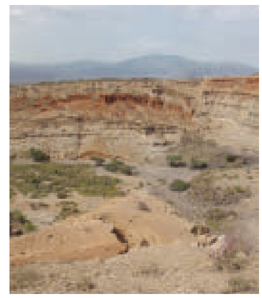
RESEARCH

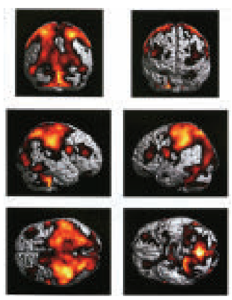

Conferences

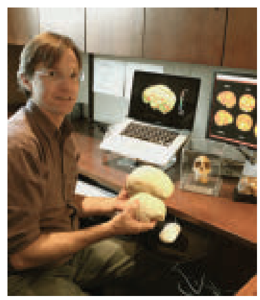

Experimental Tool-making


Homo erectus Discovery


Olduvai Gorge, Tanzania

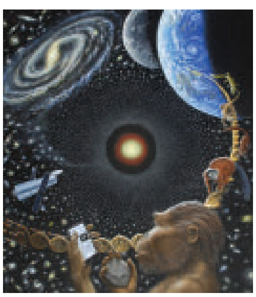

Ape Tool-making


Tools and Cognition


Brain Evolution


Ethnoarchaeology

EDUCATION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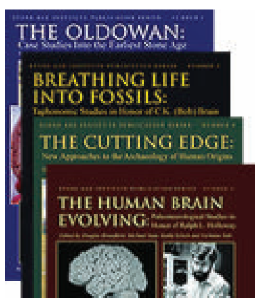
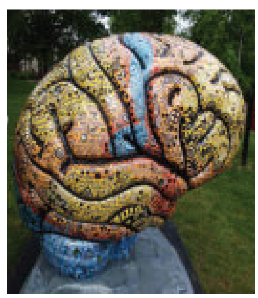
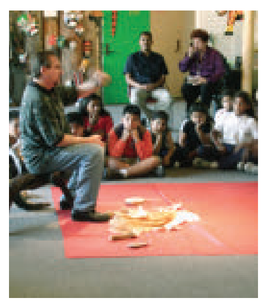
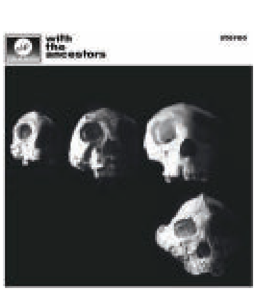


Publications


The Brain Extravaganza

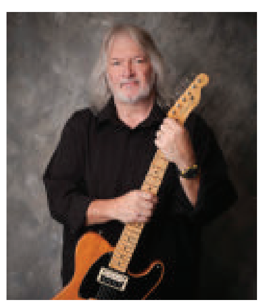

Community Outreach

MUSIC



The Stone Age Institute Band


Carrie Newcomer, vocals


Seymour Duncan, lead guitar


Booker T. Jones concert

THE 3-D PRINTING REVOLUTION

Dreams made real, one layer at a time

By Rachel Ehrenberg

Joshua Pearce takes unusual satisfaction in strolling through Walmart. The shelves laden with toys, household items, tools and clothing inspire in him a certain smugness, a pride in American entrepreneurship. But it's not because Pearce admires the chain as an empire built by a self-made man. Pearce swells with pride at Walmart because the store is full of mass-manufactured objects that he could make himself.

"I take great pleasure — and my wife teases me about it — walking though Walmart and saying, 'I could print that, I could print that, I could print that,'" Pearce says.

Pearce is at the forefront of what may be the next manufacturing revolution. Using a technique known as 3-D printing, regular people can now make goods typically produced in huge quantities in factories overseas. Need a mug? A tape dispenser? A chess piece? A pair of shoes? It's as simple as pressing the print key.

1,000 dollars

Typical cost of a personal 3-D printer

300 percent

Approximate growth of personal 3-D printer sales in 2011

3-D printing builds objects by piling up successive layers of material, hence its more technical moniker, "additive manufacturing." You start by designing your product on a computer screen with drafting software. That design then goes through a program that slices it up, translating it into a stack of two-dimensional layers. The printer constructs the object by depositing the first layer of material — such as molten plastic that hardens — and then another and another, gradually creating the desired shape. As the printer head moves back and forth, your 3-D vision becomes reality.

The last few years have seen an explosion in the sale of personal 3-D printers. Like computers, the machines were once found only in well-funded academic, government and industrial settings. Available since the late 1980s, these machines cost tens of thousands of dollars and primarily printed prototypes. But now anyone can send a design to the 3-D printing equivalent of Kinko's to have any number of copies made. And home printers, in most cases smaller than a washing machine, are available for around $400 to $4,000. In 2011 alone, annual sales of personal 3-D printers grew by almost 300 percent, to more than 23,000 units worldwide. People are printing jewelry, smartphone cases, headphones, lamps — even food.

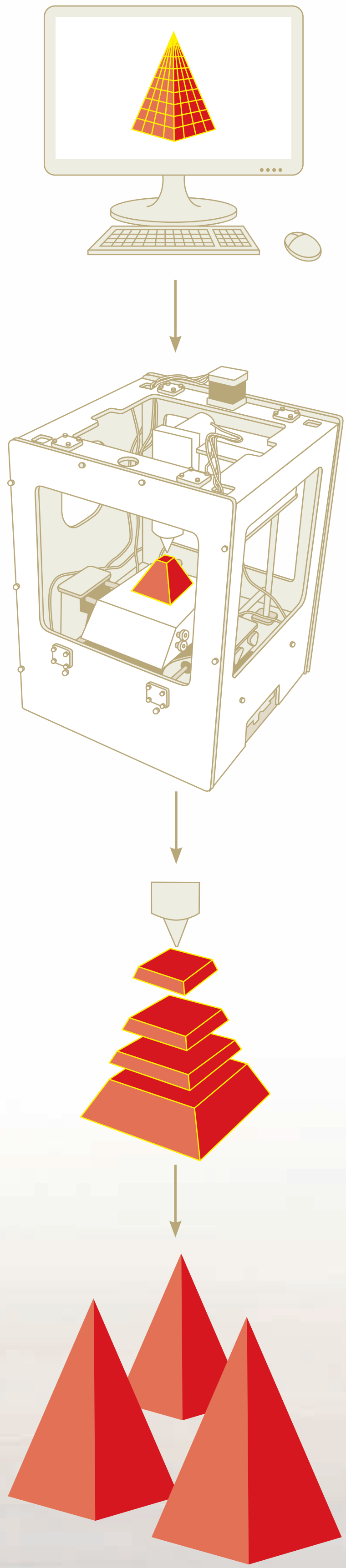
Many herald 3-D printing as a game changer, a "disruptive" technology that will turn traditional manufacturing on its head. But the technology is also at the peak of hype.

