

WHAT IS EVERYTHING MADE OF? p.50

BLIND VISION p.44

SCIENCE ILLUSTRATED

150 YEARS OF OIL

**The Fascinating History
(and Uncertain Future)
of the Resource That
Transformed the World**

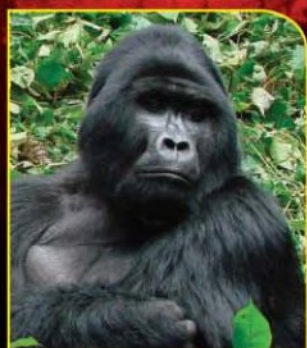
p.58



p.10

ACTOR 'BOT

Robotic Theater and
More Amazing
Photos



p.34

Last of the Mountain Gorillas?

A Bold Attempt to
Save an Iconic Species

p.70

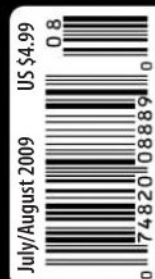
Not Your Average Bird Brain

Is a Crow Smarter
Than You Are?

p.42

A Stellar Family Tree

How One Star Can
Breed Generations More



CELESTRON ASTRONOMICAL EQUIPMENT, YOUR TICKET TO THE UNIVERSE!



Like an epic movie, our universe features action, drama, mystery, and unique plot twists that will intrigue you for the rest of your life. Let Celestron put you in the front row with one of our quality computerized or non-computerized telescopes. Available in a wide variety of sizes and optical designs at a price that will fit your budget.

The curtains have been drawn, it's time to let the plot unfold. Celestron invites you to join us in celebrating the 2009 International Year of Astronomy today!

To learn more visit us at www.celestron.com.

 **CELESTRON[®]**
www.celestron.com

**A****B****C****D**

PRICES REDUCED ON ALL NEXSTAR SE MODELS. SAVE UP TO \$200 TODAY!

For more details, visit www.celestron.com.

93970

Official Product
**SKYSCOUT®
PERSONAL
PLANETARIUM®**
of IYA 2009

A

21024

Official Product
**FIRSTSCOPE
COMPACT
TELESCOPE**
of IYA 2009

B

11068

NEW PERMANENT
**NEXSTAR® SE
COMPUTERIZED
TELESCOPE**
PRICE REDUCTION!

C

11074

**CPC® GPS
COMPUTERIZED
TELESCOPE**

D

Adorama - 800.223.2500 - www.adorama.com
Scope City - 800.235.3344 - www.scopecity.com
Optics Planet - 800.504.5897 - www.opticsplanet.com

Telescopes.com - 888.988.9876 - www.telescopes.com
Astronomics - 800.422.7876 - www.astronomics.com
Oceanside Photo and Telescope (OPT) - 800.483.6287 - www.optcorp.com
Hands on Optics - 866.726.7371 - www.handsonoptics.com

21st Century Shaker



Push Flip-Top closed.



Shake.



Push Flip-Top open.



Pour.

The new Flip-Top Cocktail Shaker is a feat of hydraulic engineering and high-tech sealing technology – a neater, cooler, easier way to mix cocktails.

There *are* advantages to living in the 21st century.

See video at metrokane.com

AT:

*Bed, Bath & Beyond, Sur La Table, KitchenKapers.com, Amazon.com, Winestuff.com,
Le Gourmet Chef, Chef Central, Zabar's, BevMo!*

 **rabbit™**
BARWARE
by Metrokane

Contents

JULY/AUGUST 2009

PARTICLE PHYSICS

P.50



From atoms to quarks: science's quest to find the smallest building blocks of matter.

NEUROLOGY

P.44



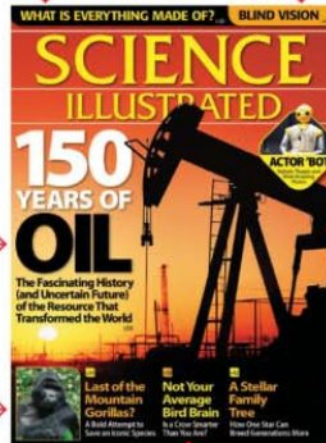
The fascinating phenomenon that is furthering our understanding of how the brain sees.

ENERGY

P.58



A look at the 150-year history of the petroleum industry—and the future of oil.



"Green oil began to erupt from the ground, cresting at twice the height of the derrick. And it didn't stop." P.58

ASTRONOMY

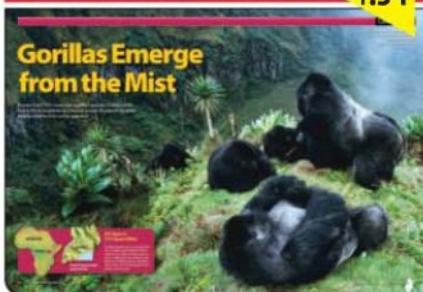
P.42



Infrared images cut through gas and dust to show that some stars may give birth to others.

CONSERVATION

P.34



With only around 700 mountain gorillas left in the wild, the clock is ticking for researchers.

INTELLIGENCE

P.70



When it comes to brain power, birds are giving primates a run for their money.

NEUROBIOLOGY

P.56



A hormone that promotes trust and bonding could revolutionize treatment for autism.

ASK US p.26



WORLD OF SCIENCE p.82



ASK US p.28



Departments

Bull's-Eye p.8

Robot theater, creative CT scanners, peculiar bird reproduction, and an herbal remedy for Alzheimer's—all in this month's gallery of amazing images.

Science Update p.17

Cellotape x-rays, dino tail feathers, fungus fuel, more than 1,000 new species, ancient gecko feet preserved in amber, and the first space beer.

Ask Us p.25

Can wind turbines kill animals? Why do peppers make us sweat? Do reptiles get fever? Why are all fingerprints unique? What's a railgun?

World of Science p.80

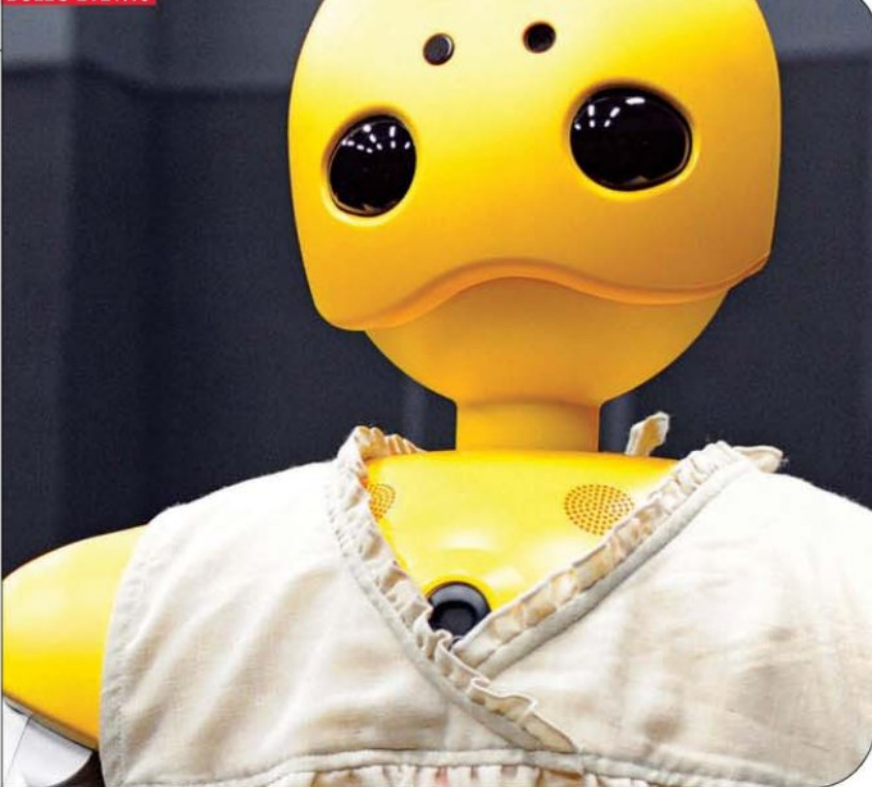
When animals invade, chromosome highs and lows, birds that use stone tools, and other nuggets of scientific knowledge.

Letters p.6

Trivia Countdown p.84

Brain Trainers p.88

BULL'S-EYE p.10



SCIENCE UPDATE p.20



**WRIGHT'S
REPRINTS**

For licensing and reprints of *Science Illustrated* content, contact Wright's Reprints at 877-652-5295.



Please recycle
this magazine.



PEFC
PEFC/29-31-75

The paper used for this magazine comes from certified forests that are managed in a sustainable way to meet the social, economic and environmental needs of present and future generations.

DISCOVER YOUR Universe

OPT has the largest selection of astronomy equipment on the planet. Whether it's an entry level telescope or a complete robotic observatory, our experienced and knowledgeable sales staff can help you choose the right telescope at the right price. We've been in business over 60 years and serving the astronomical community since 1980.



OPT

optcorp.com | 800.483.6287





Amazing Brain

I found your article "What Is Consciousness?" [May/June] quite interesting. The philosophical problem with this issue is the idea of consciousness as one thing at the center of the mind. That one thing appears to be the eventual outcome of many neurological events, however. Most of our thinking may be taking place on a level that we are not consciously aware of.

Karl Hanson Glenview, Ill.

A Solid Issue

In "Jupiter Changes Its Spots" ["Science Update," May/June], you say the spots or storms on the planet are caused by an uplift of surface material. What material? According to NASA, there is no known surface on Jupiter.

Pat Eidenier Blanchester, Ohio

EDS: Although Jupiter is a gas planet, the word "surface" is occasionally used in discussions of its structure. The material we referred to is believed to originate in the deeper reaches of Jupiter's atmosphere.

Zero-Sum Solution?

In "Could Quicklime Help Cool the Planet?" ["Science Update," May/June], you report that Cquestrate plans to make quicklime (CaO) from limestone (CaCO₃) to sequester CO₂ in the oceans. But the process releases CO₂. The production of quicklime and its use to sequester CO₂ is, therefore, a zero-sum equation.

Don Chesnut Lexington, Ky.

EDS: The conversion of limestone to quicklime does release CO₂. But according to Cquestrate, its process sequesters twice as much of the gas as it emits.

Fit to Be Tied

You claim in the "Headbreakers" answers [May/June] that there is a 1-in-4 probability of forming a knot from the pile of rope shown. But for any length of rope greater than six feet with a diameter of less than or equal to a quarter of an inch, the probability of a knot being formed based on a random sampling of 1,000 piles of rope is close to 75 percent.

William D. Howell, Sr. Eustis, Fla.

EDS: For a random pile of rope, there are any number of configurations that could result in a knot. The picture showed what the pile looked like, but the crossings were ambiguous. The probability is based only on which strand is over and which is under in each of the three rope crossings.

Correction

In "The Next Moon Race" [May/June], we stated that the minimum surface temperature on the moon is -472°F. That temperature is actually around -400°.

SCIENCE ILLUSTRATED

Editor-in-Chief Mark Jannot

Creative Director Sam Syed
Deputy Editor Jacob Ward
Senior Associate Editor Jennifer Abbasi
Science Editor Martha Harbison
Editorial Production Manager Felicia Pardo
Translator Jonathan D. Beard
Copy and Research Director Rina Bander
Copy Editor Ellen Weiss
Staff Editors Lauren Aaronson, Doug Cantor, Bjorn Carey, Nicole Dyer, Seth Fletcher, Mike Haney, Susannah F. Locke
Fact Checkers Brooke Borel, Melynda Fuller, Erika Villani
Editorial Assistant Amy Geppert
Contributing Art Director Patrick F. Albertson
Photo Editor Kristine LaManna
Contributing Mathematician I. Martin Isaacs
Contributing Writers Henrik Bendix, Jesper Bindlev, Søren Bjørn-Hansen, Tina Frederiksen, Ulla Host, Rasmus Kragh Jakobsen, Thea Mikkelsen, Gorm Palmgren, Lars Petersen, Ole Presskorn, Helene Rosenstand, Ib Salomon, Anker Tiedemann, Klaus Wilhelm
Editorial Interns Lindsey Konkel, Marshall Louis Reaves

Group Publisher Gregg R. Hano

Associate Publisher, Advertising Wendi S. Berger
Executive Assistant Christopher Graves
Marketing Director Mike Gallic
Financial Director Tara Biscello
Vice President, Corporate Sales and Marketing Pete Michalsky
Northeast Advertising Office: Alex DeSanctis 212-779-5129, Chris Young 212-779-5148, Susan Faggella 212-779-5007, Taryn Guillermo 212-779-5030
Midwest Advertising Office:
Manager John Marquardt 312-252-2838
Ad Assistant Krissy Van Rossum
Los Angeles Advertising Office:
Manager Robert Hoeck 310-227-8958
Ad Assistant Kate Gregory
Detroit Advertising Office:
Manager Edward A. Bartley 248-282-5545
Ad Assistant Diane Pahl
San Francisco Advertising Office: Jill Stankoski 415-496-2700
Southern Regional Advertising Office:
Manager Jason A. Albaum 404-892-0760
Digital Sales Development Manager Brian Glaser
Sales Development Managers Kerri Levine, Alexis Costa
Creative Services Director Mike Iadanza
Marketing Art Director Shawn Woznicki
Promotions Manager Eshonda Caraway
Consumer Marketing Director Bob Cohn
Associate Directors Lauren Rosenblatt, Andrew Schulman
Sr. Planning Manager Raymond Ward
New Business Manager Cliff Sabbag
Retention Director Connie Cotner
Single Copy Sales Director Vicki Weston
Publicity Manager Amanda McNally
Human Resources Manager Kim Putman
Production Manager Betty Dong
Group Production Director Laurel Kurnides
Operations Director Mimi Rosenfeld
SCIENCE ILLUSTRATED DENMARK
Editor-in-Chief Jens E. Matthiesen
International Editor Christian Baekgaard
Art Director Hanne Bo
Picture Editors Allan Baggesø, Lisbeth Brännich, Peter Eberhardt

BONNIER CORPORATION

Chairman Jonas Bonnier
Chief Executive Officer Terry Snow
Chief Operating Officer Dan Altman
Chief Financial Officer Randall Koubek
Vice President, Consumer Marketing Bruce Miller
Vice President, Production Lisa Earlywine
Vice President, E-Media Bill Allman
Vice President, Enterprise Systems Shawn Larson
Vice President, Human Resources Cathy Hertz
Vice President, Corporate Communications Dean Turcol
Brand Director John Miller
Publishing Consultant Martin S. Walker
Corporate Counsel Jeremy Thompson

SCIENCE ILLUSTRATED is published under license agreement with Bonnier Publications. Copyright 2009 Bonnier Publications, Copenhagen, Denmark.

For customer service, go to scienceillustrated.com/manage. You can also call 866-429-0139; outside the U.S., please call 386-597-4388. Or you may write Customer Service, P.O. Box 420235, Palm Coast, FL 32142-0235.

MAIN OFFICE
 2 Park Ave., 9th Fl.
 New York, NY 10016
 Fax: 212-779-5108
 Web: scienceillustrated.com

NEW SUBSCRIPTIONS
 Phone: 866-429-0139
 Web: scienceillustrated.com/subscribe

LETTERS
 Please send letters to the editor to letters@scienceillustrated.com. We regret that we cannot answer unpublished letters. Letters may be edited for length or clarity.

SUBSCRIPTION INQUIRIES
 Report address changes and subscription questions to: SCIENCE ILLUSTRATED
 P.O. Box 420235
 Palm Coast, FL 32142-0235
 Phone: 866-429-0139
 Web: scienceillustrated.com/manage



He was a
hardworking farm boy.

She was an
Italian supermodel.

He knew he would
have just one chance
to impress her.

The fastest and easiest
way to learn ITALIAN.

Arabic • Chinese (Mandarin) • Danish • Dutch • English (American) • English (British) • French • German • Greek • Hebrew • Hindi • Indonesian • Italian • Irish • Japanese • Korean • Latin • Pashto • Persian (Farsi) • Polish • Portuguese (Brazil) • Russian • Spanish (Latin America) • Spanish (Spain) • Swahili • Swedish • Tagalog (Filipino) • Thai • Turkish • Vietnamese • Welsh

Rosetta Stone® brings you a complete language-learning solution, wherever you are: at home, in-the-car or on-the-go. You'll learn quickly and effectively, without translation or memorization. You'll discover our method, which keeps you excited to learn more and more.

- You'll experience **Dynamic Immersion®** as you match real-world images to words spoken by native speakers so you'll find yourself engaged and learn your second language like you learned your first.
- Our proprietary **Speech Recognition Technology** evaluates your speech and coaches you on more accurate pronunciation. You'll speak naturally.
- Only Rosetta Stone has **Adaptive Recall™**, that brings back material to help you where you need it most, for more effective progress.
- And Rosetta Stone includes **Audio Companion™** so that you can take the Rosetta Stone experience anywhere you use a CD or MP3 player.

Innovative software. Immersive method. Complete mobility. It's the total solution. Get Rosetta Stone—**The Fastest Way to Learn a Language. Guaranteed®**



SAVE 10%!

**100% GUARANTEED
SIX-MONTH MONEY-BACK**

Level 1	Reg. \$259	NOW \$233
Level 1&2	Reg. \$419	NOW \$377
Level 1,2&3	Reg. \$549	NOW \$494

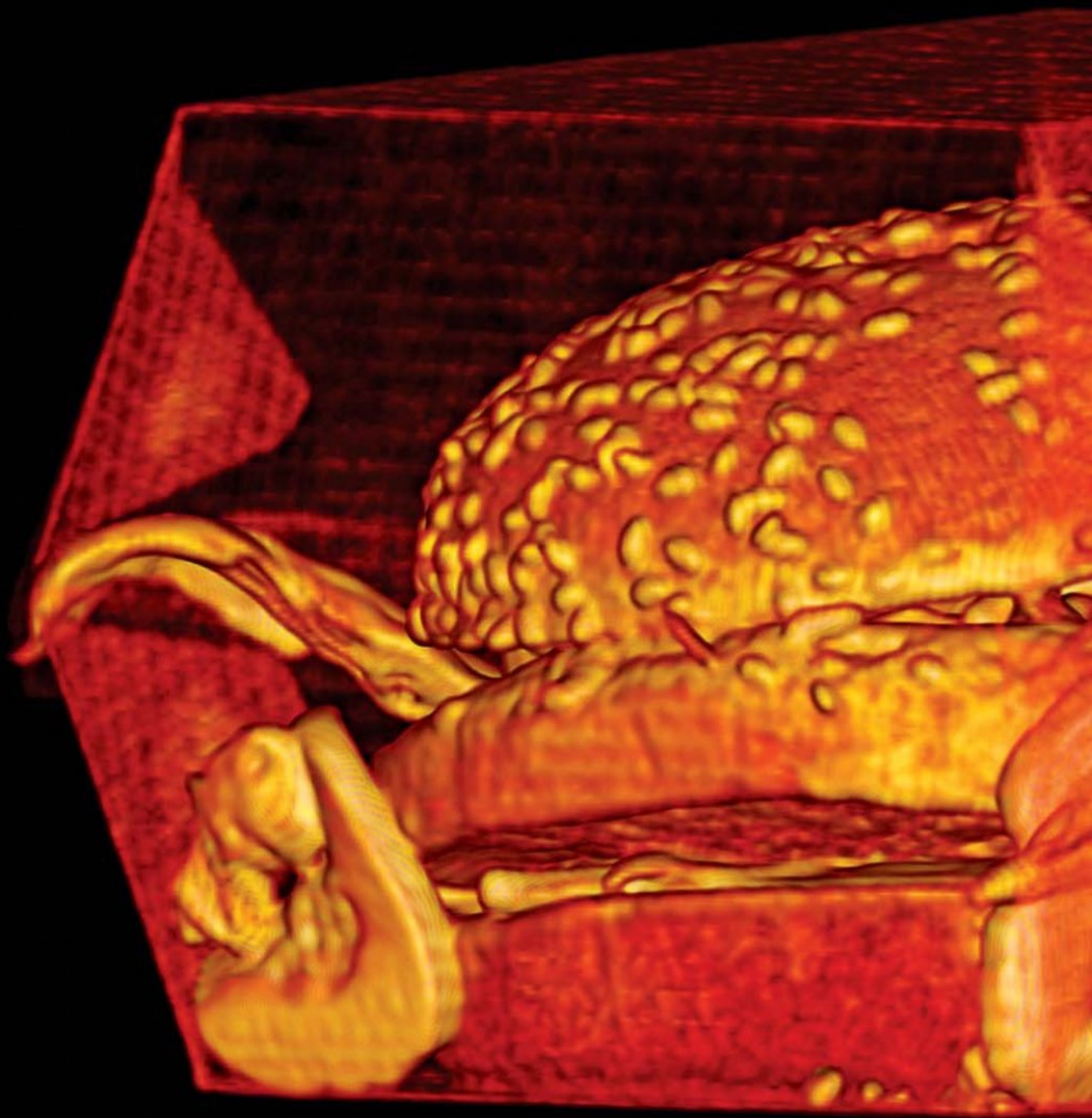
©2008 Rosetta Stone Ltd. All rights reserved. Offer applies to Personal Edition only. Patent rights pending. Offer cannot be combined with any other offer. Prices subject to change without notice. Six-Month Money-Back Guarantee is limited to product purchases made directly from Rosetta Stone and does not include return shipping. Guarantee does not apply to an online subscription or to Audio Companion purchased separately from the CD-ROM product. All materials included with the product at the time of purchase must be returned together and undamaged to be eligible for any exchange or refund.

