

SCIENCE ILLUSTRATED

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CANON EF 70-200MM F/2.8L IS II USM LENS

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► Canon EF 70-200mm
f/2.8L II on Canon
EOS Rebel T2i, shot
at 120mm, f/2.8 and
1/160 sec, ISO 400.

PHOTOGRAPHS & STORY BY KARL ERNEMANN



▶ Canon EF 70-200mm f/2.8L II on Canon EOS 5D Mark II, shot at 88mm, f/2.8 and 1/100 sec, ISO 400.



▶ Canon EF 70-200mm f/2.8L II on Canon EOS 5D Mark II, shot at 175mm and minimum focus distance, f/2.8 and 1/8000 sec, ISO 400.

A stellar performer like Canon's EF 70-200mm f/2.8L zoom is a tough act to follow, but Canon has clearly aimed at bringing its legendary wide-aperture, long-range telephoto zoom to new heights of imaging perfection with the new EF 70-200mm f/2.8L IS II USM. Based on my hands-on experience they have succeeded admirably, creating a lens that retains all the outstanding features that have made it the mainstay of pros and enthusiasts, but with significant upgrades that enhance its image quality, convenience, flexibility, and real-world performance. The result is a lens that delivers breathtaking performance over its entire range and, in my opinion, sets a new benchmark in its class.

Using an advanced optical design incorporating one fluorite and five Ultralow-Dispersion (UD) elements, the new EF 70-200mm f/2.8L II provides enhanced light transmission; unsurpassed correction for chromatic aberration, which eliminates color fringing; noticeably better sharpness, especially at its fast f/2.8 maximum aperture; and a closer minimum focusing distance of 3.9 feet [1:5X magnification at 200mm] for greater convenience in capturing close-ups and working in tight quarters. I found that its next-generation Image Stabilizer (IS) system delivers up to four stops of correction for camera shake at all focal lengths, and allowed me to shoot exquisitely sharp images handheld at extremely low light levels. As with all L-series lenses, it's super-rugged and weather-sealed to withstand the rigors of professional use under the most challenging conditions.

After an extended test-drive, I can attest that this new Canon EF 70-200mm



f/2.8L II delivers astonishing image quality in the low-light situations I encounter when shooting weddings and portraits and provides the lightning responsiveness and swift, silent AF essential for pro-caliber street and editorial photography. It balances and performs splendidly on both my Canon EOS 5D Mark II full-frame and APS-C-format 7D, and you can access instant manual focus anytime by just grabbing the focusing collar, a big plus. When shooting at wide apertures it yields gorgeous bokeh—smooth, natural-looking transitions from the crisp point of focus to the beautifully blurred background. As for the upgraded IS, I couldn't believe I'd shot stunningly sharp portraits handheld at 1/20 sec with the focal length set at 135mm, but there it was on the Metadata! This lens sure wins my "Best of Breed" ribbon, and I heartily recommend it to any serious shooter who demands the absolute ultimate in real-world performance.

▶ Canon EF 70-200mm f/2.8L II on Canon EOS 5D Mark II, shot handheld at 135mm, f/2.8 and 1/60 sec, ISO 1000.

KEY SPECS:

- Focal length and maximum aperture: 70-200mm, f/2.8 over the entire focal-length range.
- Diagonal angle of view: 34 degrees at 70mm to 12 degrees at 200mm for full-frame [24x36mm] format.
- Focus adjustment: Internal focusing system; USM silent drive. Full-time manual focusing is available at any time.
- Closest focusing distance: 3.94 feet [1.2m] over the entire focal-length range.
- Maximum magnification ratio: 1:5X at the 200mm setting.
- Filter size: 77mm
- Maximum diameter x length: 3.5x7.8 inches [88.8x199mm]
- Weight: 52.6 ounces [1,490g]
- Included accessories: lens cap, pouch case, lens hood ET-87



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MEAT
Scientists have found a way to grow meat from stem cells. Could this save animals and land? Can we stomach it?

Meat grown from stem cells could save animals and land. Can we stomach it?

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Can Allergies Fight Cancer?

Some studies suggest that allergies may protect against cancer. But what's the link? And how can we use this knowledge to fight the disease?

Allergies seem to protect some people against cancer. What's the link?

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"When the natural cycle of an area changes ... blazes can become a menace."

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New DNA analysis is lifting the veil on the mysteries of King Tut's life—and death.

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Natural team players, ants form the world's most perfect living machine.

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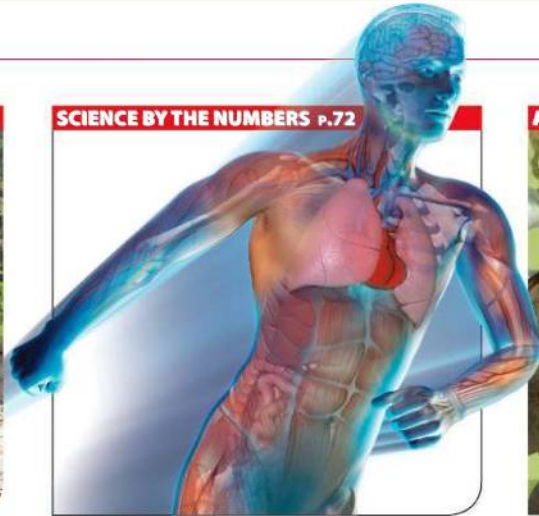
The Richter scale explained, and how earthquakes help us understand our world.

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You ask, we answer: How does the sun burn? How many dinos were there? Why can't we tickle ourselves? What's a supervolcano?

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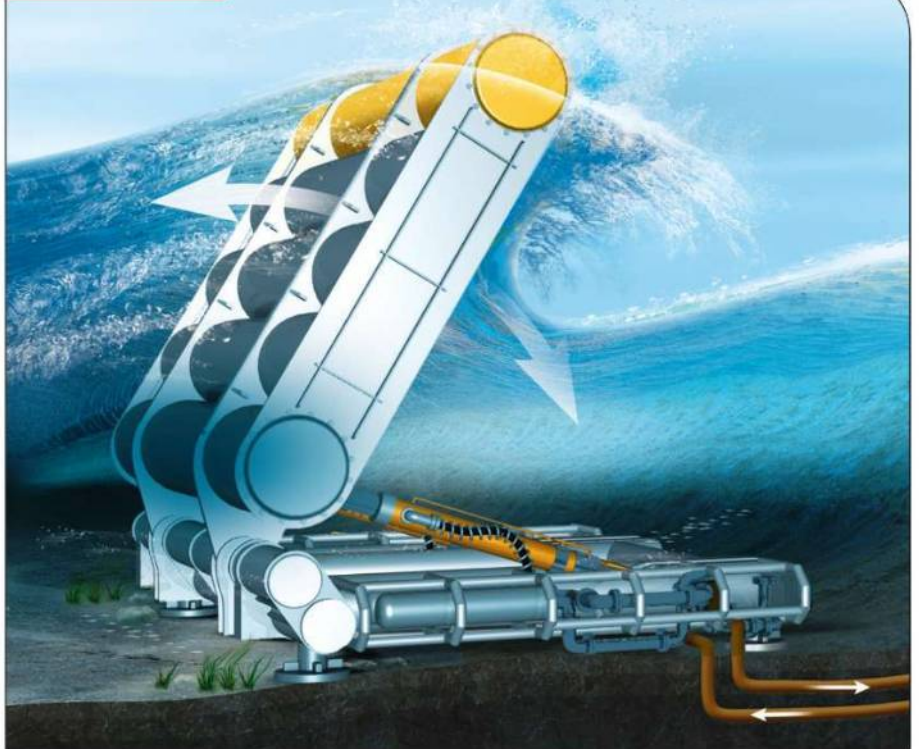
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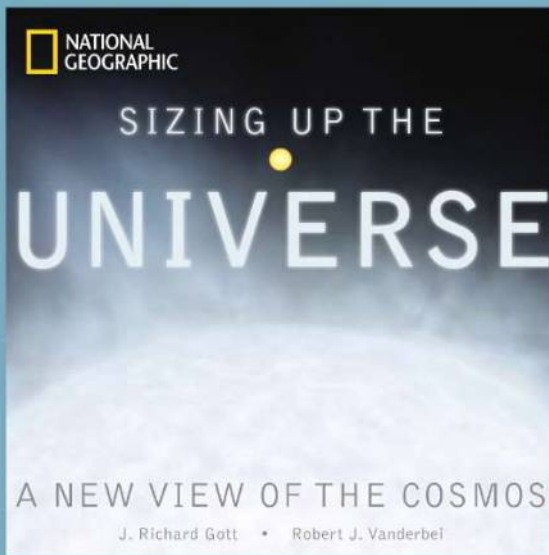
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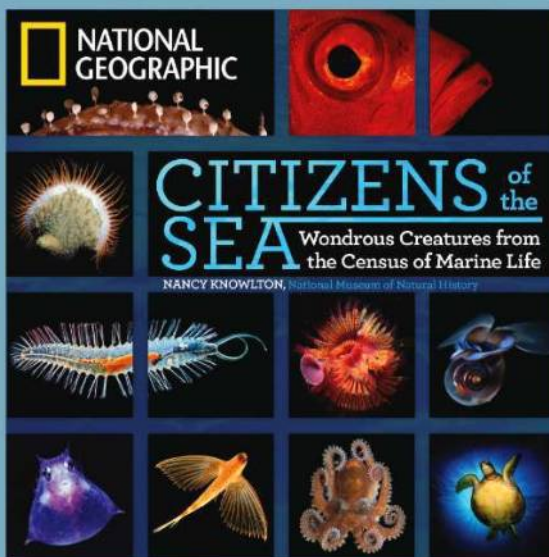


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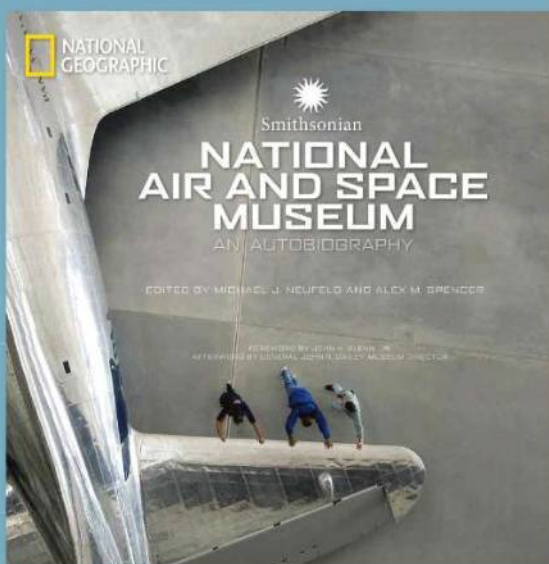
THINK BIG

The vast scale of objects in space is made clear in this groundbreaking new guide to the visible universe. Filled with astonishing images, comparison charts, new discoveries, and a spectacular foldout map of the universe, this book, by prestigious authors J. Richard Gott and Robert Vanderbei, is sure to stretch your imagination and give you the big, BIG picture.



THINK DEEP

Meet the wondrous creatures of the sea in this fun and surprising new book, based on the Census of Marine Life, a 10-year global mission to measure the diversity of the ocean. Who and how many species inhabit the sea? Where and how do they live? Amazing underwater images and engaging text tell their stories.



THINK FAST

Go behind the scenes for an exclusive tour of the Smithsonian National Air and Space Museum—one of the most popular museums in the world. Learn its history, view its collections, and hear from its curators in this first-ever, richly illustrated volume. The perfect gift for those interested in aviation, space flight, and the quest to know the universe.



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Airing Grievances

"Wind Power Storms Forward" [September/October] did not mention negative effects, like noise and flickering shadows, endured by those living near wind turbines. There is no limit on their size in my county—they are 500 feet tall. I belong to a group of concerned citizens who are trying to get our county board to enact reasonable regulations before the installation of new turbines.

Neil Miller Via e-mail

Splitting Hairs

I just finished reading "Why Did the Neanderthals Die Out?" [Sept./Oct.]. For years, there have been many theories on this subject, but it is very likely that no one will ever know for sure. I think it should be remembered that in the bird world, there are many species, but they are all birds. Likewise, *Homo sapiens*, Neanderthals and Cro-Magnons, among

other early humans, were basically the same with some differences, but were nonetheless all humans.

Hank Drozdik Apple Valley, Calif.

Teaching Technology

"Grains of Truth" [July/August], which dealt with pollen and its use in forensic sciences, was excellent. As a high-school forensic-science teacher, I was excited to add this to my arsenal of resources. The photomicrographs are outstanding and visually exciting to my students. Thanks for the excellent article, and keep up the good work!

John Clauss

Holy Name High School, Reading, Pa.

Heavyweight Champion

In "How big can carnivorous land mammals grow?" [Ask Us, July/Aug.], you state that the polar bear is the largest living carnivorous land mammal. Other sources, however, rate the Alaska brown (Kodiak) bear as the largest, with the polar bear second in size.

Curtis Kelly Chicago

EDITORS: It's a toss-up as to which bear is the biggest—both can weigh close to 2,000 pounds—but the Kodiak bear is an omnivore. They eat a varied diet of fish, berries and other plants, and the occasional deer or elk. Polar bears are true carnivores, subsisting almost exclusively on seals, walruses, seabirds and small mammals, such as foxes, making the species the giant of living land carnivores.

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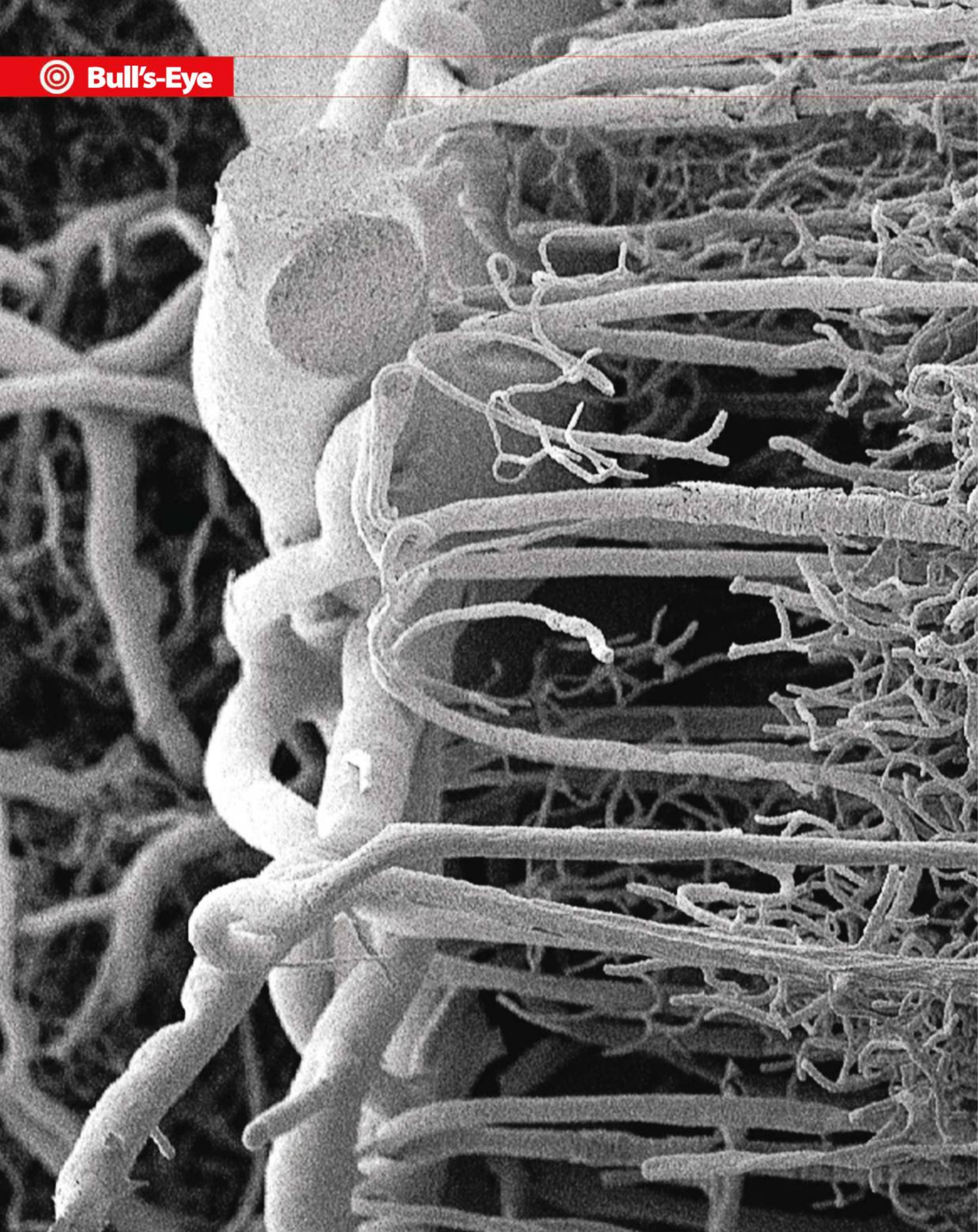
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BREAKING UP

In the summer of 2009, a team of glaciologists kayaked 25 miles through meltwater [shown here] in the middle of the Petermann Glacier in northern Greenland, using radar equipment to track the ice's thickness and internal structure. Based on satellite images, the team's leader, Jason Box of Ohio State University, predicted a large break in the glacier that year. This August it broke off an iceberg four times the size of Manhattan, the largest fracture since 1962. Melting surface water, which is heavier than ice, acts as a wedge in small cracks, exerting pressure and enlarging fractures. The process is probably helped along by rising sea temperatures, which are 100 times as efficient as surface-temperature changes in melting ice. In August, the scientists retrieved GPS equipment and cameras they had left behind to further study the major changes that led up to and followed the break.



BRAIN FRAME

To fire, neurons in the brain require energy, and as their activity increases, so does the local flow of oxygenated blood, which travels down larger vessels near the surface [left] to the tiniest capillaries [right]. All that action changes the brain's magnetic environment, which can be detected with functional magnetic resonance imaging, one technique that gets a workup in *Portraits of the Mind: Visualizing the Brain from Antiquity to the 21st Century*, by Carl Schoonover (November; Abrams), which explores the history of brain imaging. To get this shot, researchers in Spain filled the blood vessels in a human cadaver's cerebral cortex with a liquid resin that hardens after injection before dissolving the surrounding brain matter.



CHEMICAL WELFARE

During recent crises, emergency responders and disaster victims across the world have turned to social media like Facebook and Twitter to gather and disseminate information and better target aid. But old-fashioned on-the-ground responses are still a large part of recovery efforts. In China in early August, severe floods caused a landslide in the northwest that left more than 1,400 dead and hundreds missing. Protective-gear-clad rescuers [shown here] sprayed the streets with disinfectant, despite concerns that the toxic chemicals could actually do more harm than good.



ALY SONG/REUTERS



FIN'S WAKE

High demand for shark fins, displayed here for sale in Hong Kong, has left dozens of species of the fish endangered or vulnerable. Most of the fins are destined for shark-fin soup. At prices that can reach more than \$100 a pound, the soup is prized in China and Japan, with the cachet of caviar, a delicacy that has driven sturgeon to near-extinction. To sate demand for the fins, fueled in part by China's increasing affluence, fishermen kill as many as 73 million sharks worldwide every year, often by removing the fins and tossing the mutilated fish back into the ocean to die. At a meeting of the Convention on International Trade in Endangered Species in March, representatives from China and Japan defeated a proposal that would have regulated the trade.





DALE DE LA REY/AFP/GETTY IMAGES

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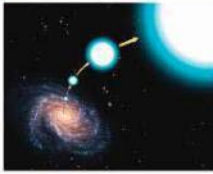
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Science Update



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A superfast star's
origin is traced to
the Milky Way



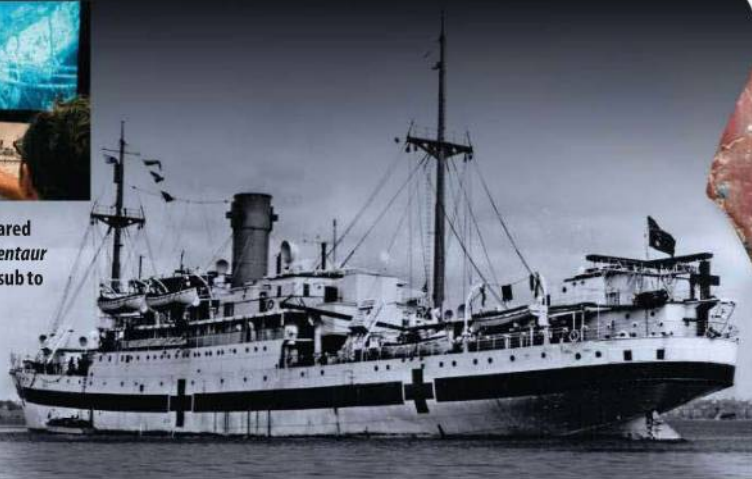
P. 22
An Egyptian
temple exalted a
cat goddess



P. 24
Asian elephants
have a hybrid
charging style



David Mearns [left] compared historical images of the *Centaur* with footage from a minisub to confirm the discovery.



Wreck-Hunters Find Sunken Hospital Ship

Scientists use sonar to locate an Australian vessel torpedoed in 1943

ARCHAEOLOGY After more than 65 years on the seafloor, the *Centaur*, a World War II Australian hospital ship, has been found nestled in the narrow channel of a canyon more than a mile below the ocean's surface. A Japanese submarine torpedoed the vessel on May 14, 1943, 52 nautical miles off the Australian coast, near Brisbane. Of the 332 people aboard, only 64 survived.

The Australian government hired well-known shipwreck-hunter David Mearns in 2009 to find the *Centaur*. After just nine days at sea, on December 20 last year, Mearns and his crew located the sunken vessel using sonar.