"Everybody's talking about it right now," says Hod Lipson, an engineer and computer scientist at Cornell University. "It could be huge or it could just be a blip."

Whether 3-D printing turns out to be a mere blip or a battering ram that renders present-day manufacturing unrecognizable remains to be seen. For now, there is no doubt that the technology is a powerful tool. It eliminates the time and expense of creating complicated, intricate objects. It can also remove the "mass" from mass manufacturing by making a limited run of a product affordable. Anyone can produce small batches, or even a batch of one. The technology democratizes innovation, says Lipson. If you can think it, you can probably print it.

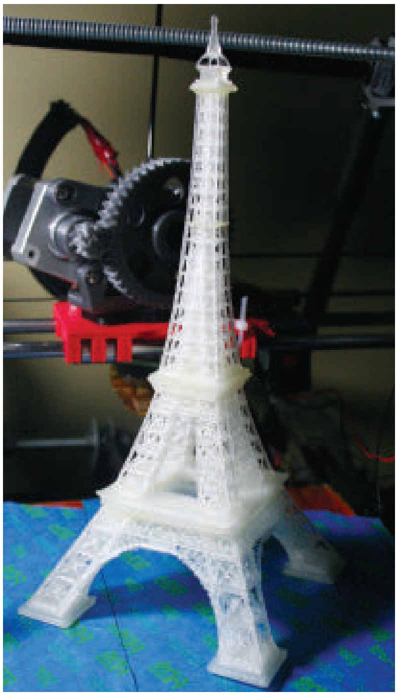
Stuff abounds

Still, envisioning what exactly 3-D printers will deliver is difficult. In some respects it is like trying to imagine back



A vision realized For about $1,000, anyone can buy a 3-D printer that builds objects layer by layer out of plastic. More expensive machines can handle metals, ceramics and other custom materials. The user starts by drafting an object with computer-aided design software. The machine then starts to build the object by depositing the material one layer at a time. Some machines spray or squeeze layers of liquid or powder that harden into a solid (shown). Others use heat, lasers or binders to fuse grains of loose powder into solid layers.

OPPOSITE PAGE: EVA KOLENKO/3D SYSTEMS; THIS PAGE: S. EGTS




The accessibility of 3-D printing has inspired hobbyists, designers and artists to create an incredible array of objects: models of famous landmarks (left), kitchen tools (middle top, and in production, middle bottom) and musical instruments (right).

FROM LEFT: JUSTIN HAWKINS/PRYNTECH; WALTER HSIAO; OLAF DIEGEL/ODD GUITARS

in the 1960s the role computers would play in people's lives today. If you had asked someone then what was so special about computers, you would probably hear about how fast they can do calculations. Their pervasive role today — not just in number-crunching but in banking, communication, entertainment and more — would have been hard for most to foresee.

One thing does seem certain: "I think initially," says Lipson, "we'll have a lot more junk."

Junk proliferates on Thingiverse, a website created by 3-D printer manufacturer MakerBot where people upload and share their designs. There are specs for heart-shaped charms, models of the Eiffel Tower and a plastic octopus wearing a monocle and top hat. Another site devotes itself to downloadable designs that enable people to create the intricate, blocky structures found in the computer game Minecraft.

"There is a lot of stuff that has no value, no improvement for humanity," says Pearce, a materials scientist and engineer at Michigan Technological University in Houghton. "There is a possible moral hazard that we will make a lot more junk."

> **"With 3-D printers, the cost of manufacturing complexity goes to zero. Complexity is now free."**
> HOD LIPSON

But among the clutter, there are also plenty of utilitarian items: shoehorns, tie hangers, pliers and boxes customized for carrying batteries, ammunition, pills and playing cards. Replacement parts abound, including flushing mechanisms for toilets, kitchen stove knobs and a cap for a Jack Daniel's bottle.

A capacity for creating tchotchkes and everyday items, though, doesn't mean a technology can't also be revolutionary. Because the approach is amenable to a variety of materials, including metals, concrete and even living cells (*SN: 1/26/08, p. 56*), it is poised to lead to entirely new products. 3-D printing is already changing the way doctors design prosthetics and is prodding engineers, architects and designers to think differently about the construction and function of car parts, airplanes and even whole buildings.

"Here's why I think this is real," Lipson says. "It has to do with what makes for an industrial revolution. Something that used to be a major factor in cost came out of the equation."

When the steam engine came along, the cost of power plummeted. You didn't need expensive animals to do mechanical work. Networked computers did the same thing for the cost of communication, Lipson says. It became virtually free to send information. Additive manufacturing also removes something that was once expensive. "With 3-D printers, the cost of manufacturing complexity goes to zero," Lipson says. "Complexity is now free."

Complexity for nothing

Traditional approaches for creating complex objects remove material; they are subtractive. Blades, abrasives, lasers or other cutting tools whittle away at a solid block, carving out fine features. Subtractive approaches can create exquisitely complicated items, but that complexity comes at a cost: The more intricate the object, the more time and advanced skills required to make it.

Engineer Walter Holemans envisions fleets of low-cost autonomous catamarans that could be used for collecting scientific data or patrolling remote waters for pirates or other dangers. He is testing prototypes made almost entirely of printed components.

WALTER HOLEMANS

Additive manufacturing renders irrelevant the problem of getting a tool into a tight internal nook or cranny. Because 3-D printers build by setting down material as they go, a printed object can have delicate lacelike features or strange curving parts, like the antlers on a model deer head recently printed by one of Pearce's students.

In some cases, separate printed parts are pieced together. But 3-D printing can also create objects with multiple moving parts in one fell swoop. Take something as seemingly basic as an adjustable wrench. By leaving gaps in the right places, a printer head sweeping back and forth can print, in place, the threaded knob that opens and closes the wrench.

Walter Holemans, a rocket scientist who runs a small aerospace engineering firm in Silver Spring, Md., invented a new type of boat rudder and brought it to life via 3-D printing. The rudder has both moving parts and a slender curved internal spring, but was printed all at once.