Call
(866) 203-4704

Online
RosettaStone.com/sws079

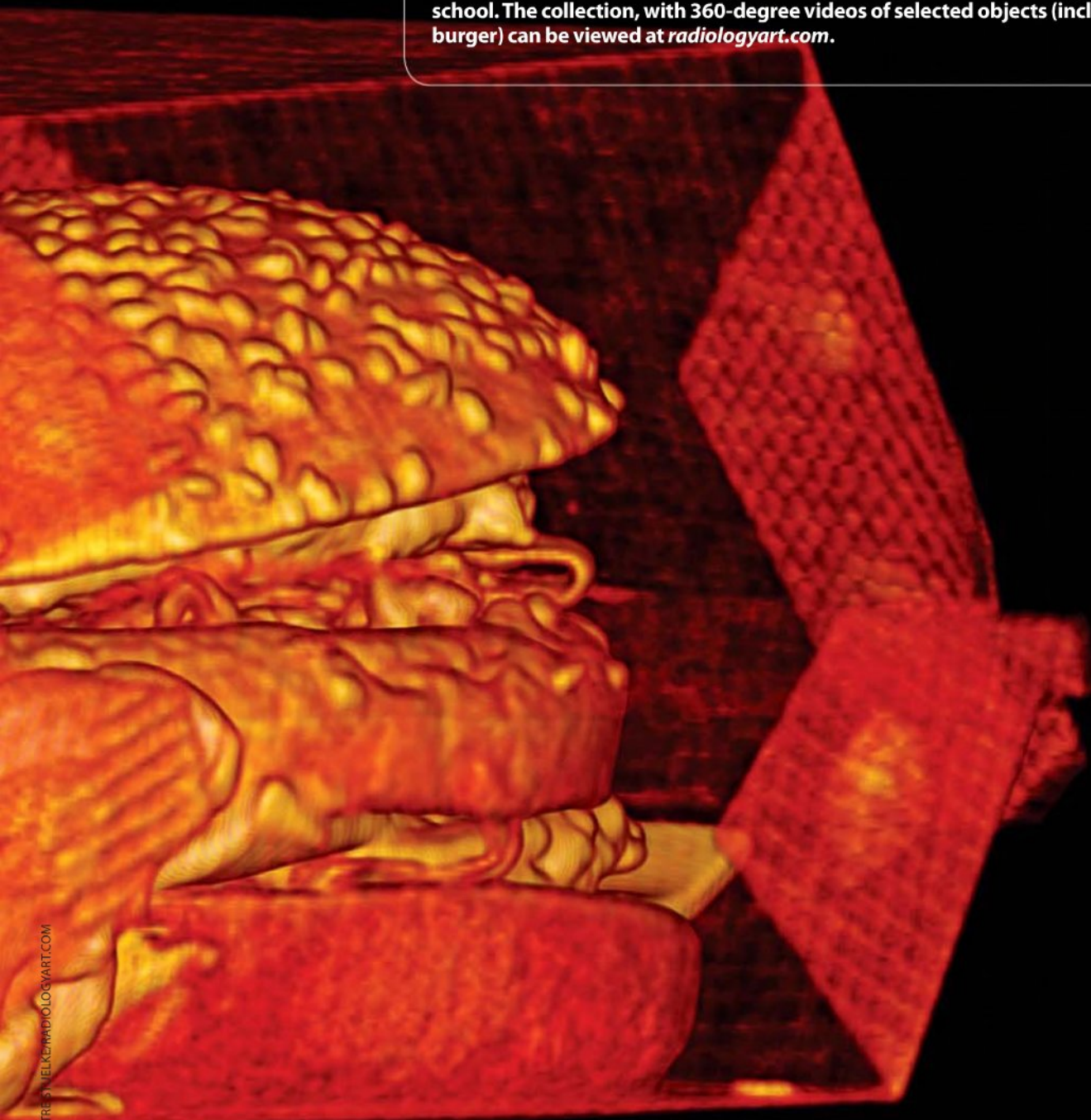
Use promotional code **sws079** when ordering.
Offer expires November 30, 2009.

RosettaStone® 



McScan

A Big Mac gets a full workup by a CT scanner in one of 42 images in artist-turned-medical student Satre Stuelke's ongoing radiology-art project. Stuelke's scans of everyday objects—from rubber duckies to Apple laptops to Barbies—began in 2007, when curiosity drove him to peer inside a TV dinner using a research scanner in a radiology lab at Weill Cornell Medical College. "The Big Mac is a cultural icon and a center of controversy," explains Stuelke, now in his fourth year of med school. The collection, with 360-degree videos of selected objects (including the burger) can be viewed at radiologyart.com.

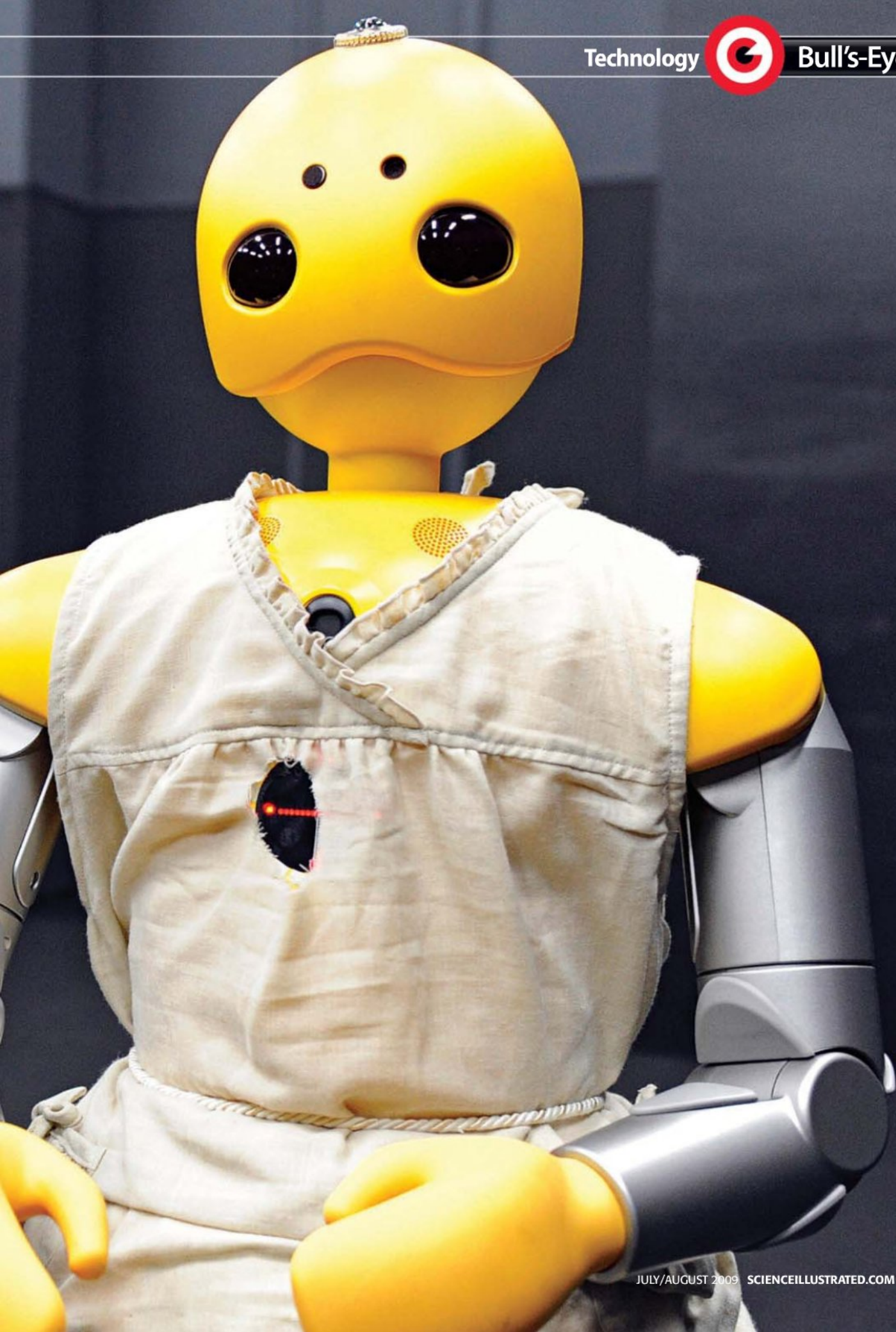




Lights, Camera, Android

Momoko [foreground] and Takeo, two of Mitsubishi's autonomous Wakamaru robots, perform in the 20-minute play *Hataraku Watashi*, or *I, Worker*, at Osaka University in Japan last November. One of the world's first theater productions starring robots, the play explores the relationship between humans and technology. Wakamaru is being developed as a household helper and companion, but for now only beta testers can snag one. Known as the "communication robot," it recognizes as many as 100 human faces and understands about 10,000 words. It also receives wireless updates to relay news and weather forecasts or remind people to take their medication.

YOSHIKAZU TSUNO/AFP/GETTY IMAGES





Opposites Don't Attract

Genetic incompatibilities between different-colored finches lead to high mortality rates among their offspring. Hence, faced with a choice between a black- and a red-headed suitor, the female Gouldian finch, shown perched on the bottom wire of a fence post in northern Australia, will almost certainly opt for black. Female offspring of mixed parentage have higher death rates than males, which seems to be why more males were produced when researchers at Macquarie University allowed only different-color finches to mate during the 2006 and 2007 breeding seasons. In all birds, an egg's gender is determined before fertilization occurs. An unknown hormonal mechanism may allow a female finch to bias the gender of the eggs she produces toward males when mating with a finch of a different color, helping to lower the odds of her chicks dying. Such mating research could help captive-breeding programs save the iconic bird, whose population is threatened by habitat loss.

COURTESY SARAH PRYKE



Sage Wisdom

Sage-extract pills, such as those shown here, have been linked to better short-term memory in healthy volunteers and increased cognitive function in Alzheimer's patients and could one day be part of the standard treatment for the disease. Researchers at the Medicinal Plant Research Centre (MPRC) in England are exploring ancient herbal remedies using modern techniques in chemistry and molecular biology. Extracts from sage leaves contain chemicals that inhibit cholinesterase, an enzyme that can hinder memory function in older adults with Alzheimer's. Although MPRC's clinical results seem promising so far, physician-prescribed sage pills are most likely still several years away.





UNLIMITED Local & Long Distance Calling

\$24.99

Per Month[†]

Get UNLIMITED Local & Long Distance Calling for only \$24.99/mo[†]!

SAY NO TO HIGHER PHONE BILLS!

- Our price STARTS LOW AND STAYS LOWsm. Satisfaction Guaranteed^{!1}
- No bundles, no hassles, no introductory pricing—just reliable phone service at a reliable price!

EASY TO SWITCH, EASY TO SAVE

- Keep your existing phone number[^].
- Vonage[®] works with your existing home phone and high-speed Internet connection.
- 25 Premium Features at no extra cost.
- Free calls to 5 select European countries and call other International locations for as low as 1 cent per minute^{!1}

SPECIAL OFFER

TRY ONE MONTH FREE!

See Details Below

Call: 1.877.361.1546

FREE MONTH OFFER ON \$24.99 UNLIMITED RESIDENTIAL PLAN ONLY. PLAN FEE WAIVED BUT ALL OTHER CHARGES APPLY. NEW SUBSCRIBERS ONLY. V Free calls to Europe Offer (available only with Unlimited Residential Plan) does not apply to certain call types, such as calls to cell phones, and is limited to Italy, France, Spain, UK and Ireland. Other International rates may vary. See <http://vonage.com/intrates> for details. Vonage 911 service operates differently than traditional 911. See www.vonage.com/911 for details. High-Speed Internet or Broadband Required. Alarms and other systems may not be compatible. † Rates exclude: broadband service, regulatory and activation fees and certain other charges, equipment, taxes, & shipping. International calls billed per minute. Offer valid in the US only. See Terms of Service for details. < 30-day money back guarantee is refunded for any paid activation fee, 1st month service charge, initial shipping charges and termination fee. Applicable only to first ordered line per account. Available only in the event of timely cancellation for subscribers who have not exceeded 500 minutes of usage and who obtain a valid return authorization number from 1-VONAGE-HELP, and return of equipment in original condition and packaging within 14 days of cancellation. Refund will not include charges for taxes, international usage, payphone calls to Vonage toll free numbers and directory assistance. Offer revocable. ^ Where available. The number transfer process takes approximately 10 business days from the time you confirm your transfer request. ©2009 Vonage.

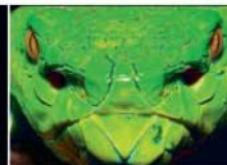
Science Update



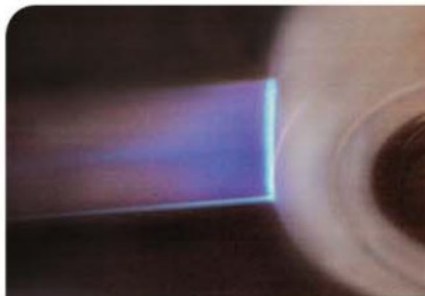
P. 18
**A new way
to diagnose
autism**



P. 19
**Creating fuel
from fungal
spores**



P. 20
**Pit viper is one
of 22 newly
found snakes**



Peeling a piece of tape in a vacuum emits electromagnetic radiation [blue].

Sticky X-rays

TECHNOLOGY Inside a vacuum, an ordinary roll of Scotch tape can emit x-rays powerful enough to make an image. The finding, published last fall by scientists at the University of California at Los Angeles, could inspire cheap, portable alternatives to traditional x-rays.

Researchers found that when you peel a piece of tape off the roll, electrons jump from the negatively charged non-sticky side to the positively charged sticky side. In air, gas molecules slow the electrons, so those collisions are not sudden enough to cause the same reaction. But in a vacuum, the electrons collide violently with the sticky side, emitting high-energy x-ray radiation as they come to a sudden stop. Before the technology can be practically used, scientists will have to devise a way to produce the effect in air rather than solely in a vacuum.

FLASH! Sprinters react faster to a starter's pistol the closer they are to the gun, probably because the shot is louder at shorter distances, say researchers at the University of Alberta. Other studies have shown that loud sounds trigger a startle response that leads to quicker reaction times.

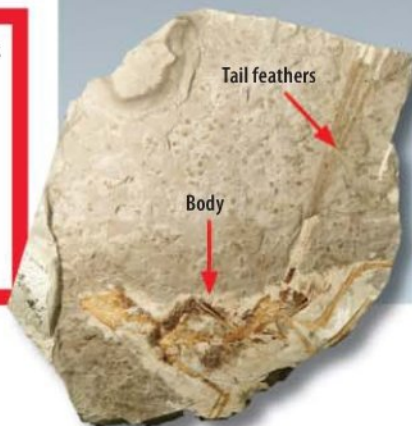
How Birds Got Their Feathers

A diminutive dinosaur's tail reveals new clues to avian plumage

PALEONTOLOGY Archaeologists from the Chinese Academy of Science in Beijing say a recently discovered fossil casts new light on how feathers may have evolved in dinosaurs, the ancestors of modern birds.

The scientists uncovered the almost-complete *Epidexipteryx hui* remains in Inner Mongolia in northern China last year. The pigeon-size dino sported four long, ribbon-like tail feathers but lacked flight feathers. Researchers think *E. hui* may have used its plumage for balance or flaunted the feathers in mating displays.

The two-legged dinosaur lived 152 to 168 million years ago, making it slightly older than the oldest known bird, the extinct *Archaeopteryx*. This timing suggests that feathers may have evolved not only for flight or warmth but for reproductive purposes as well.



Four distinct tail feathers are evident in the well-preserved fossil of this reptile.





Computer simulations show small planets like Earth forming near a gas giant [white].

Where Other Earths May Be Hiding

ASTRONOMY Rocky Earth-like planets can arise during the formation of gas giants like Jupiter, according to computer simulations published last November by a team of European scientists. The finding may help answer a major question in astrophysics: how planets form.

Researchers at Uppsala University in Sweden and Leiden University in the Netherlands calculated that the residual material from the creation of a gas giant can coalesce to form planets with rocky crusts like Earth's. Under the right conditions, multiple bodies may even form from the material and share stellar orbits with the giants. This means that potentially habitable planets could be lurking within the same orbits as gas giants in other solar systems.

FLASH! Forty thousand years ago, groups of people that had been scattered across Africa for more than 100,000 years reunited to form a single group, according to mitochondrial DNA analysis by the Genographic Project, a joint effort of the National Geographic Society and IBM to study human migration across the globe. The total African population may have been as small as 2,000 people at the time, but the reunion resulted in a population explosion—and subsequent migrations out of Africa.

Genetically Modified Crops Protect Neighbors

BIOLOGY Cotton plants that have been genetically modified to protect themselves against pests also protect other nearby crops, say scientists at the Chinese Academy of Agriculture in Beijing.

Researchers compared the number of cotton bollworms in 93 million acres of farmland between 1997 and 2007. The survey showed that the insect's numbers decreased not only in fields with cotton plants modified to produce the fungal insecticide Bt (*Bacillus thuringiensis*) but in nearby fields of non-genetically modified cotton, soybeans and peanuts as well. The researchers believe that Bt was able to reduce the total bollworm population by keeping the insects out of cotton

crops, where outbreaks typically begin.

Genetically modified crops could be a more palatable alternative to chemical insecticides for Chinese farmers, who often shun the sprays due to their health risks.



Genetically modified cotton can keep large areas free from pests such as the cotton bollworm.

Autistic Children Hear in Slow Motion

New research may allow doctors to diagnose autism in infancy

MEDICINE Researchers at Children's Hospital of Philadelphia have discovered that the brains of autistic children react more slowly to sounds than the brains of non-autistic children. The finding, published in December, may help explain why people with the developmental disorder have difficulty communicating.

Timothy Roberts and a team of scientists used an imaging technique called magnetoencephalography (MEG) to investigate brain activity in 64 autistic children between the ages of 6 and 15. Wearing a helmetlike device that picked up magnetic fields created by brain activity, the children

were presented with various sounds, including pairs of tones in rapid succession. The researchers found fraction-of-a-second delays in sound processing when compared with children who don't have the disorder. These almost-imperceptible lapses may cause autistic children to become overloaded when confronted with a string of sounds such as human speech, leading to problems in understanding and producing language.

The researchers hope their findings may allow the condition to be diagnosed in infancy—two years earlier than when the diagnosis is typically made.

FROM LEFT: W. LYRA/UPPSALA UNIVERSITY; K. WU/X. LU



Fungus Fuel on the Horizon?

TECHNOLOGY A fungus found growing inside tree branches in an Argentinean rainforest produces some of the ingredients of fossil fuels, researchers announced in November. The ingredients, collectively dubbed myco-diesel, could someday be used to power cars and planes.

Botanist Gary Strobel of Montana State University discovered the fungus, known as *Gliocladium roseum*, growing inside the branches of the ulmo tree. It is the only or-



A spore of *Gliocladium roseum* fungus, which produces hydrocarbons

ganism known to make hydrocarbons—long chains of carbon and hydrogen molecules that produce energy when burned. Scientists are now analyzing the fungus to find out which genes are responsible for the hydrocarbon production and whether the organisms can be manipulated to produce a higher yield of the compounds needed to make fuel.

Russian Stone Age Art Links Cultures

Artwork from Russia shows that remote groups of prehistoric humans may have been interconnected. Archaeologists from the Russian Academy of Sciences recently excavated 10,000- to 40,000-year-old bone carvings, including a female figurine [left], in Zaraysk, about 100 miles south of Moscow. They are similar to carvings found in other regions of Russia and Europe, indicating that distant populations may have shared ideas.



A MEG scanner measures reaction times in the brains of children with autism.



When Looks Matter More Than Policies

PSYCHOLOGY A candidate's resemblance to voters can sway their votes, as evidenced in a Stanford University study. The first experiment took place a week before the 2004 presidential election. Volunteers were shown pictures of George W. Bush and John Kerry and asked for whom they would vote. Some volunteers saw images of the candidates that

had been morphed with their own images to make the photos resemble themselves. A control group was shown unaltered pictures.

The control group preferred Bush, giving him a victory of two percentage points (the same margin of victory as the actual election). But when voters' photos were morphed with Bush's, he won by 13 percent. Even more

surprising, when Kerry's photo was changed to resemble voters, he won by 7 percent—a stunning departure from the real-life results.

Similar results were found when the experiment was repeated using photos of less-familiar candidates during the 2008 presidential primaries, suggesting that subtle influences may be at work when we vote.

Southeast Asia: a Biodiversity Bazaar



Scientists have recently discovered 88 species of spiders, including one with a foot-long leg span.

The Mekong River and its banks are home to more than 1,000 previously unknown plant and animal species

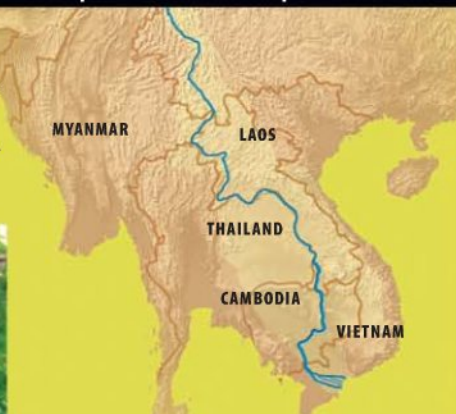
BIOLOGY Scientists are finding a treasure trove of new species in the thick forests along the Mekong River in Southeast Asia. A recent World Wildlife Fund study counts at least 1,068 unique plant and animal species discovered there between 1997 and 2007.

