

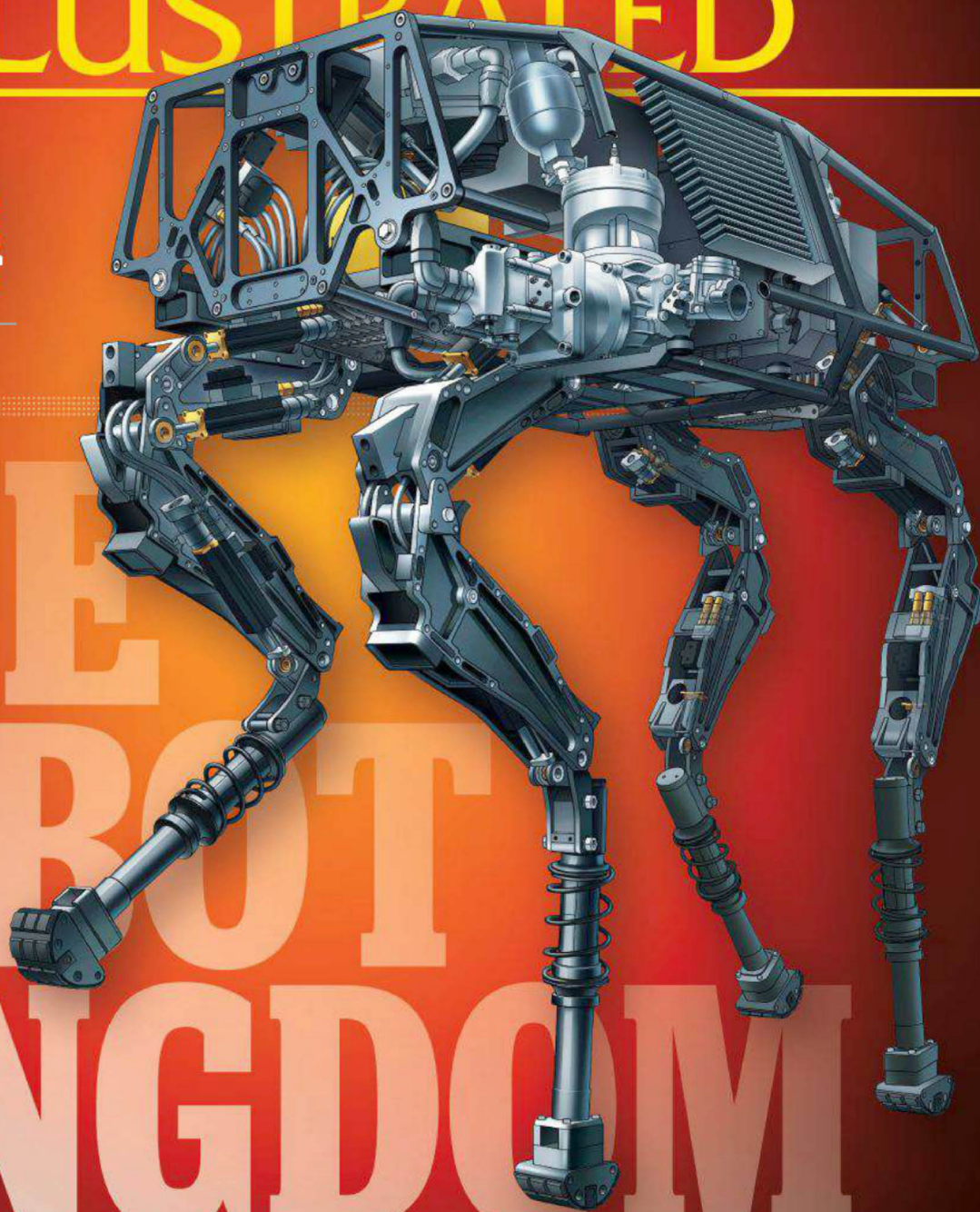
SCIENCE ILLUSTRATED

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POACHING
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BIG CHILL
VOSTOK:
EARTH'S
COLDEST
PLACE

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ON THE FRONT LINES, IN THE
BRINY DEEP, AT THE SCENES OF
NATURAL DISASTERS — THE
ANIMAL MECHS ARE COMING page 24

How to Outsmart a Millionaire

Only the "Robin Hood of Watchmakers" can steal the spotlight from a luxury legend for under \$200!

I wasn't looking for trouble. I sat in a café, sipping my espresso and enjoying the quiet. Then it got noisy. Mr. Bigshot rolled up in a roaring high-performance Italian sports car, dropping attitude like his \$14,000 watch made it okay for him to be rude. That's when I decided to roll up my sleeves and teach him a lesson.

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Taking its horn to save its life Conservationists are doing everything they can to save a dwindling number of rhinos from poachers. **Page 52**



Global Extremes:

THE COLDEST PLACE ON EARTH

When the mercury fell to -128.6 degrees F on July 21, 1983, Vostok, Antarctica, officially became the planet's frostiest spot. **Page 36**

FAST FORWARD

Car-size capsules hurtling through vacuum tubes at a speed of 370 mph may revolutionize transportation — and link the entire world. **Page 60**



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**SCIENCE
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"I just got back from a fifteen day trip to the Caribbean with long arduous tours on very rough surfaces almost every day. Without your shoes, I wouldn't have had a chance." - Burton Katz

"I actually noticed the biggest difference in my back... And then I noticed, Oh yeah... my knee feels fine too!" - NADJA Hoyer-Booth, housewife

"If you're healthy or not, if you are young or old, no matter what age you are, you have feet and you need to take care of them... Gravity Defyer is my miracle shoe." - Nisso, heel cancer survivor



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"They made me feel younger...more youthful... I literally felt like the shoes were propelling me forward when I walked." - Susan Pinckney, sales pro

"Gravity Defyer's gave me the spring in my step that makes me feel like I'm back in my mid-30's and 40's which for me -pushing 60- is a great 20 year gain!" - Robert Fleet, ex-athlete

"A shoe like this really is life changing. Especially for someone like me: an ex-athlete, or stuntwoman or anyone who has just been on their feet their whole lives." - Gloria Obrien, stuntwoman

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BULL'S-EYE

Dolphins having a ball

Somewhere near the Azores islands, a pod of hungry dolphins comes across a shoal of fish, which they chase toward the surface in a concerted effort. The shoal's defense mechanism is to cluster together in a massive, pulsating sphere called a bait-ball, in which the individual fish attempt to avoid predators by hiding in the center of the ball. However, the dolphins have the fish surrounded and trapped just below the surface, allowing the feeding frenzy to begin. On today's menu? Mackerel.

CHRISTOPHER SWANN/BIOPHOTO





Editor: Karen Grubbe

Will the Milky Way and the Andromeda Galaxy collide?

I read in your magazine that the Milky Way will collide with its neighboring galaxy. How does a collision between two huge galaxies occur?

Just last year, astronomers definitively announced that the Andromeda Galaxy and the Milky Way will collide — albeit not for another 4 billion years.

It sounds dramatic, but the collision will be more like an encounter between the two giants. Andromeda contains close to a trillion stars, more than twice as many as the Milky Way's 400 billion or so stars. The distances between these stars are so vast that collisions between them are unlikely. Instead, gas clouds will collide, triggering copious star generation in the universe's newest supergalaxy, Milkomeda.

Milkomeda's strong gravitational field could affect our solar system greatly, however. There's a 50 percent chance that the sun will be hurled farther from the center of the supergalaxy. Or it might be flung out of Milkomeda entirely, ending its life in the

sprawling intergalactic vacuum, although there's only a 12 percent chance of this scenario playing out.

The collision won't affect life on Earth, as the planet will already be uninhabitable by then. In 4 billion years, Earth's temperature will exceed 570 degrees F due to the sun's increasing radiation as it expands. The oceans will have boiled away long ago, and only lifeless deserts and salt plains will mark the seas that once enabled life on the planet.

Astronomers are positive that the Milky Way will collide with Andromeda.

NASA

Collision generated the Milky Way

Galaxy collisions are common — even our own galaxy, the Milky Way, was created by collisions between dwarf galaxies. Right now, the Milky Way is swallowing a dwarf galaxy in the Sagittarius constellation.

Why do elderly people develop bags under their eyes?

Bags under the eyes become more strongly marked with age as the skin, muscles, fat and tissue surrounding the eyes become less

flexible over time. The orbital region, including the lower eyelids, will then sag, creating noticeable bags under the eyes. Research

shows that this effect is exacerbated by the fact that fat deposits in the lower eyelids grow larger with age, increasing the skin's weight and causing the bags to droop even more.

The effect of age on the orbital region is at least partially determined by genetics. So if you develop large, drooping bags under your eyes as you age, your parents may shoulder some of the blame.

We develop bags under our eyes as we age because fat deposits there grow larger as the muscles grow weaker.

SHUTTERSTOCK

21-YEAR-OLD WOMAN



Small fat deposit

65-YEAR-OLD WOMAN



Large fat deposit





TOP 5 What are the smallest countries?

1. Vatican City

Area: 0.17 square mile
Inhabitants: approx. 800
Capital: the Vatican

2. Monaco

Area: .75 square mile
Inhabitants: approx. 36,400
Capital: Monaco

3. Nauru

Area: 8 square miles
Inhabitants: approx. 9,400
Capital: Yaren

4. Tuvalu

Area: 9½ square miles
Inhabitants: approx. 10,500
Capital: Funafuti

5. San Marino

Area: 23½ square miles
Inhabitants: approx. 32,400
Capital: San Marino

Vatican City's area is well under a square mile.



The Milky Way fuses with its neighbor

In 4 billion years, our galaxy, the Milky Way, will collide with the Andromeda Galaxy. In the course of 500 million years, the two will fuse into an elliptical supergalaxy.

CLAUS LUNAU



1. The gravity of the two galaxies attracts them to each other on an inevitable collision course.



2. The galaxies will slide past each other, as spiral-shaped ribbons of stars extend between them.



3. One of the ribbons will link the two galaxies, which will move toward each other.



4. The Milky Way and the Andromeda galaxy eventually become an elliptical supergalaxy.

The collision between the two galaxies will play out over 500 million years.

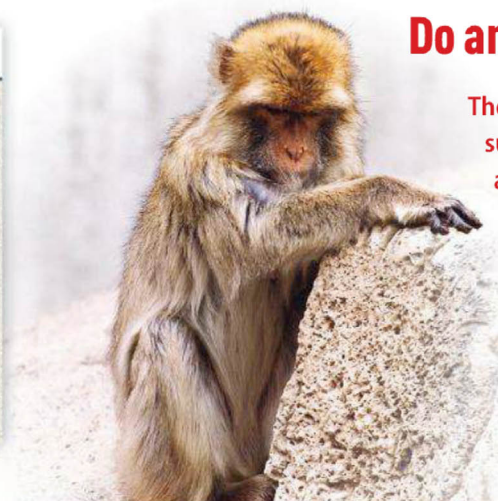
NASA



IN SHORT

What is the world's rainiest place?

Lloró, Colombia, receives more than 42 feet of precipitation a year, making it the wettest place in the world. However, measured by rainy days, Bahia Felix in Chile is the champion, with rain falling 325 days a year.



Do animals ever commit suicide?

There are no proven cases of animals committing suicide, but a number of examples indicate that animals may engage in self-destructive behavior; for example, in captivity, some rhesus monkeys bite themselves. This type of behavior is usually observed in individuals that suffered traumatic experiences early in their lives, such as separation from their mothers.

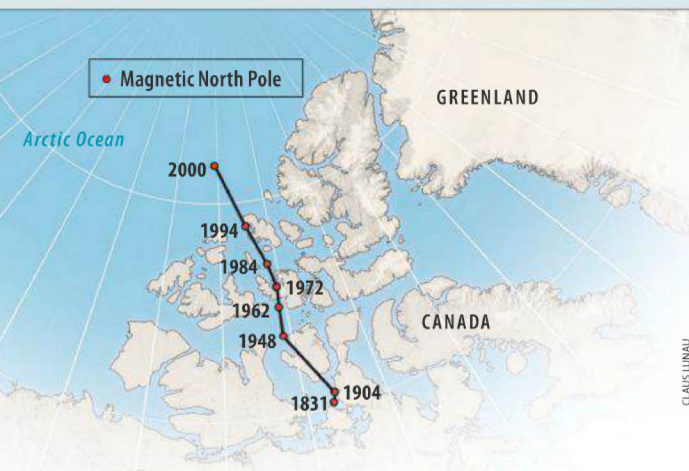
Scientists think that biting itself may help the monkey relieve its negative emotions.

THINKSTOCK

How fast can an aircraft fly?

The U.S. military's SR-71 Blackbird jet is the world's fastest: In 1976, it exceeded Mach 3, traveling three times the speed of sound at

2,193 mph



How fast do the poles move?

The magnetic North Pole was first located in 1831 by James Ross; by the time Roald Amundsen reached it, in 1904, it had shifted by about 30 miles. During the 20th century, the North Pole moved six miles a year on average, accelerating to 25 miles a year in the 1990s and to more than 30 miles a year by 2000. Some scientists think that this increased movement could be an indication that the poles are changing places.

CLAUS LUNAU

Are vampires for real?

Scientists recently unearthed a vampire grave in Bulgaria — does this mean that vampires really exist?

Vampires don't exist, but in the past, myths about bloodsucking ghosts were common. Throughout the world, archaeologists have found graves containing humans who were believed to be vampires. One of the most recent discoveries was made in Bulgaria during the excavation of a church in Sozopol near the Black Sea, where scientists found two skeletons around 700 years old with iron rods through their chests.

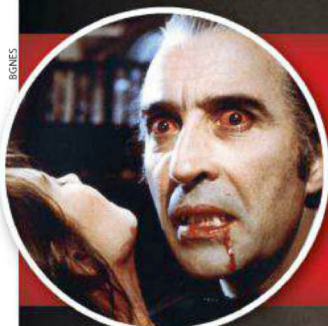
The belief in vampires originated long before modern times. The earliest known account of vampirelike creatures is 4,000 years old and stems from Mesopotamia. About 500 years ago, the belief in vampires swept across Eastern Europe, spreading to Western Europe at a later point in time.



In the Middle Ages, corpses' hearts were pierced with an iron rod to prevent them from turning into vampires.

Count Dracula was based on a real person

The most famous vampire in history is Bram Stoker's Count Dracula, who was inspired by Prince Vlad Tepes Dracula, ruler of Wallachia in Romania in the mid-1400s. *Tepes* means "the impaler," and the prince earned his nickname through his preferred means of executing his enemies: by penetrating the body with a pole and erecting it, thereby impaling his victim.



A rubber eraser is sticky, so graphite will stick to it.

How does an eraser work?

When you write on a piece of paper with a pencil, small flakes of the graphite in its lead break off and settle on the paper's uneven surface. A pencil eraser is made of a slightly sticky material that is easier for the graphite to stick to than the paper. Thus, when you rub the eraser across the paper, the graphite — and the written text — is lifted from the paper as it sticks to the eraser.

Most pencil erasers are made of rubber softened by vegetable oil or a similar substance. The softer the rubber in the eraser, the more gentle it is on the paper, whereas hard-rubber erasers will typically ruin the surface of the paper. Over time, the pencil's eraser wears away as the part that picks up the graphite is rubbed off, settling on the paper as little flakes of rubber.

How large is the planet Jupiter?

Jupiter has a mass of 1.9×10^{24} metric tons, making it the solar system's largest planet.

Do all nails grow equally fast?

Each individual nail grows at its own pace. Usually, the longer the outermost finger joint, the faster the nail grows. The nail of the index finger thus grows quickly, while the thumbnail grows the slowest, as the thumb lacks the central of the three ordinary finger joints. On the toes, which are shorter than the fingers, the nails grow around three times as slowly. Moreover, the nails grow faster on the hand that a person normally uses more often.

Observations show that the nails grow faster in the summer, and in those younger than 30.

Scientists don't know why nails grow at different paces, but it may have something to do with the amount of blood — and thus the oxygen and nutritional substances — that reaches the cells at the bottom of the root of the nail. The cells of the nail root liberate the keratin protein, which settles under the nail and pushes it forward, making it grow.

Keratin fosters nail growth

Nail bed

1. The cells of the nail root liberate the keratin protein.

2a. The keratin settles at the bottom of the nail, pushing it forward.

2b. The keratin settles under the nail, making it thicker.

Nail

Lunula

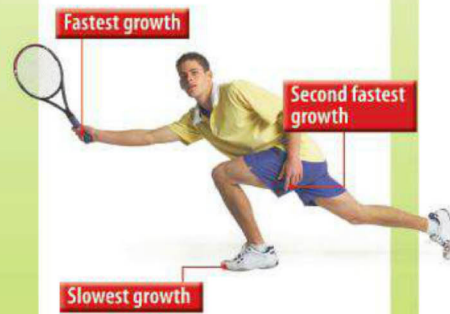
Nail root

Fingernails grow faster on the hand you use more.

GETTY IMAGES

Nail growth varies

A fingernail grows about a tenth of a millimeter a day and is fully replaced in three to six months. Toenails grow more slowly, so it may take up to 1½ years before a toenail that has fallen off is replaced by a new one.



Where is the world's largest nuclear power plant?

The world's largest nuclear plant, Kashiwazaki-Kariwa, is located about 135 miles northwest of Tokyo. It consists of seven reactors capable of producing 8,212 MW of power — enough, in theory, to supply 16 million homes with electricity. In comparison, a typical oil- or gas-fueled power station typically boasts a capacity of just 600 MW.

Kashiwazaki-Kariwa began generating energy in 1985 and was fully online 12 years later. The

capacity of the plant is rarely utilized to its full potential, because individual reactors are frequently closed for inspection or due to malfunction.

In 2007, the area was hit by a violent earthquake that was more severe than the magnitude that the plant had been designed to withstand. The damage was limited, but all of the reactors were closed for 16 months until the plant had been reinforced against stronger earthquakes.

Of the 400-plus nuclear plants in the world, Kashiwazaki-Kariwa, near Tokyo, is the largest.



Five largest nuclear power plants

	Country	Capacity
1. Kashiwazaki-Kariwa Nuclear Power Plant	Japan	8,212 MW
2. Bruce Nuclear Generating Station	Canada	6,300 MW
3. Zaporizhzhia Nuclear Power Plant	Ukraine	6,000 MW
4. Ulchin Nuclear Power Plant	Korea	5,923 MW
5. Yeonggwang Nuclear Power Station	Korea	5,875 MW

ASK US

How old is the compass?

Compasses for navigation appeared around 1000 CE, and consisted of a magnetic needle in a bowl of water.

Who was the first woman to win a Nobel Prize?

In 1903, Madame Marie Curie became the first woman to be awarded the Nobel Prize, for her work with radiation.

Wild Animals



The build is stiff, but that doesn't prevent the pronghorn from taking steps up to 25 feet long.

The heart is extremely big for the animal's size. Twice as large as a deer's heart, it pumps blood and oxygen quickly and efficiently to the muscles.

The chest is deep, with plenty of space for large lungs, which allows the animal to optimally utilize the oxygen in the air.

Is the pronghorn the best runner of all animals?

Pronghorns are native to the prairies of central and western North America, and though running animals normally specialize in either endurance or sprinting, the pronghorn masters both. Its top speed is 55 mph, but it can easily run at a speed of 25 to 35 mph for up to 12 miles.

The legs are 3 feet long, keeping the body out of prairie grass, which could slow it down.

The slim legs are lightweight and can move back and forth very quickly when the pronghorn takes a step.

Smoke is partially burned stearin gas.

Liquid stearin

The stearin becomes carbon dioxide and water vapor.

The flame results from the burning of the stearin vapor.

The wick has a coating of a fire-resistant material and wax that makes it burn.

Why doesn't a candle wick burn up?

A candle's flame comes from burning stearin vapor, not from the burning of the wick itself. The purpose of the wick is thus not to catch on fire, but to draw the molten stearin in the wax close to the flame, where it vaporizes and combusts. If the wick were to burn up, the flame would die.

Candle wicks are usually made of cotton, which burns quite easily, so the

wick must first be coated with a fire-resistant substance that will cause it to burn more slowly. The wick is also coated with wax or a similar substance, which allows it to be lit: The wax melts and vaporizes due to the heat from the match or lighting source, and this vapor burns around the tip of the wick until it has absorbed molten stearin from the candle itself.

ALAMY/IMAGESELECT

THINKSTOCK

What is the tallest tower?

In 2012, the Skytree tower in Tokyo, Japan, became the world's tallest tower, reaching a height of

2,080 feet

What became of monorails?

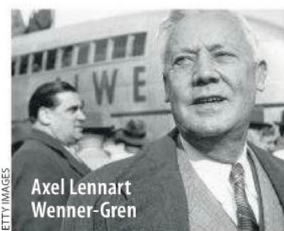
Monorails were once predicted to be the public-transportation system of the future — what happened?

In 1959, Disneyland in California introduced a monorail system that attracted attention throughout the world. It wasn't the world's first monorail, but its futuristic appearance captured people's imaginations, leading many to expect monorails to become the primary public-transportation systems of big cities.

In fact, many cities did build monorail systems. They don't take up much space, are inexpensive to create, make little noise, and wind through cities at a height where they

don't impede pedestrians or vehicles on surface roads. But monorails also present challenges: They can't connect directly to conventional railways and subways, so passengers have to transfer, and the tracks are usually made of concrete, making it difficult to establish switch tracks.

Monorails are still popular in amusement parks, which have more controlled environments and no need to tie into existing transportation systems, but they also continue to play an important role in cities like Tokyo, where a monorail carries a total of 127,000 passengers a day. In Asia, a number of new monorails have been planned.



GETTY IMAGES

Industrialist loved monorails

One of the strongest advocates of monorails was a Swede named Axel Lennart Wenner-Gren, who helped found the Electrolux group. He developed the monorail system that is still the most popular, which is called the Alweg system after the initial letters of his name.

Asia boasts the most monorails



■ In operation
■ Being built
■ Planned

In Sydney, Australia, you can ride one of the world's 51 monorails.

GETTY IMAGES

Editors: Jesper Bindslev & Tina Frederiksen

Coral safe haven near the equator

Cold ocean currents near the equator could save coral reefs.

Anne Cohen

of the Woods Hole Oceanographic Institution studies climate change and its effect on ocean life.

ENVIRONMENT The Gilbert Islands, located near the equator, may offer salvation for Pacific Ocean corals as global warming causes the ocean temperature to rise.

The corals reject their protective layer of microalgae and die when the water temperature rises. But

there is good news for those situated near the Gilbert Islands. Anne Cohen and her team from the Woods Hole Oceanographic Institution in Massachusetts studied chlorophyll-filled algae in the Pacific and found that the islands' location protects the reefs.