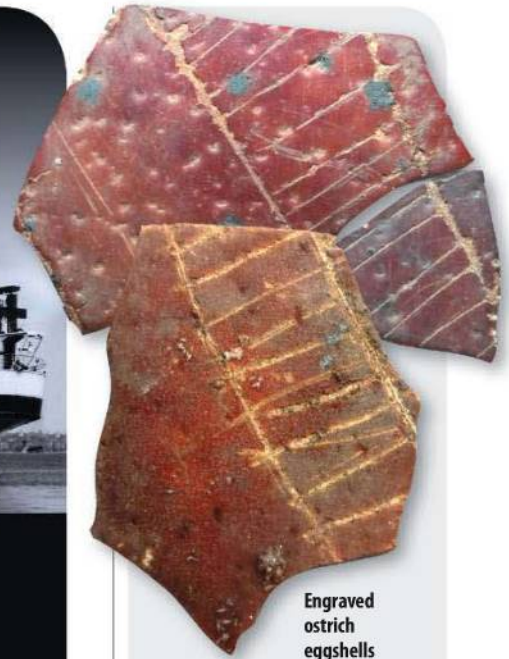


The *Centaur* was found off Brisbane.

Three weeks later, the team sent a remote-controlled minisub to film the first images of the wreck. Though still intact, the ship's bow is almost entirely severed from the rest of the hull at the spot where the torpedo hit. *Centaur's* large red crosses on

both sides of the ship and the identifying number "47" on the bow are still visible after nearly seven decades at the bottom of the ocean.

Mearns and Australian government officials hope the discovery of the wreck will provide some comfort to survivors and relatives of the deceased. In March, the government held a national memorial service in Brisbane.



Engraved ostrich eggshells

Researchers Reveal Earliest Symbolic Discourse

ANTHROPOLOGY More than 300 engraved ostrich-eggshell fragments recently discovered in South Africa are, at 60,000 years old, the earliest reliable evidence of humans communicating using symbols. The eggshells were probably used as water containers, the researchers say, and the markings may once have identified the owners.

Simple Design to Harness the Power of Waves

A Scottish company's wave farm will power 190,000 European homes by 2013

ALTERNATIVE ENERGY The key to a successful wave-power device, say engineers at the renewable-energy company Aquamarine Power, is a sturdy and simple design. That's the concept behind the Oyster, their device that's about a year into its trial run at the European Marine Energy Center (EMEC) off the coast of the Orkney Islands in Scotland.

The Oyster looks like a waffle iron. It consists of a base anchored to the seafloor and a moving upper section that swings back and forth with each wave. Connected to the upper section are two hydraulic pistons, which, as the upper section swings, pump water to land, where it runs through a conventional hydroelectric turbine to create electricity. The engineers believe that because the Oyster

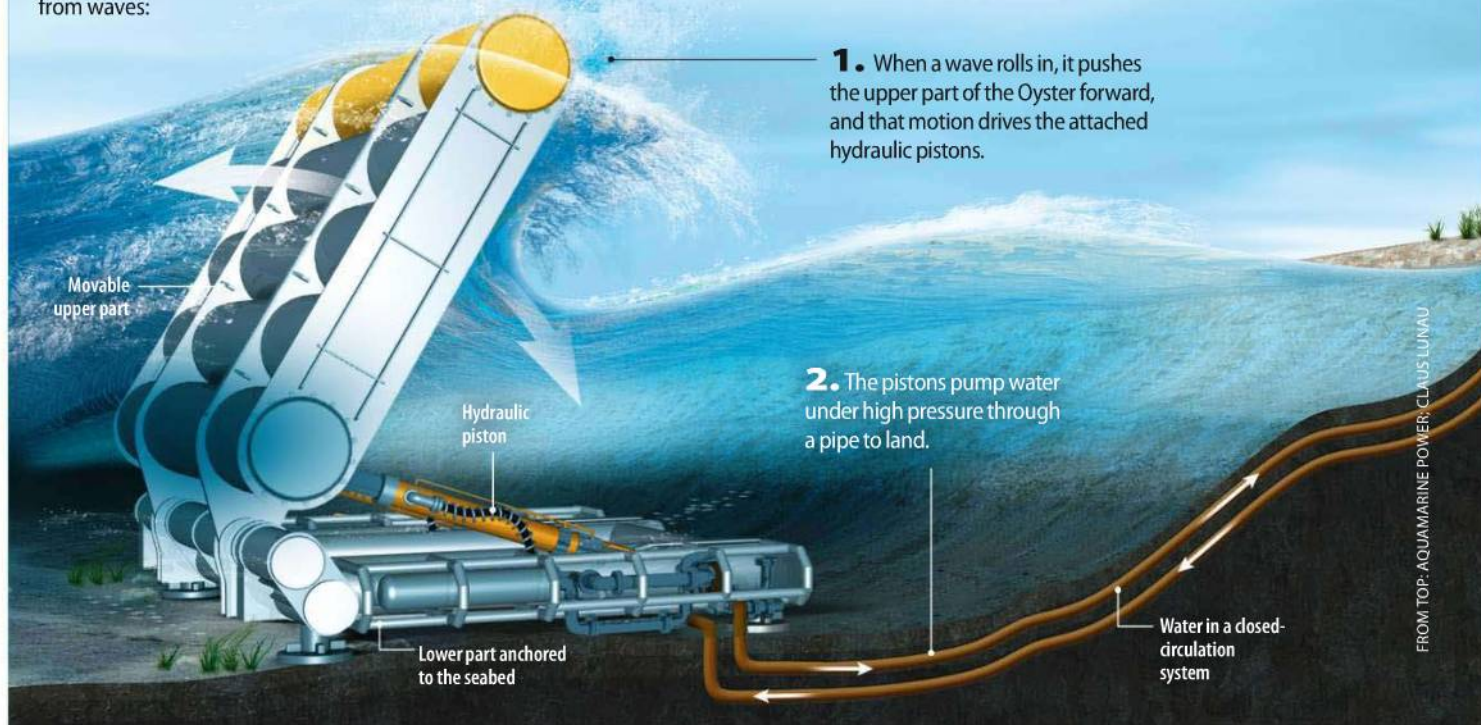
has fewer moving parts than more-complex wave-power machines, it can better withstand the ravages of the elements and the stress of performing the same motion with every wave.

The first version of the Oyster has operated for about 5,000 hours since it was installed at EMEC last November, and a second version capable of delivering more than two megawatts of power is on the way. A wave farm of 20 of these second-generation Oysters could power 12,000 homes, according to Aquamarine, which has teamed up with SSE Renewables in Ireland to develop a large farm off the coast of the Orkneys. With the installation slated for 2013, the planned farm will provide 200 megawatts and power as many as 190,000 homes in the U.K.

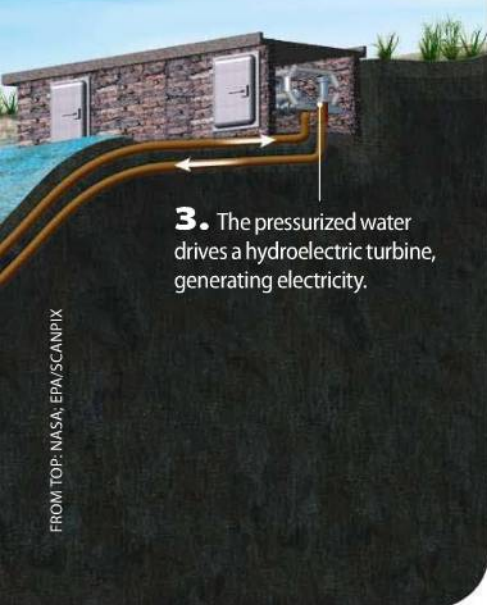


Machine Taps Energy from Waves

The Oyster can be installed about a mile from land at depths of up to 40 feet. Here's how it captures energy from waves:

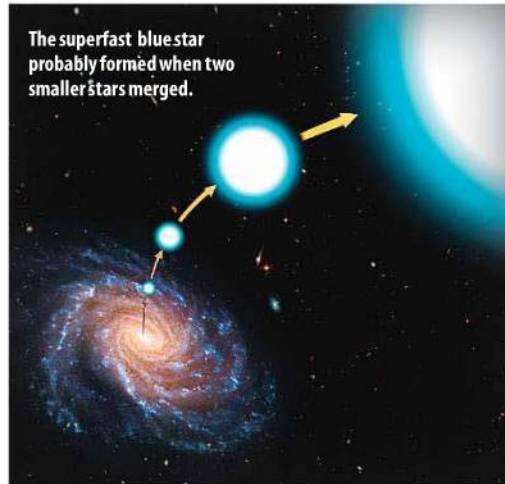


Only a small part of the Oyster is visible above water.



FROM TOP: NASA, EPA/SCANPIX

The superfast bluestar probably formed when two smaller stars merged.



Runaway Star's Origin Discovered

ASTRONOMY A blue star hurtling through the outer reaches of our galaxy originated in the center of the Milky Way 100 million years ago. So say astronomers at the Harvard-Smithsonian Center for Astrophysics, who compared the star's position with background galaxies in Hubble Space Telescope observations. Of the 16 known hypervelocity stars, which are moving fast enough to eventually escape the Milky Way, this is the only star the origin of which is known. Understanding the movement of these stars could contribute to our knowledge of dark matter, whose gravity affects stars' trajectory.

News Flash!

The sacrificial acts of a few bacteria save entire populations of them from succumbing to antibiotics, say biological engineers from Harvard and Boston universities. A group's few highly resistant bacteria produce a molecule called an indole that helps strengthen weaker members against attack. Producing the indole, however, reduces the resistant bacteria's growth and fitness.

Among bonobos, the male ape's dominance is the key factor in attracting a mate. But for those lower in the social hierarchy, being a mama's boy greatly improves their chances at getting the girl. Male bonobos that spend time with their mothers interact with females more often, explain researchers from the Max Planck Institute for Evolutionary Anthropology in Germany. The mothers also aid their sons during physical fights with other males.

New Giant Spider Found

*Recently discovered in Israel, the **Cerbalus aravaensis** spider is the largest arachnid of its type in the Middle East, with a leg span of almost six inches. More than half its sand-dune habitat in Israel has already been destroyed by agriculture and sand quarries, possibly dooming the species there.*



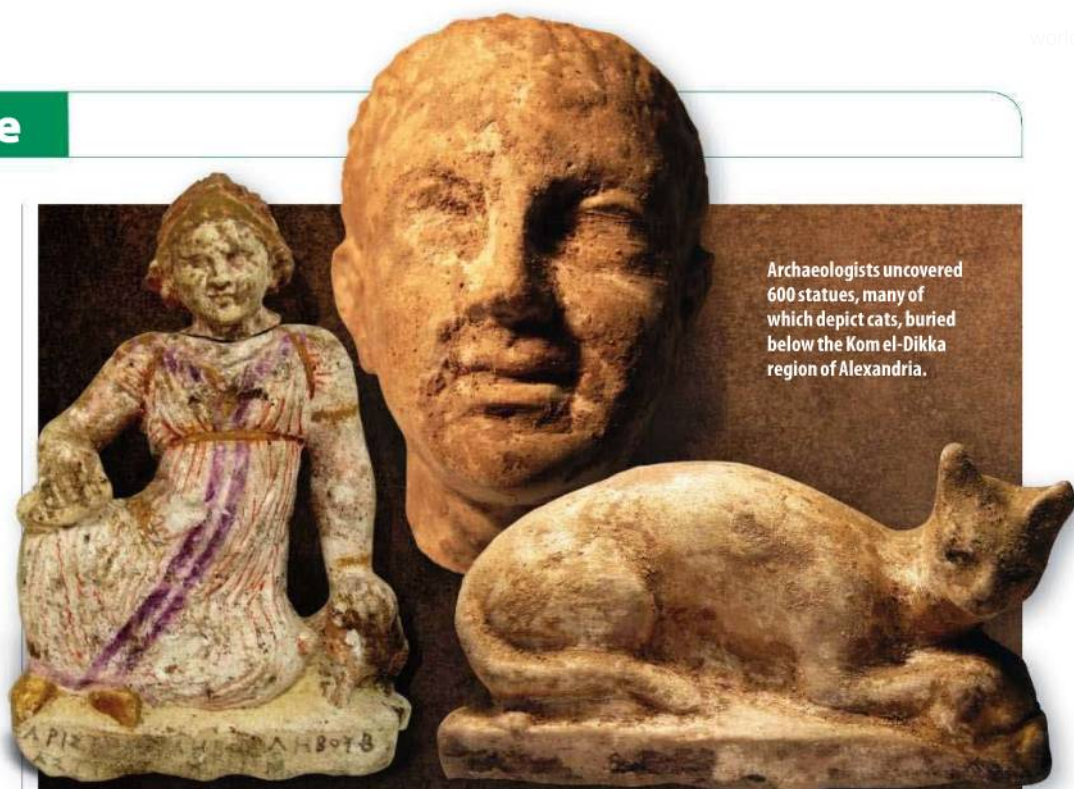
New Source of Nitrous Oxide Found

GEOLOGY Until recently, scientists believed that nitrous oxide (N_2O) could be created only by the microbial breakdown of nitrogen in soil. But this May, researchers published findings that the gas is also produced by chemical reactions in an Antarctic pond. The discovery could help scientists understand the nitrogen cycle on Mars.

Vladimir Samarkin, a biogeochemist at the University of Georgia, and his colleagues found that when nitrites in the Don Juan Pond come in contact with certain types of iron-rich rock present there, they react to release N_2O . Because the pond's cold, salty, lifeless conditions are similar to those on Mars, it could help to explain how nitrogen, a key element for life, fluxes between the Red Planet's soil and its atmosphere.



Antarctica's Don Juan Pond contains no life, but it emits nitrous oxide formed by chemical reactions.



Archaeologists uncovered 600 statues, many of which depict cats, buried below the Kom el-Dikka region of Alexandria.

Egyptian Cat Goddess Temple Discovered

A trove of cat statues indicates that the ancient site was dedicated to the deity Bastet

ARCHAEOLOGY Call her the original cat lady. Egyptian archaeologists have discovered a forgotten temple beneath the port city of Alexandria that belonged to Queen Berenice II, who reigned alongside her husband Ptolemy III from 245 to 221 B.C. Many of the 600 statues found in the temple depict Bastet, the ancient Egyptian cat goddess of war and healing.

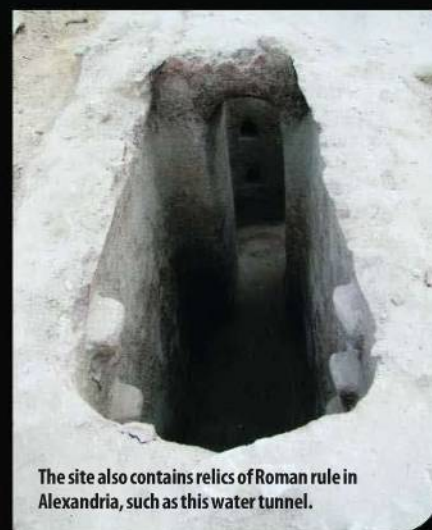
The presence of so many feline statues in one temple indicates that the space was dedicated to Bastet, says Zahi Hawass, the secretary-general of Egypt's Supreme Council of Antiquities. It is likely that Queen Berenice hosted feasts and other celebrations there, particularly to honor the goddess. It is the first time a Bastet temple has been found in Alexandria, although others have been discovered elsewhere in Egypt.

In addition to the Bastet figurines, the collection of statues in

the temple includes limestone carvings of women and children and ancient Egyptian deities in bronze and terra-cotta. Archaeologists also uncovered wells, water channels and the remains of a bath area, all of which suggest that the location might have been part of Alexandria's royal quarters.



Queen Berenice II on a coin



The site also contains relics of Roman rule in Alexandria, such as this water tunnel.

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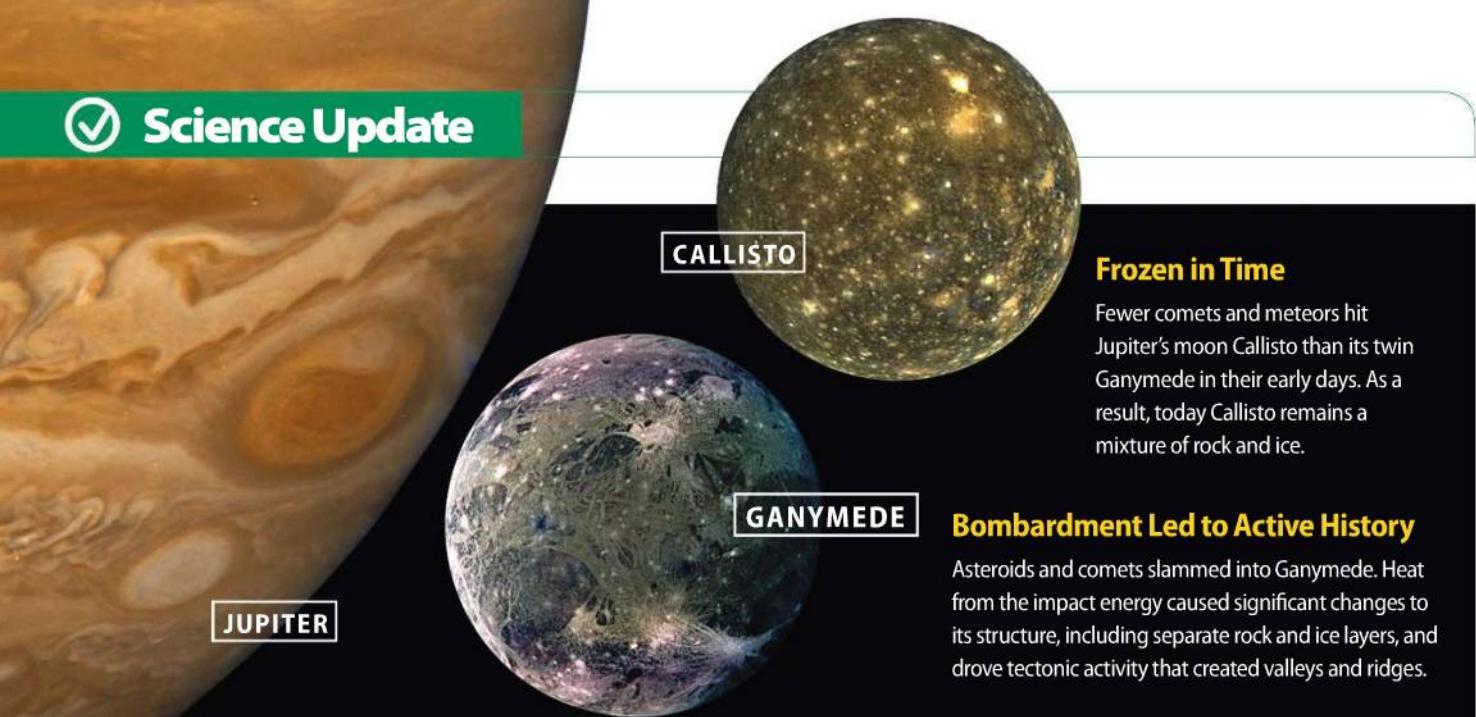
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Frozen in Time

Fewer comets and meteors hit Jupiter's moon Callisto than its twin Ganymede in their early days. As a result, today Callisto remains a mixture of rock and ice.

Bombardment Led to Active History

Asteroids and comets slammed into Ganymede. Heat from the impact energy caused significant changes to its structure, including separate rock and ice layers, and drove tectonic activity that created valleys and ridges.

Celestial Storm Shaped Jupiter's Nonidentical Twins

Planetologists offer a new explanation for mysterious structural differences in the gas giant's moons

ASTRONOMY Ganymede and Callisto, two of Jupiter's 63 moons, formed at the same time and are nearly identical in size and composition. Yet Ganymede has two distinct layers: a rock core and an icy surface shaped by tectonic activity. Callisto, meanwhile, is a heterogeneous mixture of the two materials and hasn't changed for billions of years.

Astronomers have attributed the dichotomy to a difference in temperature on the two moons, but they could

never figure out why Ganymede is hotter. In March, scientists at the Southwest Research Institute in Colorado calculated that the energy from ancient lunar impacts could have transferred heat to the moons in different quantities.

Nearly four billion years ago, asteroids and comets bombarded our solar system. Jupiter's powerful gravitational field pulled in objects zooming by. Because Ganymede is closer to Jupiter than Callisto, it would have experienced twice

as many lunar impacts as its twin, the researchers say. The heat from those impacts melted Ganymede's ice, and rocks suspended in it fell toward the moon's core, shedding their gravitational energy in the form of heat and melting the ice further. The process continued until all of Ganymede's rocks surrounded the core and the ice refroze above it. Callisto, however, did not experience enough heat from impacts to complete this process, and was left in its heterogeneous state.

Charging Elephants Don't Run

ZOOLOGY Asian elephants can charge up to 12 mph, a quick pace for animals of their size. But despite appearances, they don't technically run, say scientists from Belgium, Italy and Thailand. The international team tracked the footfall patterns of 34 elephants to see how their center of mass changed over the course of their

stride. The conclusion: The animals trot with their forelegs and walk with their hind legs when moving at high speeds.

Their half-walk, half-trot is economical—costing approximately one third of the energy expended by humans, relative to size—because their center of mass bounces less than other animals.



Elephants use an energy-saving type of movement.

FROM TOP: NASA; NORMAN HEGLUND/UNIVERSITY OF LOUVAIN

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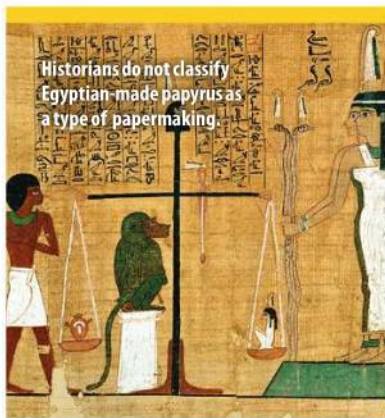
P. 28
Why can't we tickle ourselves?



P. 28
How many species of dinosaurs roamed the Earth?



P. 30
What happens when a super-volcano erupts?



Historians do not classify Egyptian-made papyrus as a type of papermaking.

Q Who invented paper?

A The word “paper” is derived from “papyrus,” the writing material used by ancient Egyptians. But papyrus is technically not paper because the manufacturing methods to make the materials differ, says Cindy Bowden, the director of the Robert C. Williams Paper Museum at the Georgia Institute of Technology.