Researchers from several institutions around the world found such creatures as a Laotian rock rat—thought to have gone extinct 11 million years ago—for sale at a food market, a spider with a nearly foot-long leg span and a new deer species. The discoveries along the 2,700-mile river included 519 new plants, 279 fish and 88 types of spiders, as well as 88 frogs, 22 snakes, 15 mammals and four new bird species. The rich

biodiversity along the Mekong River could be lost if the area is not protected, warns the report. Logging and mining activities are increasingly threatening the 232,000-square-mile region.



The Laotian rock rat was assumed to have gone extinct 11 million years ago.



River of Life

The Mekong River stretches 2,700 miles south from central China through Myanmar, Laos, Thailand, Cambodia and Vietnam.

The venomous Gumprecht's green pit viper is one of 22 newly found snakes.



The **First** Lincoln Turns 100!

Exclusive

Release

Special



Hoard

VDB Cents

The Coin with Many "Firsts"— First Shocked the Nation

Issued to celebrate the 100th anniversary of Lincoln's birth, the 1909 Lincoln Cent would have been coveted enough as a first-year-issue coin. But when designer Victor David Brenner conspicuously included his initials "V.D.B." on the coin's reverse, it caused a nationwide scandal.



Struck by the U.S. Mint, only a few 1909-dated Lincoln cents were minted before public outcry and protest got the initials removed from this spot forever. This was also the first cent to feature a portrait of a president, and it was the first to bear the motto "In God We Trust." 2009 represents the 100th anniversary of this beloved coin—a "must-have" coin for any collector!

We secured a small hoard of these coins in time for the centennial, but they won't last long! Plus, each 1909 V.D.B. Lincoln Cent comes in an exclusive PCGS encapsulated holder that features the scandalous initials. Orders will be accepted on a strict first-come, first-served basis. Call today to order yours—only \$39.95 for one or \$34.95/each for five!



New York Mint

©2009 Not affiliated
with the U. S. Mint

800-642-9160 ext. 6725

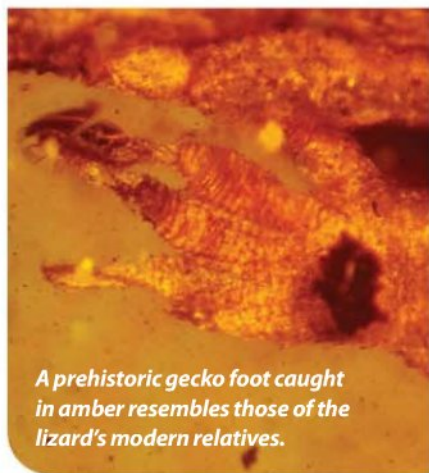


FLASH! German researchers have devised a new method to deliver Alzheimer's drugs to a hard-to-reach enzyme associated with the disease. The drugs attach to cell membranes, where the enzyme resides. The membranes eventually absorb the drugs, allowing them to target the enzyme. The procedure, which is being tested in animal models, also holds promise for treating other diseases such as Ebola and HIV, researchers say.

Sticky Feet 100 Million Years Old

ARCHAEOLOGY Geckos developed the ability to climb up vertical surfaces and even to walk upside down more than 100 million years ago, say zoologists at the Natural History Museum in London and Oregon State University. These lizards have millions of minute hairlike setae on structures called lamellae on the bottoms of their feet that help them hold onto even the smallest irregularities on seemingly flat surfaces.

The researchers recently excavated an ancient gecko's foot embedded in amber from Myanmar's Hukawng Valley. Remarkably well-preserved, the specimen, with the lamellae intact, is estimated to be 97 to 110 million years old. It belonged to the extinct group *Cretaceogecko*, a newly discovered genus that is at least 40 million years older than any previously known groups of geckos.



A prehistoric gecko foot caught in amber resembles those of the lizard's modern relatives.



Sapporo's limited-edition Space Barley isn't coming to a liquor store near you.

Space Beer Makes Its Debut

Sapporo's new brew uses barley grown on the International Space Station

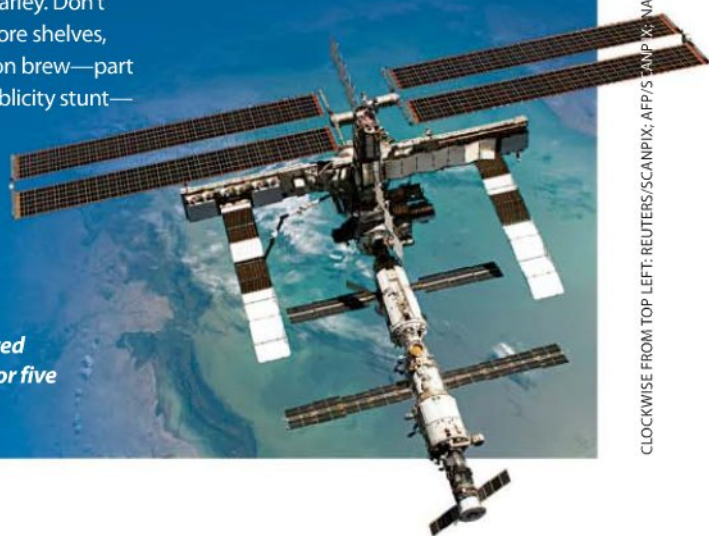
SPACE AGRICULTURE Last year, scientists from Okayama University in Japan teamed up with Russian astronauts to cultivate barley aboard the International Space Station, the latest in a series of agricultural experiments performed in the weightless conditions of outer space.

Back on Earth, Japan's Sapporo Breweries produced more than 25 gallons of "space beer" from the barley. Don't bother looking for it on store shelves, though. The limited-edition brew—part proof-of-concept, part publicity stunt—

was a one-shot deal. Thirty couples in Tokyo sampled the beer this January.

Space agriculture is an important area of research for future colonies on the moon, Mars or beyond, and the Okayama researchers say the barley proved no different from that grown on Earth. The ISS has also been home to successful lettuce, pea and wheat crops since astronauts took up residence in 2000.

Researchers experimented with barley cultivation for five months aboard the ISS.



CLOCKWISE FROM TOP LEFT: REUTERS/SCANPIX; AFP/STAMP; NASA; OREGON STATE UNIVERSITY

If you suffer from

- | | | |
|--|---------------------------------------|---|
| ☐ Stress | ☐ Constipation | ☐ Restless Legs Syndrome |
| ☐ Headaches | ☐ Back Pain | ☐ Poor Circulation |
| ☐ High Blood Pressure | ☐ Diabetes | ☐ Insomnia |
| ☐ Arthritis | ☐ Neuropathy | ☐ Sleep Apnea |
| ☐ Fibromyalgia | ☐ Edema | |
| ☐ Joint Pain | | |



You will enjoy using the Exerciser 2000 Elite™

Receive some of the benefits of aerobic exercise without stress or impact on the joints!

Energize the body

Relaxation of the back muscles

Increased mobility

Don't be fooled by cheap imitations

Helps relieve stiffness from head to toe

Increase circulation throughout the body

This is How it Works

The machine creates a right to left movement that gently moves the body back and forth. This gentle swinging motion cycles up through the whole body, increasing flexibility and range of motion.

Invest in your health today...it's a sure thing.

FEATURES

- Built in an ISO-9001 CERTIFIED facility
- FDA Class Registered
- ETL Approval
- 5-speed operation
- 2 pre-programmed selections
 - one for relaxation
 - one for energizing
- Heavy duty, high torque DC motor
- Wide cushioned ankle rest
- 16 minute digital timer with safety shut-off
- 4 years parts and 2 years labor warranty
- Weighs only 15 pounds
- 15" wide x 13.5" deep x 9.5" high

220/230 volt models available for International use

I have had such lower back pain that I could hardly stand it. I saw your ad two years ago and thought it wouldn't help me. But, I ordered one anyway. I have used it for four months now. I have very little back pain, am more regular, and I sleep much better thanks to the Exerciser 2000. —C. Cordes

As a Chiropractor, I would say the Exerciser 2000 enables people to benefit themselves at home. It is a valuable asset in moving lymph fluid, oxygenating the blood, increasing immune system function, maintaining mobility in the spine, and freeing up a spine that had become stiff and arthritic. —Garry G., D.C.

I have loved your product for many years now and couldn't live without one. It truly is the best product on the market...and I would never pay a person to do what this does better. You have the control of it all... and I love that. It definitely pays for itself many times over!! —Kathy C.

~~\$464.95~~



For additional information and more reviews from our satisfied customers visit

www.clarkenterprises2000.com

Use code **G600** when ordering by phone or website and receive factory direct pricing **\$389.95**

FREE shipping in the 48 contiguous states

90 Day No Risk Money Back Guarantee

If you are not completely satisfied, you can return the machine for a full refund.

Save \$100 on reconditioned units when available.

Price, terms and conditions subject to change without notice. These statements have not been evaluated by the FDA. Not intended to treat, cure or prevent any diseases.



Clark ENTERPRISES 2000 INC
The helping people feel better company

240 Berg Road, Salina, KS 67401

1-800-748-7172



THE ULTIMATE IN OPTICS SHOPPING:

www.adorama.com



FREE
Shipping

On Thousands Of Products
See our web site

14 Day Money Back GUARANTEE Please check our website for details



NEXSTAR 130 SLT

130mm (5.1") diameter
Newtonian Reflector
Telescope with Motorized
Altazimuth Mount & 4,000+
Object Database



SKYSCOUT

A fun learning tool for all
ages, the SkyScout personal planetarium
puts the knowledge of an expert
astronomer in the palm of your hand.
Item Includes: Carry Case,
Earphones, Hand Strap, USB Cable



NEW!
Lower
Price

Canon

EOS 50D

- 15.1 Megapixel
CMOS sensor
- DIGIC 4 Image Processor
- 3.0-inch Clear View LCD
- 9 cross-type high-
precision sensors
- Compatible with all Canon
lenses in the EF and EF-S
lineup



MOST IN-STOCK ITEMS
ordered by 5:00PM EST
Monday through Thursday & Friday till 1:00PM
SHIP THE SAME DAY



DS-2114ATS LNT 4.5" 1000MM

f/8.8 Altazimuth Reflecting
GO TO Telescope with LNT,
AutoAlign, Electronic Level
Sensor, Generation II Mount



Sky-Watcher ACUTER 70MM

Digital Spotting Scope with
32MB On-board
Memory, USB
Interface



Canon

10 X 30 IS

- Image Stabilized,
- Weather Resistant
- Porro Prism Binocular with
6.0° Angle of View, U.S.A
- Doublet field flattener lens
- Super Spectra Coating
- Closest focusing distance of 4.2 meters/13.8 ft.
- Rounded design for holding comfort



TRIPODS & HEADS

SPOTTING SCOPES



WRB603/BOXS Emergency Public Alert Radio With Weather Station With Charging Cradle

Automatically sets itself to the U.S. Atomic
Clock and adjusts for Daylight Saving Time



Bushnell

SPACEMASTER 60MM

Straight View Spotting Scope Kit
with 15-45x Zoom Eyepiece, Table Top
Tripod and Backpack Carry Case, Black



EDGE 305

GPS Enabled Personal Trainer and Cycle Computer with Heart
Rate Monitor and Speed / Cadence Sensor



SOLAR POWER

Brunton

SOLARIS 12 WATT FOLDABLE SOLAR ARRAY

The next generation of Solaris foldable-solar-tech-
nology is here. The Solaris 12 are the most compact
models in Brunton line. CIGS technology maximizes
performance while optimizing portability.



Bushnell

Yardage Pro 7 x 26 Pinseeker 1500 Laser Rangefinder for Golf Kit

with Bushnell Laser Rangefinder Case, Bushnell 3 Watt
LED Flashlight, 100-Lumen Output,



Brunton

SOLARIS 26 WATT FOLDABLE SOLAR ARRAY

The next generation of Solaris foldable-solar-tech-
nology is here. CIGS is the most efficient
thin film solar technology available.



MICROSCOPES



EPIX DIGITAL ZOOM

ePix Digital Zoom (26x-130x)
Microscope with Integrated Camera



BIOLOGICAL MICROSCOPE

with Built-in Digital Camera, 1600x Power,
LED Illuminated & USB Interface



Nikon

NATURESCOPE

20x Mini Field Stereoscopic
Microscope



Customer Relations 800-815-0702 212-741-0466
Mon-Thurs. 9-4:30, Fri. 9-1, EST
FAX # 212-463-7223

ADORAMA INC.
Source for the Educated Photographer

STORE: 212-675-6789
Store & Mail Order Hours: Mon.-Thurs. 9-7:30pm
• Fri to 3:30 (Store to 2:00) • Sun. 9:30-5:30

Ask Us



P. 26
Why do
wind turbines
kill so many bats?



P. 28
Why do
chilies make
us sweat?



P. 32
What gives
a railgun such
explosive power?

Where in the universe did the big bang occur?

A common misconception about the big bang is that it took place in space. But space, time, energy and matter did not exist before this theoretical event. So one could say that it occurred both nowhere and everywhere in the universe.

According to the big-bang theory, the universe started out as a very dense and hot point. It expanded rapidly and is still expanding today. One analogy that helps explain this phenomenon, suggested by English astronomer Arthur Eddington in 1933, compares the universe to the surface of a balloon that has been marked with many dots as it is inflated. The distance between the dots increases like the distance between galaxies. None of the points on the surface of the balloon is considered to be the center, because each point expands equally.

WHY DO SIRENS CHANGE IN PITCH?

When an ambulance passes you with its siren on, the pitch of the siren seems to change from high to low. This is caused by a shift in the sound waves. As the ambulance approaches, the sound waves are compressed toward you, resulting in a more shrill sound. As the ambulance moves away, the sound waves get farther apart, causing the pitch to decrease. The phenomenon was first described by the Austrian physicist Christian Doppler in 1842 and today is known as the Doppler effect.

Can reptiles run a fever?

Reptiles don't get fever, because they lack the means to internally regulate their body temperature.

Scientists categorize animals in terms of whether the source of heat for regulating temperature comes from within their bodies (endothermic) or from outside (ectothermic). Mammals and birds are endotherms; reptiles, amphibians, fish and invertebrates are ectotherms. Reptiles regulate their body temperature by lying in the sun or seeking shade.

For humans, normal temperature is about 98.6°F, but when we get sick, our bodies fight infection by raising our inner thermostats, a condition we call fever. Reptiles cannot generate a

constant, higher body temperature if they have an infection. But according to Lauren Augustine, an amphibian-and-reptile keeper at the Bronx Zoo in New York, reptiles do bask longer in the sun when they are ill, which helps boost their immune response.

Animals Produce Body Heat in Different Ways

The terms "cold-blooded" and "warm-blooded" for animals are now outdated. Instead, scientists use these descriptions:

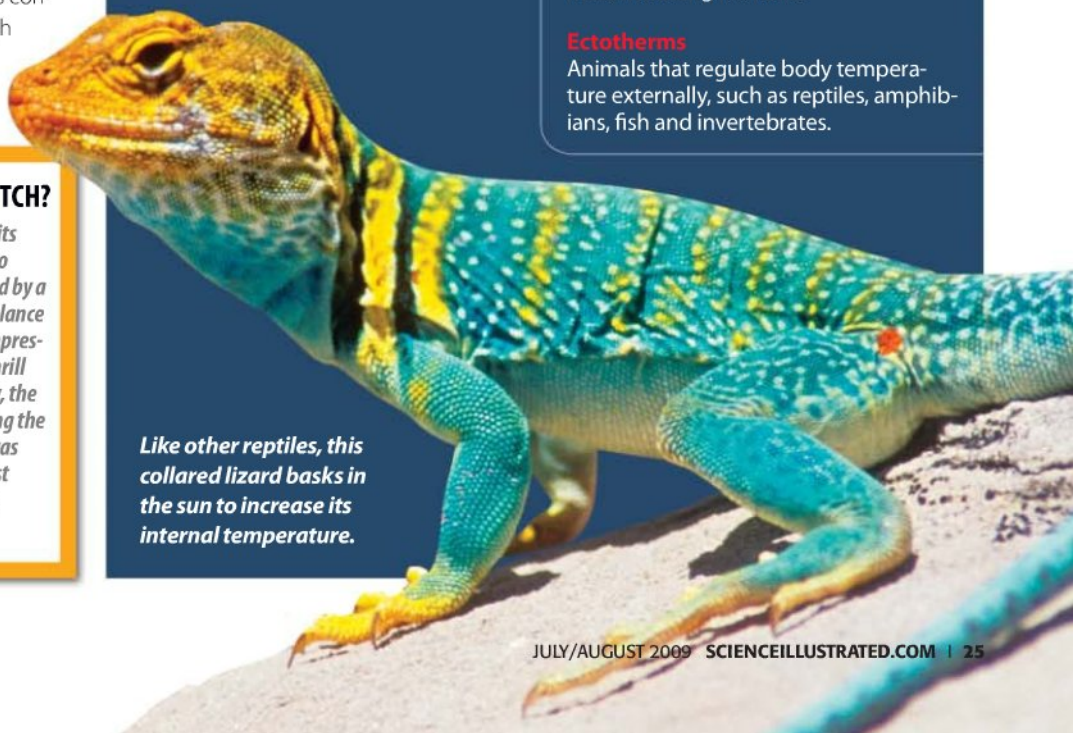
Endotherms

Animals that regulate body temperature internally, such as birds and mammals, including humans.

Ectotherms

Animals that regulate body temperature externally, such as reptiles, amphibians, fish and invertebrates.

Like other reptiles, this collared lizard basks in the sun to increase its internal temperature.



Why do we use both large and small letters?

The combination of uppercase and lowercase letters developed over the course of about 2,000 years. The oldest Latin alphabet, the standard script for English, dates from about 600 B.C. and consisted only of capital letters, or majuscules. These letters were mostly angular in shape because they were typically chiseled into stone.

Over time, tools and stone tablets were replaced by pens and papyrus scrolls and later with books, so the style of letters was adapted to better suit these new materials. Starting in the second century, people began to use smaller, rounder versions of large letters

(called uncial script) because these were easier to write by hand. Around the eighth century, uncial letters developed into the small letters we know today, called lowercase, or minuscules. The standard form of capitalization in English, in which only the first letter of a sentence and proper nouns are uppercase, emerged in the 18th century.

Though not the reason for the creation of large and small letters, the combination also makes text easier to read. The variety in the contour of the letters helps us recognize words by their shape rather than just by the letters they contain.

The Romans used only capital letters to carve inscriptions into stone tablets. Different materials led to the introduction of lowercase letters.

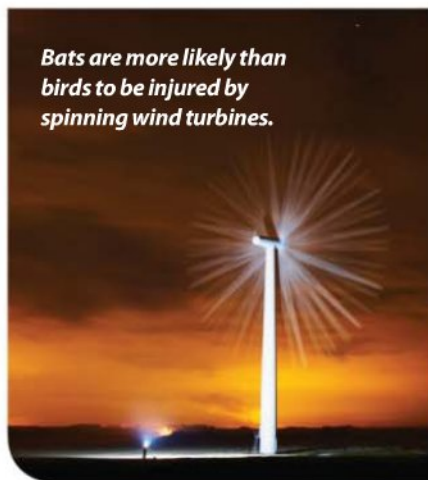


Do wind turbines harm wildlife?

Both birds and bats have been killed by this alternative energy source across the globe, but bats actually suffer the greatest risk from wind turbines. Their fragile lungs make them susceptible to hemorrhaging, and when exposed to sharp drops in air pressure that occur around the turbines' whirling blades, many bats experience internal bleeding and tissue damage called barotrauma. The change in pressure is what typically kills bats, rather than actual collisions with turbine blades. In fact, a recent study from the University of Calgary suggested that 90 percent of bats killed by wind turbines die as a result of lung hemorrhaging.

It isn't clear why the bats get so close to the turbines, but some scientists think that they might mistake them for possible roosting sites. To solve the problem, researchers have suggested installing acoustic devices that partially jam the bats' sonar, which may repel them from the turbines' airspace, or shutting down plants when the bat species most affected are known to migrate through the area.

Bats are more likely than birds to be injured by spinning wind turbines.



CLOCKWISE FROM TOP: H.C. KAPPEL/NATUREPL, CORBIS/POLIFOTO; A. DE LUCA/CORBIS/POLIFOTO



Extremely
Limited Availability

How Do You Spell Pearl Necklace? F-R-E-E.

Stauer comes to the rescue! \$295 necklace of genuine cultured pearls...FREE!

You read that right. If you'd like the Stauer genuine 18" cultured pearl necklace absolutely **FREE**, all you need to do is call us today or log on to the website www.stauer.com. There is no catch. If you're wondering exactly how we can afford to do this... read on.

Despite tough economic times, Stauer has had a very good year. It's time for us to give back. That's why we're offering this stunning, 18" strand of genuine cultured white pearls for **FREE** (you only pay the basic shipping and processing). This is a classically beautiful necklace of luminous, smooth cultured pearls that fastens with a .925 sterling silver clasp (\$295 suggested retail price). It is the necklace that never goes out of style. In a world where some cultured pearl necklaces can cost thousands, shop around and I doubt that you will see any jewelry offer this compelling!

Why would we do this? Our real goal is to build a long term client relationship with you. We are sure that most of you will become loyal Stauer clients in the years to come, but for now, in this lousy economy, we will give you these pearls to help with your future gift giving ideas.