When Holemans envisioned the rudder, he realized that traditional machining techniques would create a grainy surface that would increase drag. So Holemans considered printing a mold. He could pour in his material, and pop it out once it dried.

"I realized I could print the mold and then thought, 'well I could just print the rudder,'" Holemans says. "I could print parts that would be impossible to machine."

In the end, Holemans didn't just print his rudder. He printed much of the rest of the boat as well. The sleek, unpiloted catamaran has two 8-foot-long torpedo-shaped hulls connected by a crossbar, atop which sits a 6-foot plastic sail. Powered by the sun and wind, the Robotboat has a self-righting mechanism so it can get itself sailing again after flipping in roiling waves. It is also equipped with GPS and sensors so it "knows" where it is going. For now, the boat serves as a prototype that is being tested on real-world waterways. Eventually, Holemans and his team intend to send fleets of boats out on the oceans to gather data on oil spills, carbon dioxide and marine life, or perhaps to patrol for pirates.

Prototypes to products

Engineers and product developers have long used 3-D printing for creating prototypes. Once engineers settled on a final design, production would move to factories, typically with assembly lines or expensive injection molding machines that had to create tens of thousands of plastic containers or toy parts to justify the costs.

The plummeting cost of 3-D printing changes all that. Businesses don't have to invest huge amounts of money and then keep their fingers crossed that they'll be able to sell 25,000 toy trucks. They can

Planet of the 3-D printers

If you can make practically anything with a 3-D printer, why not make more 3-D printers? The RepRap, short for replicating rapid prototyper, was the brainchild of mechanical engineer Adrian Bowyer. He and his colleagues at the University of Bath in England had long been using 3-D printers — the $60,000 variety — for making "one-offs," prototypes of things that mechanical engineers use. Then Bowyer realized that he could harness the technology not just for making prototypes, but for making more 3-D printers. Bowyer decided to make the RepRap project open source. The printers are sold as kits or fully assembled; anyone can tweak the hardware and upload new designs, such as an improved hinge or attachable fan that cools layers as they come out of the printer head. Since developing the first RepRap in 2007, Bowyer's team has released multiple models, each named after a famous biologist (Darwin, Mendel, Huxley, Wallace), in keeping with the idea of replication and evolution. Bowyer estimates that there are upwards of 30,000 RepRaps in existence today. But he can't be sure, since anyone who owns one can print another. — *Rachel Ehrenberg* make 50 and, if the product sells, they can make 50 more. This shift in the scale of production may bring manufacturing jobs back to countries that have shipped labor elsewhere, albeit quite different jobs than the ones that were lost.

"It's becoming a solution for manufacturing," says Terry Wohlers, head of Wohlers Associates, a consulting agency based in Fort Collins, Colo., that has been keeping an eye on the additive manufacturing sector for more than 25 years.

Small-scale manufacturers, many born of a subculture of technology-oriented do-it-yourselfers who call themselves "makers," have been at the forefront of the 3-D printing charge. Colleen Jordan makes houseplants portable by creating tiny planters that can be worn as jewelry or attached to a bike frame. Sculptor Bathsheba Grossman is known for her Klein bottle opener, an intricate Escher-like piece that illustrates principles of topology and also opens beverages.

An engineer used 3-D printing to create a custom prosthesis for an Alaskan bald eagle whose beak had been shot off.

YOUNG KWAK/AP IMAGES

Many of these businesses rely on retail print shops such as i.materialise and Sculpteo to bring their designs to life. Some of the shops tailor their services to specific communities, or specialize in particular sizes and materials. Holemans sent his Robotboat design to RedEye, a division of Stratasys, which has long printed prototypes for the aerospace, engineering and medical industries. Business is booming for these 3-D printing subcontractors: Shapeways, another shop, recently christened a 25,000-square-foot space in Queens, N.Y., that will house 30 to 50 high-definition, industrial-sized 3-D printers.

While makers are leading the pack, some major companies, including Airbus, have also embraced the technology. Because 3-D printing often eliminates the need for things like fasteners, printed products often weigh less than their traditionally manufactured counterparts. Airbus has started printing some components of its cabins, and by 2050, the company hopes to print entire planes.

Governments have also taken note. Last August, the Obama administration announced the launch of the National Additive Manufacturing Innovation Institute, part of a larger effort to create a "manufacturing belt" in the nation. The pilot institute, designated for Youngstown, Ohio, is funded by NASA, the National Science Foundation, and the departments of Defense, Energy and Commerce. It will support bringing additive manufacturing technologies into industrial and academic labs, as well as training programs for manufacturers to try out 3-D printing materials and machines.

The European Union is pushing investment in 3-D printing technologies, according to a report by Reuters last fall based on leaked documents, as part of an effort to boost manufacturing output from 16 percent of its GDP to 20 percent by 2020. And last October, the United Kingdom announced its intention to invest the equivalent of more than $10 million in grants for research and development of 3-D printing technologies.

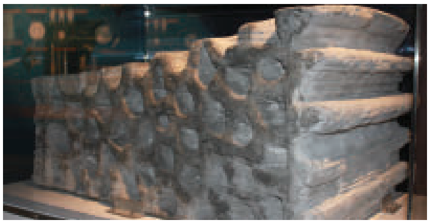
A market of one

The proliferation of 3-D printing has consequences that go beyond shifts in supply chains and manufacturing. The technology may also change how we create, use and think about products. Because making a batch of one is no longer cost prohibitive, any product can be tailored to an individual consumer. Commonplace objects can be customized. While a large manufacturing plant wouldn't make 10,000 smartphone cases embedded with an imprint of your child's hand, now, you can make that case. And 9,999 other people can make smartphone cases embedded with imprints of their children's hands.

Pearce envisions a future in which many homes will have a 3-D printer, and items such as dinner plates, coat hooks, shoes and clothing will be printed as needed. (Couture 3-D printed clothing and shoes already exist.) But these won't

The dark side of 3-D printing

There have always been ways to create makeshift weapons, reproduce keys or counterfeit drugs. But 3-D printing may make such feats a lot simpler. A number of people have already printed gun parts; the collective Defense Distributed, led by University of Texas at Austin law student Cody Wilson, aims to create blueprints for a fully printable firearm and make those files widely available. When MakerBot's website Thingiverse removed weapon-related designs from its site last year, Defense Distributed created DEFCAD, where people can upload (and download) files for printing gun parts, such as a 30-round gun magazine and a grip for an AR-15 semiautomatic rifle. Guns aren't the only printed items raising eyebrows: At a hackers' workshop last summer, a German security consultant unlocked two widely-used brands of police handcuffs with keys that he had made multiple copies of using a 3-D printer. And scientists recently reported using a 3-D printer for making "reactionware," customized polymer containers that make particular chemical reactions run with ease. Such innovations could make life easier for illicit drug manufacturers, terrorists or others with ill intent. —*Rachel Ehrenberg*



The European Space Agency is experimenting with the idea of using 3-D printing to build a moon base. Printers mounted on tractor-treaded vehicles would build the structure by depositing and binding lunar soil atop rocket-delivered inflatable domes (artist illustrations shown, top and middle row). A prototype 1.5-metric ton building block (bottom right) was produced by a printer 6 meters across (bottom left).