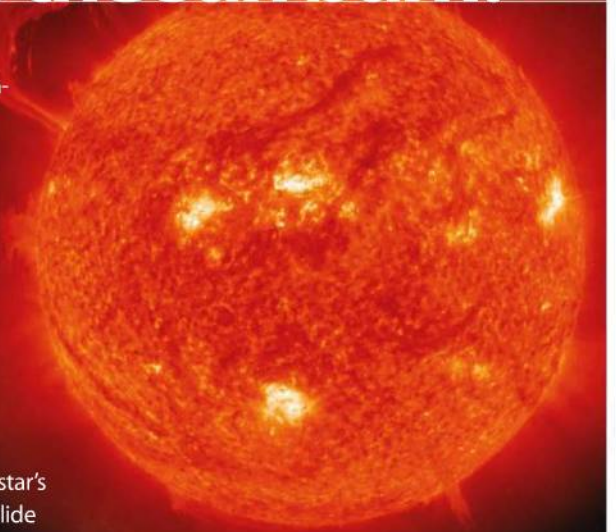
To make papyrus, the Egyptians sliced stalks of *Cyperus papyrus*, a grasslike water plant, and pounded the fragments into a flat sheet. Paper, as defined by historians, is made by draining a mixture of water and pulped cellulose fiber through a sieve. What's left behind on the mesh is then flattened and dried to form sheets. The earliest such “paper” was made in China around 200 B.C. using ground-up fishing nets, bamboo and hemp. Today it can be made from any material with cellulose, including banana stalks and daylilies.

Q If there's no air in space, how does the sun burn?

A Despite how it looks, the sun technically does not “burn”—at least not in the way a campfire or candle does. Fire is a chemical process in which oxygen reacts with another substance, such as the carbon in wood. The sun, on the other hand, smolders as a result of atoms smashing into each other, a process known as nuclear fusion.

Hydrogen atoms, the sun's dominant element, zip around the star's plasma core. When these atoms collide with enough force, they form a larger atom. When four hydrogen nuclei fuse together, they create a single helium nucleus and a neutrino to spare. Every time this nuclear reaction occurs, a tiny bit of matter is lost in the process. This matter—nearly 4.5 million tons per second—is converted into energy, the source of the sun's light and its blistering temperatures, which can reach 27 million degrees Fahrenheit in its core. The energy also prevents the sun from imploding, a danger because of the enormous gravitational pull that results from its large mass. Physicists estimate that the sun's nuclear fusion will keep it “burning” for another five billion years.

The road to understanding this burning process was long and riddled with erroneous explanations, and the sun's composition remained a mystery for centuries. As a result, many theories sprang up to explain



The Sun Is a Huge Ball of Gas

The sun consists mostly of the light elements hydrogen and helium; heavier elements account for only a small fraction of its mass.

- 72 percent hydrogen
- 26 percent helium
- Less than 2 percent heavier elements

how solar heat was generated, including the conversion of gravitational energy, and meteors striking the star. Finally, in the early 1900s, astronomers predicted that the sun was made up mostly of hydrogen and helium. With a deep knowledge of nuclear reactions, Hans Bethe, a German-American physicist, worked out the mechanisms of solar nuclear fusion in 1939 and won the Nobel Prize for Physics in 1967 for the work.

How many species of dinosaurs were there?

A **Pinning down exactly** how many types of dinosaurs existed would require discovering at least one fossilized skeleton for every species—an unlikely scenario, says paleontologist Peter Dodson of the University of Pennsylvania. Factor in mistakes made while classifying species (scientists recently concluded, for example, that a dino they had called *torosaurus* is actually the adult form of *triceratops*), and an exact number becomes even more elusive. But this hasn't stopped researchers from trying to quantify dinosaur diversity from those species they have found.

Working on the assumption that researchers will eventually unearth all the dinosaur skeletons buried in rock that is

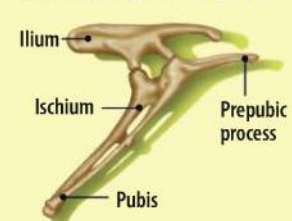
accessible to them, Dodson and Steve Wang, a paleo-statistician at Swarthmore College, used previous rates of discovery and distribution of these finds, as well as projections of future discovery rates, to estimate that nearly 1,850 species of dinosaurs roamed the Earth at some point. To date, researchers have identified approximately 650 extinct species—roughly

a third of the estimated dinosaurs. About 140 dinosaur species, the highest number of any country, have been discovered in China, whose total surpassed that of the U.S. last year. Dodson and Wang estimate that this rapid pace will continue for another century but that by 2102, 90 percent of all discoverable species will have been unearthed and new finds will plateau.

SAURISCHIAN PELVIS

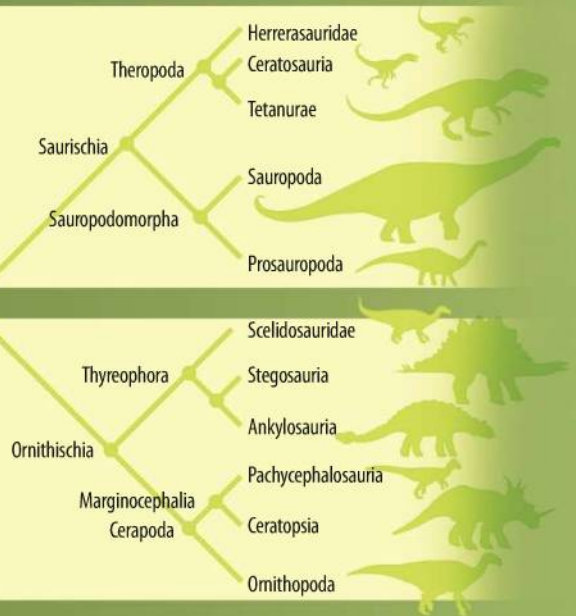


ORNITHISCHIAN PELVIS



Dinosaurs' Distinguishing Characteristics

Dino fossils are first classified into one of two groups based on hip-bone structure. Species in the Saurischian group, such as *Tyrannosaurus rex*, have lizardlike hips. Ornithischian dinosaurs, including stegosaurus, have pelvises that resemble those of birds.



Why can't we tickle ourselves?

A **Most people can't** resist giggling when their feet are tickled. But it's nearly impossible to inflict the sensation on yourself. Researchers believe the reason for this resistance lies in our cerebellum, the region of the brain that controls motor function.

In 2000, neuroscientist Sarah-Jayne Blakemore and her colleagues at Univer-

sity College London imaged brain activity in six people as they tickled themselves and were tickled by a robot. When the subjects tickled themselves, the cerebellum anticipated the sensory reaction and stopped other sensory areas in the brain from responding. When the tickle was unexpected, the cerebellum didn't stop the reaction.



Discovery Hotspots

Six countries are responsible for most dinosaur discoveries, accounting for 75 percent of all recent fossil finds. Scientists have found dozens, even hundreds, of species in each nation.

China: 140 species
U.S.: 137 species
Argentina: 76 species
Mongolia: 68 species
Canada: 46 species
U.K.: 38 species
(as of September 2010)



Scientists have discovered approximately 650 dinosaur species so far.

Who...

...invented the crossword puzzle?

British-born journalist Arthur Wynne is credited as the inventor of the modern crossword puzzle, which debuted in the December 21, 1913, edition of the *New York World* newspaper. Wynne supposedly based the puzzle on a popular children's word game played in England during the 19th century.

...discovered blood types?

In 1901, Austrian biologist Karl Landsteiner observed that when he mixed blood from two people, the red blood cells in the mixture often clumped. He then categorized blood into types—A, B, AB and O—based on the antigens each contains that cause the reaction. Landsteiner won the Nobel Prize for Physiology or Medicine for his research in 1930.

...was the first woman in space?

Soviet cosmonaut Valentina Vladimirovna Tereshkova became the first woman in space on June 16, 1963, when she piloted the Vostok 6 spacecraft for 71 hours as it orbited Earth. Before being recruited into the Soviet Union's cosmonaut program, Tereshkova worked in a textile factory and was an amateur parachutist.

Q Is running in sneakers bad for you?

A In his 2009 book *Born to Run*, journalist Chris McDougall chronicled the barefoot running style of Mexico's Tarahumara Indians. Their sneakerless long-distance treks and immunity to the kinds of foot and leg injuries that plague many runners helped spawn a subculture of barefoot joggers. Despite claims by barefoot enthusiasts that shoes

hurt more than help by altering how our bodies naturally evolved to move, research into the subject is inconclusive. As of yet, there is no evidence that directly supports either argument, says Benno Nigg, an expert in biomechanics at the University of Calgary. Nigg's research suggests that our bodies adjust to whatever footwear we have on.



Many volcanoes are cone-shaped, with a long, narrow magma vent. In these systems, magma rises in small increments, and successive eruptions create the conical form.



Supervolcanoes form when a pool of magma collects just below the Earth's surface. When it erupts, the land collapses into the vacated chamber, creating a depression known as a caldera.

What is a Supervolcano?

Supervolcanoes, though exceptionally rare, are the world's most powerful volcanoes. By definition they spew out at least 240 cubic miles of ash and other magma fragments per eruption—nearly the volume of Lake Michigan—and they rate an 8 on the Volcanic Explosivity Index, the scale's highest score. In comparison, Eyjafjallajökull, the Icelandic volcano that disrupted trans-Atlantic and European air travel for six weeks when it erupted earlier this year, released just 0.03 cubic mile of material.

Supervolcano eruptions occur on average once every 100,000 years, says Jacob Lowenstern, a senior geologist at the Yellowstone

Volcano Observatory and the U.S. Geological Survey. These eruptions occur where magma pools just below the Earth's surface, such as at continental hotspots or along convergent plate boundaries, making the western part of the U.S. a supervolcano center.

One of the most powerful eruptions known took place in Colorado roughly 27 million years ago, when an estimated 1,200 cubic miles of volcanic material was released. Yellowstone National Park has been home to three of the largest supervolcano events recorded in the past few million years, the most recent occurring 640,000 years ago.

Widespread Damage

When the volcano beneath Yellowstone National Park erupts again (which isn't expected to happen for at least another few thousand years), ash, pumice, liquid magma and gas could cover a large area of the western U.S.

A super-eruption in Yellowstone could halt air transportation globally, disrupt the Earth's climate, and affect a decade of agricultural seasons.

Yellowstone

Ash fall

How...

...do monarch butterflies navigate?

Eastern North American monarchs travel thousands of miles to the same stand of oyamel fir trees in central Mexico every year. Their guide is what's known as a time-compensated sun compass, in which they use the sun to map the journey. Photoreceptors in monarchs' antennae chart the sun's location, and the butterflies adjust their flight path accordingly.

...do sinkholes form?

When groundwater penetrates material such as limestone, carbonate rock or salt beds, it dissolves the minerals as it moves. This creates empty pockets in the rock that can't support the weight of the land above it and cave in.

...do scientists measure distance in space?

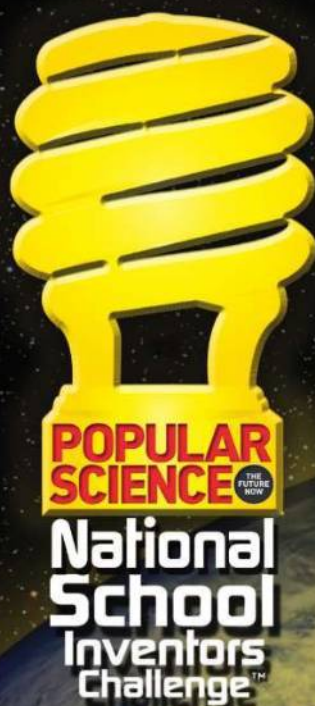
Each object requires its own method. Calculating the distance between stars, for example, is different from calculating distance between galaxies. For objects in our own solar system, astronomers use the time it takes for light to be reflected from an object, multiplied by the speed of light, to determine the distance between it and wherever the measurements are being recorded, such as a satellite.

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HaptiVision Concept

High School Winner **GRAND PRIZE WINNER!**

Name: Victor Youk
Invention: HaptiVision

Middle School Winner

Name: Anthony Iovino
Invention: Rapid Response RFID/Body Monitor

Elementary School Winner

Name: Kaitlyn Barnes
Invention: Let's Talk

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Q What defines a pandemic?

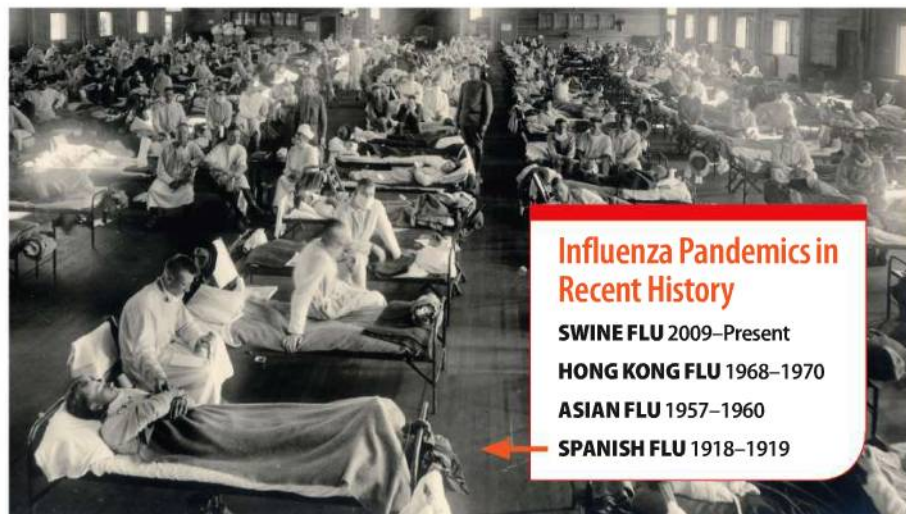
A The World Health Organization uses the term for any infectious disease that spreads among a significant portion of a population over a large geographic area. Based on this, WHO declared the influenza-A H1N1 virus, a.k.a. swine flu, to be a pandemic in June 2009. Although an epidemic can afflict many people in one country, a pandemic can sicken people over the entire world. With increases in global transportation and urbanization, today's epidemics can turn into pandemics faster than ever.

WHO's definition does not require that a disease be especially dangerous for it to be deemed a pandemic, and there are also no time limits. Some outbreaks, like influenza pandemics, tend to last only a few years, whereas others, such as HIV/AIDS, can stretch on for decades. The disease doesn't have to be transmitted directly between

humans; it can be passed indirectly through another animal, like mosquitoes in the case of malaria.

Most influenza outbreaks are not pandemics. Seasonal influenza epidemics follow predictable patterns, and populations have usually built up some immunity to them

over years of exposure. A flu strain that does become a pandemic, however, typically emerges from a non-human animal population—like pigs, chickens or rats—or is entirely new. The Spanish flu of 1918–1919, which killed 20 to 40 million people worldwide, may have originated in birds.



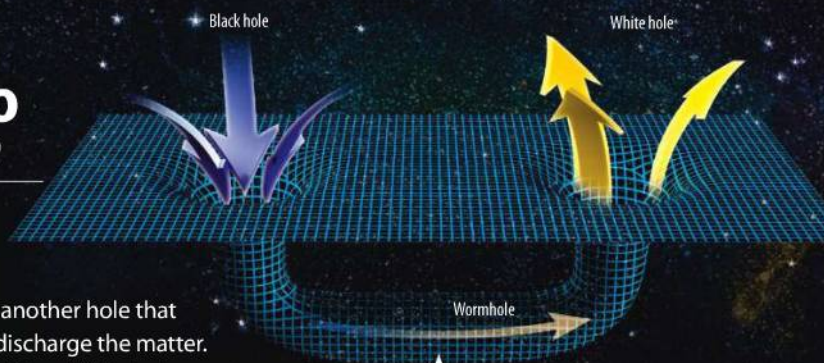
Q Where does matter that gets sucked into a black hole end up?

A One theory is that white holes, which have never actually been observed, expel matter sucked into black holes back into the universe. The concept is an entirely mathematical solution to the equations in Albert Einstein's general theory of relativity, which explains how gravity governs time and space.

After using Einstein's equations to support the existence of black holes—where gravity pulls matter and light seemingly into oblivion—physicists started questioning where that matter goes. In 1935, Einstein and Nathan Rosen, an Israeli theoretical physicist, posited that a bridge, or wormhole, might connect a black

hole to another hole that would discharge the matter. One problem: White holes can exist only in a universe where time can move backward, which is improbable in our universe. But scientists haven't ruled out the possibility that they exist in other universes, which, of course, also have yet to be observed.

Other scientists have suggested what is perhaps a more plausible explanation: The matter getting sucked into a black hole could get stretched and torn apart, and eventually become part of the black hole itself.



White Holes Emit Matter (Theoretically)

A tunnel through the universe called a wormhole can connect black and white holes, in theory. Matter that is sucked into the black hole passes through the wormhole and is ejected from the white hole at the other end.

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Endangered Gem Disappearing

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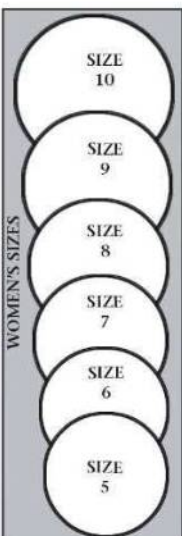
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The discovery of King Tutankhamun's tomb in 1922 revealed treasures like this gilded death mask.

The Man behind the Mask

King Tut is the most iconic of ancient Egypt's pharaohs. But who was he? New DNA evidence may finally answer lingering questions about the ruler's lineage and his mysterious death

By the fall of 1922, English archaeologist Howard Carter had spent six years digging in Egypt's Valley of the Kings. He was losing hope that he would ever find an undisturbed royal tomb—his ultimate goal—when his team encountered steps leading to a forgotten chamber. Although robbers had penetrated its outer rooms, the inner tomb, which held the burial room and treasury, was found untouched, a first for any Egyptian expedition. Behind a sealed wall, the sarcophagus of the pharaoh Tutankhamun lay intact amid piles of precious grave goods destined to accompany him on his journey to the afterlife.

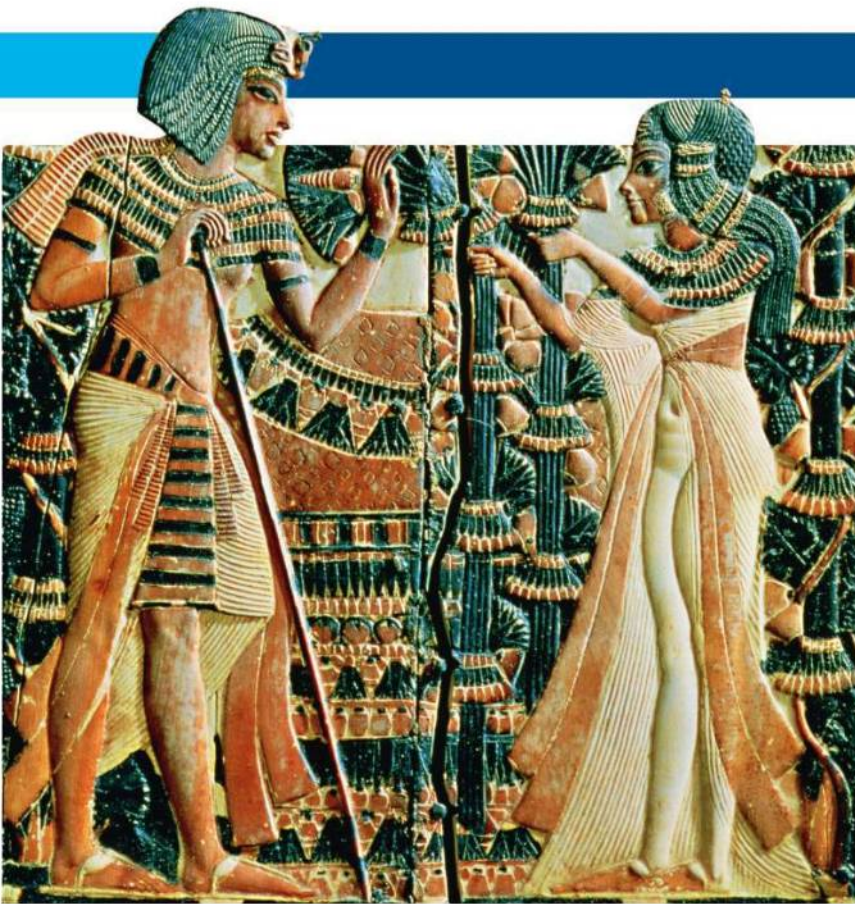
The artifacts provided historians with new clues to ancient Egypt's power in the Mediterranean, its affluence, religious beliefs, politics and funerary traditions. Within weeks, the *New York Times* heralded Tutankhamun as “the most sensational Egyptological discovery of the century.” In the decades following the discovery, traveling museum exhibitions displayed the King Tut collections, further catapulting the pharaoh into the public eye.

Researchers have determined that Tutankhamun died in 1323 B.C. at the age of 19, only nine years after he ascended to the throne. Although pharaohs' chambers were typically expansive and cut into the valley's hills, Tut's was small and built on the valley floor, suggesting that the chamber was hastily converted from one meant for a non-royal. Tut's death, archaeologists reported, was unexpected, and his kingdom unprepared for his burial.

The evidence of Tut's sudden death kicked off



King Tut's mummy is displayed in a climate-controlled case in his tomb in the Valley of the Kings.



Above: A relief of King Tut and his wife. Foot deformities indicate that he would have needed a cane to walk. Top right: CT images reveal bone loss [yellow arrow] and malformation [black arrow] in the pharaoh's left foot. Bottom right: Tutankhamun was buried with 130 walking sticks, some of which show significant wear.

fervid speculation among modern scholars. Some took a suspicious hole in his skull as an indication that he had been murdered by a blow to the head. Others argued that Tutankhamen had been poisoned or had died in an accident.

In 2007, Egyptian and German scientists used improvements in DNA-collection techniques and radiology to try to solve the mystery. Zahi Hawass, the secretary-general of Egypt's Supreme Council of Antiquities; Carsten Pusch, a molecular geneticist at the University of Tübingen's Institute of Human Genetics; and their colleagues published the results of the two-year collaborative project this February in the *Journal of the American Medical Association*. The study was the first-ever DNA analysis of royal mummies, and it offers insight into the life and death of Tutankhamun. Ancient Egypt's best-known king rose to power on an inbred lineage, the researchers reported, and was weakened at a young age by physical deformities and disease.