The wind around the equator moves warm surface water in an east-west direction, while the Southern Equatorial Undercurrent sends cooler water in the opposite direction, so the water around the islands is cooler than in many other places. According to the new calculations, the cold water inflow will increase by some 50 percent, supplying the islands with cold, nutrient-rich water and mitigating the effects of global warming.



TIM KLEIN/STEWART & THINKSTOCK

Cancer drug cures Alzheimer's

MEDICINE A drug approved for cancer treatment has been shown to nearly cure Alzheimer's disease in mice.

The demented mice had forgotten how to make a nest, but after being treated with Bexarotene for only three days, they once again began to collect small pieces of toilet paper for a nest. The treatment also helped the mice recover other

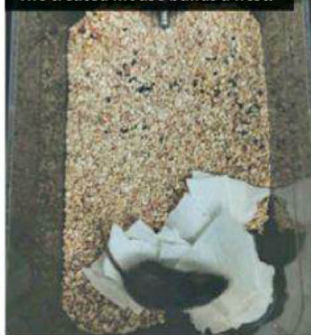
lost capabilities, such as remembering the location of a platform immersed in a pool, so that they could swim to it quickly to get out of the water.

The experiments also showed that the drug made the brain work more efficiently. The mice had been genetically manipulated to develop the human version of Alzheimer's at six months of age.

The affected mouse is apathetic.



The treated mouse builds a nest.

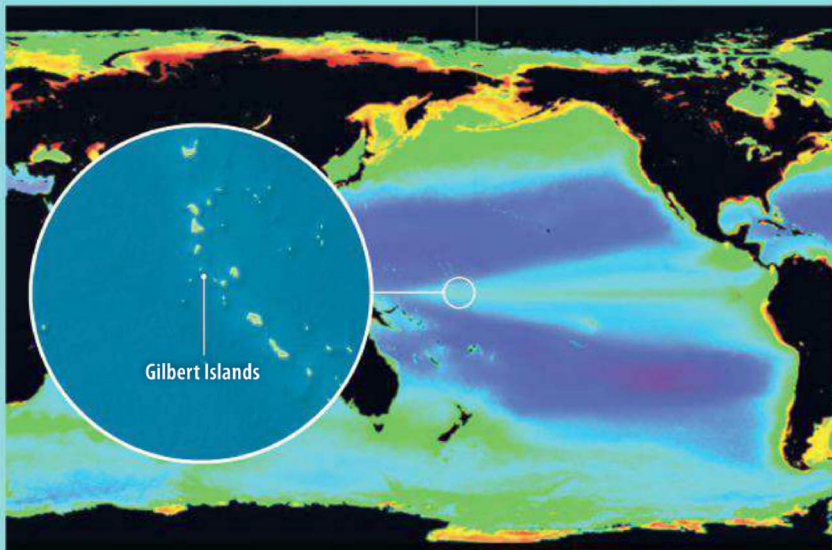


The sick mouse has forgotten how to build a nest. But three days after treatment, it has regained this ability.

CHAMBER ET AL.

20,000,000

gallons of water were held back by a dam that the Maya built in Guatemala to supply the 80,000 citizens of Tikal.



More chlorophyll

Less chlorophyll

Islands located in plankton belt

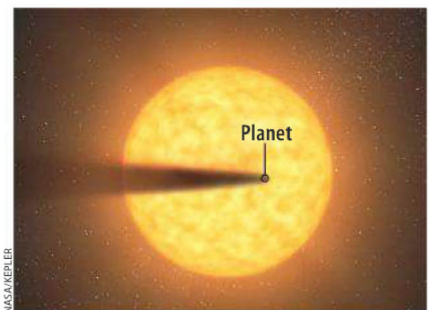
The satellite image shows the amount of chlorophyll — and thus plankton — in the ocean. The amount decreases from east to west, only to increase around the Gilbert Islands, which are located along a stretch of the equator that is swept by a cold ocean current.

DICTIONARY

Chlorophyll enables plants to absorb energy from light. Chlorophyll is found in plant plankton — an important source of food in the ocean.

OLDER WOMEN BEAR HEALTHY CHILDREN

» Women ages 35 to 44 have babies who are just as healthy as children born to women between the ages of 25 and 30, according to research from Germany's Max Planck Institute. Younger mothers do not automatically confer better health to their babies, it seems.



A small planet has become so hot from orbiting its star that it leaves a trail of evaporated rock behind it.

Small planet is close to boiling away

ASTRONOMY Some 1,500 light-years from Earth, a small planet the size of Mercury is orbiting so close to its star that it is evaporating. The planet is so hot that, as its rock boils away, it leaves a trail of evaporated rock in its wake, something like the tail of a comet.

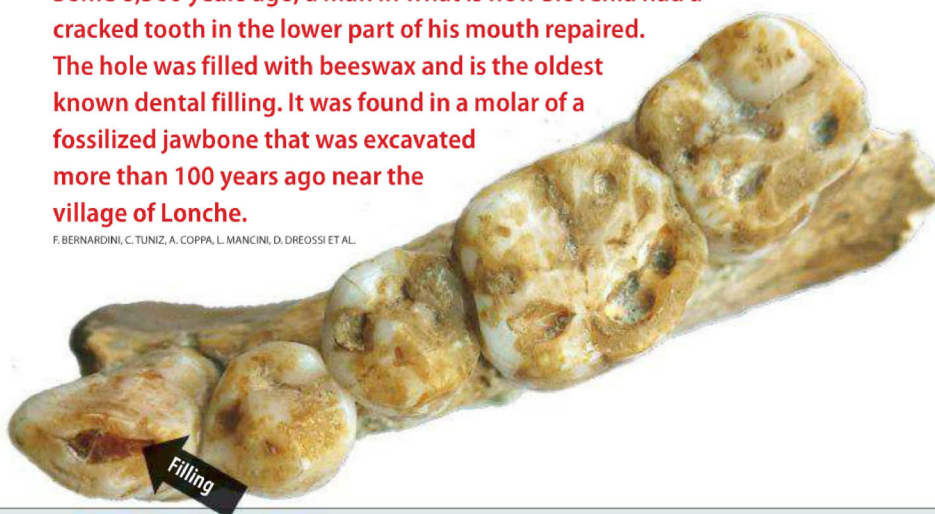
On the side of the planet facing the star, the temperature exceeds 3,000 degrees F, which has converted the surface into a boiling ocean of lava. Every second, 110,000 tons of rock evaporate from the planet into space. The small planet will have boiled away in a few hundred million years.

Astronomers found the planet by observing the light from its star. The data showed that the star's light dims at regular intervals of almost 16 hours; this is when the planet passes in front of the star, as seen from Earth. However, the star is not uniformly obscured by the planet each time it passes, which is likely because the planet's trail of rock dust is constantly changing shape.

Beeswax served as the first dental filling

Some 6,500 years ago, a man in what is now Slovenia had a cracked tooth in the lower part of his mouth repaired. The hole was filled with beeswax and is the oldest known dental filling. It was found in a molar of a fossilized jawbone that was excavated more than 100 years ago near the village of Lonche.

F. BERNARDINI, C. TUNIZ, A. COPPA, L. MANCINI, D. DREOSI ET AL.



SCIENCE UPDATE

■ Around 24,000 years ago, large holes appeared in the ozone layer as bromine was released into the atmosphere via a volcanic eruption. It could happen again.

Wind turbine provides water in desert

New turbine generates power and water

TECHNOLOGY French engineering company Eole Water has developed a new type of wind turbine that can produce pure drinking water seemingly out of thin air. The wings power a generator that produces power, a fraction of which is used to suck air in through the nose of the turbine and condense the humidity in the air back into water. This water is then collected and flows through a stainless-steel pipe into a storage tank located at the bottom of the wind turbine. There, it is filtered and purified, producing fresh drinking water.

Eole has erected a 79-foot-tall turbine in the desert near Abu Dhabi in the United Arab Emirates. This prototype can produce more than 16 gallons of water an hour, but, ultimately, the company expects the new turbine type to deliver up to 265 gallons of

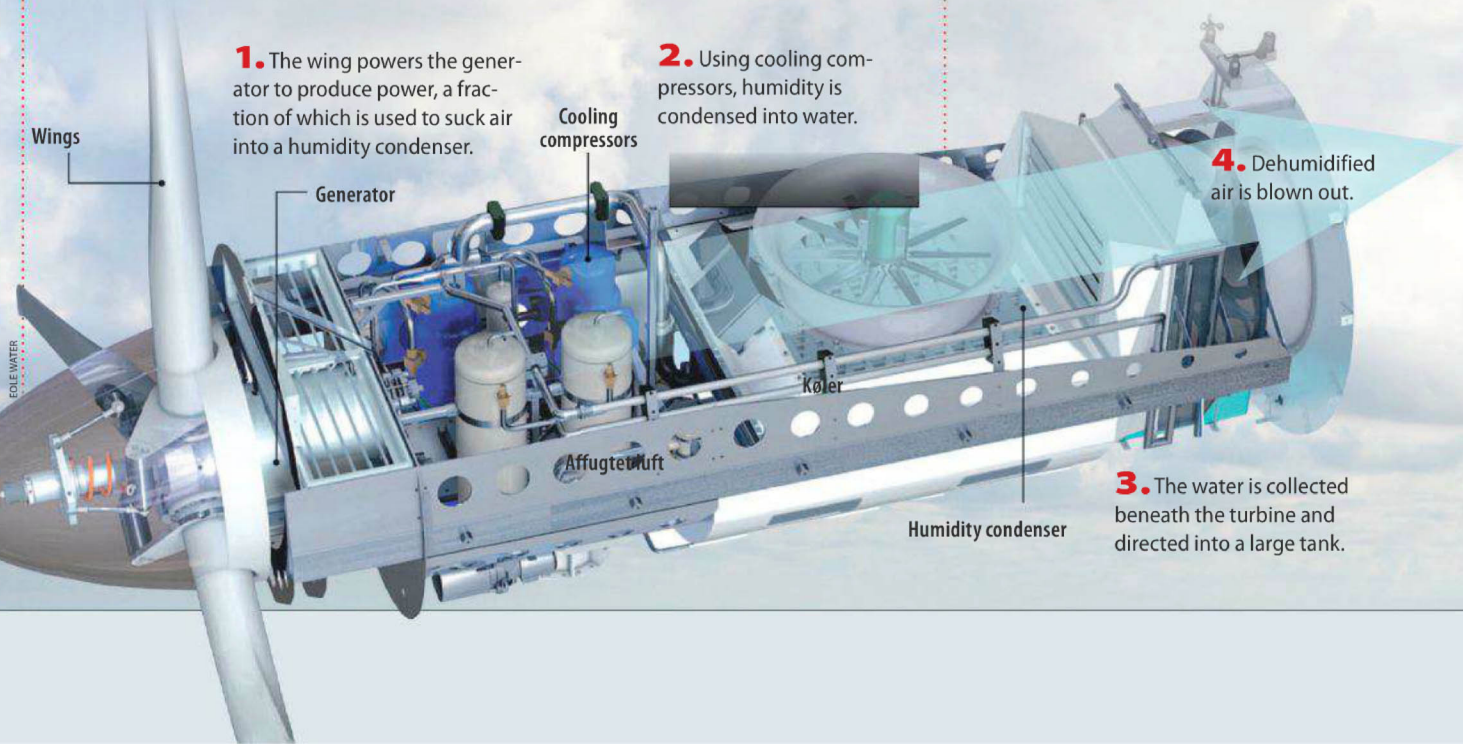


A new type of wind turbine can produce both power and water for people living in remote regions, such as deserts.

water a day, depending on humidity, temperature and wind speed. The wind turbine is expected to help supply small communities that have limited resources of both power and water.

Drinking water is extracted from the air

The new wind turbine generates power in the traditional way, but it can also produce drinking water condensed from the air.



INCREDIBLE
— but true!

Round beer glasses make us drink more

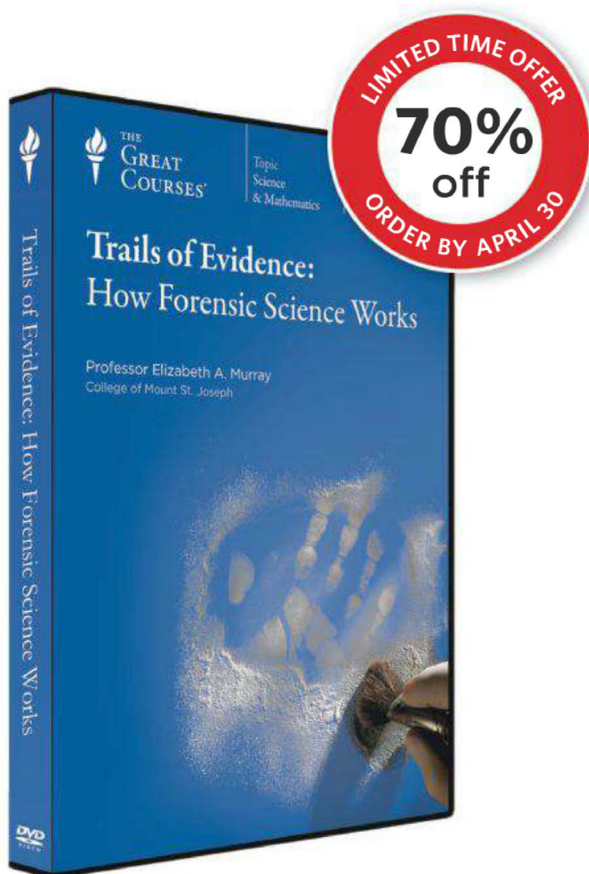
We consume more alcohol when drinking out of a glass with rounded sides, compared to one with straight sides, says scientist Angela Attwood from the University of Bristol. It took test subjects almost twice as long to empty a glass with straight sides.

Robot outpaces Usain Bolt

Inspired by the cheetah, U.S. scientists have developed the world's fastest robot — it's speedier than even Usain Bolt. When Bolt set his 100-meter world record, he ran at a top speed of 28 mph. The robot bests him at 28.3 mph.

Fathers become less virile

Fathers who sleep close to their children produce less testosterone, say U.S. scientists. Their conclusion was based on data collected by studying 362 fathers in the Philippines.



Go Inside the Forensics Lab

Ever wonder how accurate detective dramas are? The truth is, fictional portrayals of crime scene investigations often get it wrong. It's a shame, because knowing how scientists approach cases isn't just fascinating, it can actually help you be a better juror or witness, sharpen your analysis of headline-grabbing crimes, and make you a more critical thinker.

In **Trails of Evidence: How Forensic Science Works**, award-winning College of Mount St. Joseph Professor Elizabeth A. Murray—one of the nation's foremost experts in forensic anthropology—uses her extensive real-world experience to take you from the crime scene to the lab to the courtroom. During 36 riveting lectures, you'll learn the details of landmark forensic cases, including the first use of DNA fingerprinting and the dental evidence that helped convict serial killer Ted Bundy, to see how forensic science really works from the inside.

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7. Traces of Hair and Fur
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28. Human Memory and Eyewitness Accounts
29. Criminal Minds—Psychology and Psychiatry
30. When Forensic Evidence Is on Trial
31. Forensic Scientists and Expert Testimony
32. Comparing Crimes and Crime Labs
33. Crimes—Nobody's Supposed to Get Hurt
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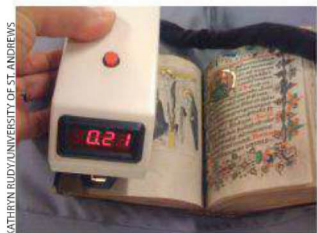
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Computer games stimulate the brain's reward system, research from Aalto University in Finland shows. This may help explain why some people become addicted to gaming.



A scanner registers the wear and tear on the pages of a book from the Middle Ages.

Worn pages in books reveal plague fears

ARCHAEOLOGY In medieval times, people primarily prayed for their own salvation. So claims Kathryn Rudy of Scotland's St. Andrews University, who used a densitometer to register the amount of wear received by the individual pages of a number of medieval religious books. The more grime and discoloration on the page, the more fingers touched it, thus the more it was read. The dirtiest pages were those with prayers for the reader's own salvation from the plague, whereas the pages with prayers for the salvation of others showed less wear.

GOLD NANOPARTICLE DESTROYS HEPATITIS

U.S. scientists have developed a gold nanoparticle that combats the virus that causes hepatitis C. This may lend hope to the 170 million people in the world who are affected by the disease. The treatment was almost completely effective in laboratory tests.

Water-strider sex is brutal

Force and possession are essential to mating.

BIOLOGY Male water striders — the small insects that skate gracefully on the surface of water — resort to brutality during mating.

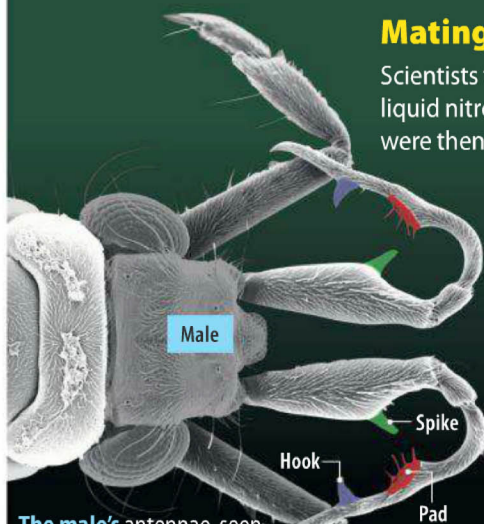
The male's antennae have adapted to hold on to the head of an unwilling female, fixing her in place during mating. By studying the animals' sexual behavior, Locke Rowe from the University of Toronto in Canada has identified three microscopic components of the male's antennae that are necessary to ensure successful mating. The three tiny pieces — a spike, a hook and a hairy pad — fit like keys in a lock in

order to hold on to the eye, neck and lower side of the female's head.

Using gene technology, Rowe altered the male's antennae so that the growths became smaller or were missing altogether. This had a severe negative effect on affected males' ability to mate. If the parts were only slightly smaller, the male's chance of mating successfully was reduced to one-third; if the parts were missing, the male had no way to hold the female in place, and she was able to break free before mating was complete.

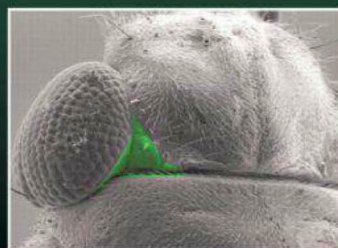
Mating by possession

Scientists filmed the water striders and froze them with liquid nitrogen during the mating process. The insects were then studied in a scanning electron microscope.

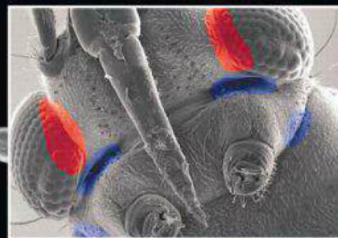
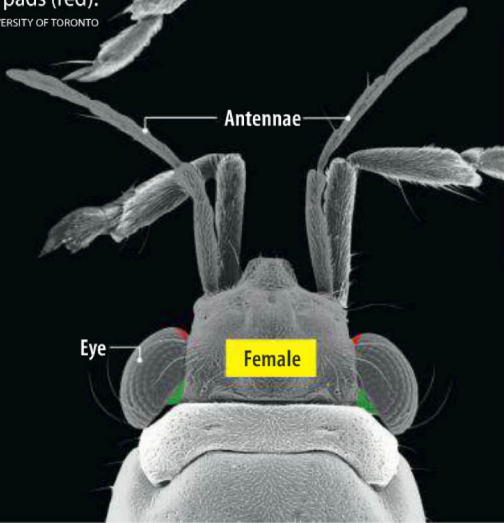


The male's antennae, seen from above with spikes (green), hooks (purple) and hairy pads (red).

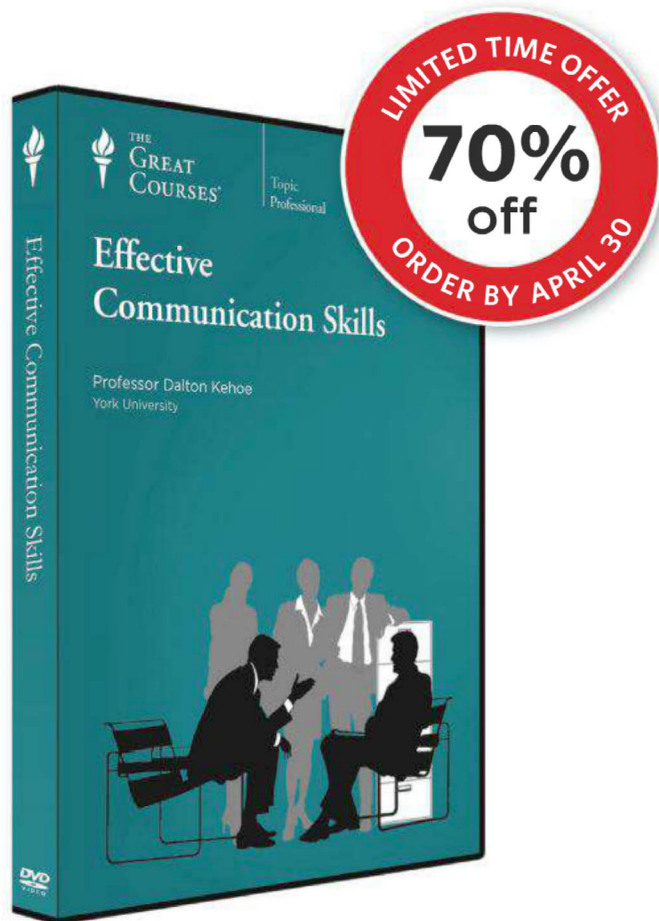
KHILA ET AL./UNIVERSITY OF TORONTO



The female's head, seen from above. The green area indicates where the male's spikes hook into her.



The female's head, seen from below. The red and purple areas indicate where the male's pads and hooks hold her in place during mating.



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16. Healing Relationships with Dialogue Talk
17. Focus on the Other—The Heart of Dialogue
18. Assertive Dialogue to Manage Disagreement
19. Compassionate Confrontation
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Unknown shark appears in a fish market

Marine biologists don't always need to participate in lengthy expeditions to find new species. Two scientists from CSIRO Marine and Atmospheric Research in Australia found a new species of small shark in the Tashi Fish Market in northeastern Taiwan. The new creature, a short-nosed dogfish measuring about 3 feet long, has been named *Squalus formosus*.

W. WHITE/CSIRO



LOCAL FOCAL POINT

Gardens by the Bay amusement park, Singapore



Artificial forest glows in the dark

In a Singapore amusement park, 16 artificial trees provide shadow during the day and light after dark. The trees, which stand 80 to 160 feet tall, are covered in 162,900 plants of more than 200 different species, including orchids and tropical twining plants. Solar cells in the "canopies" power the lights.