We did find a magnificent cache of cultured pearls at the best price that I have ever seen. Our pearl dealer was

stuck. A large luxury department store in financial trouble cancelled a large order at the last minute so we grabbed all of them. He sold us an enormous cache of his roundest, whitest, most iridescent cultured 5 1/2-6mm pearls for only pennies on the dollar.

But let me get to the point: his loss is your gain. Many of you may be wondering about your next gift for someone special. In the past, Stauer has made gift giving easier with the absolute lowest prices on fine jewelry and luxury goods. This year, we've really come to the rescue.

For the next few days, I'm not offering this cultured pearl necklace at \$1,200. I'm not selling it for \$300. That's because I don't want to **SELL** you these pearls at all... I want to **GIVE** them to you. This cultured pearl necklace is yours **FREE**. You pay nothing except basic shipping and processing costs of \$25.⁹⁵, the normal shipping fee for a \$200-\$300 necklace.

It's okay to be skeptical. But the truth is that Stauer doesn't make money by selling one piece of jewelry to you on a single occasion. We stay in business by serving our long term clients. And as soon as you get a closer look at the exclusive selection, you're not going to want to buy your jewelry anywhere else.

Stauer is a high end jeweler that still understands value. As a matter

of fact, our average client spends more with us than at Tiffany's, but we still know something about affordability. We believe Stauer was the largest buyer of carat weight emeralds in the world last year and this year we are on track to be the largest buyer of carat weight sapphires, so we know about volume buying discounts. We were only able to get so many pearls at this price. This offer is **very limited** to one per shipping address. Please don't wait.

JEWELRY SPECS:

- Genuine 5 1/2-6mm white cultured pearls
- 18" strand - Sterling silver clasp

Cultured Pearl Necklace (18" strand)
Your Cost—FREE — pay shipping & processing only.

Call now to take advantage of this extremely limited offer.

1-800-806-1654

Promotional Code 305-08

Please mention this code when you call.

Stauer

14101 Southcross Drive W.,
Dept. FWP305-08
Burnsville, Minnesota 55337
www.stauer.com



Ask about our
satin and velvet
travel case.

Why do chili peppers make us sweat?

The telltale mouth burn and the case of the sweats you get from eating a hot pepper are caused by the chemical capsaicin and a group of related substances called capsaicinoids, found mainly in the white internal ribs that run through the center of chili peppers.

Capsaicin binds to the nerve receptor TRPV1, which has two roles in the nervous system. First, it carries pain signals from the body's nerves to the brain, which accounts for the burning sensation you feel in your mouth when you bite into a hot pepper. Second, TRPV1 helps regulate body temperature. When capsaicin binds to TRPV1, it fools the brain into thinking your body temperature is higher than it really is, and this makes you sweat in an attempt to cool down. Recent research suggests that capsaicin may also induce cells to convert energy into heat, a process called thermogenesis. This is the same cellular process that keeps hibernating animals, like chipmunks and bears, warm.

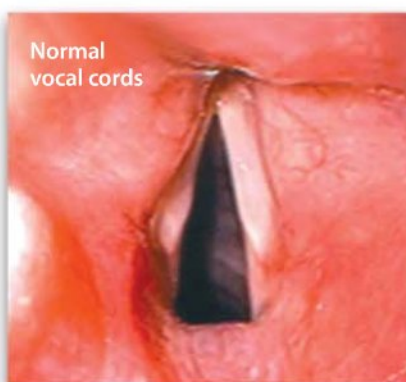
Chili peppers contain the chemical capsaicin, which may trick the body into thinking it feels hot.



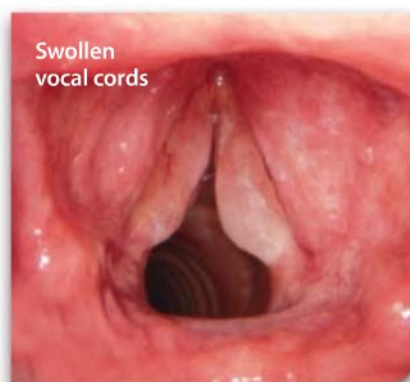
Why do we lose our voice when we get sore throats?

Damage to the vocal cords—the two folds of elastic muscle tissue that allow us to produce sound—causes changes in the voice or even total loss of speech. The cords extend across the inside of the larynx, a tubelike structure located at the top of the windpipe. When we are silent, the vocal cords are relaxed, and the gap between them is wide open. But when we speak, they close and air from the lungs pushes through, vibrating the cords and producing sound. Faster vibrations cause higher-pitched sounds, and low vibrations make deeper ones.

If the cords become irritated from a bacterial or viral infection, they swell up and vibrate differently, changing voice quality or making speech completely



Normal vocal cords



Swollen vocal cords

Vocal cords allow us to talk. If an infection causes them to swell, we can lose our voice.

impossible. This is called laryngitis, and it usually clears up within two weeks. Smoking, alcoholism or excessive overuse,

however, sometimes causes chronic laryngitis, which may require speech therapy or surgery to correct.

IDENTITY THEFT REPORT:

IDENTITY THEFT UP 22%, HITS 5-YEAR HIGH

Leader in I.D. Theft Protection Strikes Back with Free Protection Offer for All

TEMPE, ARIZONA – Identity theft has topped the Federal Trade Commission's list of consumer complaints for the past eight years.

Now, a stunning new survey shows a record 9.9 million Americans were victims of identity theft last year – a shocking 22% increase over the prior year – according to Javelin Strategy & Research. This news mirrors a just-released report from the Federal Trade Commission that cites a 21% increase in identity theft complaints during the same period.

Apparently, individual consumers are not the only ones at risk: a recent review cited by the Wall Street Journal reports that the cost of information breaches to U.S. companies was also on the rise, with the average total per-incident cost in 2008 rising to \$6.65 million*.

These studies send a clear message: in the wake of the global economic crisis, identity theft is a big business. It's up to consumers to take proactive steps to protect themselves.

That's why for a limited time, LifeLock, the industry leader in identity theft protection, is offering 30 days of guaranteed identity theft protection service at no cost.

"All you have to do is call 1-877-899-8599 for an individual membership, or 1-877-899-8699 if you are enrolling more than one member," said Todd Davis, the CEO of LifeLock known for giving out his real Social Security number in advertising to show his confidence

in the service. "It's that simple."

Immediately upon enrollment, all LifeLock members are protected by LifeLock's \$1 Million Total Service Guarantee.

Why should you protect your identity? Consider some of the Javelin survey's specific findings:

According to the survey, more than one in every ten victims knew the person who stole their identity.

It also appears identity thieves are moving dramatically faster than they used to when it comes to actually using stolen information. The Javelin survey revealed incidents of using stolen information within just a week of the theft more than doubled from 33% to 71% over the past three years.

The Javelin survey revealed women are 26% more likely to be victims than men. The survey also named higher income consumers (households with combined incomes of \$75,000 or more) to be at higher risk. Latinos were named the most likely demographic group to become victims of new account theft. Latinos are 47% more likely to become victims, versus 32% of all victims. It's important to point out that no one can stop all identity theft, but what LifeLock doesn't stop, they fix at their expense, up to \$1 million.

To get LifeLock free for 30 days during this special offer, call 1-877-899-8599 for individual memberships, 1-877-899-8699 for multiple enrollments, and use promo code FREEMONTH.



Todd Davis, CEO of identity theft protection company LifeLock, demonstrates his confidence by sharing his Social Security number: 457-55-5462. To protect yourself FREE for 30 days call today and use promotion code FREEMONTH.

HOW TO GET FREE IDENTITY THEFT PROTECTION

Call one of the numbers below to protect your family **FREE for 30 days**. Representatives are available 24 hours a day. Hurry – this exclusive offer is limited only to those that call and use the promotion code below.

PLEASE NOTE: If the line is busy, hang up and try the number again.



SINGLE

TEL: **1-877-899-8599**



MULTIPLE

TEL: **1-877-899-8699**

PROMO CODE: **FREEMONTH**



Kim Barnes

■ "When I first learned about a company called LifeLock that protects families from identity theft, my husband was skeptical. I signed us up anyway, and forgot about it. A couple of months later, on a family vacation, my husband received a phone call asking if he was applying for a new credit card. Someone was trying to steal his identity. LifeLock had stopped the thief cold."



Bobby Jo Harris

■ "I'm a former chief of police of a major city. I knew identity theft was a \$50 billion a year business, and a prime focus of organized crime. But they got me anyway. Even though I was a senior law enforcement official, it took weeks to clear my name. I decided: never again. A reporter recommended LifeLock to me and I tried them out. I've never had a problem since. I highly recommend them to you."



Earl Laurie

■ "I had seen a news report about LifeLock. The reporter tried to use the CEO's Social Security number to open new accounts and couldn't. That's when I signed up. Later, I heard from the Navy and the VA that they had lost my private information. Then someone tried to open two credit card accounts under my name. They tried to steal my identity, but LifeLock worked exactly like they said it would."



Zach Friesen

■ "My identity was stolen when I was seven, but I didn't find out until ten years later when I was denied a student loan and a job due to poor credit. That's when I discovered I was \$40,000 in debt because someone purchased a houseboat in my name. It took over ten years to clear my name. You can be sure my kids will be protected by LifeLock."



Aaron Freeman

■ "Thieves broke into my home and got everything – my passport, birth certificate, Social Security card. They could have ruined me financially. So I put LifeLock to the test. A few days later, I started getting phone calls that the thieves were trying to open new credit accounts. LifeLock's system worked just like they said it would and stopped the thieves cold."

Why is every fingerprint unique?

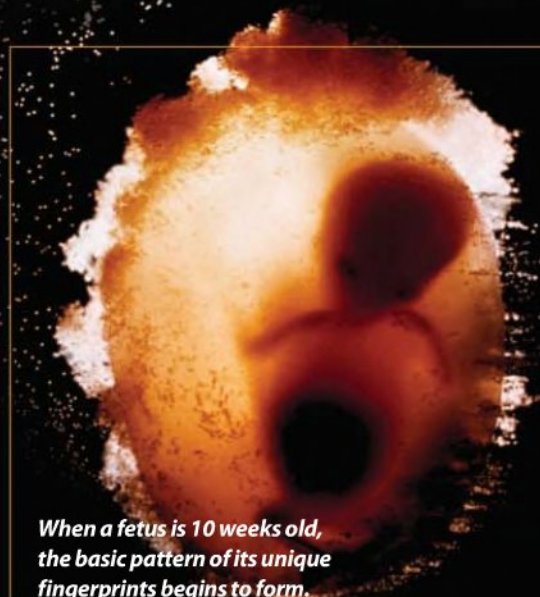
Fingerprints form during fetal development. Genes determine differences in developmental timing that result in the three basic shapes: whorls, loops and arches. The small variations to these shapes, which make no two sets of fingerprints the same, are random and not inheritable.

At about week six in the womb, the tips of the fingers start to develop raised,

swollen tissues, called volar pads. These pads stop growing around week 10 and are absorbed when the rest of the finger tissue continues to grow. This physical process causes the skin to contract into the ridges and grooves that make up fingerprints.

Exactly when the contraction occurs determines the basic shape. If the skin begins to fold into ridges while the

volar pads are still prominent, the print is usually a whorl, which is a circular or spiral pattern. If the folding happens after they've been absorbed a little more, the fingerprints are loops. But if the skin folds very late in the process, when the pads are almost gone, arches are formed instead. Random differences in the patterns also emerge during the absorption, making even identical twins' fingerprints unique.



When a fetus is 10 weeks old, the basic pattern of its unique fingerprints begins to form.

Loop



Whorl



Arch



Fingerprints Come in Three Basic Shapes

Loops are the most common, occurring in about 65 percent of fingerprints. They form a hairpin pattern [here a double loop is shown]. Thirty percent of fingerprints are whorls—circular or spiral patterns. Arches, the least common shape (5 percent), rise up like tiny mountains.

How is metal fatigue in bridges detected?

Metal fatigue, caused by repeated stress on a steel structure, is the culprit behind some bridge failures, such as the collapse of Milwaukee's Daniel Hoan Memorial Bridge in 2000. Fatigue cracks in a metal bridge can be detected with the aid of ultraviolet light used in conjunction with fluorescent dye to reveal the length of the crack. The depth of the fissures can then be measured with ultrasound.

The Federal Highway Administration (FHWA) requires visual testing of all highway bridges of more than 20 feet long

every two years. But a FHWA study in 2001 found that more than 90 percent of fatigue cracks, which can progress into fractures, are missed during visual inspections.

Researchers at Matech, a Los Angeles company that makes devices to detect and monitor metal fatigue, have devised a method for finding cracks even before they can be revealed by UV light. The Electrochemical Fatigue Sensor detects stray currents generated as the exposed metal in a small scratch rusts. FHWA is exploring the method as part of its Steel Bridge



Fluorescent dye makes the cracks in this metal glow under ultraviolet light.

Testing Program, an initiative launched in 2007 to identify better technologies for metal-fatigue detection.

U.S. GOV'T GOLD

U.S. GOLD COINS AUTHORIZED FOR IMMEDIATE RELEASE

The United States Rare Coin and Bullion Reserve Vault Facility today announces the final release of U.S. Gov't Issued Gold Coins previously held in The West Point Depository/U.S. Mint. For a limited time, U.S. citizens will have the opportunity to purchase these \$5 Gov't Issued Gold Coins for the incredible "at-cost" price of only \$124.00 per coin. An amazing price because these U.S. Gov't Issued Gold Coins are completely free of dealer markup. That's correct, our cost. This may be your final opportunity to buy U.S. Gov't Issued Gold Coins "at-cost." The Gold market, which recently skyrocketed past \$1,000/oz., is predicted by experts to have the explosive upside potential of reaching up to \$2,000/oz. in the future. **Due to extremely high Gold demand, availability of these special at-cost Gold Coins may vary based on current vault inventory.** The United States Rare Coin and Bullion Reserve will release these U.S. Gov't Issued Gold Coins "at-cost" on a first-come, first-serve basis. Orders that are not immediately received or reserved with the order center could be subject to cancellation and your checks returned uncashed. Good luck. We hope that everyone will have a chance to purchase this special U.S. Gov't Issued Gold "at-cost." Order your Gold immediately to avoid disappointment. Special arrangements can be made for Gold purchases over \$50,000.



U.S. Gov't Issued American Eagle Gold Coins
U.S. Gov't Issued American Eagle Gold Coins

Coins enlarged to show detail



AUTHORIZED BY CONGRESS: PUBLIC LAW 99-185

By Executive Order of Congress Public Law 99-185, Americans can now buy new Government Issued Gold. Congressionally authorized United States Gold Coins provide American citizens with a way to add physical Gold to their portfolios. Gold American Eagles are made from solid Gold mined here in America, forged at the U.S. Mint at West Point, and produced with a U.S. Dollar denomination... making them Legal Tender United States Gold Coins. They are highly liquid, easily transportable, and, unlike paper assets, American Gold Eagles have a tangible value you can feel each time you

hold your own Gold. Though no one, including The United States Rare Coin and Bullion Reserve, can guarantee a Gold Coin's future value will go up or down, numerous experts are predicting Gold to reach \$2,000/oz. Now is the time to consider converting part of your paper assets into Gold. The United States Rare Coin and Bullion Reserve has a limited supply and urges you to make your vault reservations immediately. Call a Sr. Gold Specialist at 1-800-309-6107 to start your Gold portfolio and begin protecting your wealth today. If you've been waiting to move your money into Gold, the time is now.



DO NOT DELAY - LIMITED SUPPLIES AVAILABLE!

GOV'T ISSUED GOLD COIN

BEGINNING TODAY, TELEPHONE ORDERS WILL BE
ACCEPTED ON A FIRST-COME, FIRST-SERVE BASIS
ACCORDING TO TIME AND DATE OF ORDER.

ONLY **\$124.00**
EACH

VAULT CODE: SI2-124

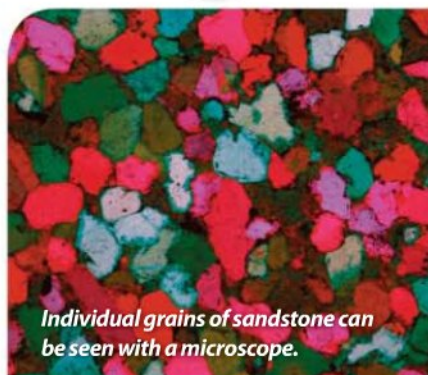
Call Toll Free 24 Hours a Day, 7 Days a Week

1-800-309-6107

MASTER CARD • VISA • AMEX • DISCOVER • CHECK

SPECIAL AT-COST OFFER LIMITED TO PURCHASES OF 5 COINS
PER HOUSEHOLD (\$620) PLUS SHIPPING & INSURANCE.

UNITED STATES
RARE COIN & BULLION RESERVE



Individual grains of sandstone can be seen with a microscope.

Can loose sand turn into tall mountains?

Any type of rock can become a mountain, although the process can take millions of years, says Sarah Fowler, a research fellow in earth sciences at the American Museum of Natural History in New York. This includes sedimentary rock, which is made when small particles of material, such as sand, become tightly packed. Mineral-filled fluids cement the particles together into rock. Sandstone is an example of a sedimentary rock made primarily of sand-size mineral or rock grains.

Most mountains were made when one of Earth's tectonic plates collided with another, pushing up whatever soil and rock—including sandstone—lay above it. Some of the highest mountain ranges in the world, like the Himalayas, are partly composed of sedimentary rock.

ASK US AND WIN A SCIENCE ILLUSTRATED T-SHIRT!

Send your question to our editors. If we answer it in an issue, we'll send you this cool T-shirt. E-mail your questions to:

askus@scienceillustrated.com



What is a railgun?

Railguns are powerful electromagnetic machines that can accelerate all types of projectiles, from cannonballs to satellites, along metal rails.

Currently being tested by the military, railguns are capable of reaching targets 230 miles away, much farther than the 20-mile range of the standard MK 45 five-inch gun now used by the U.S. Navy. Railguns can also discharge at velocities of about 7,800 feet per second, around twice as fast as projectiles propelled by gunpowder. The incredible force of impact allows railgun ammunition to match the destructive energy of explosive weaponry without the hazards of transporting explosives.

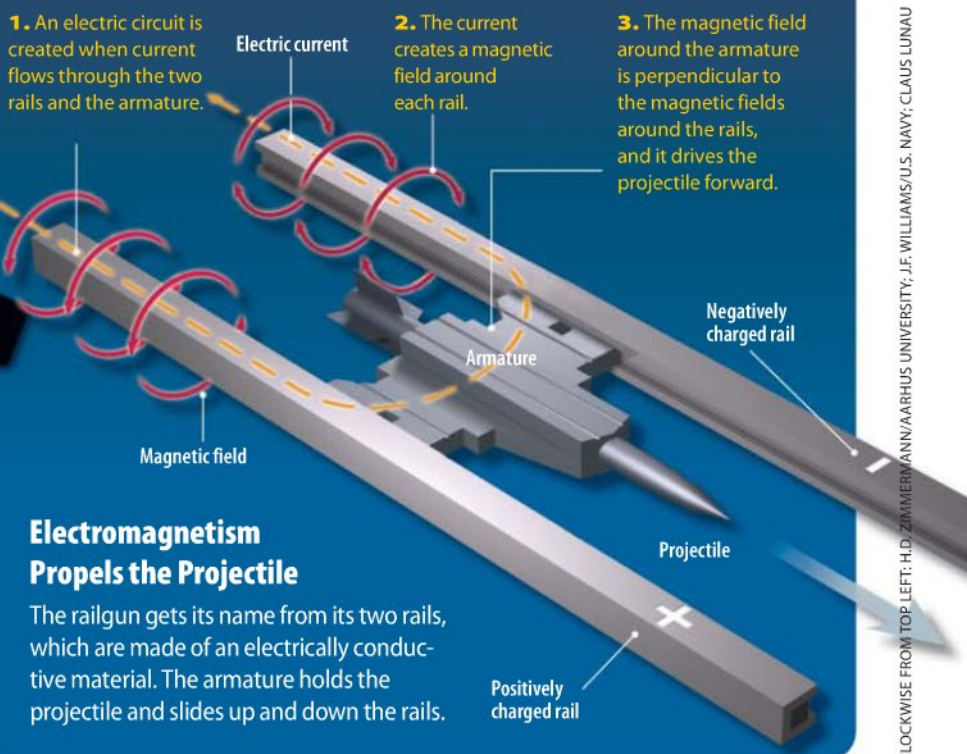
Railguns need a very strong electric current—about a million amperes—to accelerate the projectile at the desired velocity. This requires a huge power source and enormous capacitors to fire it. An intense flash of heat is also produced from both the aerodynamic drag on the



The U.S. Navy carries out a test-firing of a railgun for shipboard use.

projectile and the launch current. In the best models by the Navy so far, projectiles can reach temperatures of more than 1,800°F.

The Navy is testing railguns as a way to fire missiles from warships. Last year, it successfully shot a seven-pound aluminum slug with 10.6 megajoules of energy from a railgun. By 2018, the Navy hopes to have a prototype railgun that can deliver roughly six times that amount of kinetic energy.



Electromagnetism Propels the Projectile

The railgun gets its name from its two rails, which are made of an electrically conductive material. The armature holds the projectile and slides up and down the rails.

POPULAR SCIENCE magazine is hosting the 1st annual School Inventors Challenge. We are calling the youth of America to come up with an invention that **improves our world**.