Turbulent Times

Tutankhamun came to power in 1333 B.C. during Egypt's 18th dynasty, which lasted from approximately 1539 B.C. to 1292 B.C. It was one of the most powerful and prosperous periods in the civilization's history. The



Scientists extract bone biopsies from Tutankhamun to map his genetic relation to other royals.

country's military and foreign-policy influence stretched into Asia and the Mediterranean, and pharaohs built monuments and temples at a rapid clip.

Sometime in the last 100 years of the empire, the dynasty saw one of the biggest religious conflicts in Egyptian

history. Just two years after ascending to the throne in 1353 B.C., the ruler Amenhotep IV upended his civilization's traditional beliefs, demoting Amun, the long-standing king of the gods, below Aten, the sun-disk god. The pharaoh also declared himself the sole intermediary between Aten and the Egyptian people. The so-called "heretic pharaoh" officially changed his name to Akhenaten, abandoned the Egyptian capital of Thebes (modern-day Luxor), and built a new ruling city named after himself about 200 miles south of Cairo, where Tell el-Amarna stands today. The shuttering of temples that funded local governments rendered political leaders powerless. When Akhenaten died in 1336 B.C., an interim ruler named Smenkhkare, about whom little is known, assumed the throne for two or three years.

Tutankhamun came to power next. Although he's famous today, scholars believe the boy-ruler was not a pivotal figure in Egypt's history. Only nine years old at the time of his ascen-

sion, Tut was essentially a figurehead dominated by his chief advisers, Ay, a high priest, and Horemheb, a military general. Most likely at their bidding, he restored Amun as the king of the gods, rebuilt the ruined temples, and reestablished Thebes as the capital city. Tut's nine-year reign was notable only for decisions that he didn't make himself.

Tut's somewhat unremarkable reign, combined with the haste with which his tomb was assembled, left much about his heritage unknowable for decades. Who was his father? Why was he eligible to rule? Several inscriptions dated to Tut's monarchy identify Amenhotep III as his father, but the term can also be interpreted as "grandfather" or "ancestor." Other inscriptions point to Akhenaten, and some scholars say that his father may have been Smenkhkare.

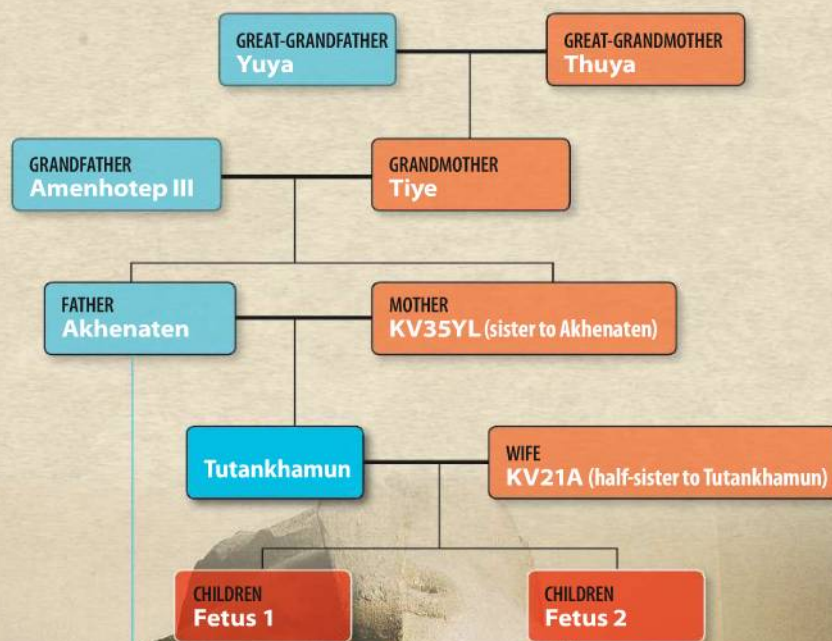
Several royal mummies unearthed in the Valley of the Kings that date to the time of Tutankhamun provide clues to his heritage. Until now, however, the mummies couldn't be identified because their tombs were stripped of useful markers, such as artwork emblazoned with personal histories, by grave robbers centuries earlier. But by leaving the bodies behind, the robbers left perhaps the best clue of all: DNA.

Modern Forensics, Ancient Questions

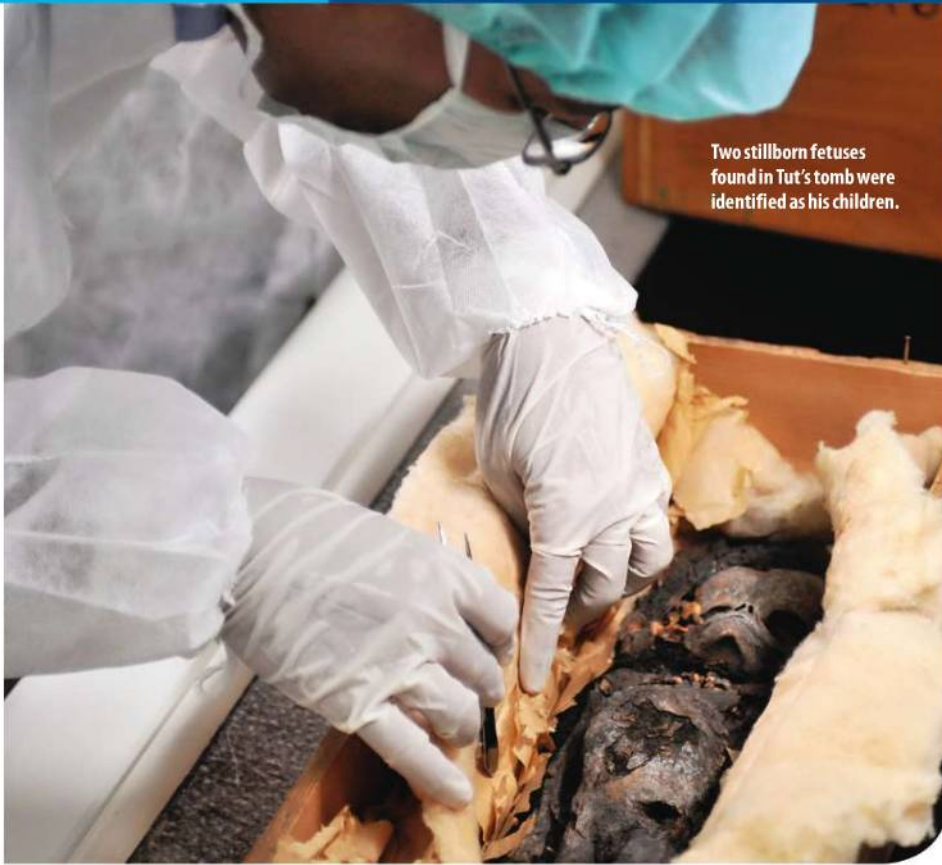
Geneticist Carsten Pusch had previously proved that DNA of sufficient quality and quantity to trace ancestry and disease could be obtained from ancient remains. In 2007, he and Hawass teamed up to determine how members of the royal family from the mid- to late-18th dynasty were related using a technique similar to a modern-day paternity test. Eleven mummies were selected for testing, all dating to roughly the period of Tutankhamun's rule. In addition to Tut himself, the mummies included two stillborn fetuses found in his tomb, assumed to be his daugh-

Mapping a Pharaoh's Family Tree

DNA analysis of Tutankhamun and several previously unidentified mummies has cast light on the pharaoh's lineage. There is now 99 percent certainty that he was the son of Akhenaten and Akhenaten's sister, identified as mummy KV35YL. Tutankhamun himself was married to his own half-sister, and he fathered two stillborn fetuses.



Statue of Akhenaten, Tutankhamun's father, displayed in the Museum of Egyptian Antiquities in Cairo



Two stillborn fetuses found in Tut's tomb were identified as his children.

ters. Four of the 11 mummies had been identified prior to the study using evidence found in their tombs. Five additional older royal mummies from the period between 1550 B.C. and 1479 B.C. (approximately two centuries older than the Tut group) served as genetic and physiological control samples.

The team extracted DNA from 55 mummy bone biopsies. To reduce the risk of contamination by the researchers, the samples were sent to two separate labs. Only results confirmed by both labs were used in the final analysis.

The researchers looked at microsatellites, repeating sequences of DNA base pairs passed down from parents to children that can be used as a sort of genetic fingerprint. By matching one mummy's dominant sequences with those of another male and female, the mummy's parentage can be determined. Using this technique, the team compiled a five-generation family tree of Tutankhamun's immediate lineage.

The results revealed that Tutanka-

mun's father was a mummy known as KV55 (for King's Valley, grave number 55). KV55 was determined to be the son of Amenhotep III, whose mummy had previously been identified based on artifact inscriptions. Amenhotep III was known to be Akhenaten's father, so the researchers concluded that KV55 was the remains of Akhenaten. Tutankhamun's father, therefore, was Akhenaten, and his grandfather Amenhotep III. The father-son connection is supported by previous research, which found that KV55 and Tutankhamun shared the same blood type, as well as a slightly cleft palate and a characteristic overbite. CT scans of KV55's bones, conducted in concert with the DNA analysis, indicated that he was between 35 and 45 years old when he died, as evidenced by bone growth and damage; these results correspond to what historians know about Akhenaten.

The DNA also showed that Tutankhamun's parents were brother and sister and that his wife was his half sister. Inbreeding, a common occur-

rence among ancient Egyptian royalty, kept royal wealth from passing to outsiders. And it was considered the way of the gods, who were said to copulate with siblings. Pharaohs typically took additional wives or concubines, so it is not surprising that Nefertiti, Akhenaten's legendary queen and senior wife, was not Tutankhamun's mother. Akhenaten's sister—Tut's mother—was the mummy called KV35YL ("YL" for Younger Lady).

A Frail Pharaoh

With Tutankhamun's lineage settled, the researchers turned to the question of his mysterious death. His inbred parentage assured him the throne, but biologically it was no blessing. Inbreeding most likely contributed to several skeletal deformities, including a clubfoot and malformed toe bones, that showed up on Tut's CT scans.

The scans also revealed non-hereditary progressive bone loss in his left foot, possibly the result of Köhler disease or Freiberg-Köhler syndrome. These disorders temporarily shut off blood supply to foot bones, killing the tissue in the bone. As a result, Tutankhamun would have had pain and swelling in his left foot, beginning as early as the age of three, when the disease typically sets in. More than 100 walking sticks found in his tomb and several paintings depicting him with a cane and seated rather than standing on his chariot support the findings.

The researchers ruled out leprosy, plague or tuberculosis as culprits in Tut's death. (And the hole in his skull, it was previously determined, resulted from the mummification process, not violence.) They did, however, discover genes from the parasite *Plasmodium falciparum*, which causes the most severe form of malaria, in Tut's bone marrow. Although it's unlikely that malaria directly killed him—he had traces of multiple infections, indicating that he may have built up partial immunity to the disease—the combination of bone deformities and

malaria could have caused an inflammatory, immunosuppressive state, Pusch says. Combined with an already weakened immune system from his inbred lineage, the pharaoh's health would have been compromised.

So what provided the death blow? CT scans taken in 2005, during one of Hawass's previous projects, revealed a left leg fracture with no sign of healing. Hawass believes Tut broke his leg just before his death. With his immune system unable to fight off infection, the injury could have caused a bacterial overload in the bloodstream called septicemia, which can trigger multiple-organ failure and death in severe cases.

A New Beginning

Not everyone is satisfied with the new findings. A series of letters published in the June issue of *JAMA* contested the conclusions. Researchers from the Center for GeoGenetics at the Natural History Museum of Denmark questioned the reliability of the DNA samples, arguing that they might have degraded or been contaminated despite the precautions taken by Hawass's team. A group from Arizona State University disputed the age ascribed to KV55, calling its identity as Akhenaten into ques-

tion, and researchers from Stanford University Medical Center argued against the CT evidence that Tutankhamun had a club left foot. Yet another group of scientists, from the Bernhard Nocht Institute for Tropical Medicine in Germany, believe that Tut's foot malformations point to sickle-cell, not Köhler disease.

Hawass's team, however, remain confident in their analysis, and they have counterarguments for each objection. Improved CT technology, they say, allowed for a more accurate determination of KV55's age than previous scans, for example. As for the sickle-cell theory, which received significant press coverage, the researchers say they found no evidence of the hereditary disease among Tut's newly identified relatives, which means Tut himself was unlikely to have had the disease.

Hawass and Pusch's work has broad implications for Egyptology. The collaborative project offers a new approach to deciphering history, one that merges the natural, life and cultural sciences with the humanities and medicine and ushers in an age of what they've dubbed molecular Egyptology. Time will tell if the emerging field can solve more of ancient Egypt's remaining mysteries, among them finding the final resting place of Nefertiti. ■



Empirical Evidence: Travel



Visit the Royal Resting Ground

The Valley of the Kings, located about 300 miles south of Cairo, has 63 explorable tombs, spanning 500 years. Visitors can also now come face to face with King Tut's mummy, which was moved from his coffin in 2007 into a climate-controlled case. The valley sits across the Nile from the city of Luxor, built around the 4,000-year-old site of Thebes.

GETTING THERE

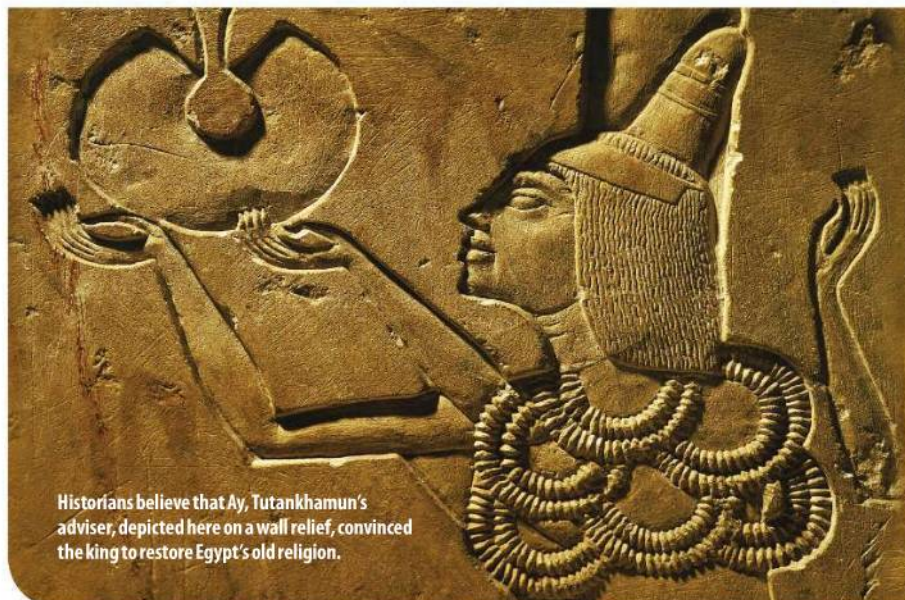
From Cairo, most visitors fly to Luxor. The one-hour flight leaves several times a day and costs approximately \$200 round-trip. Adventurous travelers looking to save money can take one of several trains that depart Cairo for Luxor every day. The downside: The trip can take up to 10 hours.

GETTING AROUND

Traveling from Luxor (where the hotels are located) to the Valley of the Kings involves crossing the Nile. Most visitors join daily tour buses that drive them to the site, or hire a private car or taxi for the day. Any of these options can be arranged through your hotel.

CLOSER TO HOME

For those on a budget, exhibitions in New York City and Denver offer a glimpse of the treasures found in Tutankhamun's tomb. Both run until early January. Visit kingtut.org for more information.



Historians believe that Ay, Tutankhamun's adviser, depicted here on a wall relief, convinced the king to restore Egypt's old religion.

Can Allergies Fight Cancer?

Some studies suggest that those who suffer from allergies are less prone to cancer than their hay-fever-free friends. The mysterious connection between the immune system and cancer could help researchers fight the disease

Since the 1950s, scientists have drawn three conclusions about the relation between allergies and cancer: Compared with people who don't have allergies, allergy sufferers have (1) a higher risk of cancer, (2) a lower risk of cancer and (3) the same risk of cancer.

A recent review of the studies, published by scientists at Cornell University, pinpoints a nuance that could explain the apparent contradiction. Study authors Paul Sherman, Janet Sherman and Erica Holland analyzed the results of more than 600 studies published since 1955 on the correlation between allergies and cancer. Like some of their predecessors, the authors found that, with the exception of asthmatics and lung cancer, allergy sufferers do not tend to have a higher risk of cancer, as had often been assumed. In fact, they found that allergy sufferers have a lower risk of cancer that occur in those tissues exposed to substances from the outside world, like those of the throat and skin. The Shermans and Holland also suggest that how the body reacts to allergens forces out carcinogens that could have

later caused cells to become cancerous.

This new finding, Paul Sherman says, provides evidence to support the prophylaxis hypothesis, a little-researched theory first proposed in 1991 by the controversial evolutionary biologist Margie Profet. According to the hypothesis, allergy symptoms like sneezing and watery eyes evolved

through natural selection to expel foreign particles containing carcinogens from the body—much like turning on a firehose to clean a sidewalk—and thus reduce the occurrence of cancer.

Two Dueling Theories

Not all scientists think the prophylaxis hypothesis has merit. Manuel Penichet, an immunologist and microbiologist at the University of California at Los Angeles and one of the leading scientists in allergeo-oncology, says another major allergy-cancer hypothesis, called immunosurveillance, may be taking place.

Immunosurveillance, a theory first suggested by Frank Macfarlane Burnet in 1957, posits that allergic reactions alone do not protect the body from cancer. Rather, the same immune cells that cause allergy symptoms might also eradicate cancerous and precancerous cells before they further develop, Penichet explains. Instead of using a firehose to keep things clean, the immune system might just spray the area with molecular bullets.

In most cases, the allergy mechanism works like this: Loose allergens

BACKGROUND

Close to Half of Us Have Allergies

Allergies arise when the immune system reacts strongly to something that is not directly dangerous to the body, such as pollen, house-dust mites, bee stings, or certain foods or drugs.

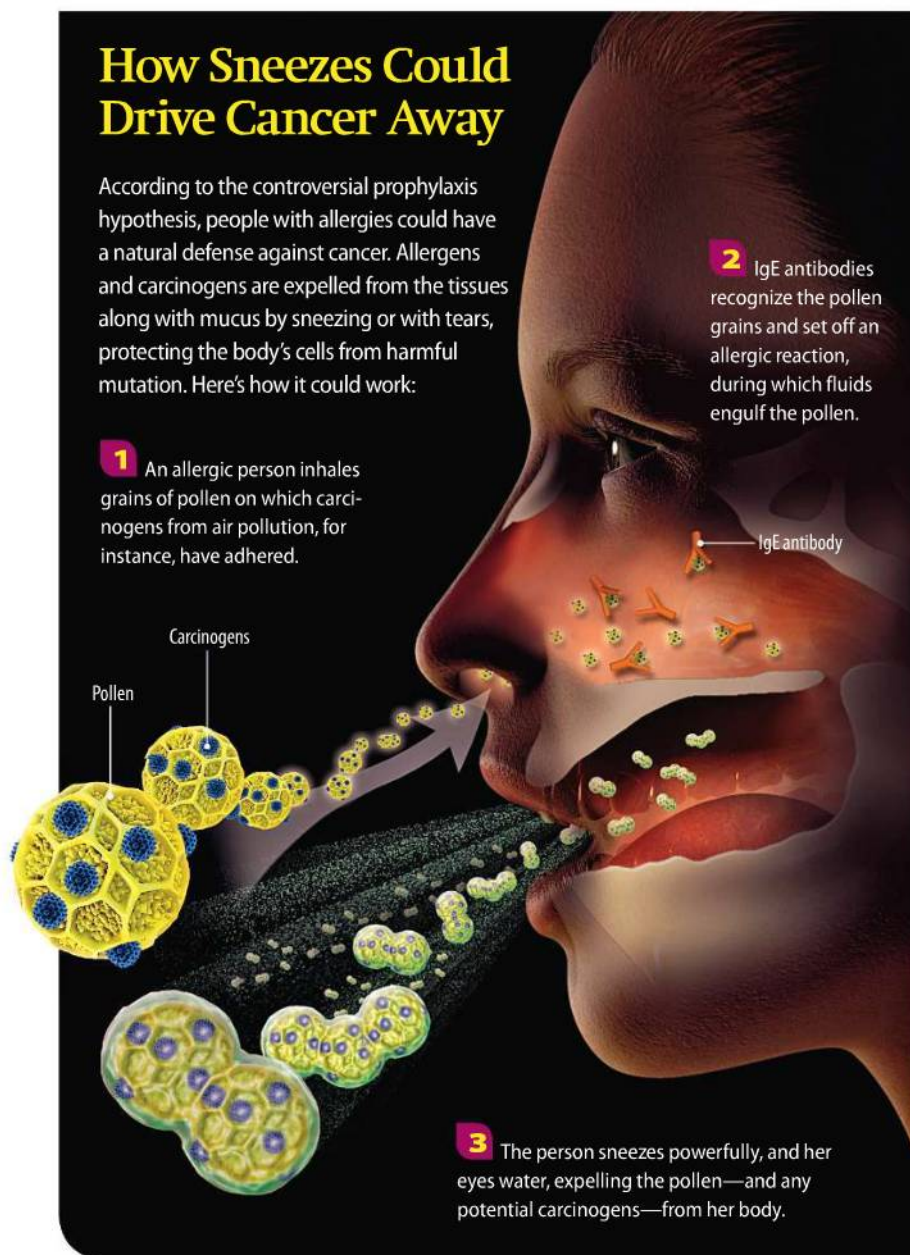
The mucus membranes and skin that come into contact with the allergens respond by watering or itching, and the reaction is manifested in such forms as hay fever, asthma, hives or rashes. About half the population of North America suffers from some kind of allergy.

enter the body's tissues, often through cavities such as the nose. The allergens come into contact with immunoglobulin E (IgE) antibodies—a specific class of large Y-shaped proteins involved in the allergic response. IgEs are usually linked to mast cells, which are large storage containers for chemical mediators and enzymes. When IgE encounters an allergen, the antibodies tell the mast cells to open the levees, unleashing chemicals that induce allergic symptoms, such as watery eyes, that help eradicate the perceived threat. If prophylaxis is to be believed, this wave of body fluids should be enough to indirectly prevent cancer by washing away carcinogens carried on the allergen. If immunosurveillance is correct, it's the overactivated immune system itself, not the runny nose, that directly kills cancer cells.