ALAMY/IMAGESELECT

Heat and rain once dominated weather in the Arctic

GEOLOGY Climate researchers have long known that the Arctic was periodically warmer than today. But now, an international team of scientists has discovered that the Arctic went through extremely warm periods at least twice, 400,000 years ago and 1.1 million years ago.

After analyzing drill cores from Lake El'gygytyn in northeastern Siberia, the team, led by Martin Melles of Germany's University of Cologne, found that the temperature increased between 7 and 9 degrees F during those two periods, and there was twice as much precipitation as today. During the warm periods, there was no inland ice in Greenland.

The lake was formed 3.6 million years ago as a crater following a meteor strike. As the lake filled with water, sediments settled on the floor, and these layers have now helped scientists construct a picture of a lake with trees on the shores and a mild climate with an average temperature of 55 degrees F and an additional 12 inches of precipitation per year.



A technician analyzes different layers of the drill core from Siberia's Lake El'gygytyn.



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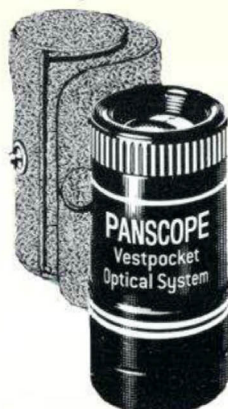
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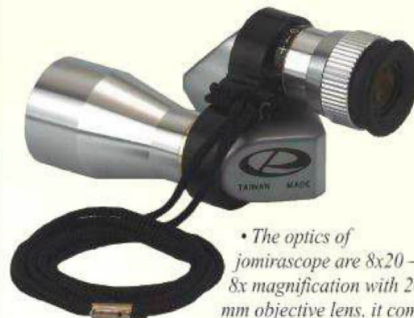
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GEAR & GADGETS

Editor: Søren Bjørn-Hansen

Audi's new car electrifies

Sleek, futuristic and Earth-friendly, Audi's take on the electric car, the E-Tron, is poised to make being green supercool.

THE AUDI E-TRON is equipped with four powerful electric motors, two in the front and two in the rear, that boast 313 hp and allow the electric supercar to go from 0 to 60 in just 4.8 seconds.

THE REARVIEW MIRROR has been replaced by a high-resolution OLED display, which reveals much more about what's behind the car than a traditional mirror does. It can be dimmed or turned off and displays other information too.

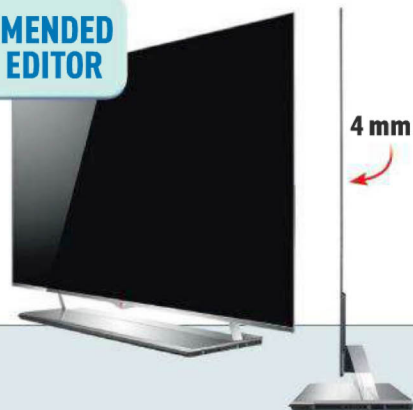


Ultrathin TV coming up

This will be the year of ultrathin televisions: OLED technology is maturing, allowing manufacturers to produce TVs with extremely thin displays, better picture quality and lower power consumption. LG's 55-inch OLED TV is only 4 millimeters thick and is protected by a carbon-fiber casing.



Product: LG 55EM960V
Price: \$10,000
Available: Summer 2013
lg.com





THE CAMERA, which supplies images for the digital rearview mirror, is located in an aerodynamic casing. It has a much larger field of vision than a mirror, and in cold weather, it's heated to avoid fogging.



THE LITHIUM-ION BATTERIES are liquid-cooled, providing the car with a range up to 155 miles. At some 1,200 pounds, they make up almost half the car's weight.

Pedal-powered washing machine

After watching a woman wash clothes in a slum in Peru, designers Ji A You and Alex Cabunoc decided to create a simple, manually powered washing machine for developing countries. Named Gira-Dora, it eliminates the need for hand washing clothes and requires no electricity: The user sits on the tank and uses the foot pump to operate the drum, which functions as a centrifuge to wash the clothes and then spin them dry.



GIRADORA



Marshall's sweet music

The people behind the legendary Marshall guitar amplifiers are introducing their first music system for home use. The Hanwell iPod dock, which is named after the city in which company founder Jim Marshall's first shop was located, was designed to reflect the same principles as the company's guitar amplifiers: analog controls for bass, treble and volume, highlighted by gold accents. It also features an audio cable.

i **Product:** Hanwell iPod dock
Price: \$800
Available: Now
marshallheadphones.com



MARSHALL

Tech-friendly clothes

Alphyn Industries has introduced a line of pants, shirts and jackets that feature special pockets for iPhones and iPads, making it easier to carry and use your electronic gear without needing to lug around a separate case. The pants have a transparent pocket through which you can control your smartphone; the LEDGE jacket has a built-in panel that folds down to make a shelf.

i **Product:** PADX-1 LEDGE pullover
Price: \$199
Available: Now
alphynind.com



ALPHYN

Dinner on the moon

Only a dozen people have ever set foot on the moon, but now anyone can eat off it. Designer Sebastian Errazuriz has created a series of melamine dishes celebrating our solar system; besides the moon, you also can dine on Earth and the sun.

SEBASTIAN ERRAZURIZ



i **Product:** Moon bowl
Price: \$25
Available: Now
kikkerland.com



New robots learn old tricks

Nature is nothing if not ingenious, filled with adaptations and specialties we've learned to use to our advantage. Scientists are now attempting to go one step further by mimicking animals' talents — in the water, on land and in the air — in intelligent robotic animals that will be able to find their way through burning buildings, carry military cargo and clean up oil spills.

SmartBird, a free-flying robotic bird designed by electronics company Festo, is inspired by the herring gull.

THOMAS BAUMANN/FESTO



GRACEFUL CARBON-FIBER GULL

Don't be fooled by its elegant flight — SmartBird is no bird. Its skeleton is made of carbon fiber, its body consists of foam plastic, and it's got electronics in place of guts.

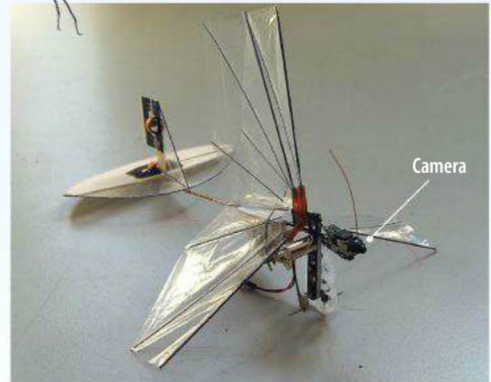
BIONIC DESIGN In the air, the remote-controlled robot called SmartBird moves like a real bird. It can take off, fly and land as effortlessly as its flesh-and-blood counterparts. Technicians from German electronics company Festo spent months analyzing the way a herring gull flies in order to create a robot that is capable of doing the same thing.

The company developed SmartBird as part of its Bionic Learning Network, in which biological principles are adapted for industrial application.

With a wingspan of 6½ feet, SmartBird is bigger than real gulls, but it only weighs a pound. Like the birds that inspired it, the

robotic bird achieves flight thanks to its two-piece wings: The innermost part provides thrust and the outermost gives momentum. The latter part's angle can be controlled with great precision by small motors that constantly adjust to the wind conditions and that can rotate 45 degrees in a mere fraction of a second.

The angle of the tail determines whether SmartBird flies up or down, and also provides part of the thrust. The direction of the robot's head can also be controlled, enabling SmartBird to use its entire body to turn, which makes it highly maneuverable — just like a real gull.



ROB SPEER/BRUNNEN/DELFT UNIV.

The DelFly Micro has a wingspan of about 4 inches, about the same as a large dragonfly.

Robotic insect carries a camera

SEARCH OPERATION One of the most impressive small flying robots inspired by an insect is the DelFly Micro, which remains airborne via two sets of wings, just like a dragonfly.

The robot weighs only a tenth of an ounce and can fly for three minutes at a maximum speed of 16 feet per second. It can be operated by remote control and is equipped with a small camera that wirelessly transmits video to a computer.

The Micro has been designed to fly into buildings on the verge of collapse to search for people trapped inside. Its even lighter successor, the DelFly Nano, is already on the drawing board.

ENERGY SOURCE

Before robotic animals can run free, they must be able to supply their own energy.

Smaller battery

Chemical batteries run out of energy too fast to power robots. Until new batteries are invented, both the batteries and the robots must be small and energy-efficient.



THINKSTOCK

ROB SPEER/BRUNNEN/DELFT UNIV.

JELLYFISH BECOME OCEAN RANGERS

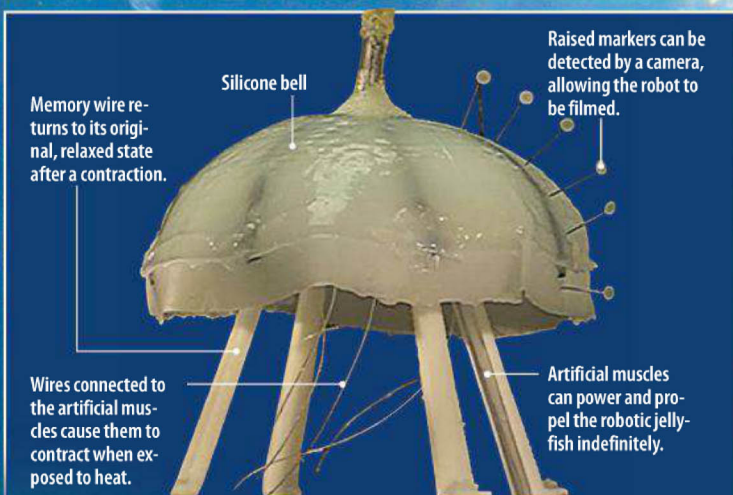
If scientists can perfect them, an armada of artificial jellies will one day patrol the oceans for scientific and industrial purposes. The robotic jellyfish can even power themselves by harnessing energy from seawater.

SEA PATROL When equipped with the proper sensors, artificial jellyfish can map out marine life, continuously inspect the quality of the water, and even help clean up after oil spills by using special filters.

Mimicking jellyfish in a robot is very practical: They can cover long distances using a simple locomotion technique without consuming much energy. U.S. scientists recently developed a robotic silicone jellyfish with muscles made of metal wire that is wound in carbon nanotubes coated with platinum dust. When the dust comes in contact with the hydrogen and oxygen found in water, it generates heat, causing the metal wire to contract, which enables the jellyfish to "swim."

And because hydrogen and oxygen are abundant in seawater, the robot will have a limitless power supply, allowing it to roam about for months or even years.

UT DALLAS & VIRGINIA TECH



Seawater provides power

Seawater enters the robot through the top of its body, supplying hydrogen and oxygen; when these elements react with the platinum dust coating the nanotube-wrapped wires, water and heat are generated. The heat forces the artificial muscles to contract, propelling the robot forward before the muscles relax — a propulsion process that can repeat itself indefinitely.



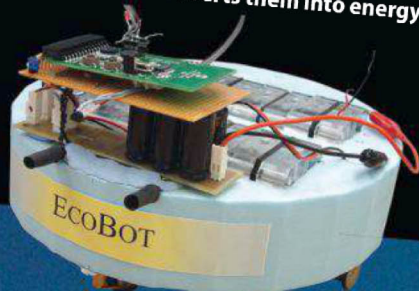
Jellyfish easily cover long distances as they pulse through the water.

THINKSTOCK

ENERGY SOURCE

Artificial digestion uses flies for fuel

If a robot were equipped with an artificial digestive system, it should be able to extract energy from its surroundings, just as living creatures do. The British-designed EcoBot II catches flies just like an insectivorous plant and converts them into energy.



IAS ECOBOT TEAM

COLIN VANDELL/NATURE PL



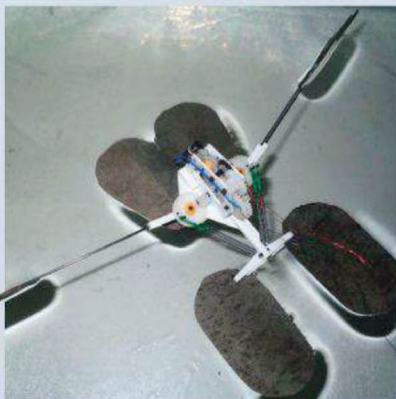
The water strider excels at jumping across the surface of the water.

Foam feet are highly water-repellent

WATER-QUALITY INSPECTION

Although researchers have developed robots that can walk on water like insects such as water striders do, they have struggled to replicate the insect's ability to leap atop the surface. Water striders' legs accomplish this thanks to their superhydrophobic quality, in which extreme water repellence allows the bug to use the water's surface tension like a trampoline.

Chinese scientists have solved the problem by outfitting a microrobot with feet made of water-repellent nickel foam, which prevents it from sinking despite its weight of four-tenths of an ounce — some 1,000 times heavier than a real water strider. The robot can cover almost 14 inches in a single jump, enabling it to scale small obstacles on the surface of the water. Possible uses include reconnaissance and water-quality inspection.



The water strider robot can jump on water, thanks to water-repellent feet made of porous nickel foam.

AMERICAN CHEMICAL SOCIETY

Movements recognized by peers

RESEARCH In order to fully understand animals' behavior, it is necessary to study them in their natural environment. That's the idea behind the robotic zebra fish developed by a team of U.S. and Italian scientists. The 6-inch robot mimics its live model both in appearance and in its tail movement; experiments showed that zebra fish were attracted to the robot when it moved, provided that they could see the motion — despite the fact that the robot is six times larger than the fish.

When it moved its tail, the robotic fish attracted live zebra fish, but they shied away when it was still.



M. SMITH/GETTY IMAGES & A. ROBERTI/NEW YORK UNIVERSITY

Silicone robot changes color

SEARCH OPERATION Some animals can change their coloring, which they do for both camouflage and communication purposes. A soft robot that resembles a cross between a starfish and an octopus now mimics this useful trick.

The crawling robot is made of silicone laced with channels that can

accommodate various liquids. The liquid's color can be manipulated to allow the robot to blend into its surroundings or, conversely, it can be made luminous to attract attention. The latter application could be useful in search operations by enabling the robot to attract attention to itself and to people in distress.

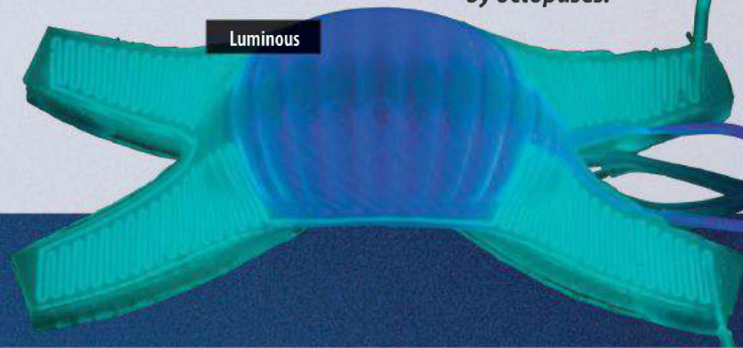


SHUTTERSTOCK

Camouflaged

Color-changing robots are inspired by octopuses.

Luminous



HARVARD UNIVERSITY/DARPA



The DASH robot can swing to the underside of a ledge.

Cockroach robot to look for people in distress

SEARCH OPERATION When cockroaches or geckos feel threatened, they often jump off a platform at full speed — but instead of falling to the ground, they catch hold of the platform's edge with their hind legs, swing like a pendulum, and escape on the underside.

The U.S.-designed DASH robot can swing under a ledge in the same way; it's the first crucial step in developing robots that can move in any type of environment — a prerequisite to building a microrobot that could be used to find people in disaster areas.



PLOS ONE 2012

Geckos' and cockroaches' ability to swing from atop a surface to its underside has inspired a robot.

Shrew mouse to help firefighters

FIREFIGHTING Almost all mammals have whiskers, which improve their sense of touch. The Etruscan shrew mouse inspired a group of British scientists to develop Shrewbot, which can sense its surroundings by moving its whiskers.

The Shrewbot's abilities are particularly useful in dark places or in rooms filled with smoke, where it can help firefighters find their way or locate people inside a burning building.



The Etruscan shrew mouse's whiskers are among the most sensitive in nature.

ENERGY SOURCE

Solar-cell robot skin

Robots that move about in broad daylight should be able to recharge their batteries with solar energy, so scientists are developing efficient, flexible solar cells that can be bent and stretched to cover the entire robot as a type of skin.



L.A. CERO/STAMP/ORD NEWS SERVICE

Speedy runner can deliver supplies in war zones

FRONT-RUNNER With its long, light legs, an ostrich can run at a speed beyond 40 mph, covering long distances without consuming much energy. The gangly bird has thus inspired U.S. scientists to develop a robot that moves in the same efficient way.



FASTRUNNER/HALIC & THINKSTOCK

Although they run at speeds of 40-plus mph over long distances, ostriches use very little energy. Scientists hope to replicate these abilities in the FastRunner robots.



OFF-ROAD ROBOTIC DOG CARRIES ON

Most vehicles can't navigate through mud or deep snow on a steep incline, but many animals can do so easily on foot — a principle engineers are working to re-create in the four-legged BigDog robot.

PACK ANIMAL Its 1-cylinder engine howls and roars, but the four legs of the BigDog robot manage to stagger up the muddy slope. Its name comes from the fact that it's about the same size as a large dog, but, at 240 pounds, it is much heavier.

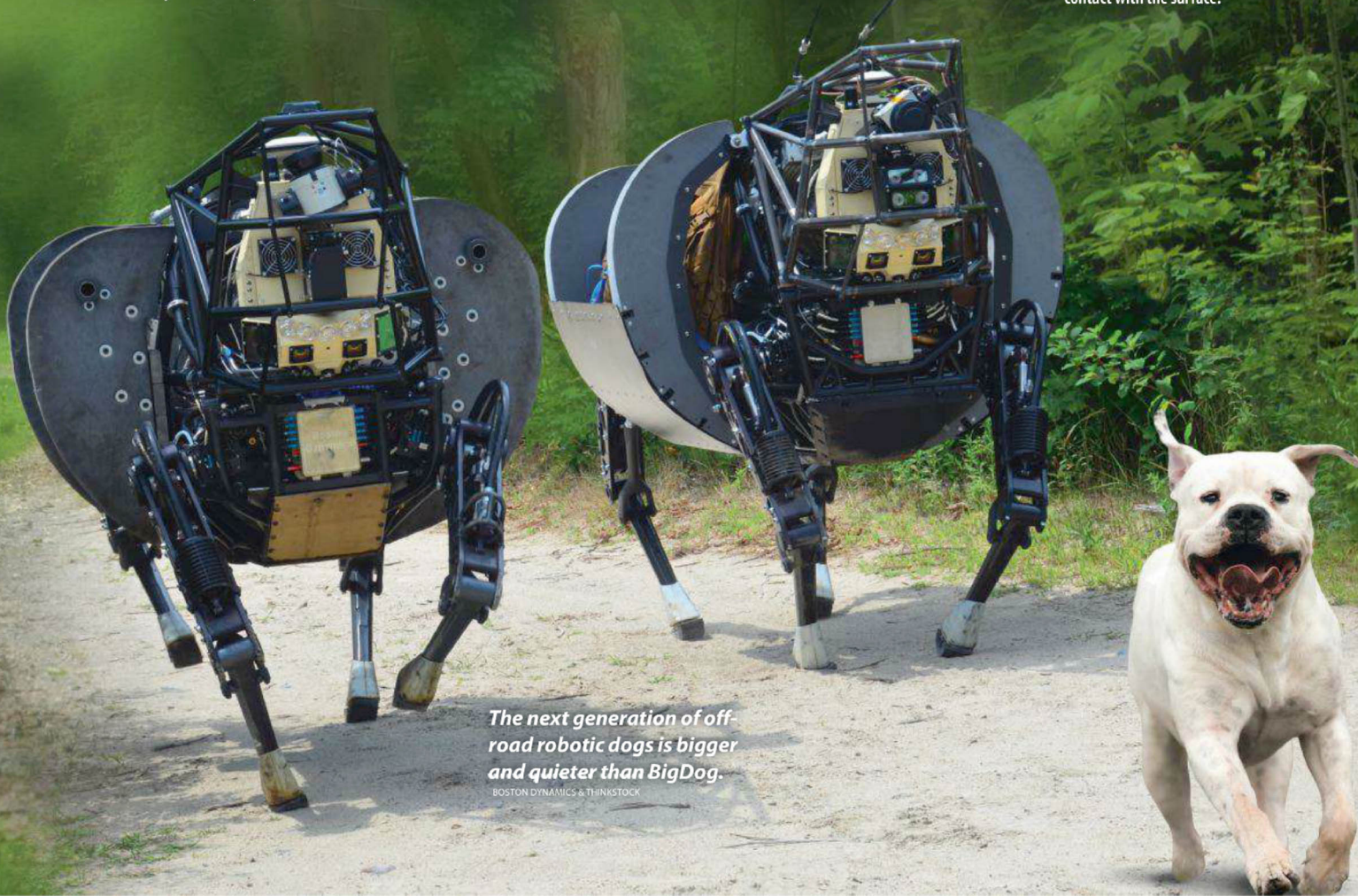
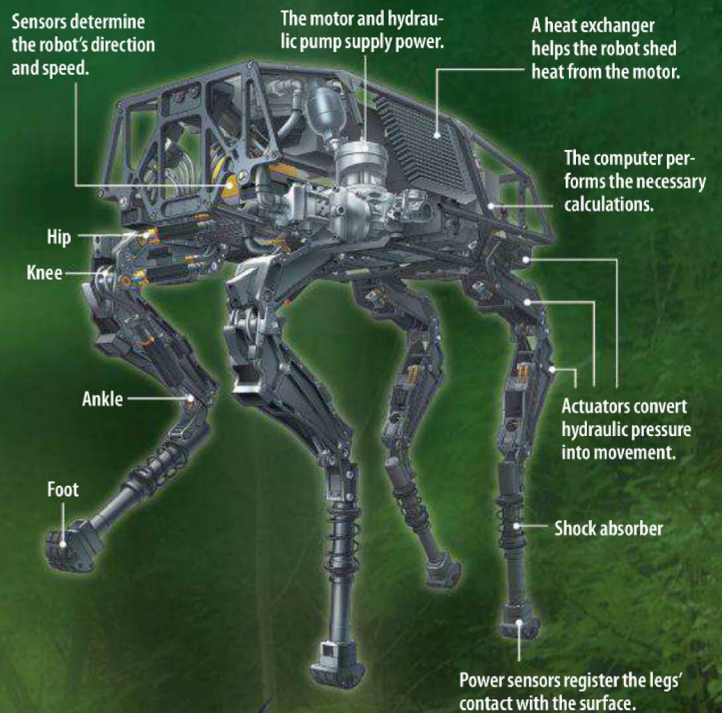
BigDog is around 3 feet tall and 3 feet long, and it can walk, run and climb while carrying a load of up to 340 pounds. The U.S. military expects to use the robot as a pack animal, enabling BigDog to carry equipment in environments where vehicles can't maneuver.