MOON BASE: ESA/FOSTER + PARTNERS; PROTOTYPE: ESA; PRINTER: MONOLITE

be ordinary accessories. They will be custom designed to fit the needs and aesthetics of a particular person or family.

3-D printing's real power is not in making things you can buy, but in making things you can't buy. You can scratch your own itch, says Pearce. "Anything that's remotely customizable, 3-D printing is going to win out. You can do fantastic things."

That customization extends beyond ordinary items tweaked to meet your fancy. It also extends to truly revolutionary products that would be unthinkable in a mass-production manufacturing economy. Consider the medical applications: Last year, engineers created a robotic exoskeleton for a 2-year-old girl with arthrogryposis multiplex congenita, a condition that makes it difficult for her to move on her own. Now she can play with her toys and hug her mom. Another engineer created a prosthetic beak for a bald eagle named Beauty, whose own beak was mangled when she was shot in the face. Doctors and engineers are even experimenting with 3-D printing to create artificial cartilage, livers and kidneys.

Wohlers notes that more than 80,000 custom titanium parts for replacement hips have been printed. "The day may come when we really can print a new finger for someone," he says.

Of course, there will also be a proliferation of mundane, lighthearted products. And there's nothing wrong with that: Computers have had an enormous impact on society, no matter how much we use them to make and watch videos of cats. ■

Explore more

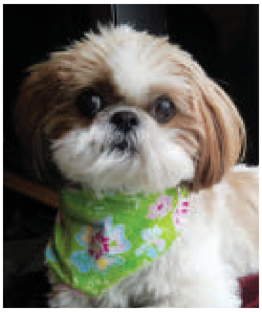
- Thingiverse: www.thingiverse.com
- RepRap wiki: www.reprap.org

A Cancer Patient's BEST FRIEND

Similarities between tumors in people and dogs mean canine studies can inform human disease

By Laura Beil

Daisy Martin didn't seem sick. Come dinnertime, she was as ravenous as ever. And at the sight of a new toy, she danced around in excited circles, same as always. Then one day, when Daisy was 8 years old, one of her family members noticed a lump, and then others, on the side of Daisy's neck, beneath her fur. The diagnosis was devastating: T-cell lymphoma, a cancer so merciless that Daisy's family feared losing her within weeks. The one hope was to enroll Daisy in a study of an experimental drug, available more than an hour's drive away at the University of Minnesota in St. Paul. Her family was torn. Would the treatment cause more suffering? Would she lose her hair?



Daisy (pictured right) is a doe-eyed Shih Tzu. As with research volunteers of the human kind, her participation in the drug trial meant she could obtain care that her family could not otherwise afford. She would help scientists collect data that could benefit future generations of ailing dogs, even if she herself could not conquer the cancer.

And the trial reaches beyond canine patients. Whether Daisy recovers, and how she recovers, will provide information about a drug that could one day help dog owners as much as dogs themselves.

When it comes to cancer, dogs now exist at the nexus of human and veterinary medicine. "I just came back from a meeting of the connective tissue oncology society, where two of the talks were results from studies of pet dogs. Neither of the two people presenting the talks were veterinarians," says Chand Khanna, a veterinarian by training who heads the comparative oncology program at the National Cancer Institute, part of the National Institutes of Health in Bethesda, Md.

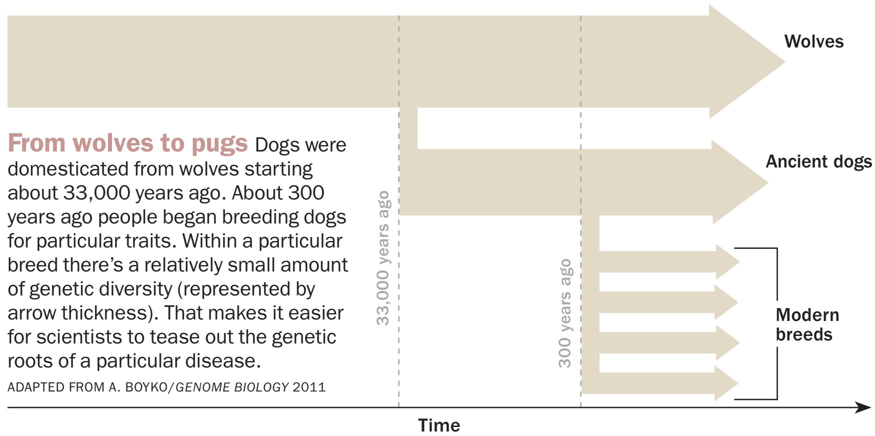
And last year, Harvard Medical School invited Elaine Ostrander, an NIH cancer geneticist who has long worked with dogs, to deliver the esteemed Franklin H. Epstein Memorial Lecture. Her talk, given to the faculty of Harvard's Beth Israel Deaconess Medical Center, covered the human implications of "good dogs with bad genes." She says that when she learned of her selection for the honor, she thought, "Hot diggity dog! We've made it!"

FROM TOP: ELKE VOGELSANG/GETTY IMAGES; COURTESY OF CINDY MARTIN

Khanna, Ostrander and other researchers with similar interests have long contended that dogs offer an under-recognized bounty for oncology. No matter the species, cancer arises when some tragic combination of a body's genetics and its surroundings conspire to take the brakes off cell growth. Dogs' environmental exposures occur alongside those of people: For centuries, pooches have lived with people, sleeping in their homes and eating their foods. And dogs' genetics are not so different either. When the partial genetic instruction book for a poodle was published in 2003, followed by a more detailed look at a boxer in 2005, scientists learned that most genes in man are shared with man's best friend. The DNA within many tumors may carry an even more similar pedigree.