More research must be done to determine if IgE has a direct role in eradicating cancer cells. "There are a few back associations that people have attempted to make," says Jordan Orange, an associate professor of pediatrics at the University of Pennsylvania who specializes in immunology. But he remains skeptical because patients who are deficient in IgE molecules do not have higher rates of cancer than those with normal IgE levels.

Capitalizing on the Link

Despite the uncertainties, scientists are working on ways to exploit different components of the immune system, including classes of immunoglobulins other than IgE, to protect the body from cancer. For instance, the San Francisco biotech company Genentech received FDA approval in 1998 to sell a drug called Herceptin, an antibody that binds a protein that when overproduced is believed to contribute to breast cancer. The antibody-binding renders the protein ineffective and prevents the breast-cancer cells from growing. And in April, the FDA approved Provenge, made by the Seattle



firm Dendreon. Provenge is the first treatment that helps the immune system kill cancer cells. The procedure sensitizes a patient's white blood cells to a protein that contains prostatic acid phosphatase, which is emitted by prostate cancer cells. The white blood cells guide the immune system to the cancerous cells, which are then eradicated by a host of specialized cells and proteins.

Meanwhile, Penichet and a team at UCLA are exploring whether IgE itself can be used to combat cancer.

They are working with antibodies that target molecules expressed by various cancers and are currently studying the effects of these antibodies in mice.

For now, Paul and Janet Sherman hope doctors will reconsider how they treat allergies. "Until recently, people haven't asked why allergies are there," Janet Sherman says. "They just thought it to be an annoying phenomenon that needs to be eliminated." It seems allergies may not be malfunctions of the immune system but rather an important facet of the body's defenses. ■

Island Treasures

An isolated existence has driven Socotra's flora and fauna down their own evolutionary path

For millions of years the Socotra archipelago has been isolated in the Indian Ocean. The result is a unique assemblage of fauna and flora—ancient animals and plants found no place else.

This collection of islands, together a territory of Yemen, tore itself loose from the African plate 40 million years ago. Several of its native plants, like the dragon's blood tree, are living fossils, dating back 20 to 25 million years. Rare species abound: 37 percent

of Socotra's plant types are found only on the island, and the same is true for most of its reptiles and snails.

In July 2008, Unesco added Socotra to its list of World Heritage sites as one of the planet's most important places to preserve. Inclusion on this list opens up funding for preservation efforts, including support for scientific study.

That designation could be a matter of survival. According to the International Union for Conservation of Nature, 30 of the island's plant species

Where on Earth?

Politically the Socotra archipelago belongs to Yemen, but geologically it is part of Africa.





The Trees Have Survived from Ancient Times

The mushroom-shaped dragon's blood tree gets its name from its red sap, which flows out when its bark is cut. Islanders use the sap as a cosmetic and to treat wounds. Belonging to the lily-of-the-valley family, this 20- to 25-million-year-old species was once common in many parts of the world, but just six species exist today; this one is found only on Socotra.



FROM TOP: CHRIS HELLIER/ALAMY; MARTIN N. JOHANSEN; PRECEDING PAGES: MICHELE FALZONE/ALAMY; INSETS: COURTESY JESSE ALLEN/NASA, NASA

are at risk of extinction, and another 114 are classified as vulnerable. Even the fairly populous species, such as the dragon's blood tree, face increasing problems. For one thing, they're re-treating. The few young trees that could

keep the population going are found almost exclusively on the most remote mountainsides, whereas in the past they were more widespread. No one is quite sure why. Some scientists hypothesize that domesticated goats overgraze the trees found on the plains, leaving only those inaccessible to goats able to thrive. Anthony Miller, the director of the Centre for Middle Eastern Plants at the Royal Botanical Garden in Edinburgh, Scotland, and an expert on the tree, says that global climate change, which can change rainfall patterns on

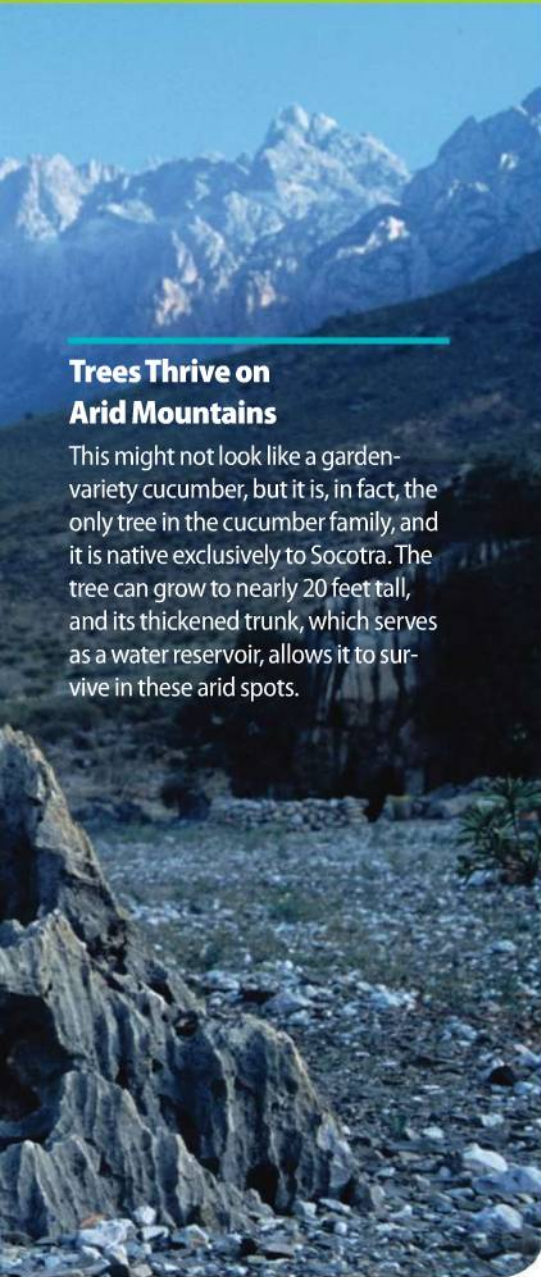
Beauty Stinks of Death

The pollen of the *mish'hermihim* blossom attracts flies with a stench like that of carrion. The plant minimizes its water loss by carrying out photosynthesis only in its stem.



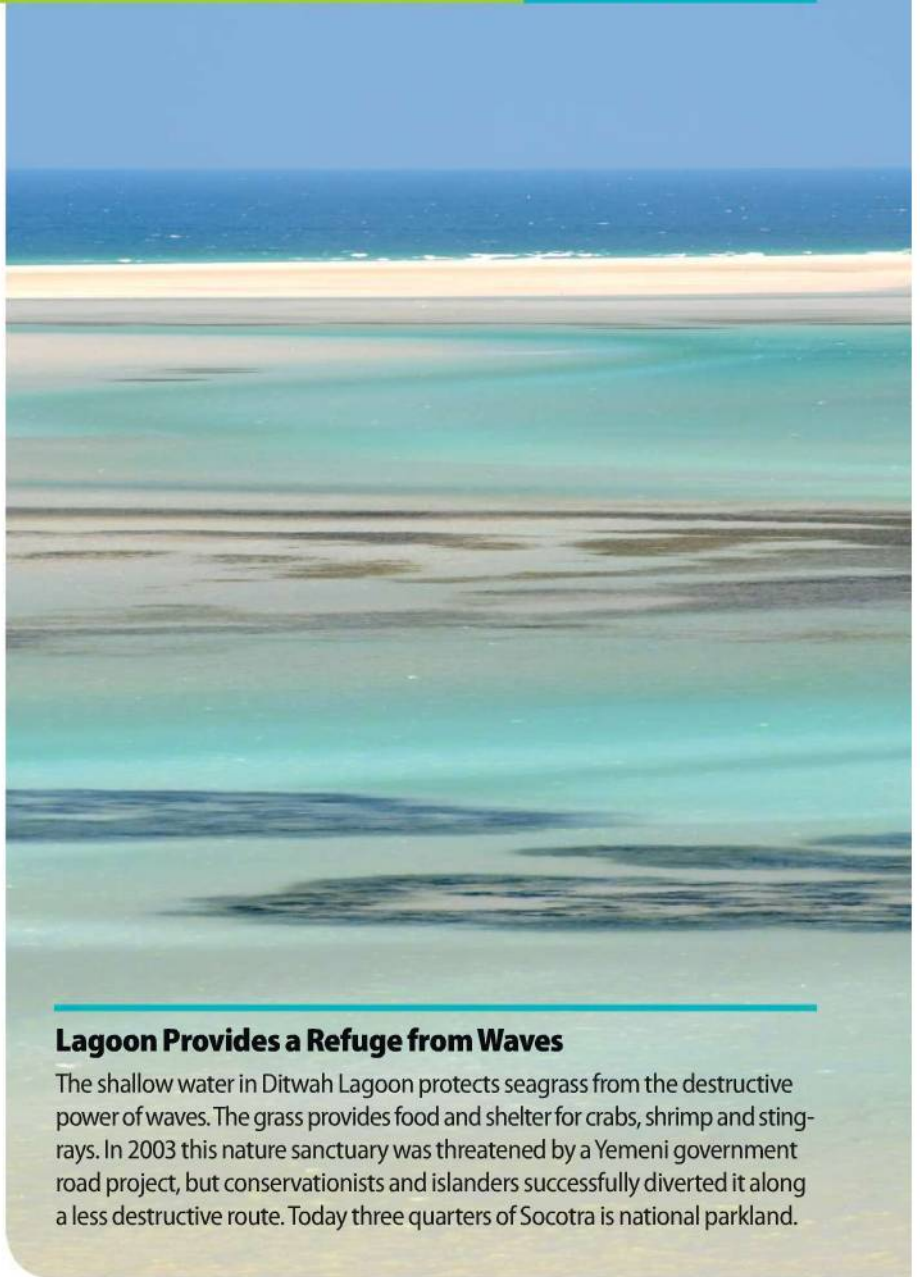
Trees Thrive on Arid Mountains

This might not look like a garden-variety cucumber, but it is, in fact, the only tree in the cucumber family, and it is native exclusively to Socotra. The tree can grow to nearly 20 feet tall, and its thickened trunk, which serves as a water reservoir, allows it to survive in these arid spots.



Lagoon Provides a Refuge from Waves

The shallow water in Ditwah Lagoon protects seagrass from the destructive power of waves. The grass provides food and shelter for crabs, shrimp and sting-rays. In 2003 this nature sanctuary was threatened by a Yemeni government road project, but conservationists and islanders successfully diverted it along a less destructive route. Today three quarters of Socotra is national parkland.



Geckos Use Sign Language

Geckos constitute 18 of the archipelago's approximately 30 species of terrestrial reptiles; 15 species are native to the main island. Some species communicate by lifting their heads and necks; others rise up on their legs and move their tail up and down or sideways. Socotra rock geckos [right] are active during daylight hours and often bask in the sun on rocks.



Sun Scorches the Landscape

Dragon's blood trees grow, among other places on the island, in the dry Diksam region, which has the island's largest limestone plateaus and gets about six inches of rainfall a year.



Strange Bugs Abound

Socotra is home to at least 29 families and more than 50 species of beetles. The beetles make up a significant number of the approximately 600 species of insects found on the islands. This jewel beetle comes from the wood-boring family Buprestidae.

MARTIN N. JOHANSEN

the island, is the more likely culprit.

The threats to Socotra's trees are particularly unfortunate because the island's plants show immense medical promise. Researchers from Yemen and Germany has discovered that extracts from dragon's blood sap are mildly effective against antibiotic-resistant staph bacteria, and that a chemical from the cucumber tree inhibits malarial parasites. The research team has also found that substances extracted from both trees are toxic to cancerous cells during in-vitro tests.

Meet the Island Chain

The Socotra archipelago consists of four islands about 240 miles south of the Arabian peninsula. At roughly 1,400 square miles, Socotra is by far the largest. The other, much smaller islands, Abd Al-Kuri, Samha and Darsa, have little vegetation and are sparsely populated (Darsa has no inhabitants).

Socotra's climate is determined by its monsoon seasons, which occur twice a year: the northeast winter monsoon, which lasts from November until February, and the southwest summer monsoon, from May to September. But instead of rain, the dominant summer monsoons bring hot, dry winds from the African continent. The northern part of Socotra typically gets no precipitation during this season and a scant six inches of rain annually.

Only the hardest or most inven-

Locals Net a Catch

Socotran fishermen once fished with cotton lines and homemade hooks from the island's shores, or floated out on locally made rafts or in hollowed-out canoes imported from Africa and India. Now they've moved on to small motorboats [right], from which they fish with nets.

MARTIN N. JOHANSEN

Empirical Evidence: Travel



Visit the Socotra Archipelago

Getting to Socotra can be tricky. There are few flights to the archipelago, and the U.S. Department of State warns against travel to Yemen due to terrorist activities. But if you make the trek, you'll discover the source of dragon's blood, a red resin long regarded for its medicinal properties, and experience the islands' rich natural heritage.

WHERE

Although the dragon's blood tree can be found throughout the main island, Rokeb di Firmihin and the central and western parts of the Haggeher mountains feature the greatest density of individual specimens.

WHEN

From early October to late April is recommended, particularly after January. Avoid visiting during Ramadan, a month-long Muslim holiday, when shops and services will be closed, and the monsoon season from May to September.

GETTING THERE

Felix Airways flies to Socotra four times a week from Al-Mukalla, Yemen, and Yemenia Airway offers two flights a week, also through Al-Mukalla. To get around the island, rent a car with a driver and guide.

WHERE TO STAY

Hotels are mostly limited to the island's capital, Hadibu, but camping sites are available near the most popular locations on the main island.

KEEP IN MIND

You'll need a visa, which must be obtained from a consulate prior to travel. Be mindful of local customs—women should dress modestly, and alcohol is prohibited. And pack any medications you'll need during your stay because there are few pharmacies.



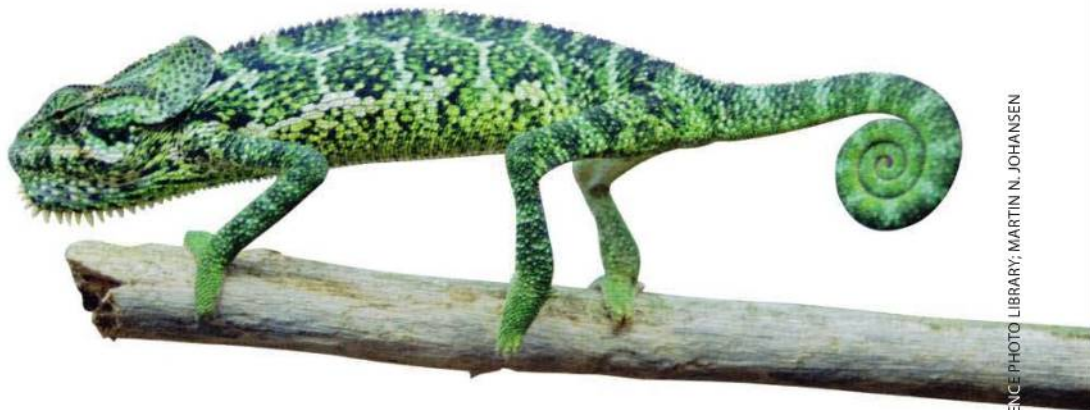


Fish Are Central to Socotran Life

Tuna [below], shark and kingfish are among the most important sources of income for Socotra's fishermen. They catch these prized fish along the main island's coasts, then salt and dry some to sell on mainland Yemen. The rest, they eat—fish is a mainstay of the Socotran diet.

The Socotra Chameleon Is 15 Million Years Old

In 2008, studies of the Socotra chameleon's DNA suggested that it has been isolated from its nearest relatives—in Africa and on the Arabian peninsula—for 10 million to 15 million years.



Crabs Are Far from Home

Two species of freshwater crab found only on Socotra live in its streams. Their closest relatives live thousands of miles away. The common ancestor of the crabs probably arrived when the island was attached to the Arabian peninsula millions of years ago.

FROM TOP: MARTIN N. JOHANSEN; SCIENCE PHOTO LIBRARY; MARTIN N. JOHANSEN

tive plants survive the heat. Many, like the desert rose and the cucumber tree, have adapted to the climate by developing thick stems or trunks to conserve water. Others control water loss by reducing their surface area. The flowering *mish'hermihim* plant, for example, has no leaves.

The Human Era

For the vast majority of their history, Socotra's plants and animals lived undisturbed. The first humans broke this peace a few thousand years ago,

although it is unclear where they came from. Today Socotra has 44,000 inhabitants, who harvest dates, raise cattle and goats, and fish the waters around the islands. Most are nomadic, and herd animals across the island. Socotrans follow strict local conservation rules, carefully managing grazing schedules to avoid land overuse.

Approximately 75 percent of the land-mass on Socotra is national parkland and thus protected from development.

Since the island's airport opened in 1999, tourists have begun to visit. Only

70 tourists came in all of 1999, but now several thousand arrive every year, even though the island still has only a handful of hotels. Tourism means increased pressure on the environment, but it also means more international awareness about Socotra and its World Heritage status. With global biodiversity numbers in sharp decline and development pressures on the island increasing, interest and support from the international community will be crucial to the preservation of Socotra's very special plant and animal life. ■

Giant Plants Create Life on Bare Rock

The desert rose's trunk resembles an elephant's foot, while pink flowers bloom from the top. The specimens found on Socotra can be more than 16 feet tall—far bigger than their African relatives.



Recent research shows that the amount of CO₂ released from wildfires could be a significant contributor to global warming. But can—and should—we fight these fires?

EARTH ON FIRE



Wildfires are fought from the air by a tanker dumping fire-retardant chemicals ahead of a blaze and on the ground by firefighters who risk their lives in the scorching heat and intense smoke.

California is one of the world's great front lines in the fight against wildfires, and each year its Department of Forestry and Fire Protection deploys incredible technology and manpower to extinguish them. Since 1954, the state has used aircraft to fight the fires. Today's planes can dump as much as 24,000 gallons of water or flame retardants over burning areas.

Last year, the biggest blaze was known as the Station Fire. One of the largest wildfires in the state's history, it forced residents in and around Los Angeles to flee their homes. In the end, the fire burned roughly 161,000

acres, cost almost \$100 million to fight, and killed two firefighters.

The Station Fire was far from an isolated event. Sixty-two fires burned in California in 2009 alone, and earlier that year, in the wake of a drought and a three-day heat wave, Australia experienced its own record-breaking wildfires. On a single Saturday, thousands of individual fires were reported in the country's southern state of Victoria. And in August this year, Russia also experienced devastating wildfires, estimated to have burned almost a million acres and caused several billion dollars in damage.

A Global Problem

About 400 million years ago, the oxygen content of Earth's atmosphere rose above 13 percent, making it possible for lightning, volcanic eruptions or sparks from a rock slide to set areas of vegetation aflame. (Layers of charcoal in the sediment of past eras make it possible to know just when fires began burning.) Since then, wildfires have been part of Earth's natural cycle.

As a result, most forests and wild areas have adapted to fires. Every land ecosystem has what's known as a "fire interval," the period of time between cyclical fires. Areas with short fire intervals often thrive on fairly frequent,



low-intensity fires, which burn the low-lying vegetation. These fires clear the ground for new growth and enrich the soil by converting nutrient-rich plant matter into ash, which is washed into the soil by rain and melting snow. Areas with long fire intervals, on the other hand, have infrequent but usually intense burns. These areas are often home to long-lived pine trees whose seeds are released by the heat of flames. "Fire is a natural process, no different from rain or hurricanes," says Richard Bahr, the Fire Science and Ecology Program leader at the National Park Service, one of several agencies responsible for managing

fires in the U.S. "It's one of the natural tools to reset the system." These areas need fire to keep life going.

But when the natural cycle of an area changes—when fires begin burning too often, too large or too intensely, or when they're prevented from burning at all—blazes can become a menace. In many areas of the U.S. and abroad, there has been a significant increase in the number and size of wildfires over the past few decades. What's more, in some areas the length of the fire season is increasing. Anthony Westerling, a climate researcher at the University of California at Merced's Sierra Nevada

Research Institute, who studies wildfires in the western U.S., has found that since the mid-1980s the occurrence of fires in that region has increased by about 300 percent, with an approximately 500 percent increase in the area of land burned; the fire season has lengthened by almost two thirds.

Some fires are caused by nothing more than extreme conditions and bad luck. A group of researchers from the National Oceanic and Atmospheric Administration's Climate Science Investigation, or CSI, program analyzed the high temperatures and low rainfall that led to blazes throughout Russia last August. The team's conclu-

FAST FACTS

- Yearly burning, at a global level:
More than 800 million acres
- Carbon dioxide emissions due to fossil-fuel combustion every year:
Approximately 8 billion tons
- CO₂ emissions due to wildfires each year:
Approximately 4.4 billion tons

Number of fires per year



The Tropics Are in Flames

Some areas experience more wildfires than others, with Africa and South America—where fires are often set to clear land for agriculture—among the hardest hit. The map shows the average number of fires per year.

sion? The hot, dry weather was part of a severe heat wave but wasn't the result of climate change [see "What Caused Russia's Wildfires?" page 54].

But other fires can be linked to global warming. Rising temperatures and changing weather patterns can cause droughts, like the ones in Australia and California last year. Droughts not only dry out vegetation, making it easier to ignite, they also eliminate the rainfall that would normally help control blazes once they start. And even minor changes

in an area's weather can lead to a major increase in fires. According to Westerling, longer fire seasons in the northern Rockies are the result of earlier snow melts—the less time brush spends covered by snow, the more time it has to dry out and catch fire—and all evidence points to climate change as a leading cause.