**CALLING ALL
TEACHERS!
WIN \$5,000**

worth of science equipment
for your school!

**BONUS PRIZE
\$1000**

of Celestron products to each
grand prize winner.

FREE TO ENTER!

Go to popsci.com/sciencecontest
Enter by June 30

Teachers of the following
age groups can enter!

3 Divisions | 3 forms of submission:

Elementary School | essay

Middle School | schematic

High School | model/working demo/animation



Sponsored by:



In Partnership with:



Museum partners:



NO PURCHASE NECESSARY TO ENTER OR WIN. The "2009 National School Inventors Challenge" Contest is open to legal residents of the 50 United States or the District of Columbia age 18 or older who are full-time or part-time teachers employed at an accredited elementary school, middle school or high school in the 50 United States and District of Columbia. For an Official Entry Form and details on how to enter and complete Official Rules, visit www.popsci.com/sciencecontest. Contest begins at 12:01 AM Eastern Time ("ET") on 2/02/09 and ends at 11:59 PM (ET) on 6/30/09. Sponsors: Science Kit LLC and Edmund Scientifics.

Gorillas Emerge from the Mist

Fewer than 700 mountain gorillas remain in the world. Can hilltop research by a brave group of primatologists help preserve this iconic species?



302 Apes in 125 Square Miles

The latest genetic census indicates that 302 mountain gorillas inhabit Bwindi Impenetrable National Park. Large variations in altitude in this relatively small park result in highly diverse vegetation, which affects the feeding habits of the gorillas that live there.

Two silverbacks—a dominant alpha [foreground] and a beta—relax with their group in the mountains of central Africa.



gorillas in Bwindi also eat a substantial amount of fruit.

There's a simple explanation of why gorillas in the park eat fruit when their southern cousins don't: because they have it. The Karisoke Research Center, which was Fossey's home base in the Virungas, stretches between 8,000 and 14,500 feet, an extreme altitude where almost no fruit trees grow. Bwindi Park, however, is lower and more hospitable to many types of fruit and herbaceous plants. The gorillas there take full advantage of the variety. Rukina's group grazes on these plants at an elevation between 6,500 and 8,000 feet. When fruit is most abundant, the gorillas spend nearly two thirds of their feeding time eating it.

An even greater variety and number of fruit trees grow in the lowest parts of the park, and gorillas there eat more fruit as a result. Biologist Jessica Ganas of the Max Planck Institute has observed the diets of two groups in the lower altitudes. She found that the groups, though sharing the same food options, had developed different preferences of fruit and plant species. This may be an indication that, over time, individual groups have developed "cultural" differences in diet. Their choices, in other words, may be based on learned behaviors passed down in specific groups, rather than dictated by instinct or environment. Among



Questionable paternity keeps youngsters like this one safe if a new leader seizes power.



The higher the bulge on the head, the more offspring a silverback will sire.

WINNER



A flat top appears to be a much less attractive quality in a leader.

LOSER

Aping Our Position

Humans aren't the only animals that have sex facing each other with the female on her back. Bonobos, chimpanzee cousins native to the Democratic Republic of the Congo, have also been observed in this position, and recently, gorillas joined the list.

Researcher Thomas Breuer photographed gorillas mating face-to-face in 2005. He captured

a series of images of two lowland gorillas, George and Leah, in Nouabale-Ndoki National Park in the Republic of the Congo. Wild gorillas are only rarely spotted in the position. Why the apes sometimes opt to mate in this way rather than in the far more common position among animals, in which males mount females from behind, is still not known.



George and Leah mated twice. Here they embrace after their first encounter.

A gorilla breaks apart a termite mound for her meal. Almost exclusively herbivores, gorillas occasionally eat insects.



nonhuman apes, such learned behavior has previously been observed only in chimpanzees and orangutans. Although more evidence is needed before scientists accept a theory of cultural behavior in gorillas, the possibility that they may be even more mentally complex than previously thought is an exciting one.

Diet Affects Group Size

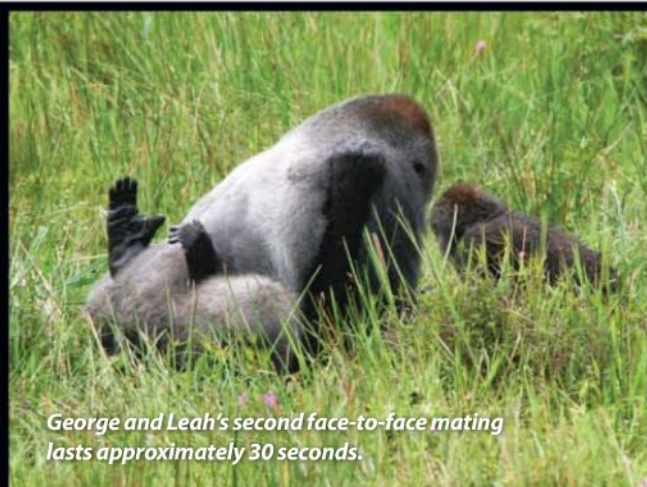
To the west of Bwindi and the Virungas live the western-lowland and the cross-river gorillas, which along with the mountain gorillas and the eastern-lowland species round out the gorilla family. The lowlands of Central Africa offer fewer herbaceous plants than the mountains, and the gorillas there must travel to obtain fruit. This lifestyle can support only small groups averaging 10 gorillas, with just one mature male.

In the Virungas, on the other hand, the herbaceous plants that make up the gorillas' diet are consistently in oversupply. Here many individuals can inhabit the same area without conflict arising over food. Similarly, there is an abundance of food in Bwindi, so gorillas there can easily share the fruit that they find without competition between apes.

Thus, although the groups in Bwindi and the Virungas have similar average sizes—about 10 to 12 gorillas—it is common to find troops of as many as 20 in both regions. There is greater variability in the Virungas, and a few groups there have more than 30



A few moments later, George lays Leah down on her back. He watches her face throughout the encounter.



George and Leah's second face-to-face mating lasts approximately 30 seconds.

gorillas. In fact, the largest group ever documented there numbered 65 at its peak (the same one now has only 42, Robbins says).

The larger the group, the more females, which typically far outnumber males in gorilla communities. The females have a tremendous impact on the group's hierarchy, because their numbers determine how many young males stay in the band with the hope of mating, as well as whether or not the alpha-male silverback will allow another silverback to remain in the group.

Robbins has discovered that Bwindi's gorilla groups contain several blackbacks, males aged 8 to 10 years. Essentially gorilla teenagers, blackbacks begin to mature into white-haired silverbacks at age 12 or later, a transformation that takes about two years. In several cases, Robbins has observed beta-male silverbacks in a group in addition to the alpha male. This is in marked contrast to lowland gorillas, whose so-called harems very rarely include more than one adult male.

Making Sense of Beta Males

Robbins believes that the presence of other sexually mature males can actually be an advantage for the alpha male. In lowland groups large enough for just one mature male, an invading silverback that overthrows the previous ruler will kill all of the unweaned babies to speed up his chances of mating with their mothers. Among multi-male

mountain-gorilla groups, however, usurpers are often beta silverbacks that have been living, and mating, within the group for years. Because some of the infants could belong to that male, he will not risk killing his own offspring. Thus, the alpha silverback may have been dethroned, but his infants will survive. The trade-off: During his rule, about 15 percent of the young born to the group will not be his own.

Rukina came to power as a beta male under a gorilla named Zeus, who researchers believe had been the leader for about 10 years. Starting in 2000, Rukina began provoking confronta-

tions with Zeus, and the frequency of the attacks increased as the alpha aged and weakened. The final showdown came in 2003, when three of the females came into heat at the same time. A vicious battle for dominance ensued, and Rukina's strength won out. Zeus survived with serious injuries, but the group abandoned him, and he died six months later.

Since then, no gorilla has challenged Rukina, and he is still in his prime. But possible successors are already on the scene. Marembo, a young silverback, and Byiza, a blackback, are two possible contenders.



Bwindi Park is adjacent to fields cultivated by farmers. Areas surrounding the park have some of the highest human population densities in the world.

Gorillas Use Tools in Surprising Ways

Both chimpanzees and orangutans are known for using objects as tools, but it is only in the past few years that the behavior has been documented among gorillas. Once again, it was zoologist Thomas Breuer who caught the action with his camera.

A team of zoologists has followed a group of lowland gorillas in the Republic of the Congo for the past decade. Breuer, who joined the project in 2002, was watching one day in October 2004

when Leah, a female gorilla, tried to wade across a water hole but quickly fell into hip-deep water. She walked back to the bank, picked up a branch from a dead tree, and proceeded to use it to test the water's depth before taking each step. She managed to get 30 feet out into the water before her child, screaming from the bank, finally induced her to turn back. On another occasion, Breuer observed a female named Efi use a long branch to stabilize

herself while fishing for water plants.

In addition to being the first documentation of tool usage among gorillas, Breuer's photos of both acts are remarkable for another reason. When apes use tools in the wild, it is usually for getting access to food—for cracking nuts, for instance. Leah and Efi's behavior shows that gorillas can also use tools to deal with other challenges they encounter in their environment.

Counting Dung, Counting Gorillas

Bwindi may have sufficient food to support large numbers of gorillas, but whether the population there is actually increasing remains to be seen. In 2006, Robbins and her colleagues conducted a census based on genetic analysis of gorilla dung, which contains each individual's genetic fingerprint. This was the first time the method had been used to count gorillas. The researchers also conducted a traditional field census, in which they counted the nests where gorillas sleep to estimate their numbers.

The two-and-a-half-month-long field census estimated that 336 goril-

las resided in Bwindi. The number, up from 320 in 2002 and 300 in 1997, was hailed as a victory. The disappointing news came nine months later, when the genetic results arrived. According to the DNA, there were just 302 gorillas, which meant that the same nests may have been counted more than once in the field. The lower number indicates that Bwindi's gorilla population is stable rather than increasing, but this is far from certain. Like the most recent census, the 2002 and 1997 surveys could have double-counted nests, inflating the number of gorillas in the park during those years. Or the results of the 2006 DNA census may be too low, since it's possible to miss excrement in dense

mountain forests. The next census, which will also combine genetic tests and nest counts, is scheduled for 2011.

Robbins and her colleagues are continuing their fieldwork in Bwindi today. Wild gorillas live an average of 35 years, and understanding their long-term social relationships can come only with years of research. Robbins is also conducting studies to see how vegetation differences in various areas affect the gorillas' use of the park, as well as their feeding patterns and social behavior.

In 2005 she partnered with Christophe Boesch, the director of primatology at the Max Planck Institute, to study lowland gorillas and chimpanzees in Gabon's Loango National Park in western Africa. Robbins is studying the diet of the gorillas and chimps to compare the feeding habits of two species of ape living in an identical habitat. Additionally, she plans to compare the diet and social behavior of the Gabon lowland gorillas to her group of mountain gorillas in Bwindi.

These studies, along with data already gleaned from Robbins' research, will help scientists understand how gorillas interact in their various habitats and how those environments affect their behavior and eating habits. Knowledge of what foods a species eats, for instance, could allow conservationists to make sure those foods are available. For her part, Robbins will continue her task, quietly observing gorilla life, one day at a time. ■



Two young mountain gorillas play-fight, readying for the day when they may be rivals for alpha-male status.



Efi supports herself with a long branch while fishing for water plants.



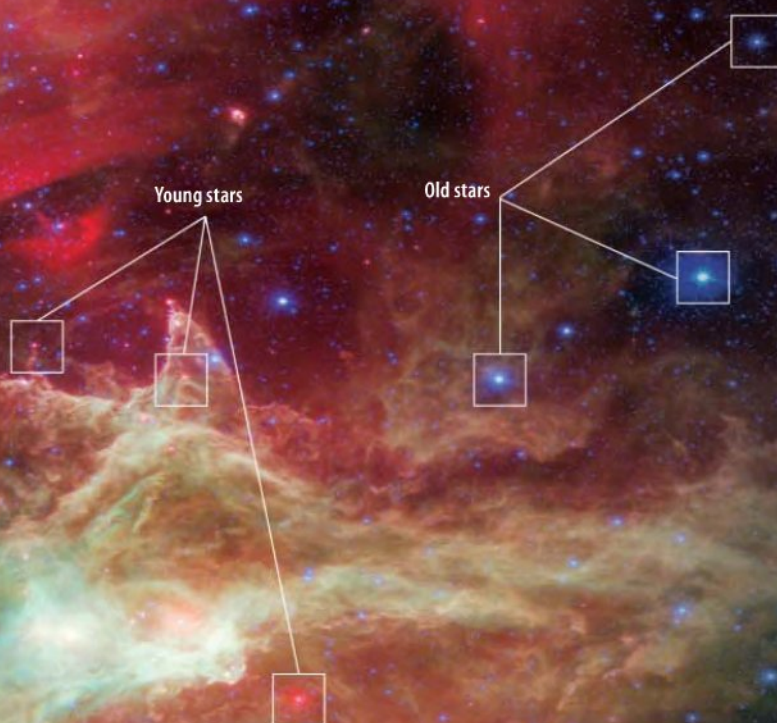
Leah uses a stick to test the water's depth before walking farther.



Rukina [bottom right] is the undisputed leader of a group that also includes Kakuma [far left], Matu [center] and Mugwere, in the background grooming her son, Mukiza.

Star Makers

Can one stellar giant give rise to generations more? NASA's Spitzer Space Telescope has probed the cosmic dust to reveal the genealogy of stars



Researchers believe that stars in the large cavities of the W5 nebula are older than those around the edges.

Cosmic Cascades Create Stars

Clouds of dust and gas found throughout the universe are breeding grounds for new stars. In some cases, the process of star formation itself may trigger the creation of several additional star generations. Here's how:

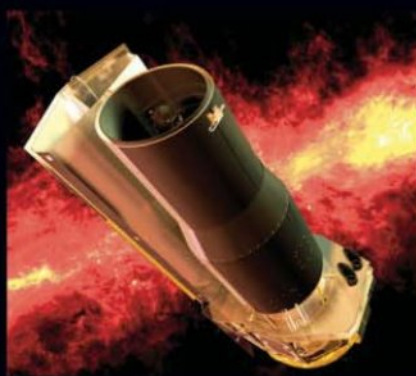
Open an astronomy textbook, and you'll learn that stars form when isolated clouds of cold gas collapse and coalesce into the bright bodies that dot our night sky. But as far back as the 1950s and '60s, scientists suspected that some stars formed in a domino sequence, with one star's birth precipitating the creation of many more. They had observed that some star-forming regions in the Milky Way's galactic plane—an imaginary line that runs through the center of the galaxy as we see it from Earth—lie in apparent age order: large stars in the middle and clumps of smaller, presumably younger stars around the edges.

Since then, scientists have found examples of these patterns throughout our universe, including many well-known areas where stars are still forming, such as the W5 nebula of the constellation Cassiopeia. But to confirm that one generation came directly from another, in a process known as triggered star formation, scientists must develop a way to gauge not just the sizes of stars but their exact ages.

How It Might Work

The most colossal stars in the universe seem to offer fertile ground for more star birth. The gases in them continually shift and create areas where dust and gases could combine to form a star.

The process may begin because giant stars, which can be 60 times as massive as the sun, are made of dense clouds of dust, hydrogen and helium.



The Spitzer Space Telescope can observe infrared wavelengths, which, unlike visible light, can penetrate clouds of dust.

The hydrogen atoms fuse to become helium, releasing heat and radiation. The radiation and astral winds carve out large, expanding pockets. As the spreading hot gas pushes outward, it hits colder, denser outer layers of gases and compresses them. According to the theory of triggered star formation, these super-condensed gases turn into a new star, and the process repeats.

The New Evidence

Last year, a team of researchers led by astronomer Xavier Koenig of the Harvard-Smithsonian Center for Astrophysics looked closely at stars' ages and got the best evidence yet for the triggered star formation theory. They analyzed the W5 nebula, some 6,500 light-years away, using images from the Spitzer Space Telescope. Spitzer's powerful lens detects infrared light, more of which is emitted from young stars than from older ones.

The composite image, rendered in false color [facing page], allowed the researchers to determine the ages of the stars forming in W5's huge pockets more accurately than was possible before. The image suggests that the stars around the perimeters of the cavities are indeed the youngest and those in the center are the oldest. The brightest, youngest stars are found entirely outside the cavities and, according to Koenig, are probably members of a third generation that coalesced from matter cast off by the clusters forming on the cavity's margins.

The oldest stars appear in the image as blue dots at the centers of the two hollow cavities, and younger stars appear as pink dots along the rims. The white-and-green areas show where dust and gas are condensing and new stars seem to be forming. The red regions represent heated dust found throughout W5's cavities.

Charting a Cascade

Koenig plans to develop ways to calculate stars' ages even more precisely. The European Space Agency's new satellite, Gaia, which is slated to chart the changing positions of stars in our galaxy between 2011 and 2016, may also provide evidence. Stars that are developing at the edges of the expanding cloud pocket should be moving outward, Koenig says. If Gaia's 3-D charts can confirm that, triggered star formation will be even closer to taking its place in textbooks alongside the traditional model. ■

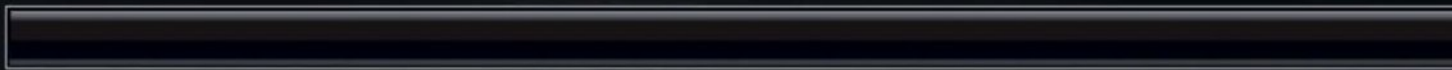
FROM TOP: NASA/ESA; CLAUDIUS LUNAU

1. Gravitational forces inside the gas cloud pull high-density regions of dust and gas together to form stars.

2. Intense radiation and stellar winds from the most massive stars push matter away, creating cavities.

3. Matter forced outward collects around the rim of these spaces, forming other stars. Some of these are large enough to produce winds and radiation, further expanding the size of the cavity.

4. Outside the rim of the enlarged cavity, more stars are created, and another generation is born.



Researchers believe that visual information bypasses a key processing area in the brain to give some blind people sight without their awareness of it.

Vision Quest

Some blind people can actually see—they just don't realize it. Can this rare condition help us unravel the mysteries of sight?

It usually starts with a stroke. A blocked or damaged blood vessel cuts off blood flow to the brain and damages the visual cortex. The patient's eyes still function properly, with the optic nerves sending the brain all the information it needs to form sharp images of the outside world. Yet the visual cortex fails to process the signals, leaving the patient with only partial vision. Some are even rendered completely blind.

Or are they? Exact numbers are hard to confirm, but nearly 80 percent of people with so-called visual-field defects can react to objects they can't consciously see. Ask them what's in front of them, and they'll tell you they don't know. But when prompted, they can usually guess whether they're being shown an "X" or an "O." They can also estimate the size of a ball they can't see, describe

which way a spot of light is moving, and even reach out and grab objects.

This mysterious phenomenon is known as blindsight. Over the past two decades, brain scans have helped explain how it happens. Scientists believe that some nerve signals from the retina bypass the V1 region, the primary visual center, and travel directly to other parts of the brain that process vision. This allows a person to register—and act on—certain visual impressions from his blind field without the conscious awareness of any stimuli.

Discovering Blindsight

The study of atypical blindness began in 1917, when George Riddoch, an English physician, and Walter Poppelreuter, a German surgeon, independently described wounded soldiers whose brain injuries caused selective blindness. For example, some of Riddoch's patients were unable to see stationary objects but could see moving objects. Animal

studies conducted over the years have offered an explanation for this discrepancy, showing that damage to different parts of the brain can result in different types of blindness. Studies in the early 1970s, for instance, found that blind animals with damage to the V1 region could be taught to choose between variously colored objects or to reach for a piece of food. One research team at the Massachusetts Institute of Technology reported that brain-damaged people who said they couldn't see a flashing light could nonetheless move their eyes toward it.

In 1973 Lawrence Weiskrantz, then at the National Hospital in London, coined the term "blindsight" after he and his colleagues encountered a blind patient who could correctly guess which of two objects had been presented to him. Most of the tests given to blindsighted patients are such "forced choice" tests. (A familiar example among the sighted is the typical eye

exam, in which we are asked to choose the clearer image seen through two seemingly identical lenses.) Researchers often use forced-choice tests to get people to answer questions about differences that their sensory systems can register but that they can't consciously perceive. For the blindsighted, a test of color discrimination might be to present a patient with a red and a blue object and ask him to point to the red one. If he gets the answer right the majority of the time, the researcher knows he can discern between red and blue, even though the patient may think that he's only guessing.

In the late 1980s and '90s, researchers Yves Rossetti and Marie-Thérèse Perenin of Inserm, the French National Institute for Health and Medical Research, advanced our understanding of the condition even further, showing that blindsighted patients could locate an object in the blind field and even grasp it. The subjects in their studies were able to open and close their hands in anticipation of picking up large or small objects, and to insert cards into various slots.

When asked to simply describe the size of an object in the blind field, however, either verbally or by using their hands to demonstrate, they were unable to. Likewise, they could not de-

scribe the sizes, shapes or orientations of the cards and slots. This suggested that visual information was somehow reaching the brain without the patient's knowledge. It's like receiving a voicemail with no notification: The information is there; you just don't know it's there.

Like blindness itself, which is a

G.Y. had no awareness that he could see anything, but he perceived movement correctly 80 percent of the time.

broad diagnosis that can encompass everything from complete loss of vision to a clear but narrowed field of vision, there are different forms of blindsight. Weiskrantz and his colleagues classified blindsight into two types. Patients with Type 1 blindsight are able to answer basic questions about lights, objects and shapes in their blind field but have no awareness of the stimuli. As far as they're concerned, their answers are guesses. Patients with Type 2 have some aware-

ness. In these cases, the answers aren't guesswork as much as intuition. Although the patients can't see the moving object or the blinking light, they report that they sense its presence.