"The genome data were transformational," says Jaime Modiano, an immunologist and veterinarian at the University of Minnesota. "It allowed us to say that a cancer in dogs and a cancer in humans are the same thing."

Canine genetic studies since have yielded important clues to how cancers of the blood, bone and brain arise. Better understanding of these diseases may lead to better treatment. The most common type of non-Hodgkin's lymphoma, for example, affects dogs and humans in almost equal proportion, and the same chemotherapy treats both. Veterinarians have long turned to human drugs to treat their canine patients, but one day the pipeline may flow in the other direction. More and more pets like Daisy are participating in tests of new treatments, studies that produce answers sooner than human trials because dogs are shorter lived.



From wolves to pugs Dogs were domesticated from wolves starting about 33,000 years ago. About 300 years ago people began breeding dogs for particular traits. Within a particular breed there's a relatively small amount of genetic diversity (represented by arrow thickness). That makes it easier for scientists to tease out the genetic roots of a particular disease.

ADAPTED FROM A. BOYKO/*GENOME BIOLOGY* 2011

"There's a lot bubbling right now," says Kerstin Lindblad-Toh of the Broad Institute of MIT and Harvard, a leader in the project to sequence the boxer genome. "This year and the next you're going to see a lot of publications."

Genes that sit, stay

Animal research has long been a part of medical science. But unlike mice and rats, the dogs involved in oncology research don't live in laboratories. They are patients, occupying a place as companions and family members. Dogs were the first animals to be domesticated, and although both dogs and humans have benefitted from the storied relationship, dogs have paid a price for their heritage.

Dogs evolved from wolves, entering human culture around 33,000 years ago. Solid records date back around 15,000 years, says Matthew Breen, a geneticist at North Carolina State University. "Fifteen thousand years ago, dogs didn't sit at our feet and watch TV. They helped the nomadic tribes survive."

Scientists can only hypothesize about the path from feral to Fido, but Breen says one theory is that early humans began tossing food to wolves as a way of bribing against attack. Over time, wolves and people became dependent on one another; wolves grew accustomed to the easy meals, people enjoyed the protection wolves offered. As time passed, relationships deepened.

"They helped us by hunting, herding and guarding. They became companions," Breen says. By the late Pleistocene, which ended about 11,700 years ago, humans were buried with their dogs. The ancient Egyptians mummified some dogs like royalty.

Following the transformation from wolves, the genetic milestone in dogdom came with the industrial revolution, Breen says. "The landowners and factory owners had something they never had — free time. As a consequence, we started to breed [dogs] because we liked the way they looked." Owners developed a fancy for long or short coats, small or large bodies, or a dog's ability to hunt or guard or just lounge around being sweet. Most breeds recognized by the American Kennel Club have been distinct genetic entities for about 200 to 300 years, Ostrander says.

All this selective breeding greatly decreased genetic diversity. Further bottlenecks came about during the lean times of the Depression and world wars, when purebred dog populations shrank. Today, many breeds such as Leonberger

Canine cancer risk Cancer is at least as common in dogs as it is in people. Selective breeding of dogs leaves particular groups at high risk of certain cancers. For example, Great Danes have about a 60-fold increase in risk of osteosarcoma compared with other dogs.

Dog breed	Cancer(s)	Risk increase
Chow chow	Gastric carcinoma	10 to 20 times
	Melanoma	7.9
Boxer	Mast cell tumor	16.7
	Hemangiosarcoma	12.4
	Lymphoma	4.5
	Osteosarcoma	7.9
Scottish terrier	Melanoma	3.8
	Subungual malignant melanoma	12.1
	Transitional cell carcinoma	18.1
Great Dane	Osteosarcoma	60.9

SOURCE: A.L. SHEARIN AND E.A. OSTRANDER/*DISEASE MODELS & MECHANISMS* 2010

CHOW CHOW, BOXER, GREAT DANE: AALTAZAR/ISTOCKPHOTO; SCOTTISH TERRIER: E. FELICIANO dogs and Portuguese water dogs are the descendants of perhaps fewer than 20 or 30 founders.

Along the way, as people handpicked the most attractive dogs for breeding — often mating uncles and aunts with nieces and nephews — they unknowingly amplified hidden genetic triggers for cancer.

About 25 percent of dogs will eventually develop a malignancy, Breen says, and the proportion is increasing. Cancer kills about 13 percent of the world's human population, and some dog breeds have a cancer-related death rate three or four times that. About half of all golden retrievers die from cancer, commonly lymphoma. Large breeds are known for their high risk of bone cancers, while brain tumors are typical among dogs with squished-looking faces, including pugs and bulldogs.

101 mutations

Yet the same genetic inbreeding that makes dogs so cancer-prone also provides an easier landscape to search for cancer's roots. In appearance, solid tumors removed from people and dogs can be practically indistinguishable. "You couldn't tell a difference between a dog tumor and human tumor under the microscope," says Peter Dickinson, a veterinary neurosurgeon at the University of California, Davis. The molecular engines of disease are also often similar.

To find genetic flaws responsible for human disease, scientists have to study hundreds, even thousands of people to account for the random, irrelevant genetic background noise. Imagine hearing a symphony, straining to listen for just the viola. You'd need to listen over and over, slowly eliminating every other instrument. The task would be easier if the violas were louder and more numerous, and had fewer violins and cellos drowning them out. Centuries of inbreeding have given dogs a simpler genetic ensemble, so scientists have an easier time finding a distinct melody.

Consider that one search for a genetic cause of gliomas, a deadly brain tumor, involves more than 700 human patients and almost 4,000 healthy volunteers in a comparison group. Dickinson and his research team are performing a parallel and probably equally powerful study with just 40 affected dogs and 150 healthy ones. They have narrowed the search for their glioma gene down to one chromosome.

Other canine gene hunts are under way. In 2012, a team of researchers that included Ostrander and Breen announced the location of a gene for histiocytic sarcoma, a form of lymphoma that is rare in humans but strikes up to a quarter of Bernese mountain dogs and flat-coated retrievers. It is an aggressive malignancy with no cure. In a cover article in *Cancer Epidemiology, Biomarkers and Prevention*, the researchers described a genetic mutation that appears to be associated with the cancer in these dogs. Importantly for their masters, the aberration turned up in a poorly understood genetic region that has been associated with other kinds of human malignancies — yet another clue in the search for cancer's origins. "People are dogs, in terms of cancer," Breen says.