Yet wildfires may, in turn, exacerbate climate change. Burning forests can release millions of tons of carbon into the atmosphere. Forests cover 30 percent of the Earth's land sur-

face and function as an enormous carbon sink. The world's forests are estimated to store more than 300 billion tons of carbon, some of which is released when forests are cut down or burned. Last year, researchers revealed that fires emit half as much carbon dioxide globally as does the combustion of fossil fuels such as coal, oil and natural gas. Their work showed that wildfires could contribute significantly to climate change and that carbon emissions from deforestation fires alone may

AUSTRALIA, 2009

The Australians called February 7, 2009, Black Saturday because it was the day the deadliest series of wildfires in the nation's history started. In all, 173 people were killed, and thousands of homes were destroyed.



cause approximately 19 percent of the Earth's retention of solar radiation.

Last year, researchers from the Met Office, the U.K.'s meteorological service, found that if greenhouse-gas emissions continue unchecked, global temperatures are likely to rise by seven degrees Fahrenheit by the end of the century. This spike in temperature, they predict, will cause droughts in many regions of the world. The resulting forest fires could therefore be part of a vicious circle: The rise in temperatures helps to spark even more fires, and the fires release carbon, which causes global temperatures to rise.

Even the smoke and soot released by wildfires can affect the environment. The same scientists who reported that CO₂ from fires could be responsible for 19 percent of Earth's radiation retention also found that smoke clouds and soot particles can temporarily decrease the Earth's albedo, its ability to reflect energy back out into space.

Lessons Learned

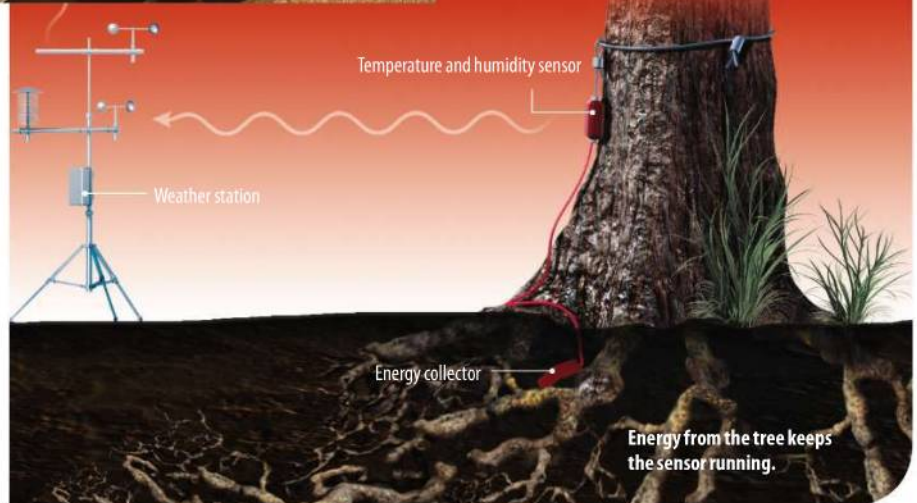
Climate change isn't the only reason the fire cycle has been disrupted. Humans have also helped to increase the occurrence and severity of wildfires in more-direct ways. Up to 95 percent of all wildfires are caused by people, often as a result of carelessness, as with a discarded lit cigarette or an aban-



Researcher Christopher Love tests the new system in the lab.

Using Trees to Guard against Forest Fires

In 2008, researchers from the Massachusetts Institute of Technology discovered that a pH imbalance between the tree and the soil in which it grows leads to an imbalance of charged particles, allowing the trunk to produce electricity. The researchers designed a system in which sensors could collect and transmit information about temperature and humidity, powered by tree-charged batteries. A company called Voltree Power, which sponsored the MIT research, is now planning to bring the climate-sensor system to forests across the U.S., to help detect and alert authorities of forest fires.



FROM TOP: CLAUD LUNAU; CHRISTOPHER HUANG; CLAUD LUNAU; SCANPIX (4)



What Caused Russia's Wildfires?

In 2007, the National Oceanic and Atmospheric Administration launched its Climate Scene Investigation program, known as NOAA CSI, to help uncover the causes behind extreme weather events. NOAA CSI was on the case when in late July and August of this year, Russia experienced a record-breaking heat wave followed by a series of wildfires that burned across millions of acres and blanketed its capital in smog. After examining atmospheric measurements from July and August, the researchers concluded that the heat wave was caused not by global warming but by a phenomenon known as blocking, in which atmospheric pressure disrupts the normal west-to-east migration of weather patterns.



done smoldering campfire. But many fires are set deliberately. In areas of Africa and South America, for example, farmers often burn forests and fields to clear the land for agricultural use.

Our early efforts to control wildfires have also, ironically, made them worse. For the first half of the century, government agencies responsible for the health of forests, such as the California Department of Forestry and Fire Protection and the National Park Service, just focused on

preventing fires. For areas with long fire intervals, this wasn't much of a problem. But for areas with shorter intervals, the lack of wildfires became the issue. Without occasional burns, deadwood, leaf litter and other wildfire fuels accumulated, while species that would have naturally grown in the area were choked out. As a result, the fires that finally occurred were fast-growing, difficult to control and more intense than the ecosystems—and firefighters—could handle.

Disrupting the cycle of fires and climate change isn't as simple as stopping wildfires from happening. "Probably the worst situation we can get into is thinking we can keep fire out for an extended period of time," Bahr says. "We can keep fire out in the short term, but nature's going to play its role and ignite something at some point. In the long term, it's going to want to go back to its natural cycle."

Those involved in the study and management of wildfires are focused on restoring the natural fire cycles of forests and other wilderness areas. The agencies that once worked on preventing and extinguishing wildfires now work on maintaining areas so that when fires do strike, they are easier to contain, and so that after the blaze, the land is more resilient. This means managing vegetation so that regions with historically long fire intervals are populated by plants best suited to that cycle, and areas with short fire intervals have plants that thrive on more-frequent burns. Lighting so-called "prescribed burns" in favorable conditions—on windless days, for example—also helps limit the potential for an unintended fire to spread.

It's also important to detect and contain unplanned burns early. Observation from the air and on the ground, as well as tree-mounted sen-

FROM TOP: MIKHAIL VOSKRESENSKY/REUTERS; SCANPIX

CALIFORNIA, 2008

More than 3,000 fires burned in California in summer 2008, with some 2,000 of them ignited by lightning strikes in a single week. California National Guard troops were deployed to help fight the fires.



Concerned persons suggest that unless there is an “*awakening*,” government in America’s small-government republic will continue being transformed into the large-government, progressive ideology. But what *awakening* is powerful enough to halt the progressive juggernaut of large-government control of what people can and cannot do?



Richard W. Wetherill
1906-1989

The writer would like you to consider that the above *awakening* to the existence of a natural law of right behavior *has that power*. The law is known as nature’s *law of absolute right*.

For nearly two decades, this behavioral law has often been carefully explained in one-page advertisements in several national magazines and newspapers, and on radio broadcasts. There is also a Website where people worldwide can learn how to get out of trouble, stay out of trouble, and start a new life.

This natural law exerts the power of life and death for every person alive today as is evidenced by the untold trillions of those people who had previously populated this planet.

“How?” you ask. *Creation’s law of absolute right states: Right action gets right results; wrong action gets wrong results. The law defines right action as thoughts and behavior that are rational and honest and fill the need of each situation.*

Therefore, people’s motivation consisting of man-made laws, judgments, beliefs, likes and dislikes, wants and don’t wants does not conform to *creation’s law of absolute right*, and when wrong results occur, people do not look to themselves.

Laws of nature never play favorites. People obey natural laws or they suffer the consequences. *That* is the awakening information for this generation. And if some people choose to ignore *nature’s behavioral law*, eventually their wrong action will cause an eternal sleep from which there has been no awakening.

WHOEVER OR WHATEVER IS THE CREATOR revealed this behavioral law to the mind of Richard W. Wetherill in 1929 in answer to his fervent appeal for an understanding of humanity’s plight. And although Wetherill took no credit for identifying this law, his efforts to inform people of the flaw in their approach to life met with an almost impenetrable wall of resistance and opposition until he published

his book, *Tower of Babel*, on January 2, 1952. Then small study groups were formed near several large cities in America. Later all the members who were able to relocate came together under Wetherill’s direction in southeastern Pennsylvania.

So much for a brief history of the group that now brings you the good news of the *law of absolute right*, and the *awakening* that it brings to a world population in deep trouble and chaos.

A few centuries ago the Founding Fathers of America did their best to establish a country ruled in a God-fearing way by representatives of the people. Newcomers from other countries who were willing to be governed by its Constitution and Bill of Rights were welcomed. Over the years, people came in droves. Now the divergence of thinking about whether the country should be transformed is causing much turmoil and confusion for the populace.

There is only one solution: everybody must obey creation’s law of absolute right or suffer the consequences of disobedience to whoever or whatever is the creator of natural laws and all that exists of planet Earth.

Visit our colorful Website www.alphapub.com where several essays and seven books describe the changes called for by whoever or whatever created nature’s law of absolute right. The material can be read, downloaded, and/or printed FREE.

This public-service message is from a self-financed, non-profit group of former students of the late Mr. Wetherill. Please help by directing others to our Website so that they can learn that obeying this natural law provides a life that is both fair and well worth living.

Ecology

Using a technique known as "burning out," a firefighter clears combustibles to contain a blaze in southern Arizona.



sors that detect smoke and carbon emissions, and satellite systems that detect infrared radiation from fires, have all been used to help fire-fighters get a head start in battling blazes. One company, Voltree Power in Massachusetts, is even working on tree-mounted sensors that could draw their power from the vegetation they're protecting, allowing them to work longer and more reliably than the battery- or solar-powered sensors currently in use [see "Using Trees to Guard against Forest Fires," page 53].

These methods might help break the vicious circle. Earlier this year, researchers from the National Center for Atmospheric Research and Northern Arizona University found that prescribed burns could help reduce the CO₂ emissions from burning forests. In the western U.S., controlled burns could reduce carbon emissions from wildfires by 18 to 25 percent, and by as much as 60 percent in some areas. Their reasoning: Prescribed burns clear out low-lying vegetation and preserve large, carbon-storing trees and help to prevent more-severe and longer-burning fires later on.

By being aware of the role of wildfires in Earth's ecosystems, we can help reduce the harm they do to the forests and fields they burn, the humans and wildlife in their path, and the climate of the planet. ■

FROM TOP: D. SPARKS/AP/POLFO; SCANPIX (3)

GREECE, 2007

Several heat waves with temperatures as high as 105°F helped set the stage for the late-August wildfires that claimed 84 lives and burned more than 670,000 acres of forests, farmland and homes.



WARNING: IS YOUR MEMORY FADING?

Breakthrough medical research reveals "forgotten moments" may be caused by "brain starvation"

Be proactive about your brain health. Leading medical researchers reveal discovery that triggers the body's own production of mental 'super fuel' (choline).

Do you remember your first kiss but not where you left your car keys? You're not alone. Millions are discovering that as they age, their short term memory and mental sharpness seem to be slipping. The cause of these inconvenient "gaps" in memory sits deep inside your brain, among the billions of tiny nerve connections. New brain cell growth starts dropping after age 25, and then dramatically after 50, starting a downward spiral that can lead to the embarrassment and frustration of age-related memory loss.

Downward Memory Spiral is Reversible

Studies have shown that the efficiency of brain cells declines after years of free radical damage and stress. It was long believed that as we got older, memory problems were inevitable. But medical experts have revealed that **the downward memory spiral may be helped.** Compelling new research shows that there's a simple way to stimulate new brain cell growth that can boost your memory, improve your focus and restore your mind's mental sharpness.*

Achieve Peak Brain Performance

Challenging mental games aren't enough to build a better brain. Your mind is the most complex and demanding organ in your body. It's also a high-performance supercomputer that requires the right chemical "foods" to perform at its peak.

One of the brain's most important nutrients is choline. Choline is a substance in our body that our brain desperately



Are you starving your brain?

If you have experienced one or more of these symptoms, you may benefit from Neurostin™.

- ☒ Do you forget names or dates?
- ☒ Do you sometimes get confused?
- ☒ Do you find it difficult to do more than one thing at a time?
- ☒ Do you often forget why you walked into certain rooms?
- ☒ Do you find it hard to concentrate?

needs to help manufacture new cells and improve vital neurotransmitters (the basic processes of thinking and memory). Until now, it was believed that there was no way to safely and naturally produce this remarkable mental "superfuel." But after years of extensive research and testing, microbiologists and brain researchers in the U.S., Europe and Israel have developed a way to help boost choline production.

The ingredients in Neurostin help support memory, and help clear "brain fog".*

How Neurostin™ Works

- Provides the building blocks of nerve cell membranes to promote optimal brain cell activity
- Assists in the production of acetylcholine, a vital component for improved mental performance
- Helps relax blood vessels to increase blood flow for maximum nutrient and oxygen delivery
- Helps dispatch antioxidants which inhibit free radical oxidation of nerve cell membranes



* These statements have not been evaluated by the FDA. This product is not intended to treat, diagnose, cure, mitigate or prevent any disease. Return postage may be required. Neurostin is not endorsed, associated or affiliated in any way with university, hospital or research facility.

Support Memory and Alertness

The Neurostin® formula is safe and contains no stimulants, ephedra or caffeine. Specific brain-boosting ingredients help improve the synthesis and transmission of neurotransmitters and help improve mental clarity.* This exciting breakthrough discovery is now available in a **time-release capsule** called Neurostin® Complex-Memory Pill that is available without a prescription to anyone looking to sharpen their memory. Neurostin® contains a unique combination of antioxidants, botanicals and nutrients to support critical processes for good cognitive function.

Protect Your Memory Now Before It's Too Late

Why wait until your lack of focus or forgetfulness creates an unsafe situation? Today it was your reading glasses, but tomorrow it could be the stove. You forget a phone number today, but tomorrow it could be where you parked your car at the mall.

Just as important is the personal toll that a fading memory can take on your family and friends. Don't you owe it to them and your future to take your brain's fitness as seriously as you do your heart health? It couldn't be easier. You can get back the mental sharpness and focus you had when you were years younger! Act today and unlock your mind's true potential!

Having Trouble Finding Neurostin?

The makers of Neurostin® are so confident that they want to offer you a 30-Day Risk Free Trial, so you can experience the results firsthand.

To get your trial supply of Neurostin® risk free, for just a small shipping and processing fee call 888-220-3039.

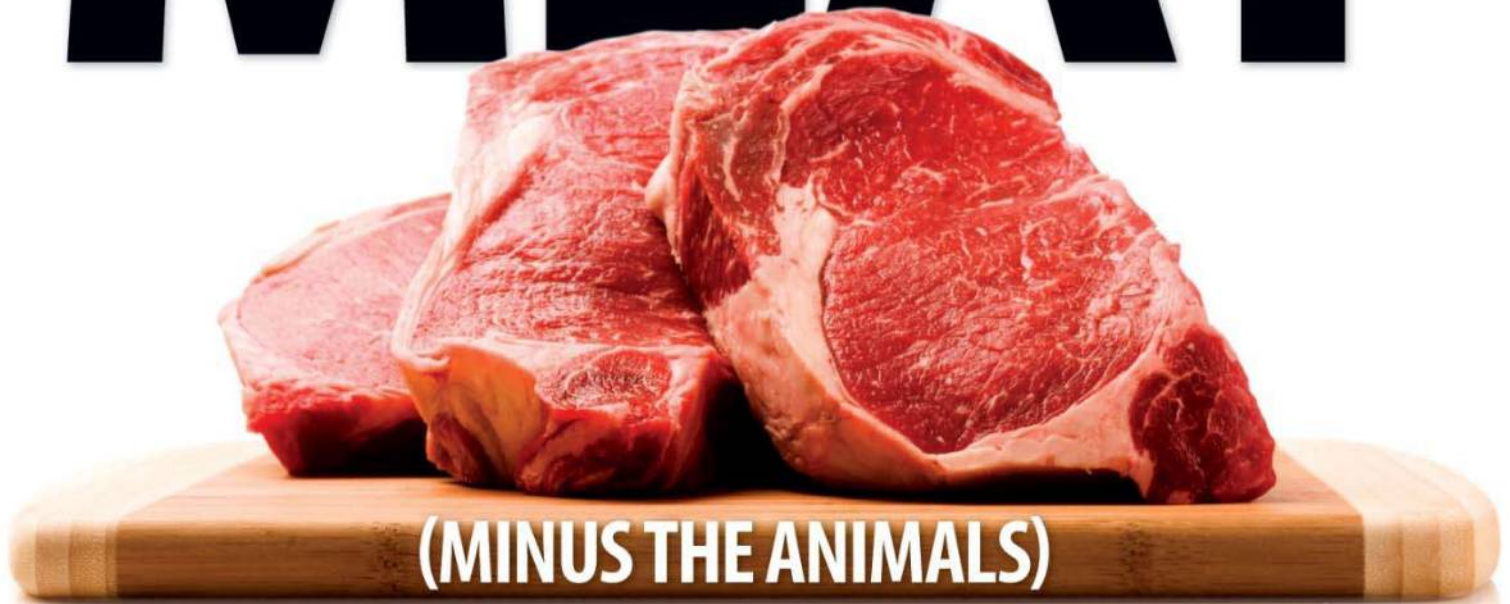


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Mention Promotional Code NU100113

www.NeurostinDirect.com

MEAT



In a few decades, the steak on your plate may not come from a cow. To satisfy the world's growing appetite for meat, researchers expect to be able to make 200 pounds of it from a single cell

Meat is nothing more than a collection of cells. It consists of muscle, blood, connective tissue and fat. But as food, it provides important nutrients like protein and vitamins. Today we get most of our meat from animals raised for that purpose, but in a decade or so, it may be possible to create meat in the lab. No acres of pasture for grazing, no barn, no slaughterhouse. Scientists around the world are working to create animal-free meat—opening up land and revolutionizing agriculture in the process.

That is the goal of the In Vitro Meat Consortium, a collective made up of scientists from the Netherlands, the U.S., Denmark, Sweden and Norway. The

idea behind their research is simple: Take a single stem cell, called a satellite cell, from an animal's muscle, coax it to differentiate into a muscle cell, feed it nutrients, and let it grow and divide. If the stem cell is cultured correctly, the result is a large quantity of muscle cells, which can then be formed into meat. For now, only very small amounts of stem-cell meat have been cultured in controlled laboratory settings, and the work is in the early stages of research. But the potential is enormous.

"There are several million stem cells in an umbilical cord from a pig," says the consortium's chairman, Stig W. Omholt of the Norwegian University of Life Sciences. "Each cell could, in principle, be turned into 220 pounds

of meat, so a handful of pig umbilical cords could be sufficient to make enough meat for the whole world."

It's Unnatural—or Is It?

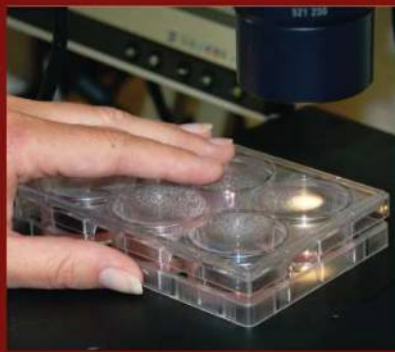
The incentives to grow cultured meat relate to public health, as well as environmental concerns, says Jason Matheny, the founder of the non-profit organization New Harvest, based in Washington, D.C., which funds research on cultured meat and other meat substitutes. Increased outbreaks of swine and avian flu, as well as the greenhouse gas emissions associated with raising livestock, have sparked interest in alternatives.

But the thought of cultured meat is hard for some people to swallow.

"Part of the challenge is that most people don't currently know how their meat is produced," Matheny points out. Production in today's slaughterhouses takes place under conditions that are far removed from nature, he says. "The common image is of meat being produced via free-range animals, but 98 percent of meat raised in the U.S. comes from factory farms with tens of thousands of animals living in waste. They are real incubators for disease because their immune systems are compromised."

Omholt imagines that in the future, meat production will take place in bioreactors, which are sealed, sterile containers intended for controlled biological processes. Culturing meat in a bioreactor is similar to how the dairy industry makes yogurt, a process that uses billions of bacteria, which are cultured to transform lactose into lactic acid. The technique is an accepted method of food production. Why should meat be different? Omholt asks.

It is relatively simple to culture living cells in the lab, but if meat is going to be made on any significant scale, industrial methods must be developed. With enough funding, and if scientists from enough fields are brought together, Omholt believes we may see industrial production of



Pig cells multiply in a lab vessel used by Norwegian scientists working on stem-cell meat. Their first goal is to produce ground meat.

in-vitro meat in the next decade.

It's going to take a significant brain trust to get there, one that includes physicians and tissues engineers, particularly those who have worked on raising skeletal or heart-muscle cells. Researchers can also use the knowledge that biologists have accumulated about stem cells to learn how to get their starter stem cells to differentiate into muscle and make them proliferate. In addition, the insights of other biologists into how embryos develop could be valuable, and mathematicians can contribute with models of how the biological processes work.

At first, cultured protein would be what is called unstructured meat, muscle fibers that are ground to resemble hamburger. Not surprisingly, it would primarily be used to make burgers and sausages. That's a huge market: In the U.S., about 42 percent of beef sold is ground meat. It could eventually be possible to produce pieces of meat, such as filets, although scientists estimate that this is at least 20 to 30 years away.

At that point, customized protein—low-fat meat, for example, which would make a cheeseburger as healthy as fish—could also be a reality. Stem-cell meat could someday even be nutritionally superior to cuts from animals.

Its taste could be manipulated as well. As a curiosity, it would be possible to raise muscle cells from animals that are more exotic than pigs, cows and chickens—lion or gazelle burgers, anyone?

What Stands in the Way

As an animal grows, its circulatory system provides a network of blood vessels to deliver nutrients to its flesh and remove waste. Growing meat in a lab will require a structure similar to what nature provides, a three-dimensional scaffold for the

BACKGROUND

Meat Production Is Hard on Our Planet

Raising cattle requires significant resources and energy. Just one beef cow in the U.S. consumes more than 5,000 gallons of water and about 15,000 pounds of feed before it is slaughtered. Some research suggests that it takes 284 gallons of oil to raise a cow to slaughter, including the oil necessary to grow all that food, although the beef industry figures it's closer to 14 gallons. Either way, that's a lot of oil—today, there are almost

32 million beef cattle in the U.S. alone.