A computer attached to 50 sensors helps the robot move, maintain its balance and find its way. The computer and

sensors also can help BigDog recover if it is pushed off course or loses its footing.

The 15 hp engine powers a hydraulic system that operates the legs, which were developed based on engineers' observations of how large mammals move their legs. The robot's maximum speed is just over 4 mph, and it can cover more than 12 miles on a single charge of its battery.

Currently, BigDog must be operated via remote control, but a new version is expected to require less human handling. A newly introduced prototype, which is built more like a donkey, is quieter and also boasts technology that enables it to find its way on its own or follow behind a soldier.



The next generation of off-road robotic dogs is bigger and quieter than BigDog.

BOSTON DYNAMICS & THINKSTOCK

The miss



Blood on a piece of cloth and a ballpoint pen revealed the culprit who brutally murdered Annie Le five days before her wedding.

SPL/SCANPIX

ing bride



DNA reveals a murderer

1

Evidence

Surveillance camera recordings

2

Evidence

Electronic footprints

3

Conclusive evidence

Trails of blood — and DNA

Five days before her wedding, 24-year-old doctoral student Annie Le vanished from a lab at Yale University. The next day, an intensive search began. Aided by a trace of DNA from a toothbrush, careful analysis of sophisticated building-access systems and specially trained dogs, Connecticut police were able to identify the murderer just a week after her disappearance.

AP/POLFO/SHUTTERSTOCK/THINKSTOCK

The morning of Sept. 8, 2009, begins much the same way as any other morning for 24-year-old Annie Le. A doctoral candidate at Yale University in New Haven, Connecticut, Le is an outstanding student and makes her Vietnamese parents proud. It has been this way since high school, when her classmates predicted that she would become the next Einstein. Ambitious and dedicated, she applied for more than 100 college scholarships, writing so many applications that her fingers hurt.

Her efforts paid off. After receiving student grants worth \$160,000 and excelling in her studies, she is now working toward her doctorate in pharmacology, her passion. And in five days, she will marry the love of her life, Jonathan Widawsky, a physics student at Columbia University in New York City. Annie Le is living the American dream.

When she arrives at work on Sept. 8, she immediately begins working on her research project, which concerns the relationship between fatty acids, enzymes, and diseases such as cancer and ►



Raymond Clark
He worked at Yale as a lab technician, taking care of the test animals, and was described as having a bad temper.

AP/POLFO

muscular dystrophy. As part of her research, Le conducts experiments using mice, so in the middle of the morning, she leaves her office at Sterling Hall to check on the rodents, which are located in a lab basement at the Yale Animal Research Center on Amistad Street, a short walk from her office.

A little past 10, she enters the center. Shortly afterward, she enters the basement room where the lab animals are held and encounters Raymond Clark, also 24. A lab technician, Clark is charged with taking care of the test animals at the research center. He cleans their cages, feeds them, and ensures that they are healthy and do not suffer unnecessarily. It's his duty to make sure that the scientists comply with Yale's ethical guidelines concerning test animals, and Clark takes his job very seriously.

Among his colleagues, he is considered a control freak with a bad temper and an arrogant streak, who is known to become aggressive with the people who frequent the building. On several occasions he has scolded the scientists, who, in his opinion, are careless with the animals.

This reputation extends outside his workplace as well. Those in his circle know his short fuse all too well: A high-school girlfriend left him because he was violent, and his baseball teammates have had to prevent him from attacking the umpire several times. Le has also experienced Clark's anger. Earlier

in the year, she received an e-mail from him complaining that she was not sufficiently careful when handling the mice she uses in her experiments. But she e-mailed him back, explaining herself, and they appeared to have buried the hatchet.

Sept. 8, 2009, night: Annie Le vanishes

Le's roommates are the first to suspect that something is wrong. She shares an apartment at 188 Lawrence Street with five other women, and when she fails to return from work at her regular time, they begin to worry. They are used to Le letting them know if she has changed her plans, but nobody has heard from her. One of her roommates, Nathalie Powers, calls Le's cell phone several times. When she doesn't answer, Powers calls the police, around 9 p.m.

At first, the New Haven police are unconcerned. They think that Le may be having second thoughts about her wedding, or that she's gone off to think things over in private. They make routine phone calls to Annie's friends and family and to the groom-to-be, none of whom have seen or heard from the young woman.

By the following morning, Le still hasn't shown up or contacted anyone, so the police pay a visit to her office at Sterling Hall. There, they find her purse, which still contains her cell phone, wallet and credit cards, and begin to suspect that her roommates'

“It is a high-security building, to which a limited number of people have access, and technology is involved. There is more information in this case than in street crime.”

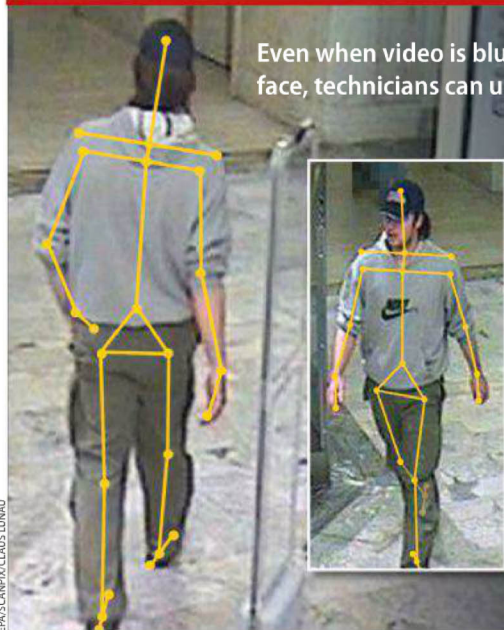
— New Haven Police Chief James Lewis

Evidence

1

SURVEILLANCE RECORDINGS PINPOINT THE MURDERER

Even when video is blurred or doesn't clearly show a person's face, technicians can use other visual cues to identify a criminal.



EPASCANBY/CLAUS LINNAU

■ Gait recognition

Everyone has a unique gait, which technicians can use to identify a specific individual from a surveillance video. Computer technology maps out the person's gait based on parameters such as the length of the step, walking speed, foot angle and the distance between the legs. This gait profile can help determine whether a suspect in custody is the same as the person caught on tape.

When Swedish politician Anna Lindh was murdered, the police identified the murderer by using gait recognition.



ELSEVIER/IRELAND LTD.

A digital 3-D model is compared to a video image.

■ Photogrammetry

Even poor-quality images can point to a suspect — computer software can combine several different angles to create a 3-D image of the entire person. This technique, called photogrammetry, enables experts to calculate body measurements such as height, shoulder width and the position of the eyes, which can help narrow down a list of suspects to just the guilty party.

fears are warranted and that something is indeed very wrong. They now think that Le has likely not disappeared on account of her own free will, but that she has been the victim of foul play.

The police question Widawsky, the groom-to-be, but immediately cross him off of their list of suspects; he has an ironclad alibi. The same is true for a professor who fell under suspicion because he had suddenly canceled a lecture the day before that Le had been scheduled to attend. With the obvious suspects ruled out, the police find themselves with no solid leads and no theories as to who may have wanted to harm Le, or why.

Colleagues and friends characterize Le as very popular, with no enemies. They also note that she is a very careful person; seven months earlier, in February, she had written an article that was published in a university newspaper. Titled "Crime and Safety in New Haven," it discussed security at Yale, which is located in a neighborhood with a criminal element. In the piece, she urged her fellow students not to keep large sums of money on their person, to be alert at all times, and to never walk alone in the parking lots after dark. It seems highly unlikely that she would have acted carelessly and ended up as one of the statistics she wrote about.

Fortunately for the police, Yale has positioned surveillance cameras to monitor all entrances. In an attempt to trace Le's movements and pinpoint when and where she disappeared, the police watch some 700 hours of recordings from 70 different cameras. The recordings show that Le entered the lab building

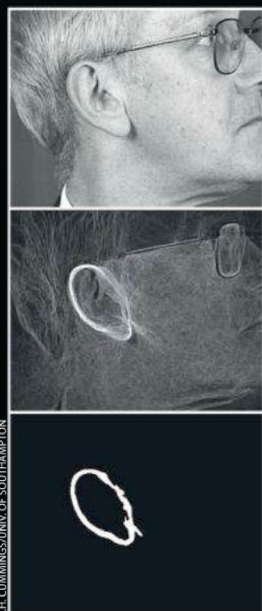


on Amistad Street at 10:09 a.m. on Tuesday, Sept. 8, wearing a calf-length brown skirt and a light-green T-shirt. But no recording can be found that shows her leaving the building. In addition to the cameras, the lab also has an electronic lock system that requires a valid access card in order to enter certain rooms. After reviewing the records for this system, the police determine that Le went directly to the basement, specifically to room G13. She locked herself in at 10:11, using her personal access card. Since that time, the ID card has not been used.

Le could not have moved about the building without the card; in all likelihood she is still in the lab building. The police cordon off the entire structure and send for a police unit with specially trained scent dogs. However, the dogs become confused by the scents of the many test animals. The search moves to the building's garbage dump, where the police finally find something. ▶

Annie Le's friends and family led a desperate — but unsuccessful — search for her when she vanished.

T. CAIN/AP/POLFO



Sophisticated software can identify a person from video images of the ear.

■ Ear recognition

Numerous studies indicate that a human ear, with all its characteristic curves and levels, is as unique as a fingerprint. This knowledge provides the basis for a new technology that makes it possible to identify a person using only photos of the ear. From the photographs, the experts create a biometric profile that can be used in the same way as a fingerprint. So if a suspect passes through a security check that uses biometric identification, he will immediately be recognized.



This image from the university's video surveillance shows Annie Le on the last day she was seen alive.

AP/POLFO

IN THIS CASE:

All entrances at Yale University are monitored by surveillance cameras. In the recordings, the police were able to see Annie Le enter the research center on Amistad Street at 10:09 on Sept. 8. But none of the recordings showed that she ever left the building. The tapes also revealed that the main suspect, Raymond Clark, changed his blood-stained clothes sometime during the day.



Nerves reveal lies

A lie detector can't actually pinpoint a lie; it measures reactions that are related to the autonomic nervous system, such as pulse rate, blood pressure and skin voltage. In theory, these are affected when someone lies on purpose. But the tests can be unreliable. A highly nervous subject may register suspicious measurements even if he or she is being honest.

Sept. 10, 2009: Raymond Clark faces questioning

In their effort to shed light on Le's whereabouts on Sept. 8, the police question people who regularly visit the research center; one of those people is Raymond Clark, the lab technician. He says that on Tuesday morning, he met Le in room G13, where he was tending the test animals. Clark claims that Le left the research center around 12:30, about 15 minutes before he did.

But the police note that Clark has scratch marks in several places on his face and his left upper arm. When an officer asks him about the scratches, Clark explains that one of his cats scratched him. The police don't buy it, however; they suspect that the marks may be defense injuries. And when Clark takes a lie-detector test at the police station, the machine records suspicious signs when he answers questions related to Le's disappearance. But without more conclusive evidence and a motive, it's not enough to charge him.

Sept. 12, 2009: A bloodstained sock appears

Four days after Le is reported missing — the day before her wedding — the police are at a standstill. They have no body and no suspect, and the only indication of a crime is a box of tissues with small bloodstains that was found on a trolley.

But they get a break in the case that day, finding a bloodstained sock and rubber glove, and a blue coat and a pair of boots marked "Ray-C" hidden beneath a ceiling panel in a corridor in the lab basement.



Police scent dogs were confused by scents from the test animals in the lab where Le worked.

Police technicians analyze everything, hoping to find DNA, which could link the objects to Le. If anything is found, they can compare it to the DNA profile they created by collecting biological material from her toothbrush and hairbrush.

Sept. 13, 2009: Annie Le's body is found

It's Annie Le's wedding day, but the bride is still missing. The party on Long Island has been canceled; instead, the groom and the guests are desperately awaiting news from the police. They fear the worst. Late in the afternoon — around the time the festivities would have started — the investigators make a grisly discovery.

As part of the search for Le, they inspect a locker room in the basement of the lab building. Around

Evidence

2

ID CARD PRODUCES AN ELECTRONIC FOOTPRINT

Electronic access cards leave a clear trail in modern admittance systems, which technicians can use to follow someone's footsteps.

■ Electronic entrance cards are equipped with a magnetic stripe that functions as an electronic key and also contains information about the card's owner. Key cards can be very important during an investigation, because they serve as an electronic footprint.

The card is scanned at entrances and doors to buildings; a computerized security system then records who has entered and the time of their entrance. The system stores this information in a database. During an investigation, technicians may obtain information about an individual's movements

before, during and after a crime. This enables investigators to follow both the victim and the criminal.

IN THIS CASE: Annie Le last used her Yale ID card at 10:11 on Sept. 8, when she entered room G13. Raymond Clark entered the same room at 11:40. He later entered another room, G22, 11 times; there, police officers found blood trails, hair and two pearls from Le's necklace.

When a magnetic card is scanned, it is logged into a database that keeps a record of its use.

THINKSTOCK

BIOLOGICAL CLUES REVEAL THE MURDERER

5 p.m., the telltale stench of rotting flesh leads a specially trained police dog, called a corpse dog, to a body. It is Annie Le, wedged behind the wall in a space used for water pipes and wiring.

When the police remove the body, they find a green felt-tip pen, a bloodstained coat and a sock. The sock matches the bloodstained sock that was found behind the ceiling panel in the corridor.

Sept. 15, 2009: Raymond Clark is arrested

A week to the day after Le's disappearance, the police arrest Clark, the lab technician. The autopsy shows that Le was strangled, and the clues point straight at Clark. However, the police still lack conclusive evidence. After an interrogation in which Clark denies any knowledge of the crime, the police collect saliva, hair and nail scrapings from him for DNA testing and then release him. Two days later, the police have an answer from the lab — and someone to charge with Le's murder. Matches have been found between Clark's DNA and DNA found on the victim's body and clothing. By 8:10 that morning, Clark is arrested in a Super 8 motel in Cromwell.

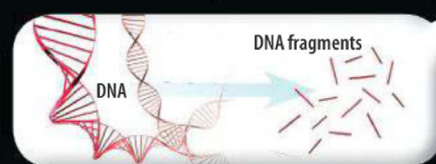
A crowd of 400 people attend a memorial service for Le on Sept. 22, two weeks after her murder. But her family and friends must wait a little longer to see Clark held responsible for his crime — he initially enters a plea of not guilty. Six months pass before he pleads guilty to murdering Le, although he fails to provide a motive. Three months later, in June 2011, he is sentenced to 44 years in prison. **BCI**

Blood, hair, saliva and skin cells are among the biological clues that forensic geneticists use to create a DNA profile of a criminal.

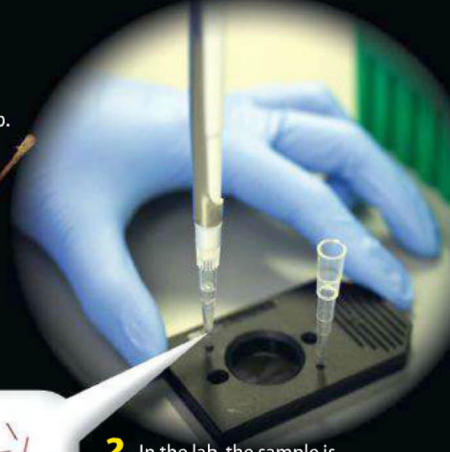
DNA profiles have become so important to crime solving that equipment used to collect DNA — gloves, masks, cotton swabs, bags — is now standard issue for the police. The swabs are used to collect biological material from items

that may be connected to the crime, such as clothing or weapons, and are then sent to a lab for DNA analysis. DNA can also be obtained from a suspect's blood or saliva for comparison to clues found on the victim or at the scene of the crime.

1. A sample is taken from a crime scene or a victim with a cotton swab.



2. In the lab, the sample is dissolved in a liquid. Enzymes are added to break up any DNA that may be present.



DNA contamination

DNA evidence may be contaminated by biological material. It's unknown how often this happens, but experts estimate that it occurs in 1 out of every 1,000 cases. DNA contamination could lead to an innocent person being convicted.

DNA contamination can occur when the evidence is collected and mixed with DNA from another sample by mistake. In Germany, scientists proved that DNA contamination could easily happen on otherwise clinically clean surfaces, such as an autopsy table. In four of the six bodies that they tested, they found DNA from other bodies that had been autopsied at an earlier date.

Australian forensic scientists have proved that DNA on cigarettes can be transferred to other evidence in a bag.

SPL/SCANPIX

3. The DNA fragments are placed on a gel, and an electrical current is introduced. The large molecules move more slowly through the gel than small ones.

4. Markers in the DNA are colored, making it possible to compare the genetic fingerprint to DNA from a suspect.



IN THIS CASE: When Raymond Clark killed Annie Le, her blood, skin and hair ended up on his clothes. The police found Clark's DNA on Le's body; underneath it was a green felt-tip pen with DNA from both. This conclusive evidence linked Clark to both the victim and the crime scene.



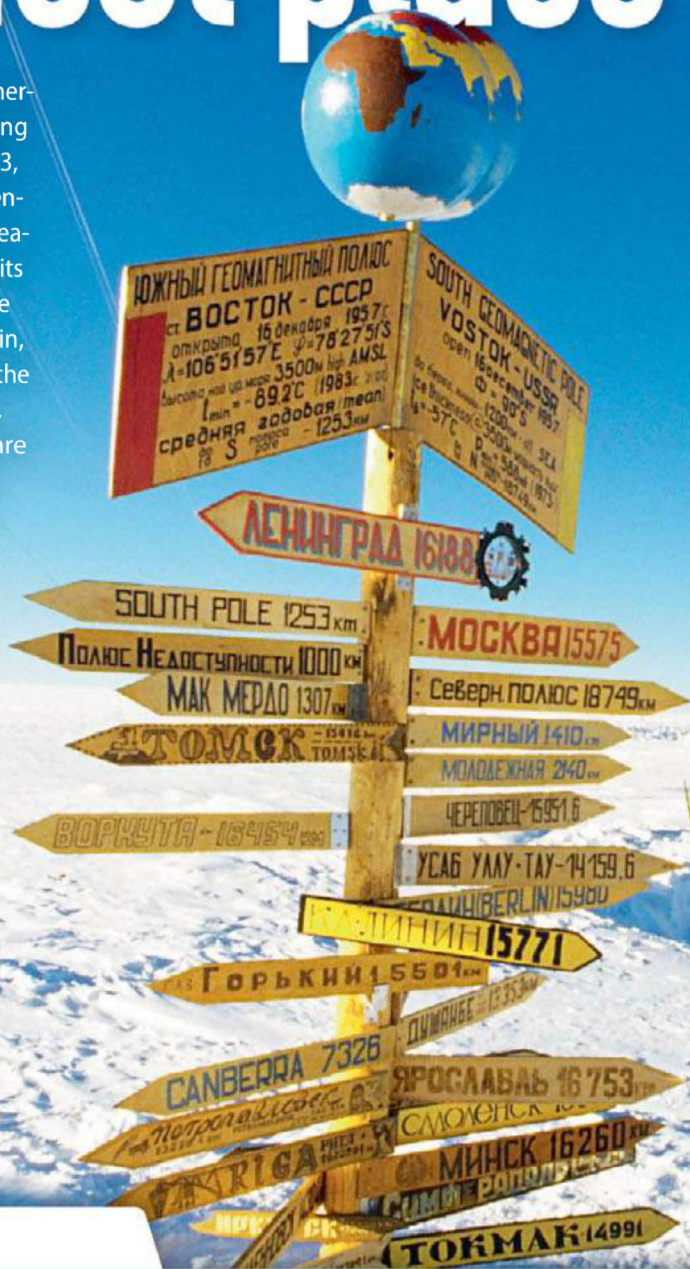


The coldest place

-128.6° F

That was the thermometer reading on July 21, 1983,

at Russia's Vostok research station in Antarctica, when scientists at the base recorded the coldest temperature ever measured on Earth. The extreme cold around Vostok is due to its location on the Antarctic Plateau, some 780 miles from the nearest coast and 11,444 feet above sea level. The air is thin, the wind is frigid, and darkness reigns for four months of the year. The Vostok station, established on Dec. 16, 1957, houses a permanent staff of 13 to 25 scientists, who are studying ice core samples in search of life in massive Lake Vostok, which is buried under 13,000 feet of ice.



Locked in a desert of ice



The coldest pole

Vostok is the southern Pole of Cold, the spot in the Southern Hemisphere with Earth's lowest temperature. The northern Pole of Cold is in Siberia.

The warmest day

Jan. 11, 2002, holds the record of Vostok's hottest day; the weather was almost mild, with a temperature of 10 degrees F.

No signs of life

Apart from the visiting scientists, nothing lives on the Antarctic Plateau, where Vostok is located. Not even microorganisms have been found in the ice desert.

Average temperatures

August is the coldest month, with an average temperature of -91 degrees F; December's average is -27 degrees F.



The heart of darkness

On April 22, the sun rises over Vostok for the last time during the polar winter; it will not be seen here again until August.

Six cool records

Vostok is easily the world's coldest place. But humans and animals are defined by extreme cold in many other places too.

The solar system's coldest place

is the Hermite crater, near the moon's north pole, at -414 degrees F.



The lunar north pole



The coldest hotels

are made of ice and kept at a temperature of 23 degrees F so that they won't melt.

The coldest country is also the world's largest. At a frosty 22 degrees F, Russia has the lowest average temperature of all nations.



The coldest capital

is Ulan Bator, Mongolia's largest city, with 1.2 million citizens.