A 2009 study by Khanna, from the National Cancer Institute, shows how true that may be. The analysis, published in *BMC Genomics*, found that the genes active in human osteosarcomas (the most common malignant bone tumor in children) and dog osteosarcomas are almost indistinguishable. If the genes are the same, the treatment can be, too. The following year, he reported in *PLOS ONE* that the drug rapamycin fights the cancer the same way in dogs as it does in people.

Better treatments unleashed

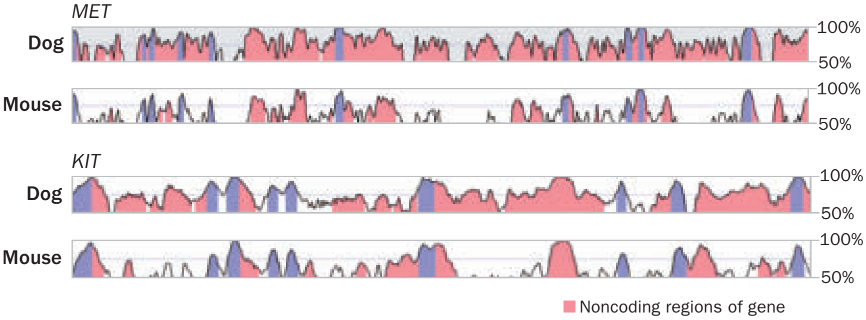
That finding is good news for dogs, but there's a larger point. Dogs have long relied on human chemotherapy drugs, but as studies find more and more instances of tumors that are almost genetically interchangeable, medical researchers are turning to dogs to test drugs for humans.

Mice and rats have long stood in for people, but four decades of the war on cancer have revealed major shortcomings to this approach. Rodents do not develop human cancers naturally, so researchers often have to graft tumors from people into mice and rig unnatural arrangements such as severe immune suppression that allow the cancers to grow.

Still, the tumor isn't inclined to this kind of existence. That's why cancer is cured many times over in labs, but not so often in actual people. The late Judah Folkman, a renowned researcher who pioneered a new class of oncology drugs, once said, "If you have cancer and you are a mouse, we can take good care of you."

By contrast, dogs have cancers that arise spontaneously in the face of an intact immune system and a normal life. While no one is considering eliminating rodent research, people are thinking about turning more to dogs, especially for modern treatments that

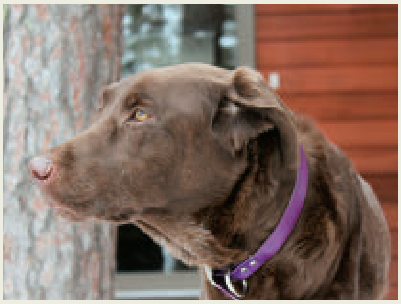
Genetic stand-ins Dogs are genetically similar to people when it comes to some genes involved in cancer — sometimes a closer match than mice, the typical research stand-in for humans. Below are representations of how similar dog and mouse versions of two gene portions are to the human form. *MET* has been implicated in both human and canine sarcomas. *KIT* causes gastrointestinal stromal tumors (GISTs) in people and mast-cell tumors and GISTs in dogs.



SOURCE: M. PAOLONI AND C. KHANNA/*NATURE REVIEWS CANCER* 2008

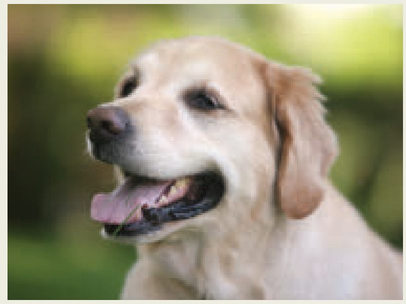
Cancer research goes to the dogs

People in clinical studies help the next generation of cancer patients. Canine efforts help not only future generations of dogs but people, too. Here are some four-legged patients who benefited from experimental therapies for their cancers:



Kodiak was 8 years old when he developed a limp in his left front leg. An X-ray found that his wrist was riddled with cancer. His owners took him to the University of Minnesota, where his leg was amputated and he received treatment with a gene therapy drug that is also in human trials for liver cancer. Today he is back duck hunting and cancer free.

A French bulldog, Devon was diagnosed with a brain tumor when he was just 18 months old and starting a champion show career. Veterinarians gave him only two months to survive with the aggressive malignancy. He received an experimental chemotherapy injected into the tumor at the University of California, Davis and lived another 21 months. He died August 12, 2010.



Barney's lymphoma was already advanced when his owners enrolled him in an immune therapy study at the University of Pennsylvania in Philadelphia. Though lymphoma usually relapses in dogs after treatment, Barney was one of four patients whose cancer disappeared for good. Six years after treatment, he is now 13 years old and shows no signs of cancer.

try to engage the body's own immune system in the fight.

In 2010, the U.S. Food and Drug Administration approved one of the first medicines to use this immune system–enlisting approach, the prostate cancer drug Provenge. The treatment amplifies an immune attack by exploiting the body's own antigen-presenting cells. These cells consume proteins that don't belong in the body, grind them up and then display them on their surface to alert the immune system.

"The immune system is rather polite," says Nicola Mason, an immunologist in the veterinary school at the University of Pennsylvania in Philadelphia. "It won't attack anything until it's been properly introduced." For Provenge, doctors harvest a type of antigen-presenting cell called a dendritic cell from a patient, incubate those cells with the prostate cancer cells, and infuse the newly enhanced dendritic cells back into the patient.

But in many ways, dendritic cells are less than ideal for making a cancer vaccine, says Mason, who is trying to improve on the method through research in dogs. The Provenge regimen is time consuming and expensive, costing about $93,000 per patient. Mason is researching the same concept with a different kind of immune cell, called a B cell. The treatment doesn't require so many cells, and is easier to carry out.

In 2011, in *PLOS ONE*, Mason published a study of 30 dogs with lymphoma, testing the effectiveness of using B cells in immune therapy. When dogs get lymphoma, they often go into remission after chemotherapy but then relapse about 90 percent of the time, she says. In the Penn study, all dogs were treated with standard chemotherapy, but 19 of them also received the immune therapy after they achieved remission. Four vaccinated canine patients have never relapsed. "This tells us that in some cases you can induce a cure," she says.

Among the dogs receiving the immune therapy that did relapse, 10 received a second round of chemo; 40 percent of those (4 more dogs) achieved remission, compared with only about 8 percent of a comparison group of 39 unvaccinated dogs that received another round of chemo treatment after relapse.