Because of their size and caloric needs, cows are the worst offenders when it comes to consumption, but they are not unique in their ability to affect the planet. Thirty percent of land worldwide is dedicated to grazing livestock or raising their food, and 8 percent of water use goes to them as well, mainly for irrigating feed crops. Livestock also contribute 18 percent of greenhouse gases globally.

Reasons to change the way meat is produced:

It's inefficient. A cow consumes about six pounds of plant protein to produce one pound of meat protein.

It pollutes. Livestock contributes 9 percent of the CO₂ and 37 percent of the methane in man-made emissions.

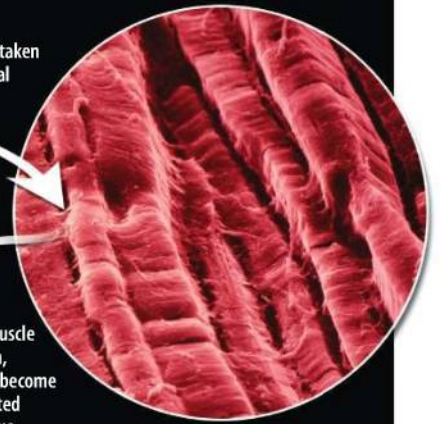
It's in demand. Global meat production could double in the next 40 years.

Three Ways to Create Stem-Cell Meat

Laboratory meat can be produced in many ways. If, for example, we start with muscle tissue from a cow, there are three possible methods. The most realistic for now is to make unstructured meat, similar to hamburger. Structured meat consists of muscle tissue that has had nutrients supplied through small blood vessels. Creating an artificial circulatory system with blood vessels is still a major challenge.



Muscle tissue taken from an animal

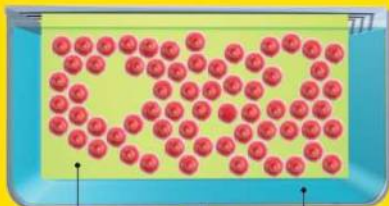


Satellite cells (muscle stem cells, which, when activated, become myoblasts) isolated from muscle tissue



In a Vat

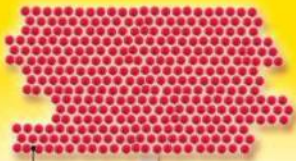
Many square feet of membrane float in a tank of nutrients. Myoblasts attach to the membrane, divide, and eventually form a layer of muscle cells.



Membrane

Nutrient liquid

Muscle-cell layers are harvested by scraping them off the membrane and folding the layers to create a solid mass, which can be ground.

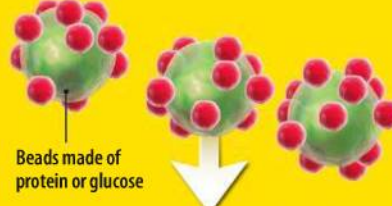


Muscle cells processed into meat



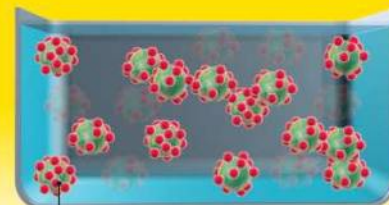
On Small Beads

Myoblasts attach to thousands of tiny beads made either of animal protein extracted from connective tissue or carbohydrates from the cell walls of algae or fungi.



Beads made of protein or glucose

The beads rest in a nutrient solution. The myoblasts multiply and coat the beads with a layer of muscle cells.



Muscle cells processed into meat



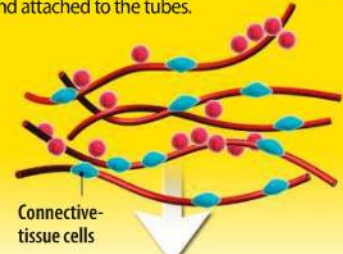
On Vessels

Scientists create a network of microscopic tubes to function as artificial blood vessels. The tubes would be made of materials that are either soluble or edible.



Artificial blood vessels

To make meat with structure, the myoblasts are cultured together with connective tissue and attached to the tubes.



Connective-tissue cells

Nutrients are pumped through the tubes to the cells, which multiply and turn into muscle tissue.



Each cell could, in principle, be turned into 220 pounds of meat, so a handful of pig umbilical cords could be sufficient to make enough meat for the whole world.



—Stig W. Omholt
Norwegian University
of Life Sciences

meat to grow on that can channel nutrients to the individual cells. (How waste will be removed in this setting has yet to be addressed.)

Tissue engineers and cell-culture biologists are developing such systems, made from biological or synthetic materials. To be used for food, however, the material must be nontoxic, because it will be ingested along with the meat. There has been a dramatic improvement in cell-culture technology over the past decade, moving from a configuration where cells are grown in a single plane to culture systems with 3-D scaffolding that can support a more natural collection of cells. “Cells that have a kind of scaffold to grow on will resemble conventional meat more easily,” Omholt says. “This is one of the major challenges, but it is also an area in which there are many possible solutions.”

In order to develop into muscle, cells need to be stimulated in various ways. The cells in an animal get “exercise” when the animal moves, which muscle cells in a bioreactor do not. The solution could be to stimulate the muscle cells with electrical or chemical impulses—or to create a scaffolding that periodically alters its configuration and stretches the cells, stimulating them mechanically to grow as they do in a living animal.

Another difficult challenge is developing a nutrient-rich organic medium in which to grow the muscle and fat cells. Currently, the most widely used medium in tissue engineering is calf

serum, a component of calf blood. Researchers are also working on solutions that are not based on an animal product, such as algae, bacteria raised on methane gas, or even food past its sell-by date, to serve as the source of nutrients. In the U.K. alone, 7.4 million tons of food are discarded every year,

and in the U.S., as much as 40 percent of all food ends up in the garbage.

Because cultured protein has no immune system, the meat in a bioreactor could be susceptible to infection and disease. According to Matheny, the pharmaceutical industry has substantial experience in making sure large bioreactors operate in sterile conditions. Contamination sometimes occurs, but not very often.

Meats, Easy and Painless

Harvested-meat research could end the painful and mechanized life of farm animals—what Omholt refers to as “meat without brain and pain”—and could reduce the pressure from livestock on the global climate. Large amounts of carbon emissions are produced throughout the life cycle of each animal, from growing and shipping their food to transporting them to the slaughterhouse. Every pound of beef produced results in 19 pounds of CO₂ emissions, compared with around a quarter of a pound of emissions for an equivalent amount of potatoes.

Omholt does not foresee cultured meat as completely replacing conventional meat production but rather as coexisting with it, potentially encouraging improvements in livestock production. The biggest advantage of culturing meat in bioreactors is that the cells would “eat” far less than any animal would. Animals require energy to make bones, hair, brains and nerves, and they consume energy to keep warm and to move. Rough calcu-

lations indicate that a fifth to a tenth as much food would be needed to produce an amount of stem-cell meat equivalent to meat from an animal.

Today almost no one outside a lab has tasted cultured meat, because the quantities available have been so limited. And ultimately it’s unknown if consumers will accept the product as a regular part of their diet.

In 2008, People for the Ethical Treatment of Animals offered \$1 million to the first company to put cultured meat on the market by 2012 or sooner. It’s an undoubtedly optimistic goal. But between the symbolic promise of that offer and the obvious value of an endlessly renewable source of nutrition for the human race, perhaps a future generation will enjoy a kind of steak dinner we never could have imagined. ■

FAST FACTS

Advantages of Culturing Meat

- + Reduced environmental impact.
- + Cleaner product; no antibiotic residues, for example.
- + Meat is sterile, so the danger of spreading disease is decreased.
- + Nutrient content can be customized.
- + No animal wastes.
- + No animals killed.

... and disadvantages

- The meat is unstructured and at first could replace only ground meat.
- The product will have to be heavily processed to make it taste like meat.
- Lacks immune defenses and is therefore more vulnerable to bacteria and infection during production.
- Consumers may be wary of a lab-grown product.

The Superior

Ants, like people, live in groups of millions. But unlike us, individuals don't pursue their own goals. Their colonies function as one organism, working together to build enormous civilizations right beneath our feet

PHOTOGRAPHS BY MARK W. MOFFETT



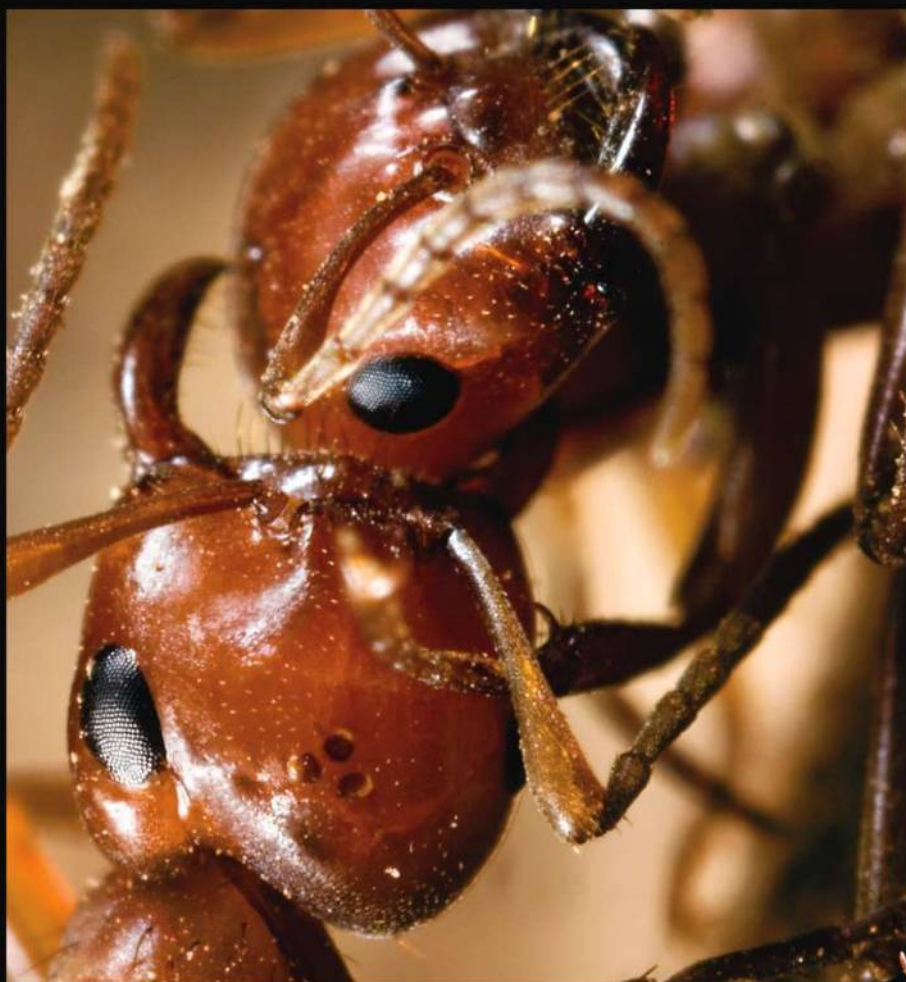
ganism



FETCHING FARMERS

South America's leafcutter ants retrieve plant parts to shred into compost for their underground gardens, where they grow nutrient-rich fungi, their sole source of food.

A lone ant carrying a heavy crumb across a kitchen floor is the picture of a hardworking individual. But there's no such thing as a lone ant. They form a seamless unit wherever they are—so much so that entomologists call them “superorganisms.” Ants share a common chemical signature with other members of their colony, meaning an individual can no more choose to break away than your toe can choose to seek out a new life. “They are with their colony to live and die no matter what,” says ecologist Mark W. Moffett, the author of *Adventures among Ants*. He photographed the ants on these pages during research trips around the world starting in 1983. ▶



MURDEROUS MANDIBLES ▲

The photographer drops a rival ant into a group of Amazon ants. The reaction is violent and immediate as a worker [bottom] prepares to pierce the newcomer's head with its pinchers. The defensive move works, and the rival ant is killed.

HANGING BY A LIMB ▶

Migrating army ants build hanging nests from logs or branches by linking toe to toe and assembling to protect the queen and her larvae in the center. Hundreds of thousands of ants will join the hanging cluster until the colony relocates for food.



PHOTOGRAPHS: MARK W. MOFFETT/MINDEN PICTURES, EXCERPTED FROM *ADVENTURES AMONG ANTS*; A GLOBAL SAFARI WITH A CAST OF TRILLIONS



OUT OF THE AIR

Even a bee in flight is too slow to escape Australia's predatory bulldog ants, which are more agile than other species and, unlike most ants, have excellent vision.



AN EASY MEAL

Ants in northern Argentina strip bare piranhas and other fish that wash ashore during frequent floods. These insects have been known to climb aboard docked ships, which is how they invaded Southern California in the 1890s before spreading across the southern U.S.



Most colonies start when winged males from one nest fly out to mate with a virgin queen who has left her nest. She gathers enough sperm from her mates to fertilize generations of eggs, which grow into females that will serve as workers. Her unfertilized eggs become males, which mate elsewhere and then die.

What happens next varies widely. With as many as 12,000 species spanning every continent but Antarctica, ants are as diverse as birds. Nomadic army ants, for example, march forth to new locations almost daily, where

they carry out aggressive, carnivorous raids on rival colonies, other insects and small vertebrates. Peaceful, herbivorous South American leafcutter ants, on the other hand, grow fungal gardens deep underground, crowned with anthills of dug-out debris tall enough to reach a man's chest.

Whether waging war or helpfully churning the soil, ants share a highly organized, efficient group dynamic that helps explain how the insects have ruled the planet's cracks and crevices since the demise of the dinosaurs. ■

SUBMITTING TO SERVITUDE

Some invaders steal other species' young to work for their colony. A group of Amazon ants, *Polyergus breviceps*, returning home use the black ant, a *Formica argentea*, as a slave to carry a pupa back to their nest.

PORTFOLIO CONTINUES ►►

Photo Portfolio Entomology



SYMBIOTIC SHELTER ▲

In exchange for shelter in the tendrils of pitcher plants, as well as some free food, carpenter ants swim in the pitchers [not shown] and eat large insects that the carnivorous plants can't digest.

REARING THEIR YOUNG ►

Larvae rear up their bodies to beg for food from bulldog worker ants. Whether an ant eventually becomes a soldier, worker or queen is largely determined by how much workers feed it in the larval stage. It's still unknown how this decision is made.





▲ SOCIAL NETWORKING

Ants are social creatures that communicate by releasing chemicals that others sense with their antennae. They rely on one another, especially when in a large colony—like these acrobat ants in Ghana—to gather information and build infrastructures.

◀ ALL ABOARD

Public transportation is not just a human endeavor. Large marauder ants will bus smaller workers to conserve the group's energy.

Shaken Up

How we measure quakes—and what they teach us about our planet

When the stress between two continental plates is released deep inside the Earth, typically when the rocks along a fault line fracture and slip, powerful upheavals happen. We call these geological events earthquakes. Scientists

measure the strength of these vibrations using seismometers, which combine classic mechanical seismographs with modern electronics.

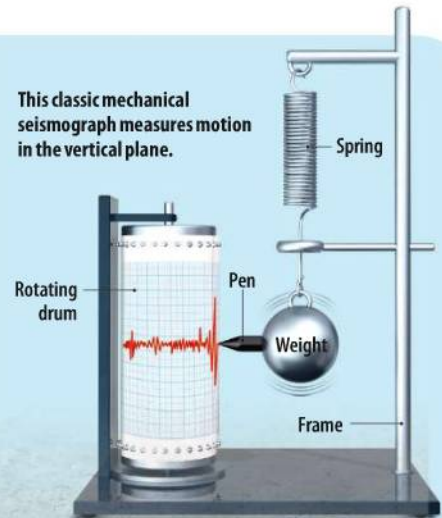
In one common seismometer design, a weight is suspended by a spring from a frame and exposed to electromagnets, which create an

electric field. If an earthquake shakes the ground, the frame moves with it, but the electric field holds the weight motionless. The larger the tremor, the more force exerted on the field. By measuring the change in the field, scientists can determine the strength of the earthquake. ■

Delicate Mechanism Registers Quakes

A classic mechanical seismograph suspends a hanging weight from a spring within a frame. When the ground shakes, the frame moves, but inertia limits the weight's movement. As the weight shifts slightly, a pen mounted on it traces a line on a roll of paper—the larger the movement, the greater the line's amplitude. Scientists apply the Richter scale, a mathematical formula, to the amplitude to determine the quake's magnitude.

This classic mechanical seismograph measures motion in the vertical plane.



Decoding the Richter Scale

Seismic Energy Determines Strength

The Richter scale, developed by American physicist Charles F. Richter in 1935, is a measurement of the amount of seismic energy released during an earthquake. The scale is logarithmic, with an increase of 1.0 corresponding to a 10-fold increase in energy.

Strength	Damage	Frequency on Earth
Below 3.0	Measurable but rarely noticed	1.3 million per year (est.)
3.0–3.9	Rarely causes damage	130,000 per year (est.)
4.0–4.9	Slight damage to furniture and fixtures	13,000 per year (est.)
5.0–5.9	Minor damage to structures	1,319 per year
6.0–6.9	Moderate damage to structures	134 per year
7.0–7.9	Major, widespread destruction	15 per year
Above 8.0	Catastrophic damage and loss of life	1 per year

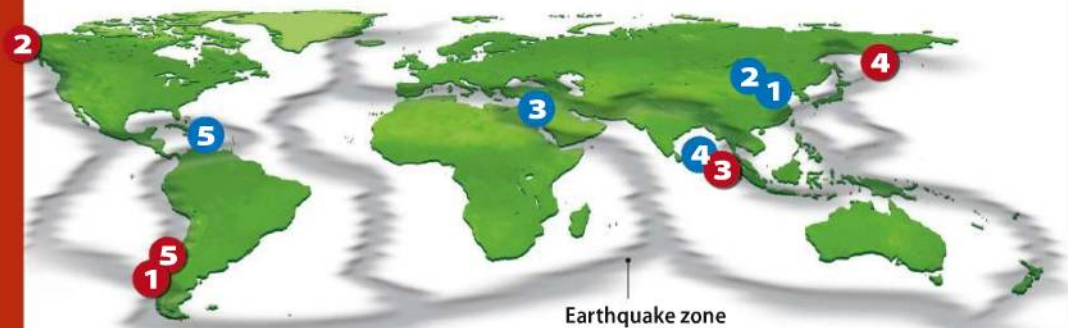


Researchers bury a barrel containing an electronic seismometer on Mount St. Helens.

FROM TOP: CLAUDE LUNAU; AWW/ U.S. GEOLOGICAL SURVEY/SPL/FOCI

The Strongest Quake

Chile holds the record for the most violent earthquake ever measured. The quake, scoring 9.5 on the Richter scale, took place in 1960 in a thinly populated area about 435 miles south of Santiago. Four foreshocks with magnitudes of more than 7.0 preceded the quake, and aftershocks—five of which also measured 7.0 or greater—continued for five months. The earthquake set off a tsunami with 82-foot-high waves and caused 1,665 deaths and \$675.5 million in damage in Chile, Japan, the Philippines, Hawaii and the U.S. West Coast.

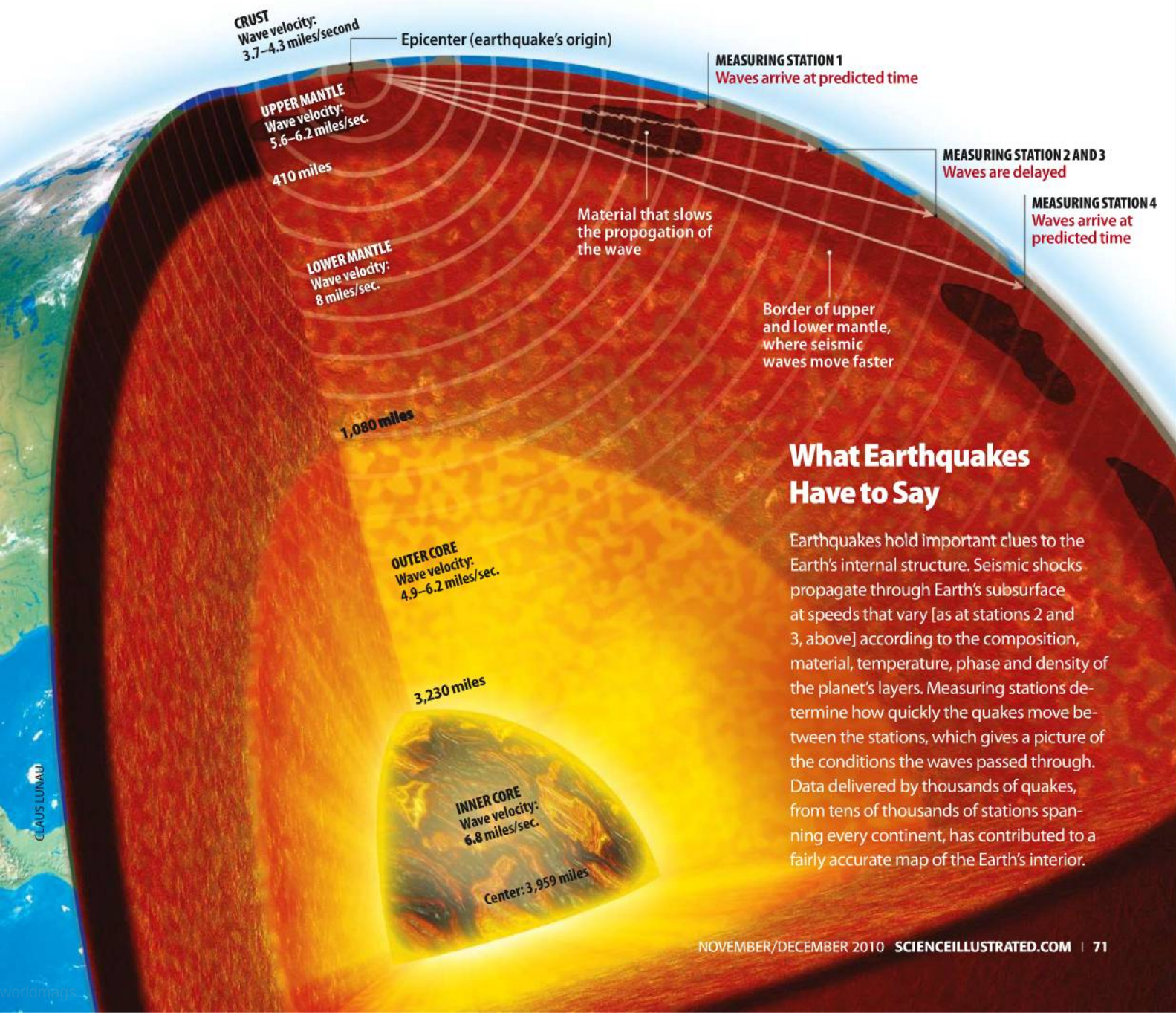


Strongest Quakes (magnitude)

- | | |
|---------------------------------------|-----|
| 1. Valdivia, Chile, 1960 | 9.5 |
| 2. Prince William Sound, Alaska, 1964 | 9.2 |
| 3. Offshore Northern Sumatra, 2004 | 9.1 |
| 4. Kamchatka Peninsula, Russia, 1952 | 9.0 |
| 5. Offshore Maule, Chile, 2010 | 8.8 |

Deadliest Quakes (death toll)

- | | |
|-----------------------------|---------|
| 1. Shaanxi, China, 1556 | 830,000 |
| 2. Tangshan, China, 1976 | 255,000 |
| 3. Aleppo, Syria, 1138 | 230,000 |
| 4. Sumatra, Indonesia, 2004 | 227,898 |
| 5. Haiti, 2010 | 222,570 |



What Earthquakes Have to Say

Earthquakes hold important clues to the Earth's internal structure. Seismic shocks propagate through Earth's subsurface at speeds that vary [as at stations 2 and 3, above] according to the composition, material, temperature, phase and density of the planet's layers. Measuring stations determine how quickly the quakes move between the stations, which gives a picture of the conditions the waves passed through. Data delivered by thousands of quakes, from tens of thousands of stations spanning every continent, has contributed to a fairly accurate map of the Earth's interior.