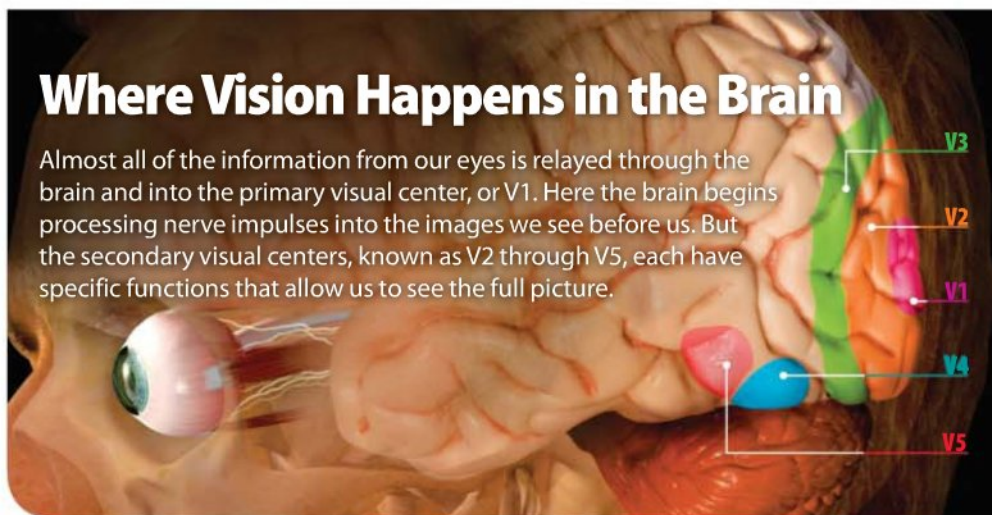
One of the most intensely studied blindsighted patients, an Englishman referred to in scientific literature as G.Y., has Type 2. As an eight-year-old, he was in a traffic accident that damaged the primary visual center in the back of the left hemisphere of his brain. This damage left him blind, with only a small part of his left field of vision intact.

Researchers subjected G.Y. to a battery of tests in an effort to understand his rare condition. A typical test began with him sitting in front of a screen, on which a bright spot moved either up and down or from side to side. He had no conscious awareness that he could see anything, so to him it seemed as though he was completely relying on conjecture when asked in which direction the spot was moving. Statistically, he should have been right half the time; however, he perceived the movement correctly 80 percent of the time.

Understanding how a blind man can track movement almost as well as a sighted person requires a look at how the brain processes visual information.

Where Vision Happens in the Brain

Almost all of the information from our eyes is relayed through the brain and into the primary visual center, or V1. Here the brain begins processing nerve impulses into the images we see before us. But the secondary visual centers, known as V2 through V5, each have specific functions that allow us to see the full picture.



1. Processing of visual information begins in **V1**—and it seems that conscious vision can't take place without it. **V1** focuses on contrasts.

HENNING DALHOFF

Vision Breaks Down in the Brain

The eye relays visual information to the optic nerve, which passes it along to various parts of the brain for processing. As in a factory, different areas perform different jobs. Area V1 deciphers basic contrasts—the borders of various parts of the picture—and then shuttles the images to the secondary visual centers, V2 through V5. Areas V2, V3 and V4 add information about spatial orientation, color and shape. Area V5 registers motion and controls the eye movements that follow it.

There are many causes of blindness. Damage to the eye, the optic nerve and the visual centers of the brain can all impair vision. When the secondary areas are affected, the result is one of the various forms of agnosia, a condition in which patients are conscious of vision but cannot recognize or interpret what they're looking at—essentially the opposite effect of blindsight. There's a surprisingly wide range of possible agnosias. Damage to V4, for instance, can cause color agnosia, in which patients can perceive but not recognize different colors: a patient shown a picture of a purple banana and an orange cow can correctly identify that the two colors are not the same, but can't say what the colors are or if they're unusual. Damage to V5 causes motion agnosia, which makes it impossible to recognize that an object is moving. The range of agnosias reveals just how much information



Students in James Danckert's University of Waterloo lab demonstrate equipment used in tracking eye movement and conducting visuomotor experiments.

these areas of the brain are responsible for: Prosopagnosia (an inability to recognize faces) and topographagnosia (an inability to navigate even the most familiar environments) are also disorders caused by damage to the non-V1 visual centers.

But it seems that only patients with injury to the V1 region are capable of blindsight. Early on, some scientists suggested that small islands of healthy brain cells in the damaged V1 could be providing blindsighted people with their unique vision. But brain imaging of G.Y. and other patients with blindsight since then has disproved this theory, showing zero activity in the primary visual center among the blindsighted.

Instead the scans show that secondary visual centers can be activated even if the primary visual center is not functioning. When G.Y. was presented with objects that moved quickly in his blind field, an area of the brain consistent with V5 lit up at the moment he discerned the motion. The scans proved that this region, which plays a decisive role in decoding motion, receives nerve signals directly from the superior colliculus, an area in the brain that lies between the eyes and V1. In the same way, the other secondary centers can receive information from the eyes or each other, without the involvement of the primary visual center. Patients might get information about color and



2. V2 registers position and spatial orientation, starts to identify colors, and helps to distinguish the child on the bike from the background.



3. V3 continues to perceive additional visual information with regard to color and shape, providing a clearer image.



4. All the details of shape and color are completed and assembled into a picture as the information moves through **V4**.



5. V5 picks up on movement and sends signals back to the eyes, allowing them to follow the moving object.

Blindsight Takes on Different Forms

In 2004 James Danckert, a psychologist at the University of Waterloo, and Yves Rossetti, a neuroscientist at Inserm, the French National Institute for Health and Medical Research, proposed a system of three basic categories for the condition. The classifications are based on a blindsighted person's awareness of vision, as well as his ability to respond to visual stimuli. Each category is associated with one of two pathways that visual information takes in the brain as it bypasses the damaged primary visual center.

ACTION BLINDSIGHT

Abilities: Patients can look toward, point to, and even reach out to grasp an object.

Awareness: Patients report that they cannot sense anything in the blind field and that their responses are simply guesses.

Pathway: Action blindsight appears to be associated with the dorsal, or "where," stream of information in the brain.



ATTENTION BLINDSIGHT

Abilities: Patients are able to detect motion and determine the direction in which an object is moving.

Awareness: Patients report that they have a feeling, or "just know," that there is something present in the blind field, but they still aren't consciously aware of seeing.

Pathway: Attention blindsight is probably also related to the dorsal, or "where," stream of information.

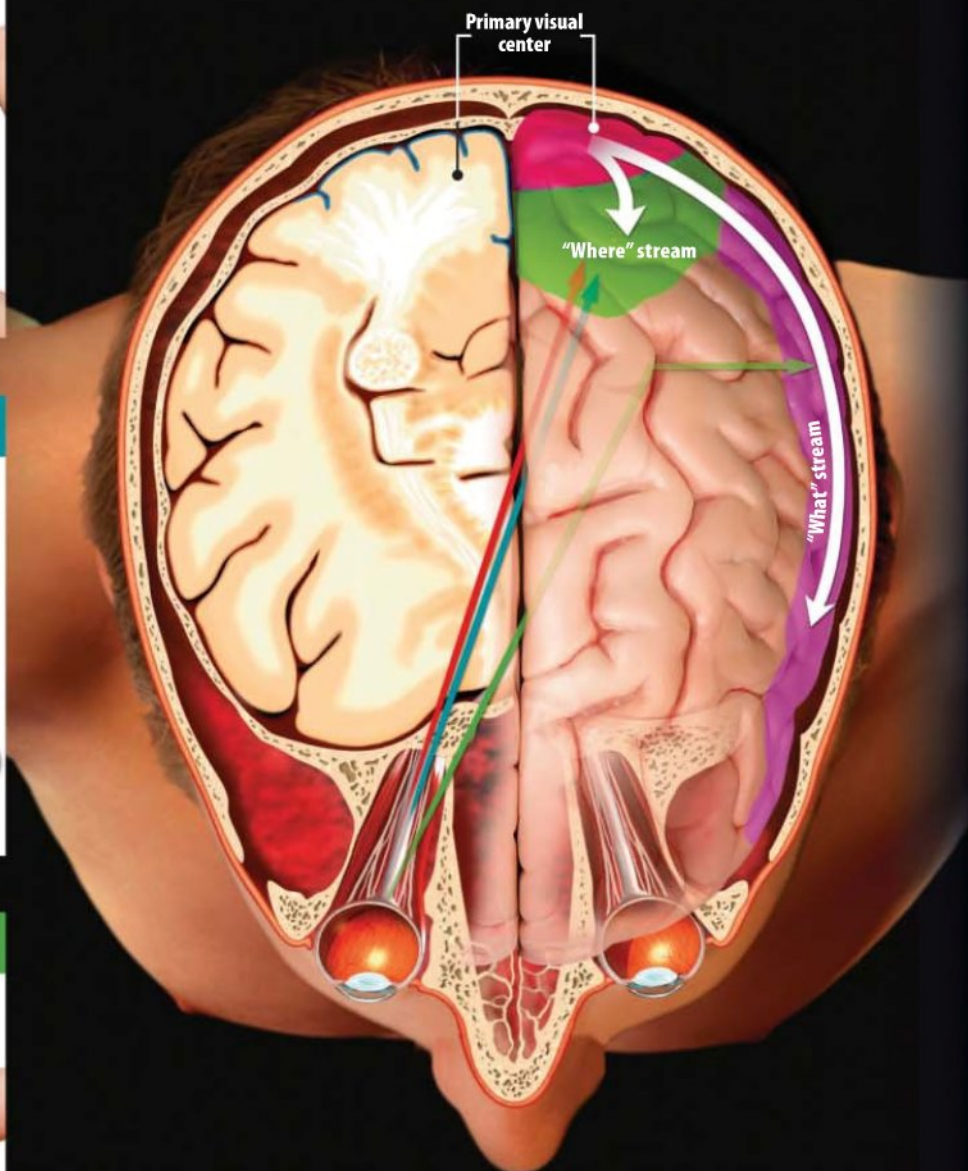


AGNOSOPSIA

Abilities: Patients are able to answer questions about the color and shape of an object.

Awareness: Despite being able to respond to stimuli, patients continue to report that they aren't aware of seeing anything.

Pathway: Agnosopsia is believed to occur in the ventral, or "what," stream of information in the brain.



shape, but they won't be fully aware of it. More than just processing details like contrasts, V1 appears to be involved in the vital task of linking our sight to our awareness of it.

Homing in on Vision's Path

Although Type 1 and Type 2 are the most commonly used classifications for blindsight, three new groupings were proposed in 2004 by James Danckert, a psychologist at the University of Waterloo in Ontario, and Rossetti at In-ferm. Unlike the old designations, the new classifications are based not only on the amount of awareness patient report but also their reaction to visual information.

Those with action blindsight aren't consciously aware of what's in their blind field, similar to Type 1 patients, and their abilities are limited to grasping at, pointing to, or directing their gaze toward stimuli. Attention-blindsight patients have a feeling that there is something happening in their blind field, similar to Type 2 patients, and as a result, they are able to respond more fully to stimuli—they can detect motion and determine the direction in which a stimulus is moving or pointing. A third type of blindsight is called agnosopsia, which means "not knowing what one sees." These patients are able to discern colors and shapes, even though they aren't consciously aware of those characteristics.

The abilities associated with the three categories align well with the leading theory on the paths visual information can take through the brain. The path from V1 to V5 in undamaged brains is believed to be twofold. Visual information flows along both the dorsal stream, which begins in V1 and proceeds along the top of the brain, and the ventral stream, which begins in V1 and continues along the bottom. Studies on animal brains show that the streams have different roles. The dorsal stream is also known as the "where" (or "how") stream. It quickly processes the information—such as size, spatial orientation and movement—needed to reach out and catch a ball, for exam-

ple. The ventral stream is also known as the "what" stream, and it handles information more slowly, focusing on the aspects—like shape, color and movement—that allow us to recognize that a dog is a dog, or a cup a cup.

Danckert and Rossetti believe that action blindsight is associated with the dorsal stream. When information is allowed to flow past the V1 area and into that stream, patients are able to quickly locate, point to, and reach for stimuli. Attention blindsight is probably also related to the dorsal stream, whereas agnosopsia is most likely a result of information making it into the ventral stream.

Beyond Vision

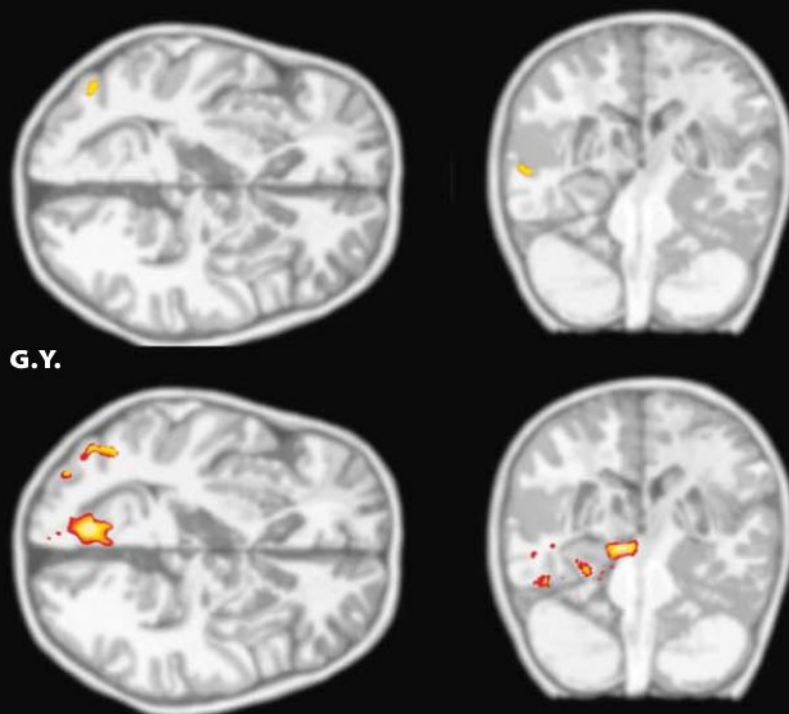
The brain is, in many ways, still uncharted territory. Researchers don't

know exactly which areas handle what information. Much of our knowledge comes from research on people with various types of brain damage, and the study of blindsight, in particular, has allowed us to continue to hone our understanding of the way the brain processes vision. In 1917, for instance, it was considered a basic fact that destruction of the primary visual center would result in total blindness. Yet now it is known that patients with V1 damage can still "see."

Today, blindsight researchers are investigating what else their patients can see and do. They're also exploring the possibility of different types of blindsight and their associated brain areas. The hope is that the research will give us a clearer picture not only of vision but of the brain as well. ■

The Brain Registers Movement

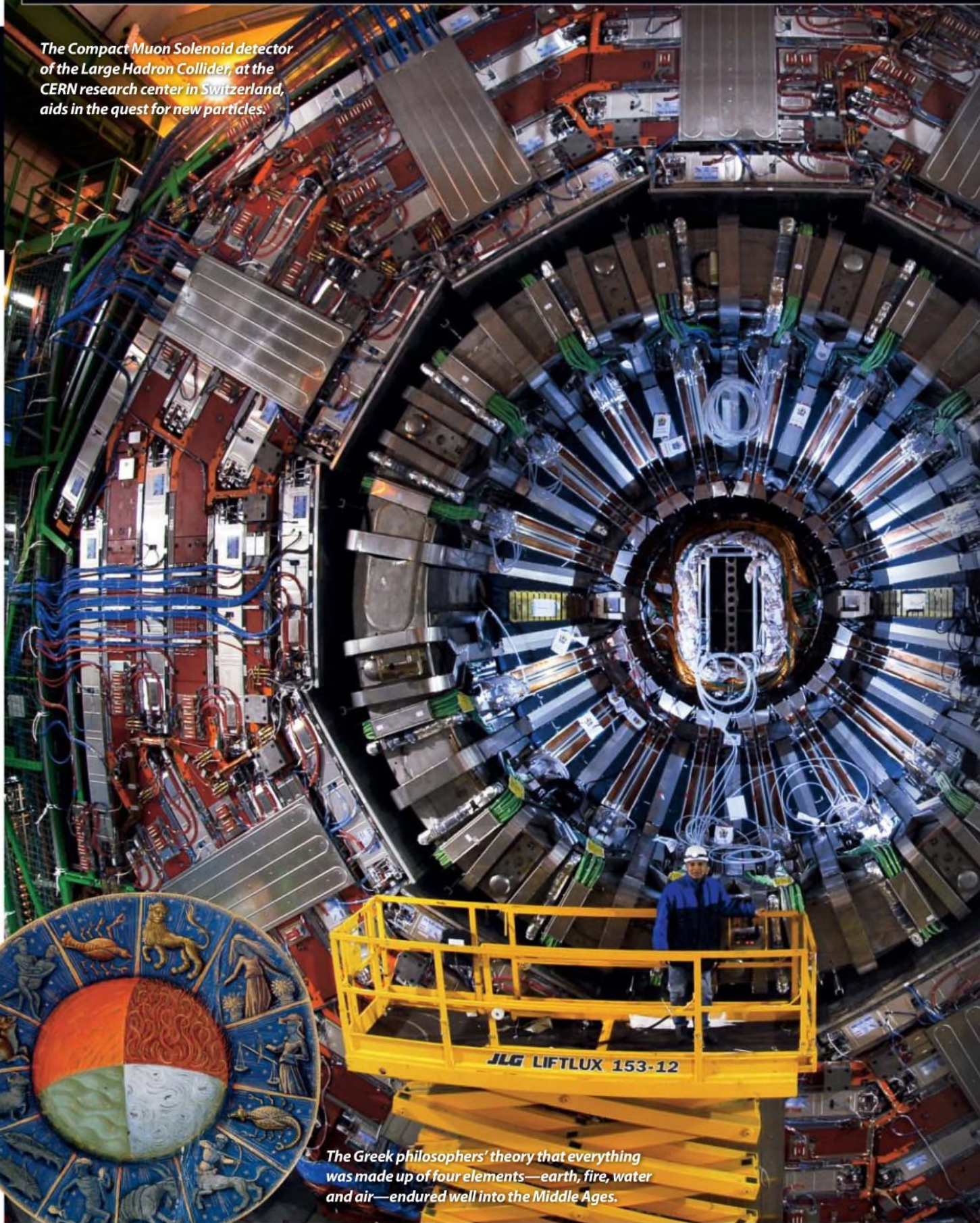
Subject G.Y. is essentially blind in his right visual field but can still detect movements in his blind field. Here we see brain activity in G.Y. and in a sighted subject as they watch rapid and slow movements.



G.Y.

Normal-vision subject

The Compact Muon Solenoid detector of the Large Hadron Collider, at the CERN research center in Switzerland, aids in the quest for new particles.



The Greek philosophers' theory that everything was made up of four elements—earth, fire, water and air—endured well into the Middle Ages.



ANSWERING
THE BIGGEST QUESTIONS
IN
SCIENCE



What Is Everything Made Of?

Scientific progress over the past 200 years has brought us closer to answers to such classic questions as:

❁ **What is the smallest subatomic particle?**

❁ **What is matter made of?**

❁ **What holds matter together?**

❁ **Can we devise a “theory of everything”?**

It might come as a surprise that atomic theory originated as far back as the fifth century B.C., when Greek philosophers believed that all matter was made from fundamental particles called atoms. From those earliest flirtations with atomic theory through the discovery of a vast menagerie of subatomic particles in the 20th century, scientists have continually strived to determine just what the universe’s matter is made of. We still haven’t found the answer, but efforts involving the world’s largest particle accelerators might uncover some crucial clues. Here, a look at how far atomic (and subatomic) physics has already come, and speculations on what will come next.

Elements and the Earliest Atomic Theories

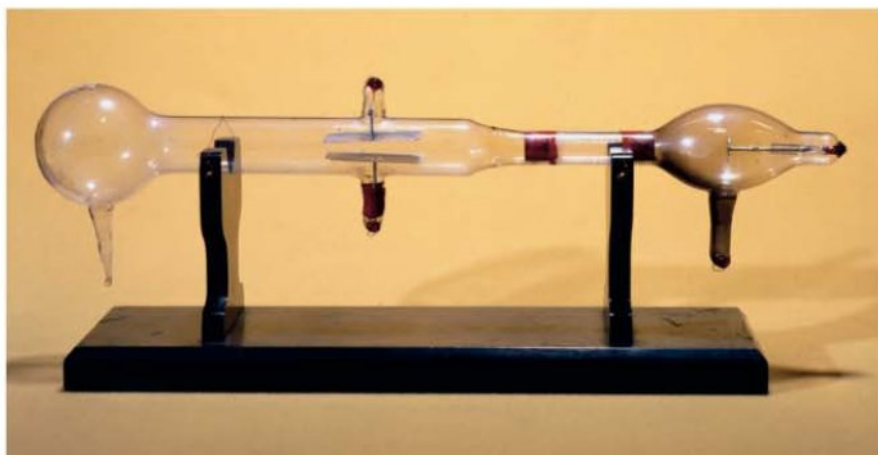
In the mid-fifth century B.C., the philosopher Empedocles asserted that all matter was composed of four eternal and unalterable elements: earth, fire, water and air. A century later, Aristotle expanded the theory by adding aether, an indefinable element that made up the heavens. Each element was endowed with its own characteristics. For example, fire was hot and dry; water, cold and wet. Similar systems emerged in Asia, where Hindus, Buddhists and Taoists developed the concept of four or five fundamental elements (these usually included water, fire, air, wood or metal) as the basis of all matter. This worldview persisted for almost two millennia, remaining popular with European alchemists throughout the Middle Ages.