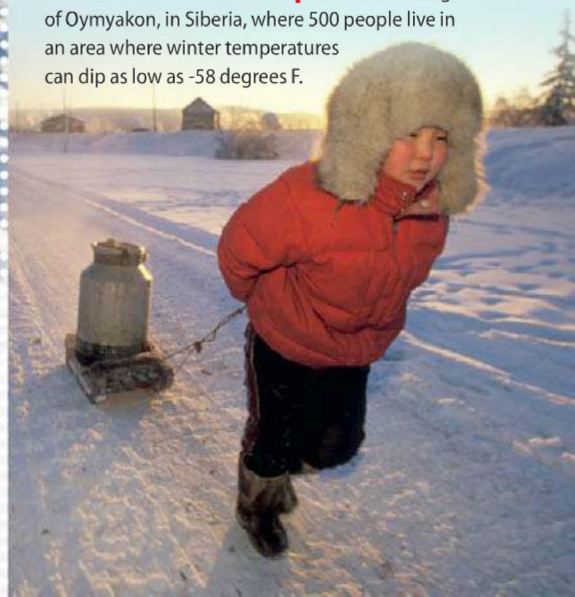


The coldest animal

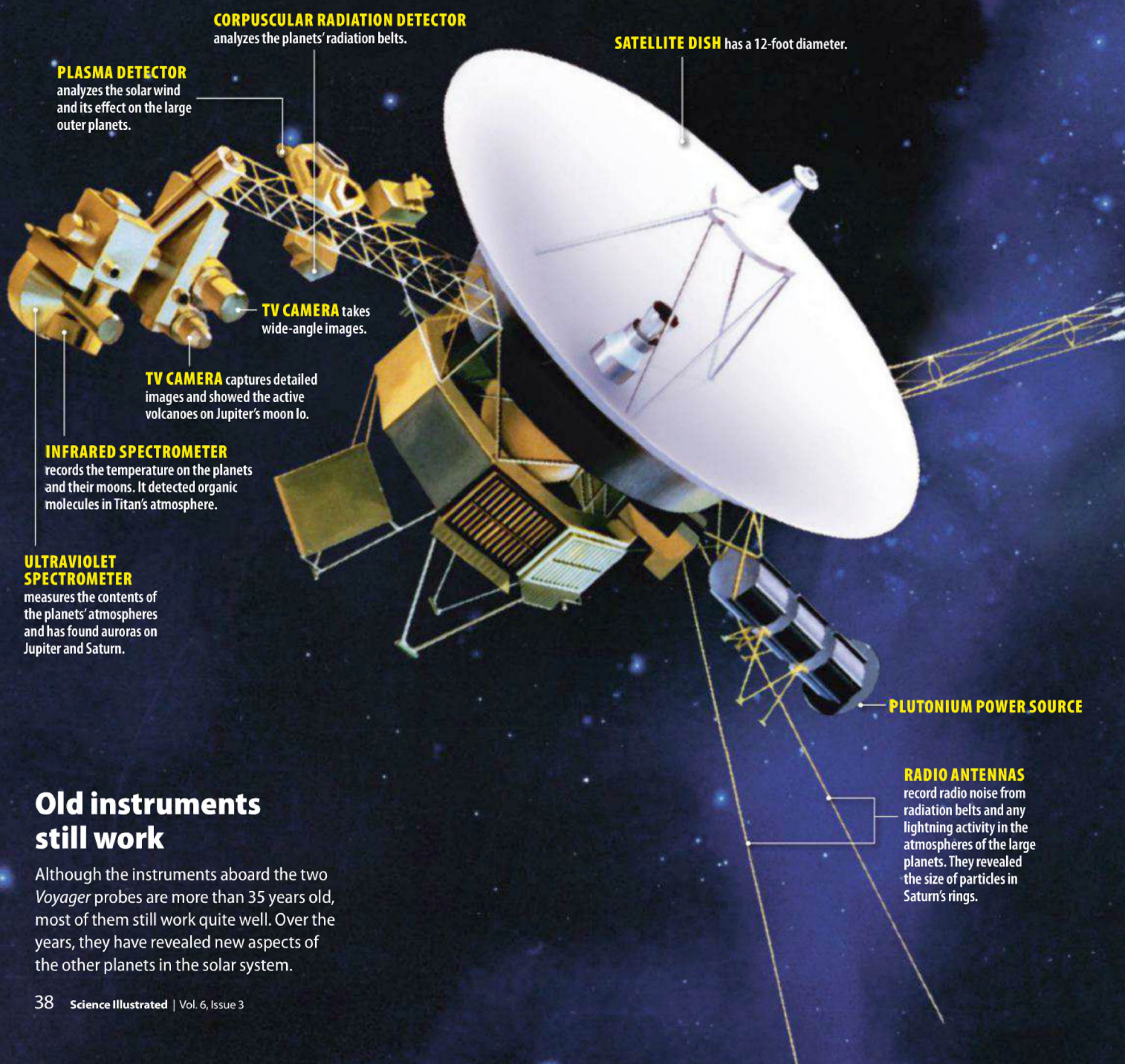
is the tardigrade.

The microscopic creature can endure a temperature of -457 degrees F, which it survives by extreme hibernation, drying out its entire body.

The coldest inhabited place is the village of Oymyakon, in Siberia, where 500 people live in an area where winter temperatures can dip as low as -58 degrees F.



VOYAGER'S LONG, STRANGE



CORPUSCULAR RADIATION DETECTOR
analyzes the planets' radiation belts.

PLASMA DETECTOR
analyzes the solar wind
and its effect on the large
outer planets.

TV CAMERA takes
wide-angle images.

TV CAMERA captures detailed
images and showed the active
volcanoes on Jupiter's moon Io.

INFRARED SPECTROMETER
records the temperature on the planets
and their moons. It detected organic
molecules in Titan's atmosphere.

**ULTRAVIOLET
SPECTROMETER**
measures the contents of
the planets' atmospheres
and has found auroras on
Jupiter and Saturn.

SATELLITE DISH has a 12-foot diameter.

PLUTONIUM POWER SOURCE

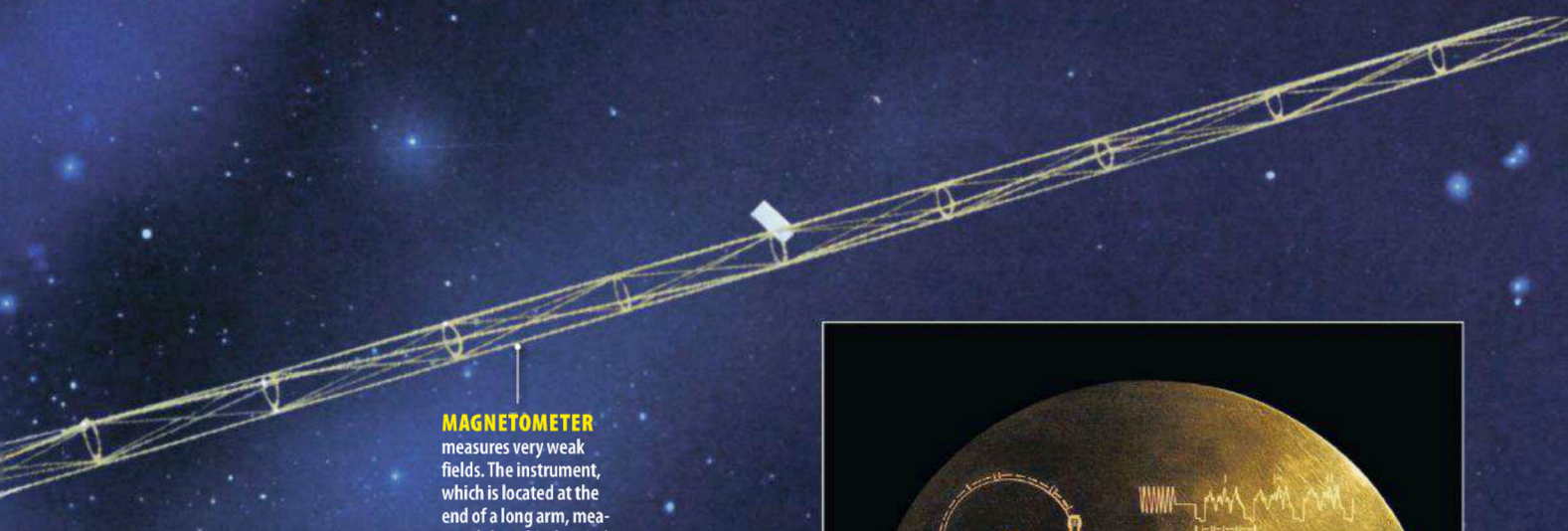
RADIO ANTENNAS
record radio noise from
radiation belts and any
lightning activity in the
atmospheres of the large
planets. They revealed
the size of particles in
Saturn's rings.

Old instruments still work

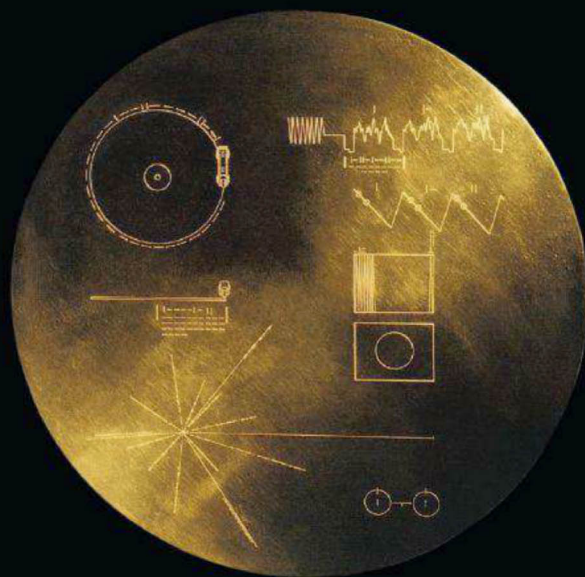
Although the instruments aboard the two *Voyager* probes are more than 35 years old, most of them still work quite well. Over the years, they have revealed new aspects of the other planets in the solar system.

TRIP

After 35 years, the *Voyager 1* space probe has finally reached the outer edge of the solar system. Along the way, it and its twin, *Voyager 2*, have provided the first close-ups of the outer planets. And once it leaves the solar system, it will be the first man-made craft in interstellar space.



MAGNETOMETER measures very weak fields. The instrument, which is located at the end of a long arm, measured the orbital periods of Uranus and Neptune.



BEETHOVEN IN SPACE

Each *Voyager* probe contains a 12-inch gold-plated plaque featuring greetings in 55 languages, 115 analog photographs of humans and animals, and 90 minutes of music ranging from singing pygmy girls to Beethoven. A map on the plaque's front face indicates the sun's location in the Milky Way in relation to a number of pulsars.

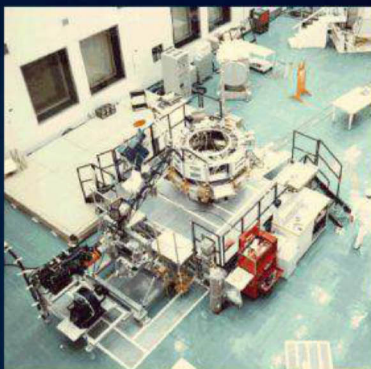
MATHEMATICS LAUNCHED *VOYAGER*

Only 10 years after the Space Age began, two young mathematicians discovered a way to have a space probe visit all of the planets in the outer solar system.

As you read this, *Voyager 1* is hurtling out of the solar system at a speed of more than 37,000 mph. Its long voyage, which has lasted more than 35 years, began in an entirely different era in space travel.

The *Voyager 1* space probe was launched in September 1977, just 20 years after the beginning of the Space Age. The aerospace industry had already made tremendous progress, peaking with the moon missions. But while the lunar trips were highly anticipated, no one at that time expected that we could launch two space probes that would visit all of the planets of the outer solar system — much less that they would one day leave our cosmic neighborhood.

The *Voyager* missions were primarily the result of two young mathematicians' groundbreaking calculations. In the early 1960s, Michael Minovitch and Gary Flandro started to look into the fuel-saving opportunities of using the outer



The two Voyager probes were built at the NASA Jet Propulsion Laboratory (JPL) in California.

planets' gravitational fields to give passing space probes an extra push. Today, the technique, called a gravity assist, is widely used, but back then it was unheard of. At first the focus was on missions in the inner solar system, but in 1965, Flandro went one step further,

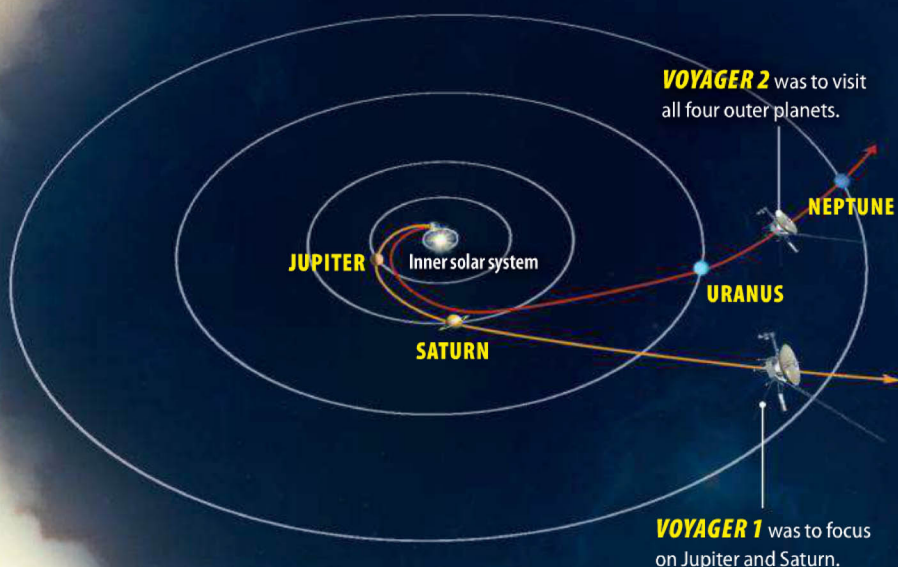
aiming for the outer planets. He calculated that a space probe could pass by the four gas giants in a single mission. First it would swing by Jupiter, whose gravity would direct it toward Saturn. The latter's gravity would push the probe toward Uranus, which in turn would push it toward Neptune.

But the mission required the planets to be aligned precisely, so the project could only be carried out if the probe were launched between 1976 and 1979. The necessary planetary alignment wouldn't repeat for another 176 years, meaning that the next opportunity wouldn't come until 2153.

NASA agreed, but Congress trimmed the project repeatedly. The original goal of having four probes pass by all of the outer planets (including Pluto) ultimately became a four-year mission in which two space probes would visit the two closest outer planets, Jupiter and Saturn.

The Grand Tour exceeded expectations

Originally, *Voyager 1* was only intended to visit Jupiter and Saturn. But analyses of more than 10,000 possible routes revealed that the two probes could visit all of the outer planets by using gravitation.



LIFTOFF 1977

The two *Voyager* probes left Cape Canaveral in August and September 1977. The probes passed by Mars after three months, but they were in for a long journey across the unknown asteroid belt.

Aug. 20, 1977



Voyager 2 is launched.

Sept. 5, 1977



Voyager 1 is launched.

March 1979

First stop: Jupiter

The visit to Jupiter was worth the wait. Several months before the flyby, astronomers could clearly observe the movements of the clouds and the eternal storms raging in Jupiter's dense atmosphere. Though astronomers learned many new things about Jupiter, its moon Io held the biggest surprise.

Voyager 1 had only two days to observe Jupiter's four largest moons at close range. It found that Io is covered by large sulfur volcanoes that are erupting, which give it a distinctive orange color. This marked the first time that astronomers observed volcanic activity elsewhere in the solar system.

CHIEF DISCOVERY:

Volcanic activity on the orange moon Io

ICY MOON MAY HAVE A VAST OCEAN

Io and its volcanoes long diverted attention from its neighboring smooth moon, Europa. But astronomers now think that Europa is covered with a thick sheet of ice that hides a massive ocean, which could harbor life.



Io



Europa



Ganymede



Callisto

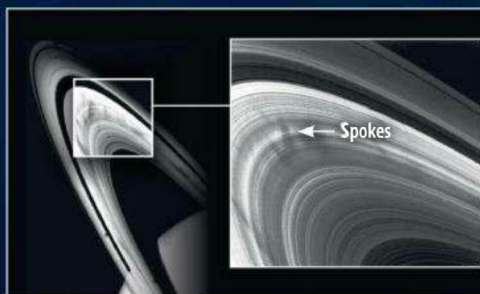
JUPITER

Nov. 12, 1980

Saturn gained thousands of rings

The first close-ups of Saturn's 43,000-mile-wide rings were overwhelming. Astronomers had expected to see four large rings, but instead found a system consisting of thousands of very narrow rings. The images also revealed dark

markings, called spokes, cutting across the rings. Because the innermost ring particles move faster than the outermost ones, this pattern should be wiped out, but it was discovered that the planet's magnetic field holds them in place.



CHIEF DISCOVERY:

Saturn's 10,000 rings

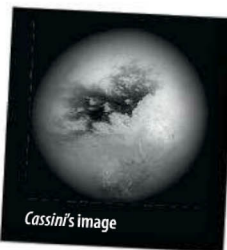
The rings consist of chunks of ice and ice-covered rocks. The speed of the ring particles varies: The closer they are to the planet, the faster they move.

TITAN HID BEHIND CLOUDS

The flyby of Saturn's moon Titan was disappointing: The images revealed only its dense atmosphere. Titan's surface wasn't clearly seen until 2004, when it was imaged by the *Cassini* probe.



Voyager's image



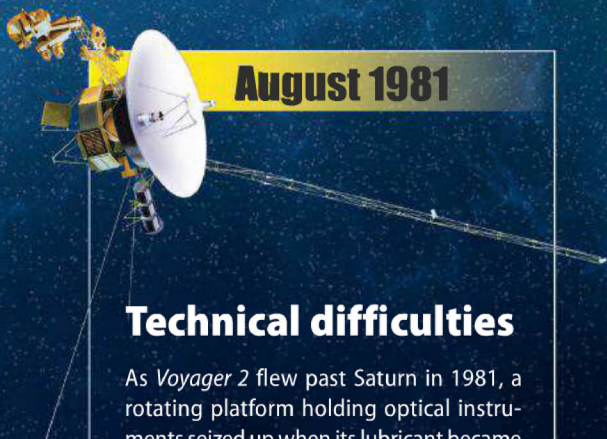
Cassini's image

July 9, 1979

 *Voyager 2* passes by Jupiter.

Aug. 25, 1981

 *Voyager 2* flies past Saturn.



August 1981

Technical difficulties

As *Voyager 2* flew past Saturn in 1981, a rotating platform holding optical instruments seized up when its lubricant became depleted due to overuse. As a result, the probe could no longer point the instruments at specific targets. To solve the problem, NASA engineers built and tested 86 models of the platform's gear box. After several years of trial and error, the engineers were able to compensate for the damage, allowing the platform and its instruments to function well enough to continue the flight past Uranus and Neptune.

Jan. 24, 1986

Tragedy overshadowed Uranus

Voyager's closest approach to Uranus was overshadowed just four days later by the *Challenger* disaster, when the shuttle exploded and killed all seven astronauts aboard. The probe captured images of the moon *Miranda* and the planet's ring system, and also discovered 10 new moons.

Challenger exploded on Jan. 28, 1986.

CHIEF DISCOVERY:
Miranda's odd geology



The probe found an ice wall 12 miles high on *Miranda*.



August 1989

Farewell to the planets

Voyager 2's final planetary mission, to Neptune, heralded the end of one era for the probe and the start of a new one. On its closest approach, it flew by the planet's north pole at the relatively close distance of 3,045 miles.

In some ways the images captured by *Voyager* resembled a view of Earth's north pole; they showed white clouds casting shadows on a sea of blue. But unlike those on Earth, Neptune's clouds are comprised of frozen methane, not water vapor, and its blue coloring does not mean that the outermost planet is covered in oceans, but that its upper atmosphere is rich in methane.

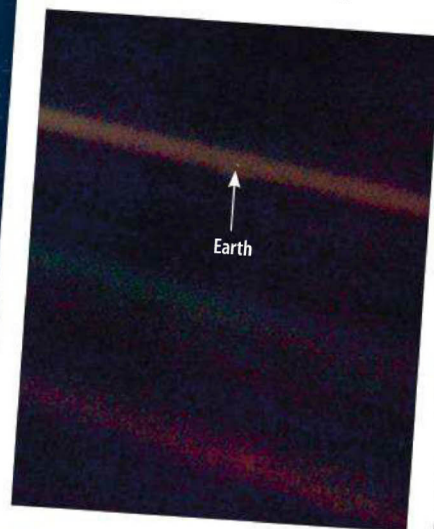
The probe also flew by Neptune's moon *Triton*, whose nitrogen geysers surprised astronomers.

CHIEF DISCOVERY:
Geysers on the Neptunian moon *Triton*

NEPTUNE

THE PALE BLUE DOT

At a distance of more than 3½ billion miles, *Voyager 1* took one of the Space Age's most famous pictures of Earth — an image that will forever remind us how small we are.



Jan. 1, 1990

Voyager's mission out of the solar system is initiated.

Feb. 14, 1990

Voyager 1 produces an image of all of the solar system's planets.

Feb. 17, 1998

Voyager 1 becomes the most distant man-made object, bypassing *Pioneer 10*.



1. In 2004, the probe passed by **the sun's termination shock**, where material from other stars has curbed the solar wind to a speed slower than sound.

2. In April 2010, the solar wind speed fell to 0. Since then, the speed has increased locally, indicating that the probe is in the **heliosheath**, where material from space affects the solar wind.

3. *Voyager 1* will soon cross the **heliopause**, the outer boundary of the solar system, and venture into interstellar space.

Solar wind reveals the edge of interstellar space

The boundary of the solar system can be defined as the place where the influence of the sun's magnetic field, as evidenced by the solar wind, ends. *Voyager 1* has begun detecting a significant decrease in solar wind, along with an increase in particles from interstellar space. In other words, the probe is about to leave our cosmic neighborhood.

CHIEF DISCOVERY:
The boundary of the solar system

VOYAGER LEAVES THE SOLAR SYSTEM

Though *Voyager 1*'s solar-wind detector no longer functions, measurements from several other instruments indicate that the probe is tantalizingly close to the edge of interstellar space.

The data are still being analyzed, but all indications are that *Voyager 1* is now crossing the last vestiges of the heliosphere, in the uncharted territory just before it reaches the heliopause, the point where the solar system ends and interstellar space begins.

In spring 2012, scientists confirmed that the intensity of the cosmic radiation from

space began to increase considerably. Since then, this radiation has continued to increase dramatically, meaning that *Voyager 1* is so far from the sun that its magnetic field can no longer protect the probe from radiation from beyond the solar system. This was followed in September by a considerable decrease in the intensity of the solar wind. In December, NASA

announced that the probe had entered a "magnetic highway" but that it had not yet detected the change in direction of the magnetic field from the sun's east-west orientation that will mark its entry into interstellar space.

Once free of the solar system, both of the *Voyager* probes should continue to transmit data as they explore the Milky Way.

Five probes are hurtling toward deep space

The *Voyager* probes aren't the only ones that will soon be leaving their home turf — three others are on paths that will eventually take them out of the solar system. Although the *Pioneer* probes were launched earlier, *Voyager 1*, now more than 11½ billion miles from Earth, will beat them to the exit.