By the Numbers: The Body

The average head sheds up to **100** hairs a day.

ANATOMY 101

With dozens of organs, hundreds of bones and muscles, and trillions of cells, your body is the most complex machine on Earth.

Although the human body can endure extreme spikes in temperature, shifts of just a few degrees often mean danger.



Over 108°F

Life-threatening hyperthermia. Significant risk of brain damage or death.

Over 106.7°

Severe hyperthermia. Delirium and death may occur.

Over 102.2°

High fever. Call a doctor.

Over 101.5°

Moderate fever. A person loses more than two quarts of extra fluid per day.

100.4°

Slight fever. Bacterial and viral infections often cause fever.

97°–99°

Normal temperature. The body's temperature changes throughout the day. It's lower in the morning and higher in the late afternoon.

Below 95°

Mild hypothermia. The skin is cold and pale; shivering occurs.

Below 90°

Moderate hypothermia. Shivering ceases. Weak pulse and respiration, possible loss of consciousness. Life-threatening condition.

Below 82°

Severe hypothermia. Brain function, heart, blood pressure and breathing slow. Most patients are comatose and will die without prompt emergency care.



The brain makes up only **2%** of the body's weight, but it receives **15 to 20%** of the blood supply.

An ear bone called the stapes is the smallest in the body. It measures **0.1 inch** long



Our sense of smell can detect more than **10,000 scents**.



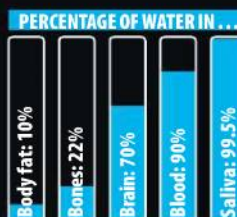
The microbes on our skin and in our tissues outnumber the human body's cells by **10 to 1**.

A woman's ovaries contain one to two million eggs at birth, but only about **400 eggs ever mature**. In comparison, a typical male ejaculation contains **300 to 400 million sperm cells**.



How long it takes a typical blood cell to circulate through the entire body

Water makes up about **60%** of a man's body's weight, but it is unequally distributed.



About **40%** of all the atoms in the human body, such as oxygen and carbon, originated in supernova explosions. The remaining 60% are hydrogen atoms formed during the big bang.

A toenail takes **12 to 18 months** to completely grow out.

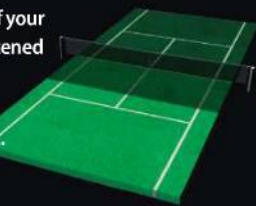


The eye's retina contains about
127 million photoreceptors.

Salivary glands produce **one to two quarts of saliva** per day.

Somewhere between
2,000 and 8,000
taste buds cover your tongue.

If the entire interior surface of your lungs were unfolded and flattened out, it would cover an area of **96 square yards**—about a third of a tennis court.



2,500,000,000
is how many times your heart will beat by the time you reach 70 years old.

There are **54 bones**, a quarter of the body's total, in your hands and wrists.



Bones are your body's blood factories. Every second, between **two and three million** new red blood cells roll off the bone marrow's assembly line.

In the fastest neurons, impulses jump from one cell to the next at a speed of more than **200 miles per hour**—faster than most high-speed trains.

DNA, found in every organism, codes for proteins essential for forming the human body.

Four chemical bases, denoted as A, C, G and T, pair up to form double helices.

Humans share 99.9% of their DNA with each other and 96% with chimpanzees.

Each human chromosome contains between 50 million and 250 million base pairs.

At least 50% of human DNA is "junk," repeated sequences that do not code for proteins.

Our Elemental Makeup

Just six elements account for more than 99 percent of the body's mass. A person weighing 154 pounds contains about:

95 pounds of oxygen Present throughout the body, mostly in the form of water

35 pounds of carbon Located in large molecules throughout the body

15 pounds of hydrogen As water and in all organic molecules

4 pounds of nitrogen Found in DNA and amino acids; also vital during pregnancy

2.2 pounds of calcium 99 percent is found in the teeth and bones

1.7 pounds of phosphorus Regulates blood sugar and normal cell growth

The average pregnancy lasts nine months, but babies born after just 22 weeks may survive, though usually with significant health problems.

AGE	LENGTH*	WEIGHT
8 weeks	About 1 in.	0.5 oz.
24 weeks	About 9 in.	2 lbs.
Birth	About 14 in.	7.5 lbs.

The **BRAIN** develops quickly. By the 10th week, **250,000 neurons** are being created every minute.

THE EYES
are complete by
week 24.

SWALLOWING
is possible by
week 21.

FINGERPRINTS
develop by
week 24.

SEX ORGANS
are discernable by
week 12.



*Measured from top of head to rear

Women naturally carry more body fat than men—optimally, 20 to 21% versus men's 13 to 17%.

On average, American women live five years longer than men.



Men's lungs typically take in 10 to 20% more oxygen than women's. About 8% of men are color-blind; fewer than 1% of women are.



Trivia Countdown

Earn more points by using fewer clues to answer each question.

		5 points	4 points	3 points	2 points	1 point
BOTANY	Name this plant	It is native to central Asia but grows in the wild in Italy and France.	Its Latin name is <i>Allium sativum</i> , from the family Alliaceae, which includes chives and leeks.	When ingested, it produces different sulfur-containing gases in the body, causing bad breath.	Each bulb contains up to 20 cloves, which have papery skin, and a long green stalk that sometimes produces flowers.	Its name comes from the Old English <i>garleac</i> , meaning "spear leek."
SPACE	Name this shuttle	It launched on April 12, 1981.	In November 1981, it launched again, becoming the first spacecraft to be reused.	The ceremonial pitch for game 5 of the 1995 World Series was thrown onboard this shuttle; video was transmitted to the Cleveland scoreboard.	It was named after the first ship to circumnavigate the globe, derived from the name of a famous 15th-century explorer.	In 2003, on its 28th mission, it broke apart during reentry into Earth's atmosphere, killing its seven-member crew.
MONARCHS	Name this king	This Egyptian ruler, the second pharaoh in the fourth dynasty, ruled in the 25th century B.C.	In 1915, Dutch poet Jan Hendrik Leopold wrote a famous poem that detailed the journey of this pharaoh's soul after his death.	Grave robbers stole his mummy from his tomb, but archaeologists later discovered other personal belongings there, including his royal ship.	His tomb was the Great Pyramid at Giza, the largest building in ancient Egypt and one of the Seven Wonders of the Ancient World.	The ancient Egyptians called him Khufu, but today he is more commonly known by his Greek name, which starts with "C."
INGREDIENTS	Name this substance	This waxy yellow substance is a purified form of an animal oil.	It is found in cosmetics, lotions, shaving creams and soaps.	It easily permeates the skin, which makes it a useful ingredient in topical medicines.	Sometimes called "wool fat," it is produced by the sebaceous glands in sheep's skin.	Its name comes from the Latin words for wool (<i>lana</i>) and oil (<i>oleum</i>).
ORGANIZATIONS	Name this institution	Established in 1846, it is run by a board that includes the U.S. vice president, chief justice, three senators and three representatives.	It has more than 137 million pieces in its collection, including artifacts, art and natural objects.	More than 30 million people visit its 19 museums and zoo every year.	The majority of its museums and research centers are in Washington, D.C., but other locations include New York City, Virginia and Panama.	It was created at the bequest of English scientist James Smithson.

What year was it?

February 26, U.S.

Country singer and songwriter Johnny Cash is born in Kingsland, Arkansas.

May 21, Ireland

Amelia Earhart lands in Londonderry [right], becoming the first woman to fly across the Atlantic Ocean solo.

September 20, India

Mahatma Gandhi, in prison in Pune, goes on a hunger strike to protest the treatment of India's Untouchable caste.

Your guess Points

Correct year 5

± 2 years 4

± 4 years 3

± 6 years 2

± 8 years 1



POL/FOTO

Your score:

24-30 Genius

17-23 Top of the class

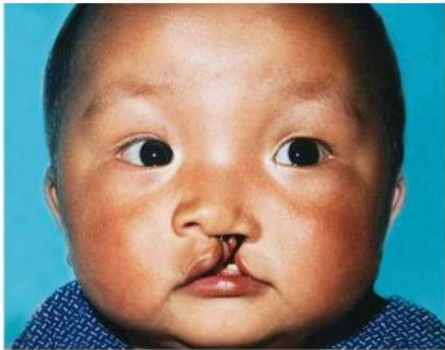
9-16 Passing grade

0-8 Hit the books

Answers appear on page 76

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Ming, 6 months, China



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Mot, 13 years, Cambodia



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Funmi, 8 years, Nigeria



Salazar, 5 years, Philippines

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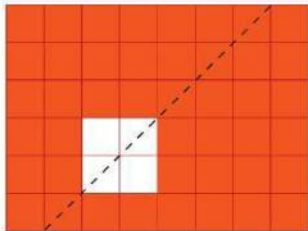
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Brain Trainers



4. Bob owns the poodle named Andy, and Carl owns the poodle named Dan.
3. See diagram.
2. 3 ounces. Let A, C and T represent the weights in ounces of an apple, acorn and twig, respectively. Then $A = 3C$ and $16T = 2$ pounds = 32 ounces. We know that $4C + 3A + 7T = 6C + 5A + 3T$, so $4T = 2C + 2A$, and thus $2T = C + A$. Since $T = 2$ and $A = 3C$, we get $4 = 4C$, so $C = 1$, and thus $A = 3C = 3$.

4. 59. All of the other numbers have a remainder of 1 when divided by 4, but 59 has a remainder of 3.
5. 73. Let the number of pennies that Alice and Bob each have equal x . Then, $x/2 + x/3 = 51$, and $x = 61.2$. Because you can't have a fraction of a penny, Alice and Bob must each have had 62 pennies originally. Therefore, they gave away 31 and 20 pennies respectively, for a total of 51. This leaves them with a total of $124 - 51 = 73$ pennies.
- HEADBREAKERS
1. D. If we insert D into the empty space, the resulting pattern is symmetric along the diagonal that runs from the upper left to the lower right corners.
3. C. It is the only card in which all the figures are different in both shape and color.
2. 20. Every possible path can be represented by a string of three Ds and three Rs, such as RDRDD, where R means "right" and D means "down." There are 20 such strings.
3. C. It is the only card in which all the figures are different in both shape and color.

BRAIN TRAINERS

1. Two possible solutions: $5 = ((4 \times 4) + 4)/4$ or $5 = \sqrt{4} + \sqrt{4} + 4/4$.

2. 20. Every possible path can be represented by a string of three Ds and three Rs, such as RDRDD, where R means "right" and D means "down." There are 20 such strings.

3. C. It is the only card in which all the figures are different in both shape and color.

TRIVIA

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A STUDY FOR CONFIRMATION OF CONCEPT

Graphs developed from data acquired by a stationery Velador setup during August 2007. Professor Hayden Brownwell constructed the setup using my Velador design when he was at Dartmouth College in Hanover, NH. X and Y are the coordinates from the CCD of the centroid of a HeNe laser. The data is to be given free of charge. The times of the eclipse are from a NASA diagram.

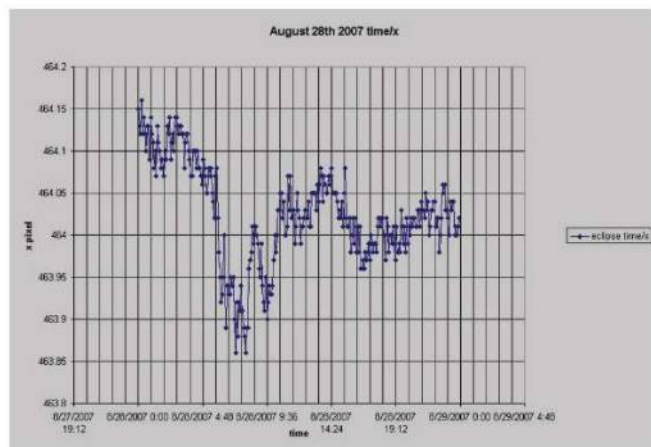
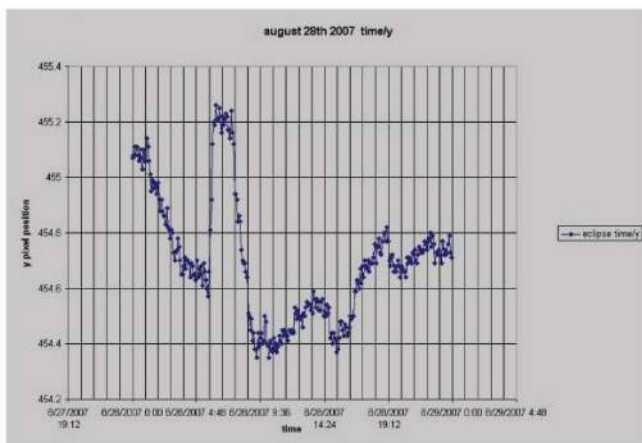
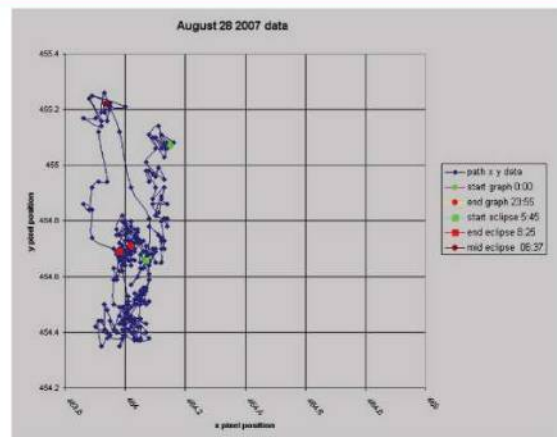
For more information - www.Laqu.bravepages.net -- www.lanceosadchey.com
email=lance23455@gmail.com • I decoded the data from his setup.

There are many other astronomical and interesting measurements in the data however first I want to show you that it picked up the eclipse. The moon over Japan and the Sun rising in the East in Hanover, NH at that lunar eclipse. Time EDT at Hanover then.

The date below taken from a diagram on a NASA site. Times are PDT on August 28, 2007

Partial eclipse starts 01:51 Total eclipse begins 02:52 Mid eclipse 03:37

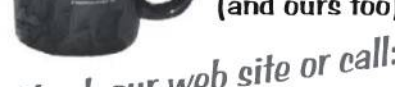
Total eclipse ends 04:22 Partial eclipse ends 05:24



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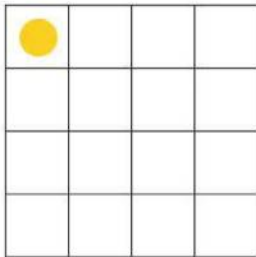
Brain Trainers

Answers appear on page 76

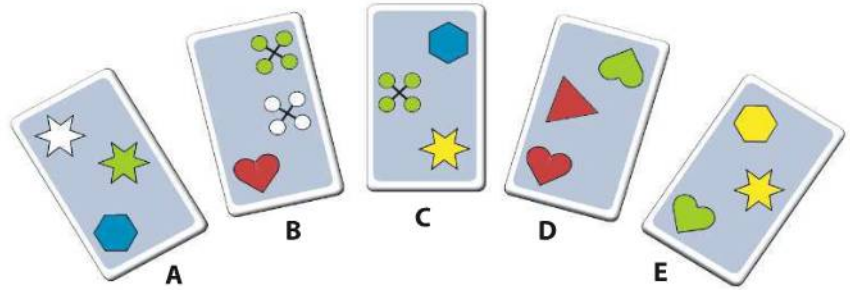
- 1 If: $1 = 44/44$
 $2 = 4/4 + 4/4$
 $3 = (4 + 4 + 4)/4$
 $4 = 4 + 4 \times (4 - 4)$
 $5 = ?$

Your equation should use exactly four 4s.

- 2 A coin starts in the top left corner of the grid and in six moves gets to the bottom right corner. Each of the moves must be into an adjacent square. In how many different ways can this be done?



- 3 Which card does not belong?



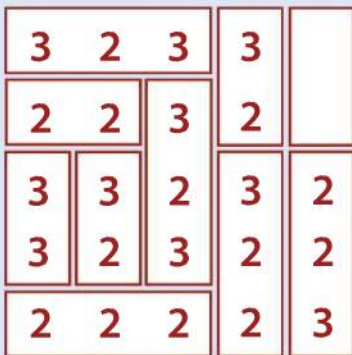
- 4 Which number does not belong?

89 49
 9 37 81
 25 59

- 5 Alice and Bob have equal numbers of pennies. Alice gives half of her pennies (ignoring remainders) to Charles, and Bob gives one third of his pennies (ignoring remainders) to Charles. If Charles gets a total of 51 pennies, how many pennies do Alice and Bob have left together?

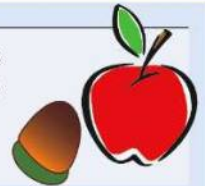
Headbreakers

- 1 Which piece from below belongs in the empty field at right?

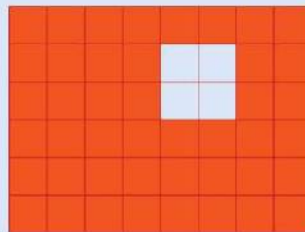


- 1 3 2 2 3 3
 3 1 3 2 2 3
 A B C D E F

- 2 An apple weighs three times as much as an acorn, and 16 twigs weigh two pounds. If four acorns, three apples and seven twigs weigh as much as six acorns, five apples and three twigs, how much does an apple weigh?



- 3 A six-by-eight-inch cake has a two-inch square piece cut out of it, as shown. Find a straight line that will cut the remaining cake into two equal pieces.



- 4 Four brothers—Andy, Bob, Carl and Dan—go to a dog show. Each has two dogs named after two of his brothers: Three of the dogs are greyhounds, three are beagles, and two are poodles. No brother owns two dogs of the same breed, and no dogs of the same breed share a name. Andy does not own a dog named Dan, and Carl does not own a dog named Andy. Bob does not have a beagle, and there is no greyhound named Andy nor a beagle named Dan. Who owns the two poodles, and what are the dogs called?

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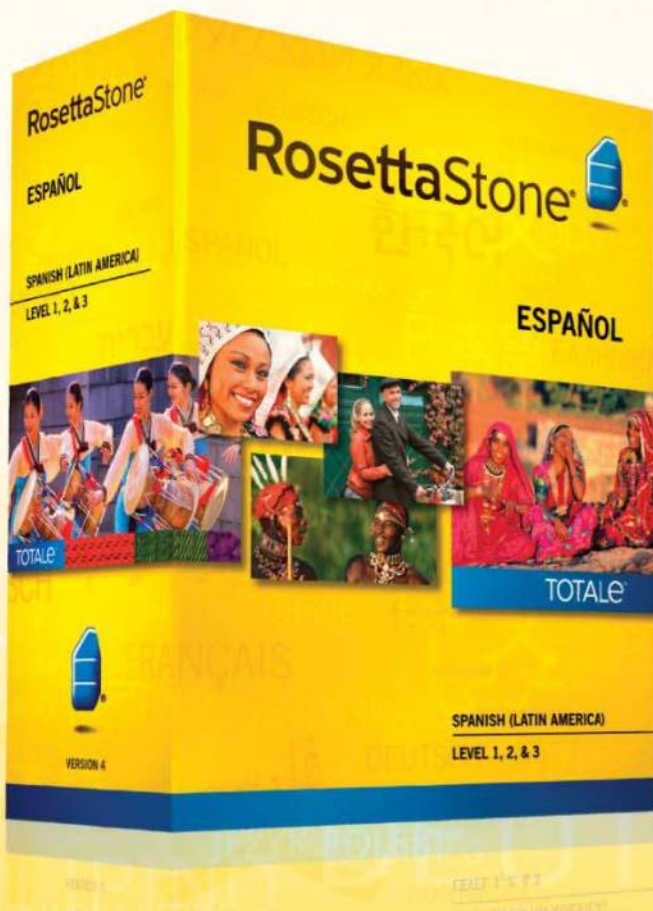
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