It's still too early to know how studies like this will advance human oncology, but dog owners are delighted when they see signs of benefits, as Ostrander says, at both ends of the leash. In December at a meeting of the American Society of Hematology, the research team presented the results of the study that included Daisy. The experiment was carried out in three veterinary schools and sponsored by the biotech company Karyopharm, based in Natick, Mass. The 14 dogs were given gradually larger doses of the experimental drug to test whether it would have any major unanticipated side effects. None appeared, and studies are continuing. Meanwhile, studies of a human counterpart are also under way.

As for Daisy, she is doing well. "We're so thankful for every single day we have with her," says her owner, Cindy Martin. Daisy's part in cancer history may be minor, but at home, she will always be a star. ■

Explore more

- Elaine A. Ostrander. Both ends of the leash — the human links to good dogs with bad genes. *New England Journal of Medicine*. August 16, 2012.

FROM LEFT: COURTESY OF JAN TAKAICHI; COURTESY OF SUSAN BUNYARD; COURTESY OF BARRY DOOHAN

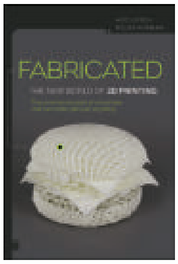
Fabricated: The New World of 3D Printing

Hod Lipson and Melba Kurman

The first chapter of *Fabricated* is set a few decades in the future: In your kitchen a 3-D printer outfitted with food cartridges cooks up breakfast, while across the street a giant printing nozzle oozes out the concrete foundation of a new home. At work, you're investigating the bioprinting black market, wherein counterfeiters sell sloppily printed organs for transplants. The scenario seems farfetched, but Lipson and Kurman make a compelling case that some version of it is not far off.

3-D printing, which creates objects by depositing or binding successive layers of material such as metal or plastic, is poised to shake up everything from manufacturing to medicine (see Page 20). Lipson, an engineer at Cornell University, and technology analyst Kurman explore how these machines are already wending their way into many facets of society, including food, fashion and education.

From hipsters in Brooklyn to the R&D labs of giant companies, people are harnessing 3-D printing to make clothing, airplane parts and prosthetics. While today the fraction of objects that are 3-D printed is infinitesimally small compared with traditionally manufactured goods, the market is growing. The



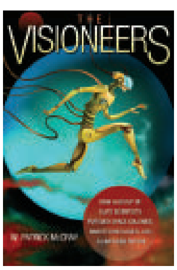
authors certainly have been bitten by the bug — but they have done their homework. While excitement and wonder over the technology's potential comes through, the authors also explore potential perils, which include generating enormous amounts of plastic waste and upending intellectual property law. Overall the book is an easy, interesting read that serves as both primer and, perhaps, prognostication. *— Rachel Ehrenberg*

Wiley, 2013, 302 p.,$27.95

The Visioneers

W. Patrick McCray

In the wake of the Manhattan Project and the Apollo program, almost anything seemed possible. And some scientists of the late 20th century went beyond the fanciful notions of futurists and science fiction writers to seriously explore where technology might take humans, society and culture.



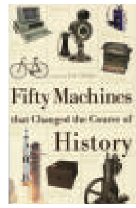
McCray chronicles the main players in two trends that captured imaginations at the time, focusing on notable techno-evangelists Gerard O'Neill, a Princeton physicist who advocated colonizing space, and MIT-trained engineer Eric Drexler, who championed nanotechnology.

Dubbed "visioneers" — the author's blending of "visionary" and "engineer" — these researchers and fellow enthusiasts didn't stop at back-of-the-envelope calculations. They used scientific principles to offer bold yet careful extrapolations of existing technological trends, and in doing so helped put pie-in-the-sky ideas on firmer ground.

Both nanotechnology and space colonization are based on the notion that the material world can be mastered and controlled, says McCray. But merely demonstrating that something is technologically feasible is no guarantee of success. Expansive visions of a technological future are of little use without equally innovative visions of social and economic futures, he suggests.

With little if any government funding devoted to space colonization, humans are unlikely to escape an increasingly crowded, polluted and energy-hungry planet in the next few decades. And it's even less likely during that time that space will become a no-holds-barred utopia where social experimentation becomes the norm. But a person can always dream. *— Sid Perkins*

Princeton Univ., 2013, 351 p., $29.95



Fifty Machines That Changed the Course of History

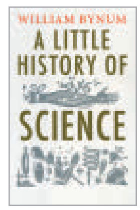
Eric Chaline

Review key inventions of the 19th and 20th centuries, from bicycles to the Underwood typewriter. *Firefly, 2012, 224 p., $29.95*

Near-Earth Objects

Donald K. Yeomans

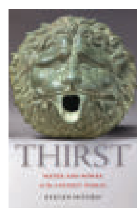
The head of NASA's Near-Earth Object Program Office describes the planet's risk of being smacked by a comet or asteroid and what can be done to prevent such a fate. *Princeton Univ., 2012, 172 p., $24.95*



A Little History of Science

William Bynum

This abridged version of the human search for knowledge covers major discoveries in medicine, astronomy and other fields. *Yale Univ., 2012, 263 p., $25*



Thirst

Steven Mithen

Learn how humans have managed water throughout history and how shortages have driven conflict and social change. *Harvard Univ., 2012, 347 p., $25.95*

The Science of Consequences

Susan M. Schneider

A biopsychologist examines how the brain shapes behavior by learning from the consequences of actions. *Prometheus, 2012, 383 p., $21*

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Scrutinizing baseball's streaks

My family owned the Oakland A's, formerly the Kansas City Athletics, from 1960 to 1980. During this period, our team won three consecutive World Series (1972 – 74) and five consecutive division titles (1971 – 75). I personally witnessed that one player would be on a streak and his attitude appeared to raise his teammates' spirits ("Hitting streaks may be contagious," *SN: 1/26/13, p. 13*). I also saw the opposite: If a player was having a bad day, this also seemed to be contagious.
Nancy H. Finley, Dublin, Calif.

On the other hand, you can sit just back with a dog and a brew and enjoy the game. Who cares why streaks happen? It's just a joy when it happens on your team and a misery when it doesn't. Can we assume that slumps are also contiguous? Bet [the researcher] can't figure that out either. But if he'd like a real challenge, why haven't the Cubs won a World Series in over a century? (The billy goat curse doesn't count.)
Gerald Karey, Silver Spring, Md.