The probes:

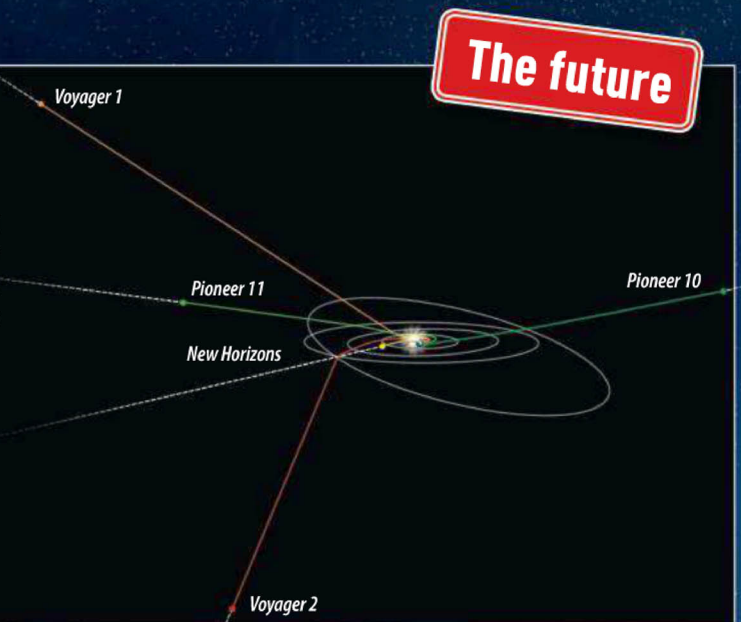
PIONEER 10 was launched in 1972 to visit Jupiter.

PIONEER 11 was sent to Jupiter and Saturn in 1972.

VOYAGER 1 began its mission to the outer solar system in 1977.

VOYAGER 2 started its tour of the outer planets in 1977.

NEW HORIZONS was launched on its mission to Pluto in 2006.



Dec. 15, 2004

Voyager 1 passes the termination shock, where the solar wind begins slowing.

Dec. 5, 2007

Voyager 2 passes the termination shock.

2012-2014

Voyager 1 crosses the heliopause; astronomers think that the final approach began in spring 2012.

VOLCA

CREATE

8

Without the heat and nutrients provided by the earliest volcanic eruptions, life may never have originated on Earth. But the same volcanoes that helped spark life also can be very destructive. Throughout history, they have wiped out entire civilizations — and the next earth-shattering eruption could happen anytime.

GETTY IMAGES

NOES

DESTROY



The young Earth

Volcanoes played a key role in the origin of life — but also came close to destroying our ancestors.

SPL/THINKSTOCK



The age of civilizations

Early civilizations emerged on fertile volcanic slopes, and some were exterminated by huge eruptions.



Earth's future

New land is emerging around volcanoes, and the next super-eruption is just a matter of time.





THE YOUNG EARTH

CREATE

The universe may have been created by the Big Bang some 13.7 billion years ago, but life on Earth may owe its existence to the smaller bangs that occurred a few million years after the planet's formation, when energy and heat from lightning and volcanoes sparked the building blocks of life.

Life on Earth may have originated from the interaction between amino acids and volcanoes and lightning.

Did electricity spark life on Earth?

A few million years after Earth's formation, its surface was dominated by volcanoes, most of which were submarine. This environment, while extremely hostile, provided the basis for the gradual development of plants, animals and humans.

Although the sun was much weaker then than it is today, volcanoes spewed large amounts of greenhouse gases into the atmosphere, enabling the planet to trap the limited heat from the sun. Volcanoes also outgassed water vapor, which

helped make the oceans; these contained amino acids that may have been delivered by meteors or been created during meteor strikes. In the warm primordial water, rich with volcanic sulfur particles, more and more amino acids were generated, but this alone did not create life.

One theory holds that lightning striking the ocean caused the amino acids to combine into proteins, the foundation of cells. Life on Earth may have begun in a soup of water, sulfur and lightning.

135,000,000
years: reign of the dinosaurs

Dinosaurs are the most famous prehistoric animals, but they weren't the first. They were preceded by big creatures, including Crurotarsi, that were wiped out by volcanic supereruptions 200 million years ago. The dinosaurs that had been living in their shadow for 30 million years thus began to thrive when the Crurotarsi became extinct. Dinosaurs assumed dominance and thrived for the next 135 million years — until they went extinct too.

NATIONAL GEOGRAPHIC

Meteors may have delivered amino acids to Earth.

Meteors helped create the building blocks of life Water and amino acids were crucial to the origination of life on Earth. The former came about in part because of volcanic activity, while the latter may have arrived from outer space aboard striking meteors, or been created when meteors struck the oceans' primordial soup.

NASA/AFPS/SCANNIX

DESTROY

Since life on Earth began, volcanoes' destructive force has ravaged animals and humans alike. More than once, massive eruptions wiped out entire species — and our ancestors were very nearly among them.



Huge volcanic eruptions wiped out prehistoric reptiles and almost killed off the ancestors of humans.

KYODO/REUTERS/SCANPIX

The mass death may have been due to a large emission of methane from the ocean floor.



Mass die-offs affected Earth

Throughout Earth's history, several extinction events have taken place. The largest one happened about 250 million years ago and is called the Great Dying.

Scientists theorize that a single devastating event killed off most life-forms on Earth. It could have been a series of large asteroid strikes, a massive emission from the seafloor of the greenhouse gas methane, or increased volcanic activity, such as the eruptions that created the Siberian Traps that now cover some 770,000 square miles of Russia. When the mass extinction ended, 57 percent of all animal families and 83 percent of all genera had disappeared from the planet, and it took some 10 million years for life to recover.

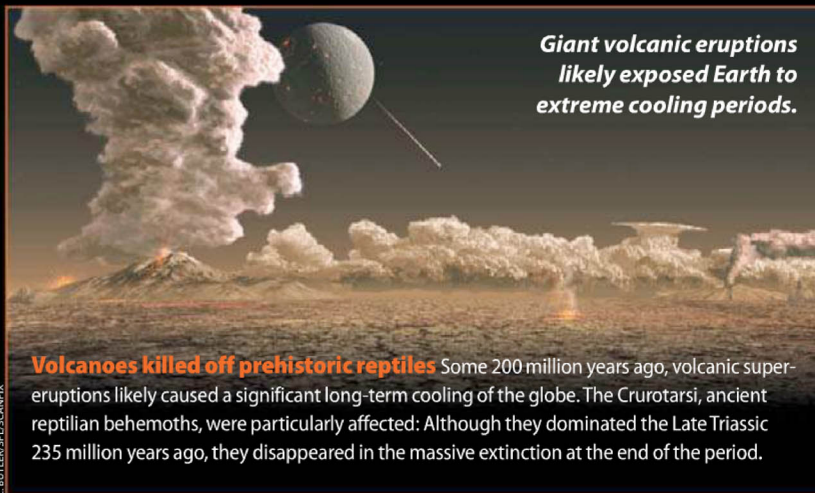
Massive ash cloud cooled the planet

During the 4½ billion years of Earth's existence, people have been in the picture only for a short time. And our story could have ended before it even began.

A huge volcanic eruption in Sumatra, Indonesia, came very close to wiping out the ancestors of humans between 69,000 and 77,000 years ago. The Toba volcano erupted with such force that its caldera covered 1,158 square miles. It spewed out 2,800 billion cubic meters of magma, 800 billion of which were ash. This ash

settled in a layer about 6 inches thick that blanketed southern Asia — and, worse, became trapped in the atmosphere, blocking out the sun. The resulting volcanic winter lasted six to 10 years and ushered in a cool period for the next millennium.

The massive eruption had a dramatic and negative impact on all life, including people. One theory holds that the world's entire human population was reduced to somewhere between 10,000 and 15,000 individuals.



Giant volcanic eruptions likely exposed Earth to extreme cooling periods.

Volcanoes killed off prehistoric reptiles Some 200 million years ago, volcanic super-eruptions likely caused a significant long-term cooling of the globe. The Crurotarsi, ancient reptilian behemoths, were particularly affected: Although they dominated the Late Triassic 235 million years ago, they disappeared in the massive extinction at the end of the period.



THE AGE OF CIVILIZATIONS

CREATE

Volcanoes' fertile soil has long enticed civilizations to live on their slopes or remnants, where residents can cultivate a wide array of crops and excavate the riches that form underground.

The Maya civilization was built on fertile volcanic slopes in Central America.

Civilizations thrive on the ashes

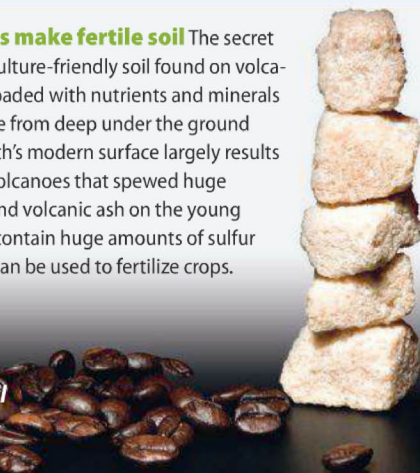
One of history's most successful civilizations was the Maya, which ruled Central America from around 800 BCE to 1530. Many Maya settlements were situated in mountainous regions on or near towering volcanoes that were blanketed with the nutrient-rich soil. This supported the agricultural foundation that helped the Maya to flourish. The

volcanoes also had large deposits of obsidian, a glassy black volcanic rock used to make swords and religious figurines.

Many other civilizations — the Etruscans in northern Italy, the ancient civilizations of Greece, the Roman Empire — have also benefited from living in proximity to volcanoes. The same thing occurred in several places in Asia, where various cultures took root near volcanoes.

Volcanic elements make fertile soil The secret behind the rich, agriculture-friendly soil found on volcanic slopes is that it's loaded with nutrients and minerals brought to the surface from deep under the ground during eruptions. Earth's modern surface largely results from the millions of volcanoes that spewed huge amounts of magma and volcanic ash on the young planet. Lava and ash contain huge amounts of sulfur and nitrogen, which can be used to fertilize crops.

Pineapple, coffee and sugar cane all thrive in nutrient-rich volcanic soil.



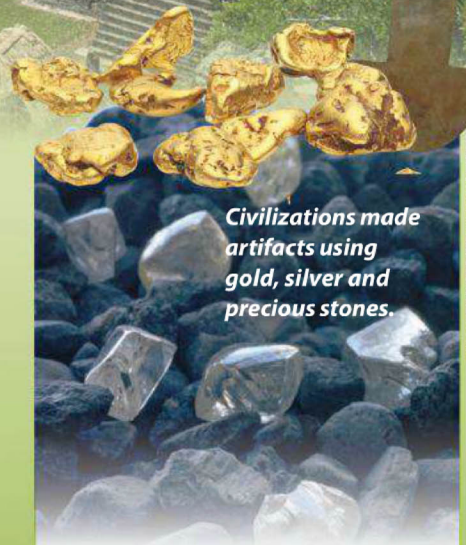
THINKSTOCK

Lava contains gold, silver and gemstones

Lava is rife with precious metals and minerals, particularly gold, silver and diamonds — relatively rare materials that have long held great value for people in many different civilizations.

Volcanic eruptions throughout the world have resulted in deposits of a variety of valuable raw materials. Diamonds reach the surface via a rare type of magma, kimberlite, which is typically found 125 miles underground. But the richest deposits are found in magma that has not yet reached Earth's surface, but that has hardened in great massifs that lie beneath the volcano itself.

Civilizations made artifacts using gold, silver and precious stones.



JOJO/GETTY IMAGES/JOJO/GETTY IMAGES

A. ROSS/ALAMY/ALAMY

DESTROY

Volcanoes' lush soil comes with a high cost — the risk that the mountain could explode at any moment, sometimes with little warning. Cities and entire civilizations alike have learned this devastating fact the hard way.

The inhabitants of Pompeii were buried in a thick layer of ash that hid the city for more than 1,600 years.

L. BATTAGLIA/GETTY IMAGES



Santorini was created by a volcanic eruption.

3.6° F drop in the average global temperature

When Thera erupted in the Aegean Sea some 3,500 years ago, it earned the distinction of being one of the most catastrophic explosions in human history.

Although no eyewitness accounts exist, analyses of ash layers and the size of the caldera as compared to that left by the eruption of Krakatoa in Indonesia in 1883 have provided geologists with a good idea of the extent of the Thera event. Krakatoa killed more than 36,000 people in just a few hours, generated 39-foot tsunamis, spread ash across all of Asia and lowered the average global temperature 1 degree. The Thera eruption was four to five times as violent and caused the average temperature of the planet to fall by more than 3 degrees.

Pompeii was destroyed by a river of hot volcanic ash

On Aug. 24, 79, the residents of the Roman city of Pompeii woke up to a day that seemed like any other. A celebration honoring Vulcan, the god of fire and volcanoes, had been held the day before, but to no avail. Before the night was over, Mount Vesuvius had exploded, spewing out a cloud of volcanic material that reached some 30 miles in height — more than 1½ million tons of red-hot rock and

lava per second. All life was wiped out within six miles of the mountain, due in large part to the superhot pyroclastic flow of gas, ash and rock that surged across the area in a matter of moments, killing thousands of people nearly instantly. Up to 80 feet of ash fell in only six hours; it hardened, encapsulating and preserving the city, which was not rediscovered until 1738.

Violent volcanic eruptions claim many lives

Over the past 2,000 years, Earth has been rocked by volcanic eruptions many times. These are among the worst:

Name	Location	Year	Duration	Death toll
Mount Tambora	Indonesia	1816	5 days	92,000
Mount Pelée	West Indies	1902	13 days	40,000
Krakatoa	Indonesia	1883	?	36,000
Mount Unzen	Japan	1792	1 day	15,000
Mount Vesuvius	Italy	79	1 day	10,000
Laki fissure	Iceland	1783	8 months	9,350
Mount Vesuvius	Italy	1631	Up to 1 month	6,000
Kelud	Indonesia	1919	1 day	5,110



EARTH'S FUTURE

CREATE

Volcanoes continue to shape Earth's surface as they generate new land — and with new technology, we are improving our chances of being able to harness the awe-inspiring power of these forces of nature.

Off the island of El Hierro, submarine volcanic activity is building a new island.

Fertile land emerges from the ruins

In 1963, the story of the formation of new land spread across the world. In the ocean off Reykjavik, Iceland, fishermen had discovered that lava from an erupting volcano had formed a small island, which was named Surtsey. And it's not alone. In recent years, emerging volcanic land has been found in several places.

The Canary Islands are gaining a sister off the island of El Hierro, and in the Red Sea a new island sprang up in the Zubair group after an eruption in 2011,

joining the other small islands in the group that were formed in the same way. Off Tonga, a pinpoint island called Home Reef was created in 2006 by a volcano that previously erupted in 1852, 1857 and 1984; volcanologists expect the islet to keep growing.

All of the Hawaiian islands were made by volcanoes, and a new one may eventually join them. It's now 3,000 feet from the surface, and scientists think that it will break the waves in 50,000 years.

Volcanic ash may revolutionize cement After the Eyjafjallajökull eruption in 2010 produced copious amounts of ash, Icelandic scientists developed a promising formula for using it to make an ecofriendly replacement for traditional cement, the production of which accounts for 5 percent of the world's carbon-dioxide emissions.

Volcanic ash may be the key to "green" cement.



The abundant energy found below Iceland could be the country's most important export someday.

86% of Iceland is heated by the Earth

Icelanders have developed a symbiotic relationship with the magma that lies below their volcano-studded country, using it to heat a network of water-filled pipes that provide heat to 86 percent of Icelanders' homes. Although it has proved difficult to fully utilize the island's geothermal energy, new technology is opening up new opportunities. In 2020, Iceland will begin supplying the United Kingdom with energy via a 930-mile submarine cable, and scientists hope one day to establish volcanic power plants, in which artificially maintained eruptions produce energy.

DESTROY

At regular intervals throughout Earth's history, supervolcanoes have caused unimaginable devastation — including the near extinction of humanity. The next supereruption could happen at any time, changing life on Earth forever.

Some scientists think that the supervolcano below Yellowstone National Park is overdue for an eruption.

A supervolcano could change life as we know it

The force of a supervolcano is so great that one of them may ultimately doom humankind. They've already wiped out a large number of animal species and have come much too close to exterminating us on more than one occasion.

Many scientists think that humans could potentially survive a supervolcano erupting — but it wouldn't be easy,

especially if it were one of the six land-based supervolcanoes. The first victims would be those living closest to the volcano, but unlike a smaller eruption, the kill zone would cover a large area: If Yellowstone blows, everyone in all of the states surrounding Wyoming could be at risk of dying. Volcanologists estimate that a layer of ash 3 feet deep would settle across fully

half the United States, with smaller amounts covering the rest of the country.

The supervolcano would spew such massive amounts of ash into the atmosphere that most sunlight would be blocked out, lowering the average global temperature by more than 5 degrees, devastating agriculture worldwide and triggering a prolonged period of famine.

Six dormant supervolcanoes could someday rock the Earth

Since Earth's formation 4½ billion years ago, supervolcanoes have occasionally rocked the planet. Today, six of these land-based volcanoes (and probably a similar number of submarine ones) are dormant.

YELLOWSTONE, the largest supervolcano, most recently erupted 630,000 years ago.

LONG VALLEY, the second-largest supervolcano, most recently erupted 760,000 years ago.

VALLES most recently exploded about 1 million years ago. It isn't very active.

AIRA most recently erupted 22,000 years ago.

TOBA most recently erupted 74,000 years ago — and almost wiped out humanity.

TAUPO is very active. It erupted 26,500 years ago and again in 181.

THE RHINO



Number of rhinos killed in South Africa



WAR

The rhinoceros is famous for its distinctive pointed horn — and may soon go extinct because of it. Demand for rhino horn is so great that its price per pound is higher than gold's. But national parks have begun using an arsenal of new defensive tactics to halt the devastating hunt and, hopefully, save the rhino.



There are only eight northern white rhinos left in the world. Four of them have permanent bodyguards.

BRENT STIRTON/ALL OVER

New weapons to stop poachers

Poachers are typically better equipped than the authorities, who are turning to technology and clever tactics to stem the slaughter.

GPS

A small GPS transmitter implanted in the horn reveals any changes in a rhino's movement patterns, which could be a sign of poachers. If the horn is sawed off, the GPS transmitter can lead the police to the offenders.

Microchip

When placed in the horn, microchips make it possible to trace sawed-off horns back to a particular animal and prove that it was obtained through poaching. Unlike GPS, a microchip can't reveal where the horn is located.

Toxification

Some national parks treat the animals' horns with a toxic solution that doesn't harm the animal but makes the horn unfit for medicinal use — and turns it pink to boot. In some cases, angry poachers killed the animals anyway.

Horn removal

Without its horn, a rhino is worthless to poachers, so many national parks simply saw it off. This must be done several times a year, because the horn grows back, and even a tiny piece is worth a lot of money to poachers.

DNA

South Africa is establishing a library of DNA profiles of the country's rhinos. This makes it possible to test a confiscated horn in order to verify whether it was poached. Unlike a chip, the DNA cannot be removed.

Relocation

When a local population has shrunk to a few animals, the entire population is captured and moved to a safer place. Individual animals are also moved to other groups to ensure genetically healthy populations.

Guards

The northern white rhino is the world's most endangered species, with only eight individuals left. Four of them live in Kenya's Ol Pejeta Conservancy, where armed guards watch over them 24 hours a day.

In late 2010, South African police received a tip: Two veterinarians were found in possession of large amounts of M99, a sedative used on very large animals. The vets were working for a safari company run by a white farmer, Dawie Groenewald. When police officers searched his farm, they discovered the bodies of 20 dead rhinos buried in a mass grave. All had had their horns removed.

Groenewald's operation included his wife, the two vets and seven others, including a helicopter pilot and a professional hunter, and he was charged with 1,872 counts of illegal hunting and rhino-horn trading — more statistics in the bloody rhino war. After some success through protection efforts in the 1990s and early 2000s, poaching is now soaring, and the demand for rhino horn seems insatiable. In 2012 alone, almost 600 rhinos were killed by poachers.

Previously, there were only sporadic confrontations between individual poachers and national-park guards, but today, authorities and poachers are locked in an undeclared open war. But it's an unequal struggle — the illegal hunting activity is largely financed by international organized-crime outfits.

Rangers saw off a rhino's horn to save it from poaching. Rhinos can easily live without horns.

BRENT STIRTON/ALL OVER



The tragedy of rhino poaching is ironic: Popular belief in rhino horn's curative powers causes prices to soar to absurdly high levels, which could lead to the species' extinction, yet the horn provides no known medical benefit whatsoever.

Poachers' high-tech advantages

Twenty years ago, the typical poacher was armed with an old rifle. Today, poachers typically coordinate in large groups equipped with off-road vehicles, sophisticated weapons and night-vision goggles, which enable them to hunt after dark. Often, they even have a helicopter at their disposal, allowing them to scan large areas for rhinos from the air.

To protect the lives of the increasingly rare animals, authorities in several countries in Africa are responding with GPS monitoring, armed watchmen and even horn removal intended to make the animals worthless to poachers. But despite additional funding for national parks, police and customs services, authorities are struggling to keep up.

The demand for rhino horn is rooted in traditional Asian medicine, which prescribes pulverized rhino horn to treat a wide array of disorders. The present boom in demand was triggered a few years ago by rumors in Vietnam that severely ill cancer patients had been cured by the substance.

This corresponded with the emergence of a new wealthy class in Vietnam, whose members can afford to try any potential remedy when they fall ill. In large cities, rhino-horn powder can now be obtained as easily as painkillers, and



Horns that authorities have sawn off in order to protect the rhinos of South Africa's national parks await destruction in a storage room; the facility enjoys tight security.

rhino-horn graters are popular presents among the rich. In the traditional-Chinese-medicine market, the demand for pulverized rhino horn has also increased greatly.

Both Vietnam and China have signed the CITES convention, which is meant to prevent trading in endangered species and their byproducts; in theory this means that both countries have obligated themselves to combating illegal hunting and smuggling. But in actual practice, they do little to enforce the rules. There is little doubt that one of the main reasons that the

price of pulverized rhino horn has now surpassed the price of gold is that there is lots of money to be made for all involved — even the authorities. Corrupt

officials are often involved in hunting rhinos and smuggling their horns.

In China, the protection of the rhino is openly obstructed by the government and the environmental au-

thorities. In 2007, the Chinese government chose to support the traditional-medicine industry with large sums of money. A year later, the government published a report that recommended the ▶

Rhino horn is as valuable as gold and drugs

- Gold \$24,700/lb.
- Horn \$30,000/lb.
- Heroin \$90,000/lb.