But in Greece, the five-element system also had competition in the form of an early incarnation of atomic theory. By the end of the fifth century B.C., Leucippus, his pupil Democritus and later Epicurus all came to believe that the world was made of an infinite number of indivisible particles—atoms—which were separated by empty space. According to Leucippus and Democritus, atoms were uniform in size and shape and could not fuse, which meant that everything in the world was transitory and could be broken down. Epicurus believed that different types of atoms must possess varied shapes and sizes and that all changes in the universe were caused by atoms arranging themselves in new ways.

The so-called alchemical model of the world reigned supreme until the 1600s. Then, modern atomic theory, which took its cues from the Epicurean model and the works of Pierre Gassendi and Robert Boyle, supplanted it.

The Rise (and Fall) of the Atom

Throughout the 1700s, experimentalism boomed. Whereas the philosophical theories of the past relied mostly on general observations of the ways in which substances interacted, these new experiments involved making precise



In 1897, while sending a current through a cathode-ray tube, English physicist Joseph John Thomson discovered streams of subatomic particles, later dubbed electrons.

measurements of various materials and their properties. This gave scientists new insights into the materials they studied. In a crucial series of experiments, the French chemist Antoine Lavoisier discovered that the total quantity of matter, as well as the mass of individual elements, was preserved during chemical reactions. Substances could change their state—from solid to liquid, for example—and they could recombine in new ways, but matter itself could not be created from nothing, nor could it be destroyed. Lavoisier also distinguished between pure elements and compounds and declared that water was, in fact, not an element but a compound made up of the elements oxygen and hydrogen.

All the progress of the 18th century came to fruition in 1808, when the

English physicist and chemist John Dalton published *A New System of Chemical Philosophy*, in which he stated that all matter consists of atoms, an element is made up of a group of identical atoms, and each element is unique because of the uniqueness of the masses of its constituent atoms.

As the list of known elements grew, the Russian chemist Dmitri Mendeleev organized them into a chart, which he formalized in 1869 and is now known as the periodic table of elements. The elements were grouped according to their masses, which progressed incrementally. Where there were blank spaces in the table, Mendeleev could predict the existence and properties of additional elements—such as gallium and scandium, later discovered in 1875 and 1878, respectively—based on these

incremental increases in mass.

But the atom's tenure as the base unit of matter lasted for just over a century. In 1897 the English physicist Joseph John Thomson was experimenting with the rays created when he passed an electric current from one electrode to another inside a near-vacuum tube—an unexplainable phenomenon at the time. Thomson proved that these “cathode rays” were a stream of negatively charged particles that were lighter than even hydrogen, the lightest atom. The particles became known as electrons.

The Secrets of Gold Revealed

If atoms were not the smallest particles of matter, they must instead have consisted of negatively charged electrons and—because atoms are neutrally charged—a positively charged component. The question then became: How were they put together to create atoms?

Ernest Rutherford, a New Zealand-born physicist, was greatly interested in radioactivity and the phenomenon's relationship to atomic structure. In 1907 he and the physicists Hans Geiger and Ernest Marsden investigated the structure of the atom by bombarding thin metal foils—notably gold—with positively charged radiation called alpha particles. In their experiments, most of the particles sailed through the foil in a straight path, while others bounced back toward their emission source, indicating that they had col-

Putting the Puzzle Together The Quest for an Explanation of Everything

Twenty-four hundred years ago, the Greeks posited that all matter was composed of indivisible particles, which they called atoms. Today scientists are still searching for the answer to a big question: What makes up our world?



CIRCA 460 B.C.

Empedocles believes that everything is made from the four elements: earth, water, fire and air.



CIRCA 420 B.C.

Democritus suggests that everything is composed of an infinite number of indivisible particles: atoms.



CIRCA 350 B.C.

Aristotle expands the theory of the four elements and adds a fifth: aether.



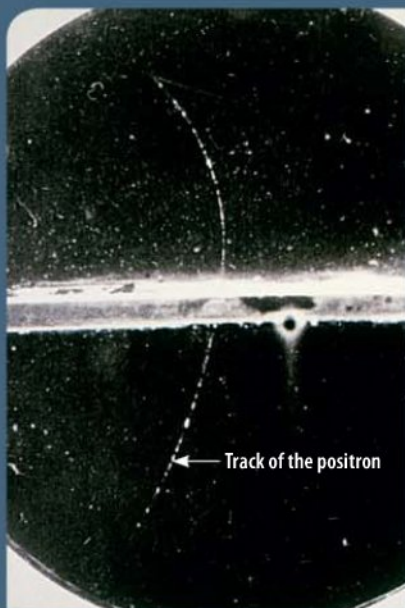
1808

John Dalton formulates the first modern atomic theory: Each element consists of identical atoms and has a unique atomic mass.

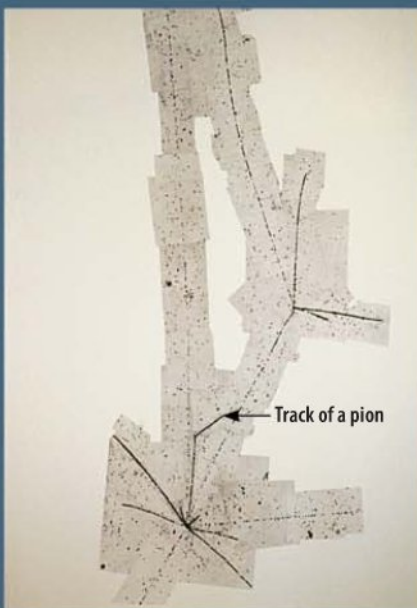


New Instruments Make the Invisible Visible

Starting in the late 1800s, scientists developed various instruments that helped them discover the smallest components of matter.



In 1932 the American physicist Carl D. Anderson used a cloud chamber to find the positron, the electron's antiparticle.



A collision between a cosmic ray and an atomic nucleus can generate a pion, shown here on a photographic plate.



In 1968 an experiment at the SLAC particle accelerator in California showed that protons are composed of quarks.

CLOUD CHAMBER

The Scottish physicist Charles Thomson Rees Wilson developed the cloud chamber at the turn of the 20th century. This device was used to detect a variety of subatomic particles. When a charged particle passes through a chamber filled with supersaturated vapor—often water or alcohol—the gases condense in the particle's wake, leaving a visible track.

PHOTOGRAPHIC PLATE

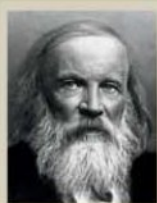
In the 1940s, the English physicist Cecil F. Powell used photographic plates to find additional subatomic particles. The plates were easier to use than cloud chambers. Powell exposed these plates to cosmic rays on mountaintops, where the radiation is far more powerful than at sea level, and in 1947 he discovered the pion.

ACCELERATOR

The American physicist Ernest Lawrence built the first modern particle accelerator at the University of California at Berkeley in 1930. Within two decades, accelerators had become so powerful and their detectors so sensitive that scientists could produce and measure a wide variety of energetic particles under controlled conditions.



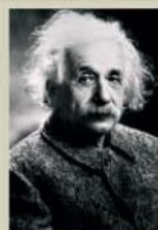
1811 Amedeo Avogadro makes a distinction between molecules (divisible particles that make up a gas) and atoms (indivisible particles which make up a molecule).



1869 Dmitri Mendeleev creates the periodic system, in which the elements are arranged according to their atomic masses.



1897 Joseph John Thomson discovers that atoms are not indivisible: He finds the electron.



1905 Albert Einstein proves that matter and energy are interchangeable and that light can behave as both a particle and a wave.



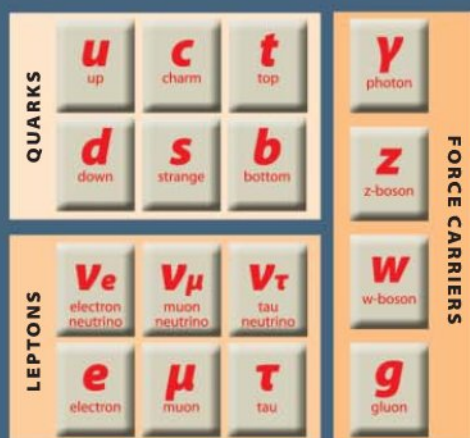
1909 Ernest Rutherford discovers that an atom contains a dense, compact nucleus.



1913 Niels Bohr proposes that the electrons in atoms orbit the nucleus at prescribed distances.

The Particle Zoo

The Standard Model describes all particles, dubbed the “particle zoo” by physicists, and most natural forces, excluding gravity.



- Quarks are the most elementary particles in the atomic nucleus.
- Leptons are another class of particles; among them, the electron is the best known.
- Force carriers are responsible for the interaction of particles.

lided with something unexpectedly dense—the nucleus. This led Rutherford to suggest a model of the atom in which the electrons orbited a compact, positively charged nucleus. He also identified protons as the elementary particles with a positive charge.

Enter the Quark, and the Eightfold Way

After Rutherford’s gold-foil experiments, the notion of the atom as an indivisible particle was well and truly over. In 1932 the English physicist James Chadwick bombarded various materials with alpha particles and

discovered the neutron, a subatomic particle with no charge but more massive than a proton. The atom could now be understood as having a dense, compact nucleus composed of neutrons and protons and surrounded by a cloud of electrons. That same year, the American scientist Carl David Anderson used a device called a cloud chamber to investigate cosmic rays and discovered an entirely different class of particle. Appearing only during collisions of other high-energy particles, the positron has the same mass as an electron and is positively charged.

In the decades that followed, dozens

of new particles emerged. In 1936 Anderson detected the muon, a more-massive version of the electron. And in 1947, scientists discovered two new particles, pions and kaons, by observing their tracks on photographic plates.

Then, in 1964, the American physicists George Zweig and Murray Gell-Mann independently proposed that protons and neutrons, as well as the majority of the newly discovered particles, were composed of even more elementary particles, which Gell-Mann called quarks. These sub-subatomic particles were grouped into octets, dubbed the Eightfold Way by Gell-Mann, and, like Mendelev’s periodic table before it, the system allowed physicists to predict the existence of subatomic particles before they were verified. The whimsically named quarks—up, down, top, bottom, charm and strange—were experimentally confirmed by 1995.

In time, physicists combined all the known particles and forces—except for gravity, for which no particle carrier has ever been found—into what is called the Standard Model. According to this model, all matter is composed of the six quarks as well as six leptons, another class of fundamental particles. In addition, there is the energy particle the photon, which carries the electromagnetic force; the W and Z particles, responsible for another fundamental force, the weak nuclear force; and the gluons, which cause the interactions between the quarks.



1924 Louis de Broglie discovers that light isn’t the only energy that can behave as both particles and waves—ordinary particles such as electrons can also exhibit wave-particle duality.



1932 James Chadwick finds that nuclei under bombardment from alpha particles can emit a particle without a charge, later dubbed the neutron.



1947 Cecil Powell finds Yukawa’s predicted particle, the pion. Later, new particles are identified in cloud chambers and on photographic plates.



1925–28 Scientific papers from Werner Heisenberg, Erwin Schrodinger and Paul Dirac [left] establish the modern form of quantum mechanics.



1935 Hideki Yukawa proposes that the particles in an atom’s nucleus are held together by a special energy particle.



1956 Frederick Reines [left] and Clyde Cowan prove the existence of the neutrino by studying a reaction involving the subatomic particle, hydrogen and cadmium.

**Subatomic Physics, Standardized**

The Standard Model produced a series of precise predictions, many of which have been confirmed experimentally, and to this extent it has been enormously successful. But many questions remain, the most pressing of which is confirming the existence of the Higgs boson, the subatomic particle thought to give matter its mass. The Standard Model predicts its existence, but the Higgs has thus far eluded efforts to find it. The Large Hadron Collider at CERN, the particle-physics research center in Switzerland, was built with the aim (among others) of finding the Higgs, but construction delays and a helium leak last September have pushed back its science schedule by years. Even without any additional problems, the LHC won't be producing any data before October this year, and analysis of the first experiments won't be finished until sometime next year.

Meanwhile, the LHC's main competition in finding the Higgs, the less-powerful Tevatron at Fermilab in Illinois, has been busily humming along, making precise measurements of a variety of subatomic particles. This March, physicists at the Tevatron continued to rule out whole energy ranges where the Higgs might be found. And although many physicists believe that the LHC will still be the first to see the Higgs, the team at the Tevatron plans to continue zeroing in on it while the LHC waits to be switched on. ■

The Search for the Higgs

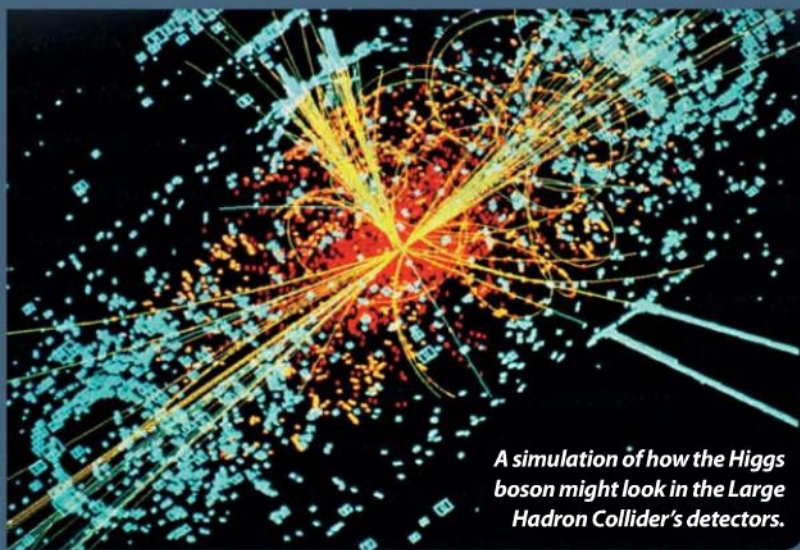
The \$8.8-billion Large Hadron Collider might produce the Higgs boson, the most elusive member of the particle zoo.

Since the 1950s, building larger and more-powerful particle accelerators has been absolutely necessary for particle physics. Creating these particles demands concentrated energy that only those accelerators can deliver.

When the Large Hadron Collider (LHC) comes back on line in September, researchers expect that it will be able to discover new particles that will confirm or disprove existing theories. Physicists hope

to see traces of the Higgs boson, a particle whose existence would explain why most elementary particles have mass.

The LHC and even larger future accelerators may also find a new family of supersymmetrical particles. Some physics theories demand that each of the elementary particles known to exist must have a counterpart—a selectron for the electron, a squark for the quark and so on.



A simulation of how the Higgs boson might look in the Large Hadron Collider's detectors.



1964 Murray Gell-Mann [left] and George Zweig separately postulate that neutrons, protons and many of the newly discovered particles are composed of more-elementary particles called quarks.

1968 Experiments with the two-mile-long linear accelerator at SLAC National Accelerator Laboratory at Stanford University provide the first evidence that protons are made up of three quarks.

1983 The W^+ , W^- and Z particles, which carry the weak nuclear force and are responsible for the nuclear decay that causes beta radiation, are observed at CERN.

1995 Evidence for the "top" quark—the sixth and final quark to be experimentally verified—is produced in the Tevatron at Fermilab in Illinois. The existence of this quark was first proposed in 1973.

1998 An experiment at Japan's Super-Kamiokande detector finds that neutrinos may have mass—a possibility physicists have speculated about for years.

2000 In yet another neutrino discovery, physicists at Fermilab produce the first experimental evidence of the existence of the tau neutrino.

2008 The first beam is sent through the Large Hadron Collider at CERN in September. That same month, however, the LHC is shut down for repairs.

The Social Factor

A brain chemical that helps us conquer fear and bond with others may be the key to treatments for social disorders like autism

Humans are social creatures. But what makes us that way? A growing body of research points to the anxiety-reducing, feel-good powers of a brain chemical called oxytocin, best known as a pregnancy hormone. Now scientists are using an oxytocin nasal spray to learn more and develop treatments for autism and other social disorders.

Overcoming Anxiety

In its best-understood role, oxytocin stimulates labor and lactation. But it also acts as a neurotransmitter that sparks activity in the limbic system, the brain's emotional center. Research has shown that its job there is related to a host of social behaviors such as mothering, bonding and mating. In an important early study on oxytocin's social role in animals, scientists at the University of Maryland showed that it is involved in prompting prairie voles to mate for life. When the researchers blocked receptors in the voles' brains for oxytocin and a related hormone, vasopressin, the animals broke their typically lifelong bonds.

Oxytocin also appears to be the driving factor behind another key social behavior: trust. In 2005, Swiss and American researchers decided to see whether a burst of extra oxytocin, delivered by a nasal spray, would make people more likely to trust a stranger with their money. The researchers gave \$10 to a volunteer, known as the inves-

Oxytocin makes socializing more pleasurable, giving you the same kind of boost you get from a gift or a massage.

tor, and told him that he could invest all or part of it with a stranger, or trustee. The investment would then automatically triple, and the trustee could decide whether to split the money with the investor or keep it all for himself.

It turned out that 45 percent of investors given a dose of oxytocin invested the full amount, compared with

only 21 percent of dose-free investors. The researchers concluded that oxytocin promotes trust in humans, possibly by inhibiting a natural fear of betrayal. A similar fear-dampening mechanism also underlies prairie-vole bonding, scientists say, since the chemical helps voles overcome their fear of physical closeness, a survival instinct.

Other studies have confirmed the link between oxytocin and anxiety reduction. In May 2008, a research team led by Thomas Baumgartner at the University of Zurich combined the methods of the earlier studies, taking brain scans while running a new version of the trust game. This game involved two rounds, so that Baumgartner could study how investors reacted to betrayals over time.

At the end of the first round, the investors were informed that half the strangers took the investments given to them and refused to share the profits. In the second round, investors who received a dose of the oxytocin continued to invest large amounts, despite the previous betrayals, while those who received a placebo spray scaled back.

Meanwhile, Baumgartner's team tracked the investors' brain activity with functional magnetic resonance imaging scanners, a specialized type of MRI, to figure out which parts of the brain were affected. In the oxytocin group, the brain scans showed decreased activity in the amygdala, a structure in the limbic system associated with fear, as well as other mid-brain regions linked to fear processing. The scans also revealed a dampening of activity in the dorsal striatum, an area that helps control behavioral responses to stimuli. Oxytocin, it seemed, didn't just lessen the investors' fear of betrayal. It also made them unwilling to change the way they treated someone based on one bad experience—or, in other words, it made them forgive.

Making Connections

The way we communicate with one another, too, seems to depend on oxytocin. For instance, children with severe autism spectrum disorder (ASD), a condition marked by problems interacting with others, have a lower-than-normal blood oxytocin level. And people with social disorders such as obsessive-compulsive disorder and borderline personality disorder seem to have altered oxytocin receptors in their brain, suggesting that their illness could be related to differences in oxytocin processing. It remains to be seen whether a low oxytocin level contributes to autism or vice versa.

Either way, experiments with oxytocin nasal spray have helped to confirm the chemical's role in social communication. When volunteers were given the spray during a 2007 study, they were able to judge people's emotional states—fearful, angry or happy—based on their expressions better than others could. Poor emotional recognition, or “mind reading,” is the hallmark of ASD. Lack of eye contact is also a sign of autism, and it likewise appears to be linked to oxytocin. Increased oxytocin in the brain has been shown to improve mind reading, eye contact and empathy in people with ASD. The spray increases how often

and how long volunteers look at pictures of faces, ostensibly giving them more information from which to infer emotional states and to empathize.

Controlling stress hormones may be a key way the brain chemical promotes social behaviors, says Markus Heinrichs, a neurobiologist at the University of Zurich. In a study released in May, Heinrichs and his colleagues showed that couples who received a dose of oxytocin communicated more positively during a heated discussion than those who got a placebo; the oxytocin group's cortisol levels were also reduced after the conflict. The level of this hormone typically increases after exposure to stress.

Another important role of oxytocin seems to be an effect on the reward-processing areas of the brain during social interactions. Somehow the chemical makes socializing more pleasurable,

giving you the same kind of boost you get from a gift or a massage.

Today Heinrichs is conducting one of the first trials that use oxytocin medicinally. He's testing the nasal spray, in combination with psychological therapy, in people with social phobia, borderline personality disorder and Asperger's syndrome, an ASD. “I'm optimistic that oxytocin can improve the treatment of several mental disorders with severe social deficits,” Heinrichs says. His first test results should be available later this year, and if all goes well, oxytocin—the chemical that fosters bonding between a mother and her baby—may someday help people with social disorders improve their bonds with the rest of society. ■

Trust in a Bottle?

Don't trust Liquid Trust, scientists say.

Since 2006, Vero Labs in Boca Raton, Florida, has been claiming to harness the trust-inducing powers of oxytocin with its product, Liquid Trust, a blend of water, alcohol and oxytocin. The less-than-an-ounce bottle sells for around \$30 at Web sites like love-scent.com and amazon.com, and a second-generation “enhanced” version with androstenone, a pheromone, is also available for a whopping \$80.