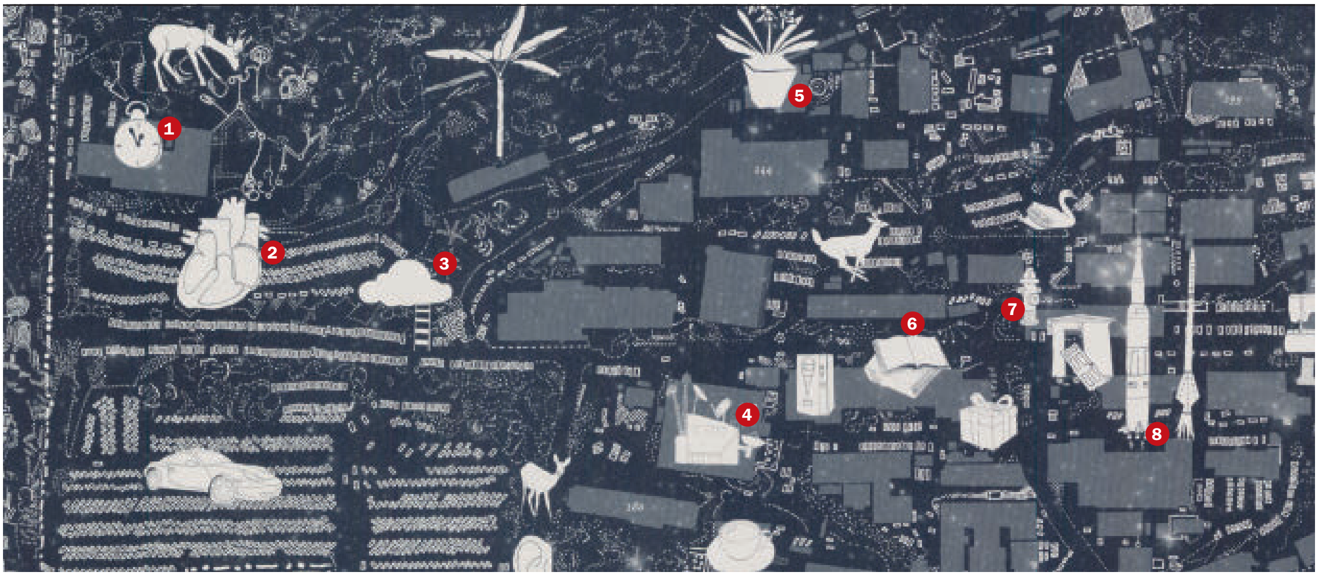
Why must the primary cause be ascribed to the star hitter? Could it be that some common factor raises the hitting of all players on the team, such as any weakness in the opposing pitchers?
Demetrios Matsakis, via e-mail

One advantage of studying the impact of hot hitters instead of pitchers is that a streaky hitter is in the lineup every day. While the researchers acknowledge that the skill of opposing pitchers could affect an entire team's hitting, determining the impact of pitchers would be difficult since a team faces dozens per month, including specialist relievers who pitch to some batters rarely or not at all. The authors quote the late baseball player, manager and philosopher Casey Stengel: "Good pitching will always stop good hitting and vice versa." — Nathan Seppa

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

See more of the Jet Propulsion Lab's oddities at **www.sciencenews.org/jpl_map**



Exploring NASA's quirky places

One building houses what has been deemed the NASA Jet Propulsion Laboratory's "best bathroom." Another, an atomic clock. And naturally the scientists and engineers at the Pasadena, Calif., lab that built the Curiosity rover have a Mars Yard that simulates the surface of the Red Planet, complete with rocks and sand.

Luke Johnson (below), a graphic designer, has illustrated scientists' day-to-day life at the storied lab, mapping what he calls JPL's "curiosities." Best known for its role in crafting and commanding spacecraft such as Curiosity, JPL is also home to decades' worth of accumulated oddities.

The mapping project started on a whim, a casual challenge to visit every building on campus, in order. JPL's buildings are numbered according to when they received funding — so Building 185 is unpredictably nestled into a nook in L-shaped Building 156 — and Johnson had to trace a serpentine path around the campus. He brought a GPS tracking device, pedometer, camera and notebook. Four days and 84 kilometers later, the trip was done — but not without leaving its mark. "I got a pretty bad sunburn," Johnson says.

JPL ended up funding the map, which is now available to employees and visitors. (There's a smartphone app, too.) The front page reads as an homage to the lab's culture and 77-year history, including biographies of former directors, a list of strange jobs at JPL and photos of campus safety signs. The back outlines walking tours with titles such as "Parking Space: The Final Frontier."

Johnson, 34, once seemed destined for medical school. But his interests tugged him in a different direction. "I spent a lot of time just doing really weird things — I was into really large-scale projections, and these funny art and design projects that I would really throw myself into," he says of his time in college. "I did get through organic chemistry, too."

He eventually landed at JPL. Now, he probably knows the campus better than anyone else — and can easily point out buildings recessed into the mountains and where to find a skeleton. "It's a weird place," he says. "You would think if you were in a place that you worked, and you passed by an underground building, you would take note of it. [But] after a while, I think that just sort of becomes normal." — *Nadia Drake*

A map (portion shown above) of NASA's Jet Propulsion Lab highlights the lab's many curiosities.

1. Atomic clock
Set your watch, if you have one, to one of the world's most stable clocks. Located in Building 298.

2. Cardiac parking lot
A lab favorite after Thanksgiving and New Year's, this distant lot is great for exercise buffs and overachievers. Follow a steep hill above the West Parking Lot.

3. Stairway to heaven
A mysterious set of stairs leading to nowhere. On the corner of Explorer and G Road.

4. Center of the universe
Command and control center for NASA's Deep Space Network, managed by JPL. Located in Building 230.

5. The "Orchid"
The 25-Foot Space Simulator, a National Historic Landmark, also houses a cryogenic chamber. Located in Building 150.

6. William Pickering's old office
Touch the original wood paneling from the office of one of JPL's most legendary directors. Located in Building 111, Room 101.

7. Fire department
When wildfire threatens the lab (as it did in 2009), JPL's own fire department is on the scene. Inside Building 310.

8. Two rockets
Freestanding rockets commemorate JPL's beginnings as a testing ground in the 1930s. Located near Building 83.

FROM TOP: L. JOHNSON, ERIN ELLIS AND CHRISTIANE HOLZHEID; PAWENA THIMAPORN

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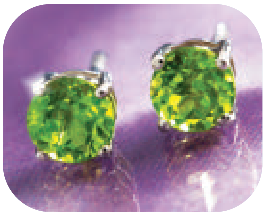

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