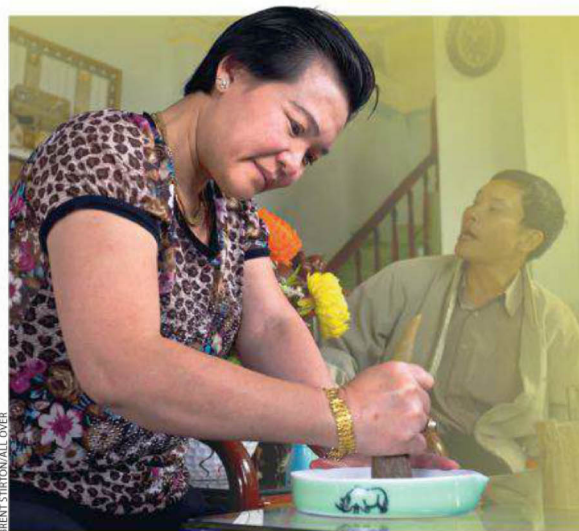
Paying a fortune — for nothing

Many Asians, especially in China and Vietnam, are willing to pay a fortune for rhino horn, due to a mistaken belief that it is an effective treatment for gout, arthritis, and a host of other diseases and conditions, despite the fact that there is no scientific evidence to support this idea. Scientists have analyzed rhino horn many times

to find an active ingredient that would support the wild claims, but all of the studies have reached the same conclusion: The horn consists of compressed hair, and like all other mammals' hair, it contains only keratin.

Keratin has no medical efficacy and is one of the least chemically reactive materials. This makes it nearly impossible for the human digestive system to break it down, so it can't be absorbed and thus has no effect.

The horn is ground or milled into a powder and mixed with water.



use of rhino horn in treating a wide array of disorders and diseases — despite the fact that a number of scientific studies have failed to find that the horn has any medicinal effect.

Yet a prominent Chinese healthcare adviser maintains that rhino horn contains medically viable ingredients. Jia Qian, the former head of China's largest traditional-medicine research institution, claims that rhino horn alleviates "everything from fevers and brain hemorrhages to SARS and AIDS."

A suspicious safari park

Some environmental organizations, including Save the Rhino, think that one cause of the sudden peak in interest in rhino horn is the Chinese government's plan to establish a rhino farm, which they fear will only increase demand. The



Farmer Dawie Groenewald is charged with the killing of 20 rhinos.

farm will harvest the rhinos' horns — which regenerate after five years — for use in producing medicine. Dozens of rhinos have already been imported to China, and though, officially, the animals were intended to be part of a safari park,

several years after its establishment, rhinos are the only residents. A major Chinese arms manufacturer run by a member of the National People's Congress — which owns a pharmaceutical subsidiary — is the project's main backer.

Rhino farms have been a controversial issue for several years. Advocates consider regulated use of the animals' horns to be the only way to end the rhino war. But critics insist that allowing legal horn in the market will only increase the demand and boost poaching. Their argument has a precedent: This is exactly what happened when a number of countries tried to legalize the sale of ivory.

The task of capturing the poachers is further complicated by legal trophy hunting. Such hunts are typically organized by breeders, who allow visitors to shoot free-range rhinos on their land for a hefty fee. A conservation authority representative must be present, the horn cannot be sold, and each hunter is only allowed to kill one animal. But once the rhino has been shot, the authorities stop watching. The Vietnamese in particular have used this loophole, requesting ever higher numbers of permits in recent years. Although the hunts are expensive, hunters still make a profit, thanks to the stratospheric demand for rhino horn.

No end in sight

The trade in rhino horn has become a million-dollar industry, tempting many to join in — including, in some cases, those charged with protecting the endangered animals. Corruption is one reason why so few poachers and smugglers are sentenced, like Dawie Groenewald, the former policeman and South African farmer who buried 20 rhinos on his estate. After two years, none of the defendants in the case have been sentenced, and the trial has been delayed several times. In May 2012, authorities seized assets worth \$7 million from Groenewald and the two vets — money suspected to have come from rhinos.

Even though rhino horn is composed of keratin — the primary component of human hair and nails — it's more than worth its weight in gold. And the magical properties ascribed to these iconic animals are apparently so powerful that last year, poachers began to expand their bloody harvest. Now, they also are removing the animals' eyes. 

Traditional-medicine myths

In traditional Chinese medicine, rhinos aren't the only animals with curative powers — but scientific studies don't bear out the claims.

Tigers alleviate arthritis

Tiger bones are very popular in traditional Chinese medicine. They are considered particularly effective against arthritis and other joint conditions, but are used as an almost universal remedy.

Bears cure headaches

Black-bear bile is used for liver problems, headaches and migraines, as well as for toothaches and other conditions that can cause extreme pain.

Musk makes skin healthy

Several hundred different traditional drugs are based on musk obtained from the scent glands of the musk deer. It is said to be particularly effective against skin and circulatory problems, as well as abdominal pain.

Sea horses improve potency

The Chinese consume several hundred tons of pulverized sea horse every year, believing that it is effective in treating kidney and circulatory problems, along with many other diseases. Large doses of sea horse are also said to cure impotence.

Vultures prolong life

Tradition holds that dried vulture brain is an excellent stimulant. It is viewed as an invigorating drug that can prolong life, or at least restore to the elderly some of the vigor and power of their youth.

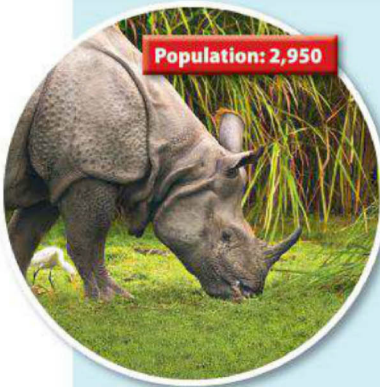
Compounds made with tiger bones and sea horses are popular throughout Asia.

M. DE FRAYE/SP/SCANPIX



All rhino species are under attack

The rhino population worldwide consists of 23,000 animals of five different species. All are threatened by poachers, and some are on the edge of extinction.

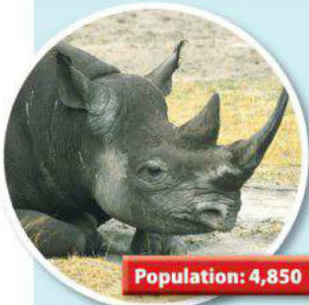


Population: 2,950

INDIAN RHINO

- India and Nepal
- Highly threatened by poachers and habitat destruction

R. PUPPETTI/GETTY IMAGES



Population: 4,850

BLACK RHINO

- Southern and Eastern Africa
- Highly threatened and under increasing pressure from poachers

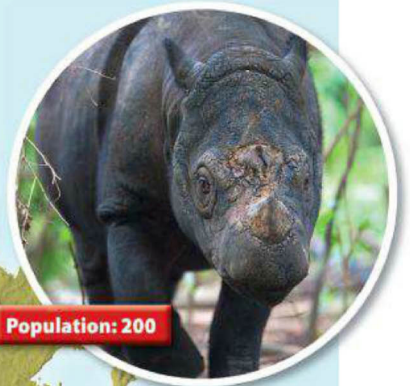
L. ROMANO/DEA/ALL OVER



WHITE RHINO

- South Africa, the Democratic Republic of Congo
- Under constantly increasing pressure from poachers. The population is still stable in South Africa, but almost eliminated in Congo.

Population: 14,500



Population: 200

SUMATRAN RHINO

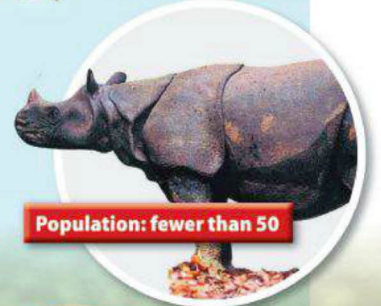
- Indonesia, Malaysia
- Highly endangered and declining fast

S. BELCHER/GETTY IMAGES

JAVAN RHINO

- Indonesia
- Nearly extinct

WWF INDONESIA



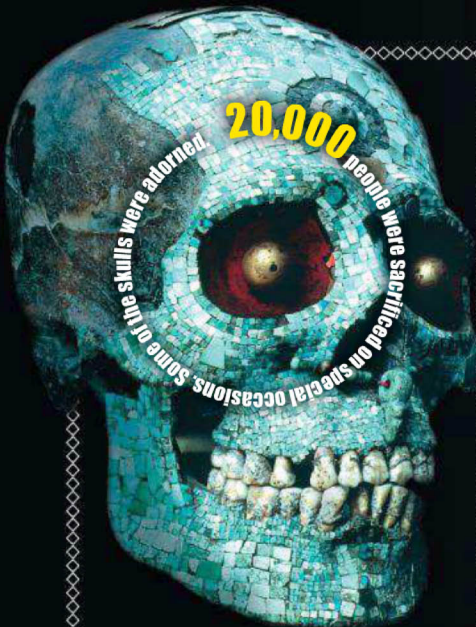
Population: fewer than 50

This female white rhino survived an encounter with poachers, and, despite her disfigurement, found a mate.

BRENT STIRTON/REPORTAGE BY GETTY IMAGE/ALL OVER PRESS

AZTECS BY THE NUMBERS

The Aztec empire thrived for just 100 years before it was crushed by Spanish conquerors. But during that time, the Aztecs developed a culture whose mix of wealth and bloodlust still holds our fascination.



THE GODS DEMANDED LIVES

500 to 700 people had to die each year in order to appease the gods. The majority were prisoners of war.

In 1980, **42 child skeletons** were found near the big temple. Children were sacrificed in times of drought, as their tears were thought to bring rain.

Priests would strip the skin from sacrifices and wear it for **20 days** in honor of Xipe Totec, the fertility god.

A body of laws from the city of Tetzco contained

80 LAWS

and punishments. Strangulation was the standard punishment for theft.

Archaeologists have found **more than 7,000 Aztec objects**, from decorated skulls to earthenware pots, while excavating the ancient temple area.

The stones that the Aztecs used to build their temples weighed up to **44 tons**.

20+ languages

were spoken in the Aztec empire. One of them, Nahuatl, is still spoken by 1 million people in Mexico.

The Aztec solar calendar divided the year into

18 months of 20 days each.

That accounted for only 360 days — the last five were considered particularly unfortunate.

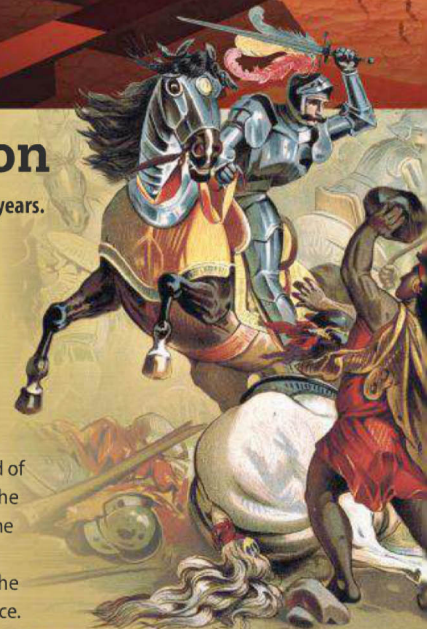
Crushed by invasion

The Spanish destroyed the Aztec resistance in only a few years.

Aztec mythology held that the creator god, **the Feathered Snake**, would return **in 1519**. When the Spanish arrived that year, the Aztecs thought that Hernán Cortés was the anticipated god.

25% of all Aztecs died of smallpox, brought to the area by the Spanish. The disease had not been present in Mexico, so the Aztecs had no resistance.

The invading army consisted of only **500 soldiers and 100 sailors**. But the horses, weapons and tactics of the Spanish gave them an edge.



The Aztecs conquered their neighbors

The Aztec empire grew to cover an area of 80,000 square miles (slightly smaller than Kansas) in what is now Mexico.

400 to 500 smaller states were subjugated by the Aztecs over 100 years and forced to pay taxes.

In its heyday, the empire included **5 to 6 million people**.

The capital, Tenochtitlan (now Mexico City), was built on a **7-square-mile** island in Lake Texcoco and had **200,000 citizens**.



MEXICO

Lake Texcoco
Tenochtitlan

ATLANTIC OCEAN

AZTEC EMPIRE

18

cult parties were held every year.

Sacrifices had to walk **114 steps** to the top of the big temple, where priests cut their hearts out.

200 feet

— 20 stories — was the height of Templo Mayor, Tenochtitlan's main temple. Two massive staircases led to the top.

40,000 to 50,000 buyers and sellers congregated every day in the large marketplace outside the capital. Judges authorized to sentence people to death ensured that order was kept.



The Aztecs got their vegetables from *chinampas*, marshy gardens **measuring 8 x 98 feet** that were surrounded by canals and could be navigated by canoe.

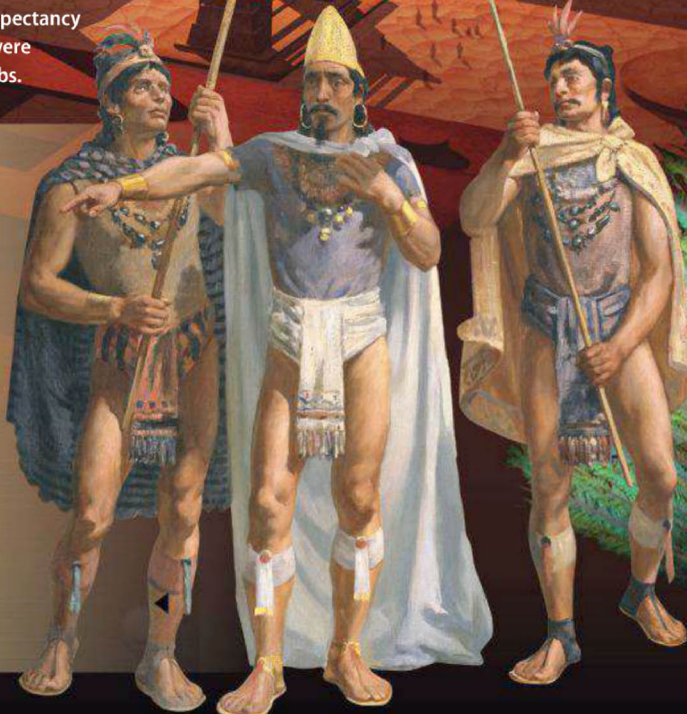
In the southern part of the empire, the Aztecs built the Nezahualcoyotl dam, **10 miles long and 65 feet wide**, which kept Lake Texcoco from overflowing.

37 yrs

was the average life expectancy of an Aztec. Diseases were treated with 1,500 herbs.

8,000 men were members of the Aztec army. When on the march, the line stretched some 15 miles long.

The last of the true Aztec emperors, **Moctezuma II**, died **in 1520**, having been humiliated by the Spanish. In 1521, the last of the resistance was defeated.



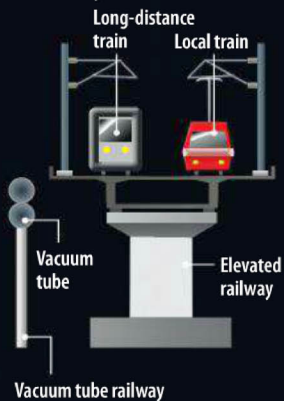
800 bundles of green feathers,

two military uniforms, a feathered headdress, two strings of greenstones, 4,000 woven garments, 40 bags of crimson dye and 20 jars of gold dust was what one conquered community paid in tribute annually.



Light vacuum railway

The vacuum-train advocates at Evacuated Tube Transport Technologies intend to send vessels through a network of airless tubes elevated 16 feet above surface roads. The system is simpler and more compact than conventional rail, and construction costs are lower than those for highways and high-speed trains.



**0 TO 370 MPH
IN 17 SECONDS**

QUIET CABIN

FASTER THAN A BULLET TRAIN



**MINIMAL RISK
OF ACCIDENTS**

**90% OF THE
ENERGY CAN
BE REUSED**

Magnetically powered capsules that speed through vacuum tubes at 370 mph may be the salvation of commuters, thanks to a U.S. visionary and a Chinese university; they are developing a cutting-edge vacuum train capable of handling as much traffic as a 32-lane highway.

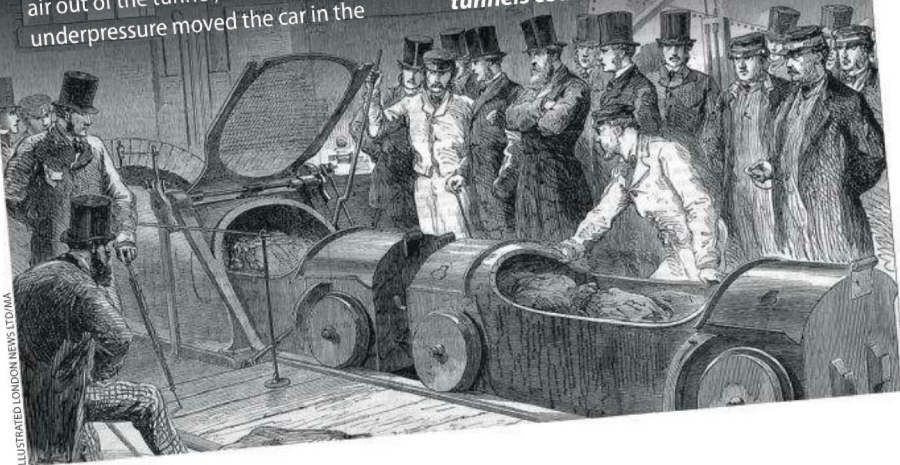
**FROM NEW YORK CITY
TO WASHINGTON, D.C.,
IN HALF AN HOUR**

19th-century vacuum trains

From 1870 to 1873, American inventor Alfred Ely Beach ran an underground vacuum train beneath Broadway in New York City. The air pressure from a giant blower sent a passenger car in one direction; when it reached its destination, the blower was inverted, which sucked the air out of the tunnel, and the resulting underpressure moved the car in the

opposite direction. A decade earlier, the postal service in London used air pressure to direct mail carts through a network of tunnels under the city. The mail reached its recipients twice as fast as it did by traditional delivery.

The cars of London's pneumatic tunnels could hold 35 mail bags.



ILLUSTRATED LONDON NEWS LTD/MA

At quitting time every day in New York City, thousands of people pack into buses, cars and trains. But in a brand-new terminal, six people enter a wheel-less cylindrical train car and settle into their seats. The door closes, and the vessel slides silently into an evacuated, or vacuum, tube. A snapping sound outside indicates that the tube's magnetic field has been activated, and the car shoots off like a bullet. In just 17 seconds, it's speeding along at 370 mph. The passengers disembark at a station in Washington, D.C., after 30 minutes — instead of the three hours that the trip would have taken via conventional train.

At least, this is how Daryl Oster, founder of Evacuated Tube Transport Technologies (ET3), envisions the future of commuting. His patented design for a vacuum train — which is now being developed further by scientists at Southwest Jiaotong University in Chengdu, China — combines airless tubes with maglev (magnetic levitation) technology, which

From 0 to 370 in 17 seconds

The six-passenger capsules at the heart of Evacuated Tube Transport Technologies' system rocket from 0 to 370 mph in no time. The passengers are shielded from the tube's magnetic field in pressurized cabins like those of airplanes.



SUPPORT COLUMNS

The train tubes, which resemble oil pipelines, run above surface traffic via 16-foot-high columns. Curves along the track bend gradually for passenger comfort.

FLOATING CAPSULE

Maglev technology keeps the capsule afloat via powerful electromagnets. The project's engineers in China have developed superconductive magnets cooled by liquid nitrogen that create minimal resistance and cost little to operate.



DARIL OSTER/ET3

replaces wheels and rails with a strong magnetic field. If all goes as Oster intends, he may well have pioneered the transportation of the future.

The concept of vacuum-tube trains — or other tube-based transportation systems — is not new. But previous attempts have used trains that run on wheels or on a magnetic rail. Thanks to magnets, ET3's light passenger capsules float through the tubes with no resistance from either the air or contact with the surfaces in the tube. In other words, nothing is impeding the capsules from moving at a very high speed, which helps to keep energy consumption low.

The thermos principle

Using a perfectly calibrated computer system, the capsules can be launched at very short intervals without colliding. The capacity of one tube would thus equal a 32-lane highway.

Oster compares the ET3 system to the way the Internet works: Tiny packets

Thanks to magnets, ET3's light passenger capsules float through the tubes.

of information, each equipped with an address, find their own way through the network as they speed through heavy traffic. The same principle will apply to the train capsules: Each will have a unique numeric code, so when a passenger enters a destination, the computer will direct the capsule to the appropriate tube. As the system grows, it will consist of a large network of tubes.

The system will not include switch tracks like those used on conventional railways; instead, the capsules will behave more like cars weaving along highways. When the capsule approaches a place where the tube divides, a magnetic navigation system will give it a tiny push into the right tube at full cruising speed.

Oster claims that it is easy to produce the airless tubes that are necessary for

his system to work. A system of pumps will suck the air out of very strong tubes that are capable of withstanding the pressure that is generated. Oster notes that we have plenty of experience with vacuums, which are used in everything from thermoses to televisions. The latter are so airtight that they can maintain a vacuum for years — just like the planned tubes that will hold the train capsules.

Passenger considerations

Because the capsules will be traveling in a vacuum, they can't give off heat, thus they must be equipped with a cooling system. The capsules' cabins will need to have pressurized air to accommodate passengers, just as the cabin of an airplane does.

In the event that a capsule stops during a trip, an emergency system will supply the passengers with air — again, like modern airplanes do. The affected portion of the route can be closed off so that air is directed into the tube via valves ►

SIX-PASSENGER CAPSULE

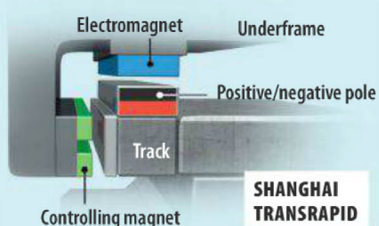
More than 16 feet in length and 5 feet in diameter, the car-size capsules weigh around 400 pounds and can carry nearly 800 pounds of cargo.

EVACUATED TUBES

A system of pumps generates a vacuum in the 5-foot tubes, which must be robust enough that the pressure of the suction will not deform them.

MAGLEV TECHNOLOGY

A linear electric motor powers the capsules through an evacuated, or airless, tube containing a magnetic field that is generated in a track above which the capsules float. Applying a current to the track accelerates the capsule from a full stop to 370 mph in 17 seconds at 1G. A similar system used in Shanghai Transrapid's maglev trains is shown in the diagram (right).



The fastest trains

INTERCITY AND EUROCITY

Maximum speed: 218 mph

Sample route: Copenhagen to Hamburg

Info: Intercity trains usually travel faster than 60 mph. Between European cities, the trains reach speeds of 125 to 218 mph.

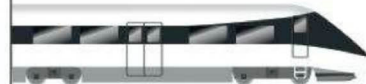


HIGH-SPEED TRAINS

Maximum speed: 357.2 mph (record)

Sample route: London to Paris

Info: High-speed trains travel at least 125 mph and often go faster than 155 mph. Consequently, all curves must be soft.

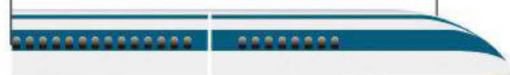


MAGLEV TRAINS

Maximum speed: 361 mph (record)

Sample route: Pudong to Longyang

Info: The train floats on a magnetic track. The speed record was set in Japan, but Shanghai has the only train that runs daily.



in order to normalize the pressure and allow the passengers to be evacuated. And this will all need to happen at a speed that allows the other capsules in the tube to slow down by air resistance.

Oster has painstakingly determined the tube's optimal dimensions to be 5 feet in diameter. This will accommodate capsules that are similar in size to a large passenger car, but with three rows of seats. His design for the capsules allows them to be very lightweight.

However, unlike a car or a conventional train, the capsule's passengers will not be able to look out at their surroundings as they hurtle through the tubes. To ease the likely discomfort this will create, Oster envisions outfitting each capsule with virtual windows — displays that can show films, television shows or other entertainment to occupy passengers' attention during the trip.

Superconductive magnets

A major advantage of the proposed ET3 system is that it consumes a minimal

Per passenger, the system uses just 1 percent of the energy of an electric train.

amount of energy, thanks to superconductive magnets developed by Chinese scientists. These electromagnets are made from superconductive wire that does not generate electrical resistance as long as it is kept below a certain temperature. The magnets also produce a powerful magnetic field without wasting energy in the process. Because its momentum will not be slowed by air resistance, the capsule will not need to be supplied with additional energy once it reaches its cruising speed. And 90 percent of the energy that the capsule uses will be recovered via electromagnetic induction when it slows down. Oster estimates that, per passenger, the ET3 system will consume just 1 percent of the energy used by an electric train.

In order to achieve superconduction, the magnets must be kept sufficiently

cool. This is typically done with liquid helium, but the Chinese scientists have been able to achieve the same result using liquid nitrogen, which is much cheaper. And because the magnets are encased within an airtight environment, only a small portion of nitrogen is required per capsule to cool the magnet that keeps the capsule afloat.

As the polarity of the magnetic field alternates, it pushes and pulls the capsule to the desired speed. Oster is now trying to find a receptive partner in the United States to build a three-mile test track, preferably in a location where the system could eventually be extended to link two major cities that are 185 to 375 miles apart, such as Boston and New York City or the Big Apple and Washington, D.C. But any stretch frequented by 12,000 cars a day would work.

Global perspective

Oster recognizes that there is still much work to do, including developing all of the system's details, so, in the spirit of

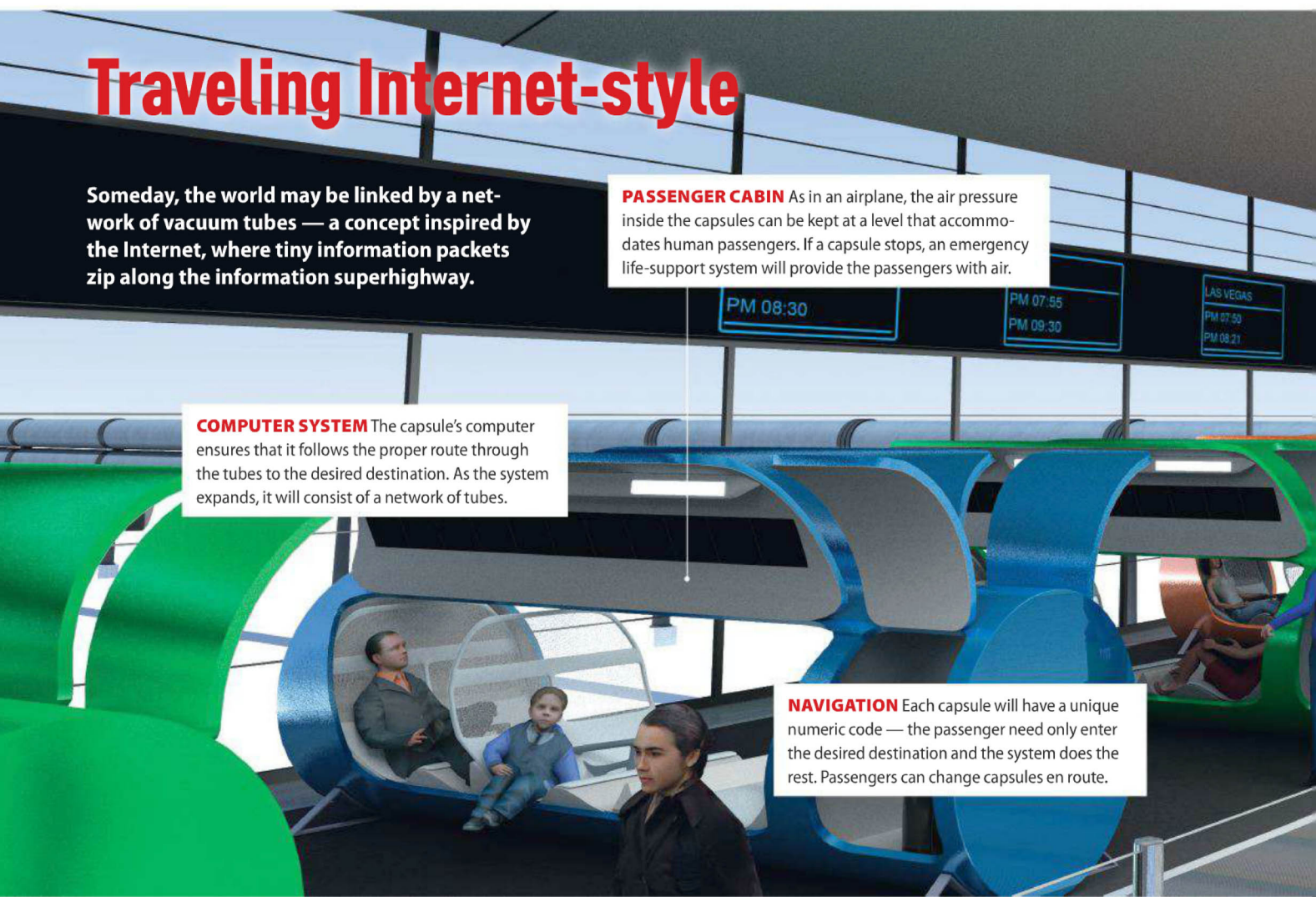
Traveling Internet-style

Someday, the world may be linked by a network of vacuum tubes — a concept inspired by the Internet, where tiny information packets zip along the information superhighway.

PASSENGER CABIN As in an airplane, the air pressure inside the capsules can be kept at a level that accommodates human passengers. If a capsule stops, an emergency life-support system will provide the passengers with air.

COMPUTER SYSTEM The capsule's computer ensures that it follows the proper route through the tubes to the desired destination. As the system expands, it will consist of a network of tubes.

NAVIGATION Each capsule will have a unique numeric code — the passenger need only enter the desired destination and the system does the rest. Passengers can change capsules en route.



open-source software systems, he has invited anyone to participate.

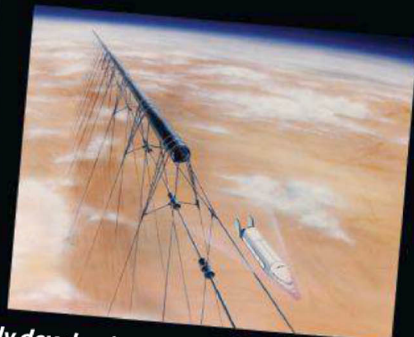
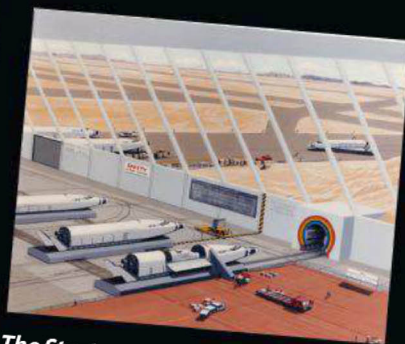
Despite the looming challenges, Oster remains optimistic. He is convinced that, in the long run, vacuum-based transportation will link the world in a new way — provided that the system's components adhere to a global standard, it can be used across national borders. He also notes how quickly new systems can become commonplace: Less than 1 percent of Americans relied on a car in 1907, but within 35 years that number had climbed to 90 percent. And although maglev technology is in its infancy, Shanghai has a maglev train that operates daily.

Oster's vision is catching on. In July, PayPal and SpaceX founder Elon Musk announced that his Tesla Motors operation would begin working on a fifth means of transport in addition to cars, ships, trains and planes. His idea? A tube system that ferries passengers between cities at high speeds — and he has invited scientists and engineers worldwide to contribute to its development. **SCI**

Vacuum launches equipment

Besides solving Earth's transportation problems, vacuum technology may revolutionize space travel, say the scientists behind the Startram Project. They intend to make it less expensive to launch equipment into space by using maglev tracks and vacuum tubes, instead of the fuel-hungry rockets now used. The project

calls for a 60-mile vacuum tube to be built at an altitude of at least 9,800 feet, where a 100-gigawatt discharge lasting a few seconds could, theoretically, launch a 44-ton spacecraft at a speed of at least 17,895 mph into low Earth orbit at a minimum force of 10G — much higher than a person could endure.



The Startram Project hopes to eventually develop its technology to the point where humans could be launched into space via a vacuum tube.

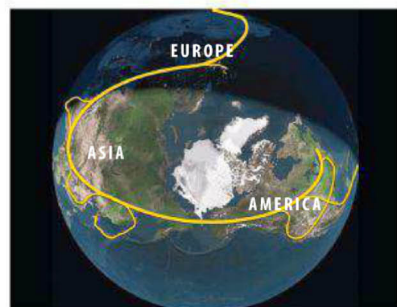
STARTRAM

CARGO The capsules can also transport cargo. Each capsule can hold almost 800 pounds and can accommodate up to three standard-size pallets.

CAPACITY The capsules will be launched at very short intervals, so the computer system must be perfectly calibrated to keep them at a safe distance. A single vacuum tube can handle as much traffic as a 32-lane highway.

Version 2.0 boasts a speed of 4,000 mph

If the ET3 system becomes a reality, at some point the continents could be linked by a vacuum pipeline. Oster thinks that a pipeline buried underground could accommodate capsules traveling at speeds up to 4,000 mph, meaning that passengers could go from Beijing to New York City in as little as two hours. The tubes could also cross bodies of water if two vacuum tubes were encased in a larger tube that functions as a floating tunnel.



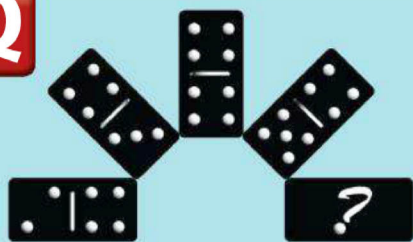
DANIEL COSTERETS

The inventor's ultimate vision is to create a global network of vacuum tubes that link all of the continents.

TEST YOURSELF

See page 70 for the answers.

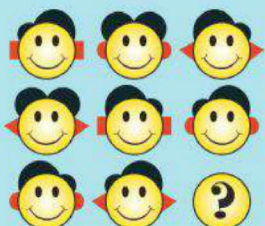
Editors: Helene Rosenstand and Erik Wied. Art: Cecilia Brøgger



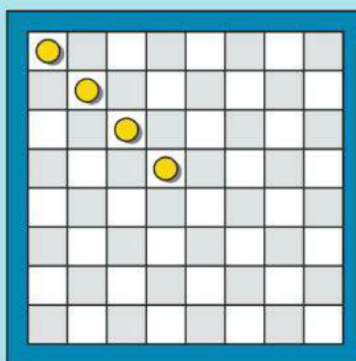
1 Based on the pattern, what number combination is on the fifth domino?



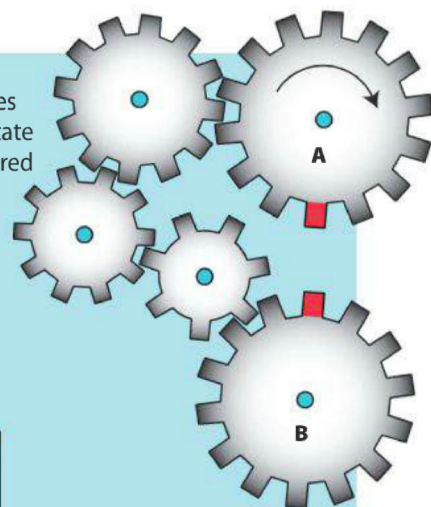
2 Determine the missing number. (There are two possible answers.)



4 Which smiley face replaces the question mark?



5 Divide the chessboard into four parts of the same shape containing the same number of squares. Each of the four shapes must be contiguous and must contain exactly one coin.



3 How many times must gear A rotate before the two red teeth are once again directly opposite one another?

Guess What? Which of the items described below is shown in the picture (right)?

1 BAMBOO ROLLS

Bamboo is laid in rows after it is harvested. The plant, which grows extremely fast, is used for many purposes in Southeast Asia, including as a building material and for food.

2 FISHING BOATS

Small flat-bottom fishing boats rock in the waves of China's longest river, the Yangtze. Fishermen are having a hard time making a living, because pollution has devastated many species.

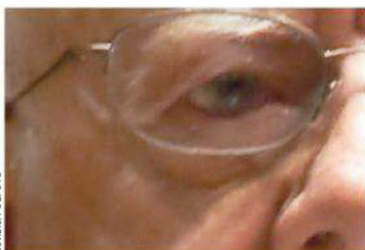
3 ASPARAGUS HARVEST

The harvesting of white asparagus in Elsholz, Germany, begins in the spring. The crop is grown using the hilling method so that the plant doesn't turn green from exposure to sunlight.



THINKSTOCK

Guess Who? Which of the people described below is shown in the picture (left)?



CORBIS/PHOTO

1 F. W. DE KLERK

Decades of apartheid in South Africa ended under President de Klerk. He and Nelson Mandela were awarded the Nobel Peace Prize in 1993.

2 JIMMY CARTER

Former U.S. president Jimmy Carter has long championed peace in the Middle East. He was awarded the Nobel Peace Prize in 2002 for his Carter Center, which promotes conflict resolution and democracy.

3 MARTTI AHTISAARI

Ahtisaari, Finland's president from 1994 to 2000, has helped solve conflicts in Namibia, Indonesia, Iraq and the Balkans. His efforts earned him the Nobel Peace Prize in 2008.

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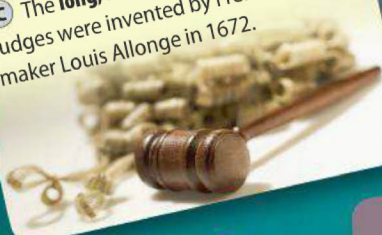
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QUIZ

1 RIGHT, 2 WRONG

HEADY THINGS 1

- A** Sherlock Holmes' distinctive hat could be worn indoors in British pubs. It is called a beerstalker.
- B** A modern salute with straightened fingers to the cap peak may date back to ancient knights raising their visors.
- C** The long, full wigs worn by British judges were invented by French wig maker Louis Allonge in 1672.



ABBREVIATIONS 2

- A** ASCII is the French abbreviation of the IT organization Association Sociale et Culturelle des Indusiris Individuelles.
- B** TNT is an abbreviation of 2,4,6-Trinitrotoluene, an organic compound with the formula $C_7H_5N_3O_6$.
- C** The German government was the first to introduce the SOS signal, in 1905. In Morse code, it is: --- ··· ---



PHYSICS 3

- A** Physicist Sir Horatio Nelson suddenly understood gravity when he saw an apple falling from a tree.
- B** The Greek scientist Archimedes invented a microscope with two lenses around 200 BCE.
- C** If 1 gram of matter were converted into pure energy, it could make a 1,000-watt light bulb shine for 2,850 years.



MEDICINE 4

- A** An ordinary person urinates 7,900 to 10,500 gallons in a lifetime, the equivalent of more than 3,000 cases of beer.
- B** Hookworms are found in tropical rivers. Like leeches, they can stick to human skin and suck blood.
- C** Paracetamol is a new type of adhesive bandage that contains a painkiller.



ZOOLOGY 5

- A** In 2001, a chimp learned to read short words and react to them.
- B** Wheel animals are tiny creatures that have a string of tentacles at one end that seems to rotate like a wheel.
- C** If an earthworm is cut into two pieces of the same length, each piece can become a new earthworm.



GEOGRAPHY 6

- A** Isle of Wright is the United Kingdom's largest island; it lies in the English Channel a few miles off the coast.
- B** Gibraltar, the 4,590-foot mountain that lies between the Atlantic and the Mediterranean, is a British territory.
- C** The world's highest mountain, Mount Everest, is growing more than a tenth of an inch taller every year.



TITLES 7

- A** The noble title of marquis refers to a tilted canopy, or overhang, that is suspended above a throne.
- B** A Muslim versed in Islamic scripture is a mullah, named for Mohammed's nephew, Abdul-Mulahim.
- C** Roman high priests were called pontifex maximus.



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ANSWER KEY

Test Yourself Page 66

Problem 1:



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Problem 2:

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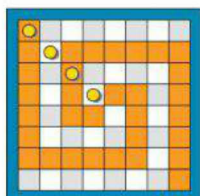
Problem 3:

Once. When gear A rotates one tooth, the small gear locked in it rotates one tooth. The same is true of each sequential gear to gear B. The two large gears have the same number of teeth, so they will rotate at the same pace.

Problem 4:

Smiley D. Each row and column must have a smiley face with a different hairstyle and ear shape.

Problem 5:



Guess What:

3. Asparagus harvest. The photo shows farmworkers harvesting the asparagus in between the many white hills.

Guess Who:

2. Jimmy Carter

Quiz — 1 right, 2 wrong

1. HEADY THINGS

A. The hat is called a deerstalker. The British typically use it for hunting, particularly when hunting deer by sneaking up on (stalking) the animal.
B. CORRECT. Historians believe that the salute may date even further back to when people raised their weapon-carrying hand to show that they had no weapon.
C. The French word *allonge* means prolonged. The long wigs became fashionable for men around 1650.

2. ABBREVIATIONS

A. ASCII is the abbreviation of American Standard Code for Information Interchange. The code defines the connection between the binary values of computers and the graphic letters and characters on a display.
B. CORRECT. TNT is an explosive that is also called trinitrotoluene. The strength of nuclear bombs is often measured in TNT explosive power. The nuclear bomb that destroyed Hiroshima boasted an explosive power greater than 16,500 tons of TNT.
C. It is true that the Germans were the first to introduce the SOS signal, but in Morse code, it is: ... --- ...

3. PHYSICS

A. Horatio Nelson was not a physician; he was a British admiral — the physicist in question was Sir Isaac Newton. Legend holds that Newton saw an apple fall in 1666, and this inspired his theory of the universal law of gravitation — but the story may not be true.
B. Dutch spectacle-maker Zacharias Janssen was likely the inventor of the microscope with two lenses, an eyepiece and an objective, and it happened in 1595.
C. CORRECT. The calculation is based on Einstein's formula $E = mc^2$. E: energy, m: mass, c: speed of light.

4. MEDICINE

A. CORRECT. We produce around 2 ounces of urine per hour, equaling 1½ quarts a day and 145 gallons a year.
B. A hookworm is a small bloodsucking worm that enters the body through the skin of the feet, traveling to the alveoli in the lungs. From there, it migrates to the digestive tract, to which it adheres itself, sucking blood.
C. Paracetamol is a painkiller that relieves headaches, toothaches and menstrual pain.

5. ZOOLOGY

A. Although chimps share 94 to 96 percent of their genes with humans, they can't read.
B. CORRECT. There are around 2,000 species of microscopic wheel animals in the phylum Rotifera.
C. The hind part of the earthworm, which doesn't have a belt, will die, while the front part may live.

6. GEOGRAPHY

A. The island is called Isle of Wight, and it is by no means the United Kingdom's largest island.
B. The Rock of Gibraltar rises only 1,398 feet. Set on the southern tip of Spain, it has about 29,000 inhabitants.
C. CORRECT. The Himalayan chain was formed when two continental plates collided. The plates still press against each other, making the peaks grow ever higher.

7. TITLES

A. The word marquis originates from *Markgraf*, meaning field earl, and referred to earls in control of the borders.
B. The mullah title is derived from the Arabic word *mawlā*, meaning master, protector or substitute.
C. CORRECT. *Pontifex maximus* was the highest religious title in ancient Rome, and was later used by emperors.

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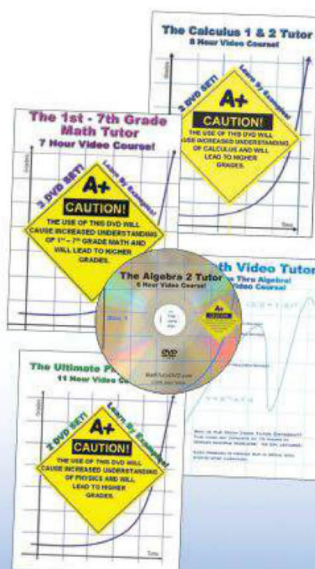
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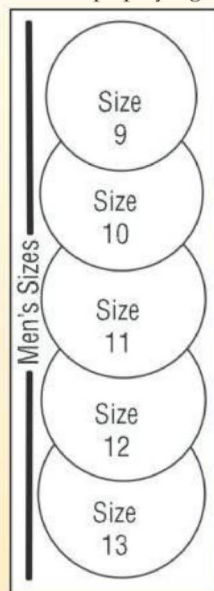
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In addition, people mistakenly formed their own laws of right and wrong action and during the rule of mankind's laws, warfare and dissention afflict the entire human race to this day.

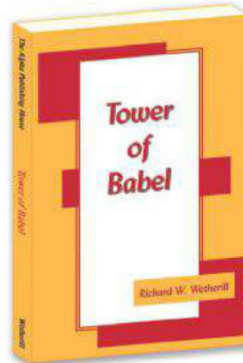
The good news is that decades ago, nature's **law of behavior** was identified by Richard W. Wetherill. He named it the **law of right action**, calling for people to behave in a **rational, honest way**. When conformed to, this natural law creates a rational, honest society, whereas society's nonconformity continues causing the increasingly chaotic situations being experienced today.

Clearly, the creator intended people to be rational and honest, but acting on their desires is preventing it.

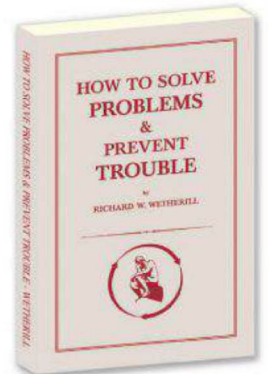
Sadly the **behavioral law** is still not known to a large segment of society, but most people know that conforming to natural laws is mandatory. Also, procedures and products are available to relieve people's unhealthy symptoms, but mankind's well-intended efforts do not address the basic cause, so we persist.

People must diligently conform to nature's self-enforcing behavioral law. That is the action which spontaneously releases multiple numbers of distortions of logic, as they contradict what this natural law deems is right action. The truth is that only by conforming to nature's behavioral law can people be given the fruits of peace and well-being promised by the creator of all self-enforcing natural laws!

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