One spritz of Liquid Trust when you're getting dressed, and trusting parties—from business associates to lovers—will fall in line, right? Wrong, says neuroscientist Thomas Baumgartner. “It is completely unproven that this product has any effect on trust behavior. And it's unlikely that the method of application can sufficiently raise the oxytocin level in the brain to induce measurable effects.” Looks like we'll have to continue actually earning trust for now.





Oil spews from a well on Spindletop Hill, the site of Texas's first gusher.

TECHNOLOGY OF THE TIME

Rags and barrels

Before oil was pumped from wells, it was collected where it seeped up from the ground or into streams. The liquid was skimmed off the water or soaked up in rags and then poured or wrung out into barrels to be bottled as sham medicine.





From the First Drop to the Last

This year marks the 150th anniversary of the first oil strike. Here's a look back at the personalities, events and technologies that have shaped the industry that's changed the world

At a time when oil companies are spending billions to get at petroleum trapped in rock miles below the sea, it's hard to imagine a world where oil just seeped to the surface and pooled unused. But just 150 years ago, the now-precious commodity was bubbling up from the ground around the world.

Petroleum, also known as crude oil, was created over the course of millions

of years. The process began when dead plants and animals that had settled on the ocean floor were covered by sediment from erosion. As the sediment piled on, temperatures in the layers below it increased, setting off chemical reactions that broke down large organic molecules into the smaller hydrocarbon molecules that make up fossil fuels, including petroleum, natural gas and coal. Eventually, land shifted over

some of the oil deposits, while the rest of the oil remained under the oceans.

Flash forward to the mid-1900s. In northwestern Pennsylvania, people used rags to soak up oil from pools on the ground called seeps, squeezed it into bottles, and sold it as quack medicine. Two enterprising businessmen, a lawyer from New York and a Connecticut bank president, saw a more profitable use for petroleum, then known as

1858

James Miller Williams strikes oil while drilling for water in Ontario.

1859

Edwin L. Drake digs the first modern well in Pennsylvania and hits oil.

1862

The world's first pipeline is laid in Canada.



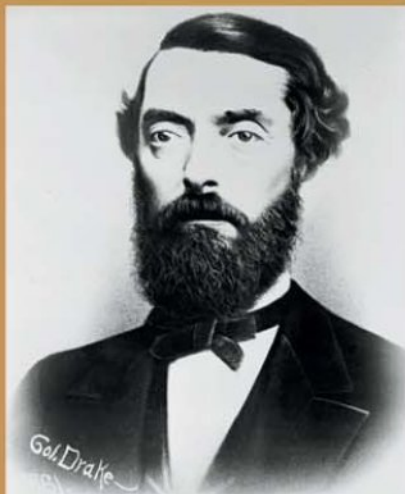
1871

The first oil wells are dug in Russian-controlled Baku [left].

The First Oil

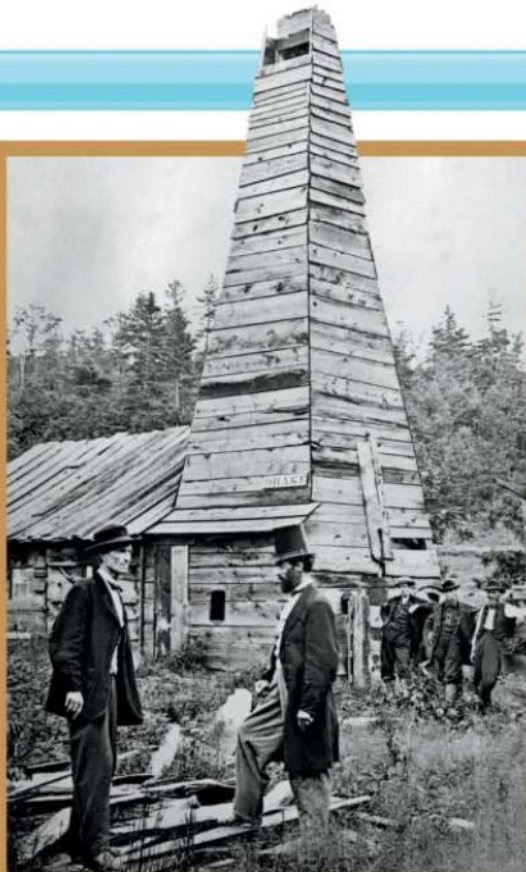
Edwin L. Drake, an unemployed railroad conductor, launched the U.S. oil rush in 1859 when he struck black gold just outside of Titusville, in western Pennsylvania. His investors, New York lawyer George Bissell and Connecticut bank president James Townsend, had all but given up hope of hitting oil when they received the good news. Western Pennsylvania was soon overrun by oil prospectors, and the petroleum boom was on.

In Drake's day, oil wells were covered by wooden structures called derricks. The tall, iconic towers held the drilling crane and machinery. Deeper holes required taller derricks, and Drake's tower measured 48 feet. By the 1880s, derricks had grown even taller and were prone to blow over in



Edwin Drake [above and center right]
tapped the first modern oil well.

strong winds. As the new industry grew, wooden derricks were replaced by the stronger steel versions still used today.



► rock oil. With whale oil in short supply due to overfishing, people needed an alternative source of fuel to light their lamps. In 1857 the men sent an out-of-work railroad conductor named Edwin L. Drake to look for oil just outside the

town of Titusville, in western Pennsylvania. His crew drilled 70 feet into the ground, and in August 1859, they hit pay dirt.

Within 15 months, petroleum was being pumped out of 75 wells in the surrounding area. Production of oil in western Pennsylvania went from 450,000 barrels in 1860 to three million two years later. At first, workers drilled the wells with pitcher pumps, the same ones used on water wells. Starting in the mid-1860s, steam-powered pumps were introduced to draw oil from deeper depths. Other wells didn't have to be pumped; in 1861 drillers tapped the first "flowing" well in Oil Creek, which gushed oil high into the air. It spewed

out 300 barrels of petroleum a day.

At first, coal-oil refineries processed the crude, but by 1860 at least 20 petroleum refineries had been built in Pennsylvania. Today petroleum is processed into several types of fuel, but the early refineries were mainly interested in one: kerosene, a combustible liquid. Far cheaper than whale oil, kerosene burned with an equally bright flame. It soon supplanted the animal product in lamps around the world. The age of oil had begun.

The Rise and Fall of Standard Oil

In 1865, 26-year-old John D. Rockefeller bought out his partner's shares in their successful Cleveland refinery, which

TECHNOLOGY OF THE TIME

A forest of derricks

The first oil derricks—the structures that dot oil fields—were made of wood, and the drilling technique was primitive. Later, derricks were made of steel, and the drills, rotary steel pipes, were steam-powered. Diamond-tipped drill bits, which could bore through rocks more easily, were developed in the late 1800s. If the drillers hit a reservoir under pressure, enormous amounts of oil shot up. The gushers sometimes ran for weeks before they could be brought under control.



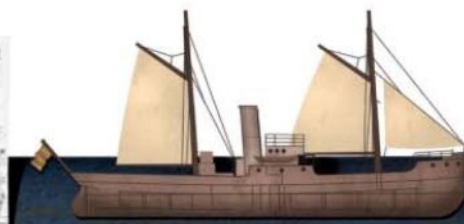
1872

Standard Oil Company is the largest oil-refining group in the world.



1878

The world's first oil tanker, *Zoroaster* [above], transports Russian oil on the Caspian Sea.



CLOCKWISE FROM TOP LEFT: BETTMANN/CORBIS/SCAMPX; CORBIS/SCAMPX; PRECEDING PAGES FROM TOP: CORBIS/SCAMPX; HENNING DALHOFF; INSETS, FROM LEFT: PRINCETON UNIVERSITY PRESS; HULTON ARCHIVE/GETTY IMAGES/ALL OVER

1908

Oil is discovered in Masjed Soleymān, Iran [right], formerly Persia; the company that is now BP is created.

1911

Winston Churchill replaces coal with oil as fuel for Royal Navy ships.

1911

The Supreme Court rules that the Standard Oil monopoly, now Standard Oil Trust, must dissolve.

1911

Gasoline sales outstrip kerosene for the first time, thanks, in part, to the automobile.

**1907**

The first drive-up gas station opens in St. Louis.

1901

The discovery of the Spindletop gusher kicks off the Texas oil boom.

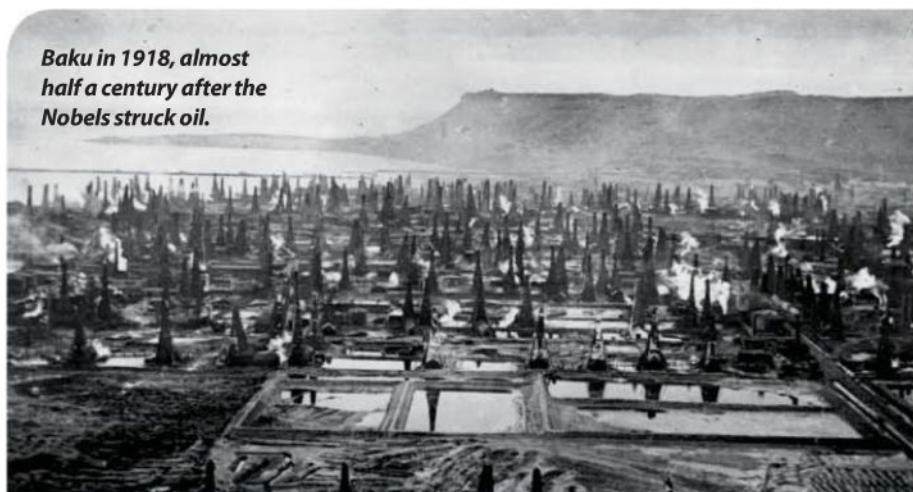
**1896**

The first offshore oil wells are drilled from piers off the coast of Santa Barbara, California [above].

1892

An oil tanker transits the Suez Canal, cutting 4,000 miles off the trip from the Russian-controlled nation of Georgia to the Far East.

Baku in 1918, almost half a century after the Nobels struck oil.



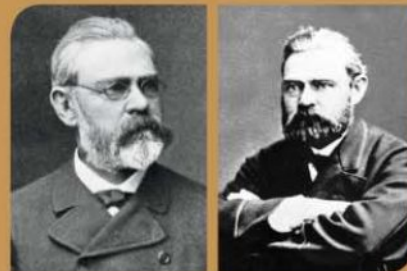
The Birth of the Russian Oil Industry

Alfred Nobel, the Swedish scientist who invented dynamite and endowed the Nobel prizes, is a well-known name. But his less-famous brothers, Robert and Ludwig, left their mark on the world too, as pioneers in the oil industry.

In 1873 Ludwig sent his brother Robert to the Caucasus region near the Caspian Sea to scout walnut timber for their rifle business. In Baku, the capital of modern-day Azerbaijan, small, hand-dug pits had supplied a primitive oil industry since the 1820s, but the first modern well wasn't created until 1871. When Robert arrived in Baku, he found 20 refineries that were already supplying kerosene to Russia. Sensing an opportunity, he spent the timber money to acquire a small refinery.

By the time Ludwig traveled to Baku in 1876, Robert had modernized the refinery and sent his first shipment of kerosene to St. Petersburg. Ludwig took over manage-

ment and soon launched a revolution in the way oil was transported. Using wooden barrels was inefficient and costly, so he devised a way to send it in large tanks built into ships. In 1878 he commissioned the world's first tanker, *Zoroaster*, which transported oil across the Caspian Sea from Baku to Russia. The Nobel Brothers Petroleum Producing Company soon dominated the Russian oil trade.



Robert [left] and Ludwig Nobel brought Russian oil into the big leagues.

1913

Henry Ford begins assembly-line production of the Model T.

1914–1918

World War I becomes the first motorized war. Oil plays a decisive role.

1923–1924

U.S. geologists begin to use seismology to search for new oil fields before drilling.

1928

The “Christmas tree” [right], a system of valves to prevent gushers at oil wells, is patented in the U.S.

1930

At 9,500 feet, California’s Standard Mascot #1 is the world’s deepest oil well, but the record will be broken time and again.

1938

Large oil fields are discovered in Kuwait and Saudi Arabia.

TECHNOLOGY OF THE TIME
The nodding donkey

Oil-pump designs had two goals: to increase pressure underground and get the oil to flow upward. The counterbalanced pumpjack, nicknamed the nodding donkey, was introduced in 1925 and is still in use.

1943

Oil is the most important natural resource in World War II. The Allies bomb the oil fields in Ploesti, Romania, in one of the war’s riskiest raids. Shortages of crude oil force Germany to rely heavily on synthetic oil.



1947

“Oily Rocks,” a 15-mile-long oil city [left]—the first of its kind—is constructed off the coast of Baku.

1951

Al-Ghawar in Saudi Arabia goes into production. It is the world’s largest oil field to this day.

1960

OPEC (Organization of Petroleum Exporting Countries) is founded.



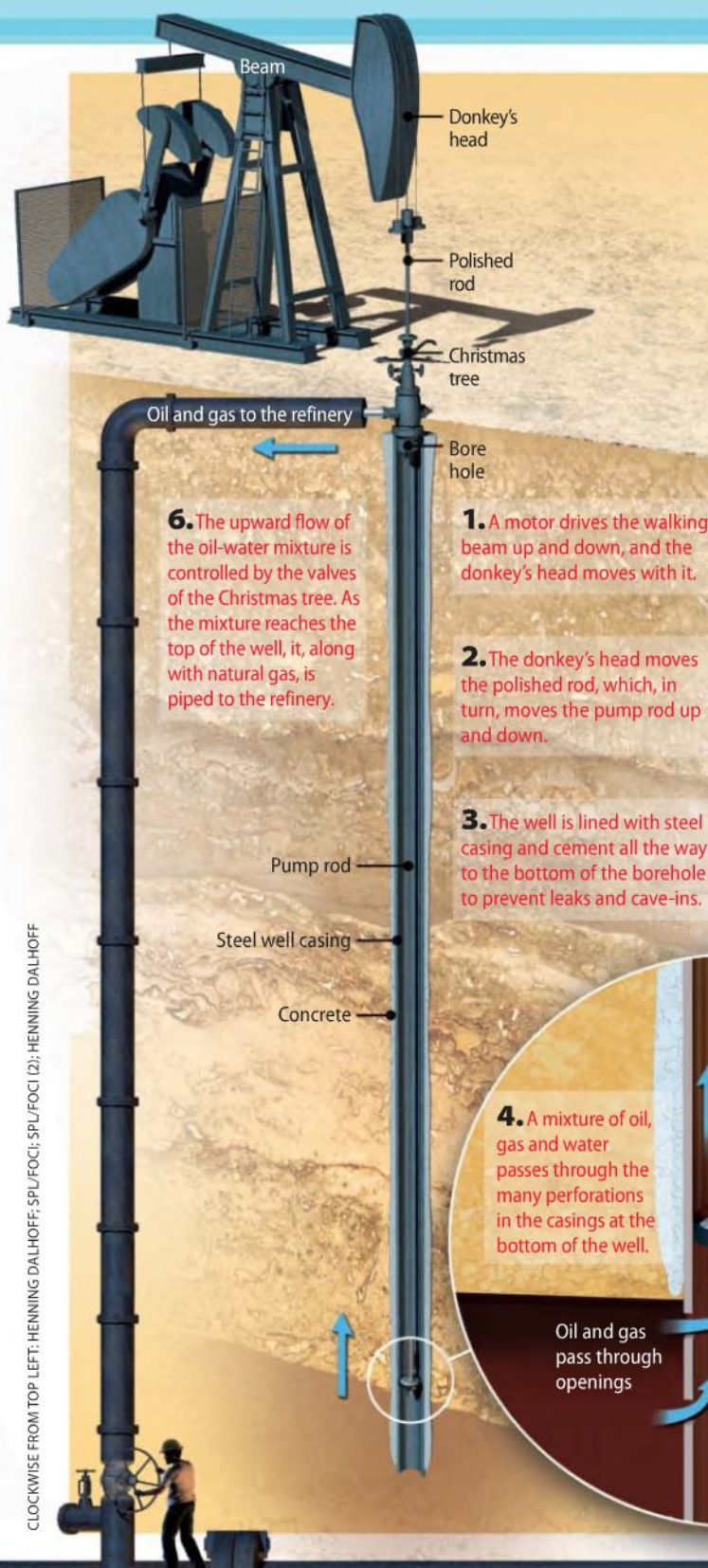
► processed Pennsylvania oil brought in by railroad. By the time the nation’s first official oil exchange—where the business of buying and selling would take place—opened its doors in Titusville in 1870, Rockefeller’s firm had become the Standard Oil Company. Rockefeller sought to tame the unstable industry, which was suffering from overproduction despite increasing demand. Kerosene was being sold at half the price of five years earlier.

Rockefeller found creative ways to stay profitable. The whiskey barrels that served as oil containers cost almost twice their cargo. So Rockefeller grew his own white oak trees from which to manufacture barrels. He also cut costs by purchasing his own warehouses, boats and, eventually, railroad tank cars, which carried the oil from the wells to the refineries. He quickly amassed enough cash to be independent of banks and investors.

Rockefeller’s business tactics were notoriously ruthless. As a major railway customer, Standard Oil was able to demand deep discounts on freight rates. With lower transportation costs, the company could charge less for its oil than competitors while still turning a big profit. So-called drawbacks from the railroads further padded his pockets: These deals gave Standard Oil a percentage of competitors’ payments to the railroads in exchange for its continued business. A campaign of undercutting competitors and pressuring them to sell enabled Standard Oil to acquire refineries across the U.S. By 1878 the company controlled 90 percent of the country’s refining capacity.

Pennsylvania oil producers, fed up with the monopoly, built the world’s first long-distance pipeline in 1879. The

FROM TOP: T. GRAHAM/ALAMY; MPI/GETTY IMAGES/ALL OVER; GOSS IMAGES/ALAMY; M. DUNNING/GETTY IMAGES; M. GARANGER/CORBIS/SCANPIX; INSET, RIGHT: ULLSTEIN BILD

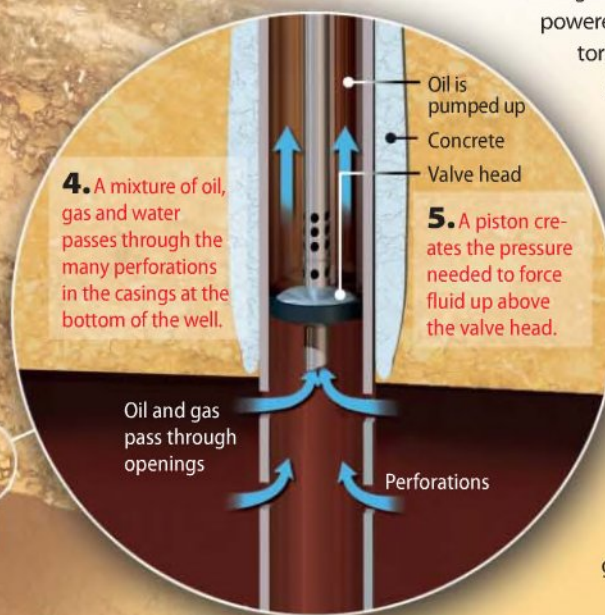


Nodding donkeys at Wyth Farm oil field in England

How a Pumpjack Works

The pumpjack, a Texas oilfield icon also known as the nodding donkey, is the surface unit that drives the reciprocating piston pumps found in oil wells. Walter W. Trout, who worked for drilling-equipment manufacturers Lufkin Foundry and Machine Company, invented the pump in 1925 to help force oil out of low-volume onshore boreholes. Roughly 650,000 of this type of well are still in operation in the U.S.

Though the first pumpjacks were steam-powered, today most have electric motors. Some even run on the natural gas coming up out of the well. In a pumpjack, a beam mechanically lifts oil out of the well through a rod. The weight of the so-called donkey's head on the front end of the beam provides extra force to the pump. Each stroke brings up between one and 10 gallons of oil mixed with water. The oil is then pumped through a series of valves at the top of the well, called the Christmas tree, which regulate flow to prevent gas and oil from escaping.



1967

Canada begins to exploit its tar sands to produce synthetic crude oil.

1968

Alaska's Prudhoe Bay Oil Field, the largest in North America, is discovered.

TECHNOLOGY OF THE TIME

Drills that can turn corners

For many years, oil wells were drilled straight down, but new drill-bit designs make it possible to steer the drill in any direction. Although horizontal wells are more expensive to drill, the recovery of additional oil reserves outweighs the cost, making them the preferred method today.

The Colors and Categories of Crude

Most people think of crude oil as a viscous black liquid, but in reality, it is typically a brown, free-flowing fluid. In some cases, it can even be green or almost clear, depending on the variety of its hydrocarbon molecules. Crude oil is 83 to 87 percent carbon, making it about twice as energy-rich as coal. It is also composed of hydrogen (10 to 14 percent) and trace amounts of sulfur, oxygen and nitrogen.



Most crude is brown and free-flowing.

Crude is divided into three categories based on its sulfur content, density (which is measured by the American Petroleum Institute's gravity system) and geographic origin. These categories and several other factors are used to set prices on world oil exchanges.

Depending on the amount of sulfur it contains, crude is labeled either sour or sweet. Low sulfur, or sweet, crudes command higher prices because they are easier and less costly to convert into usable products. Density also impacts cost—a so-called light crude may be worth more than a heavy crude because it yields a more valuable gasoline product during refining. The oil's origin is also important, as the price of crude is affected by the distance it must be transported between wells and refineries.

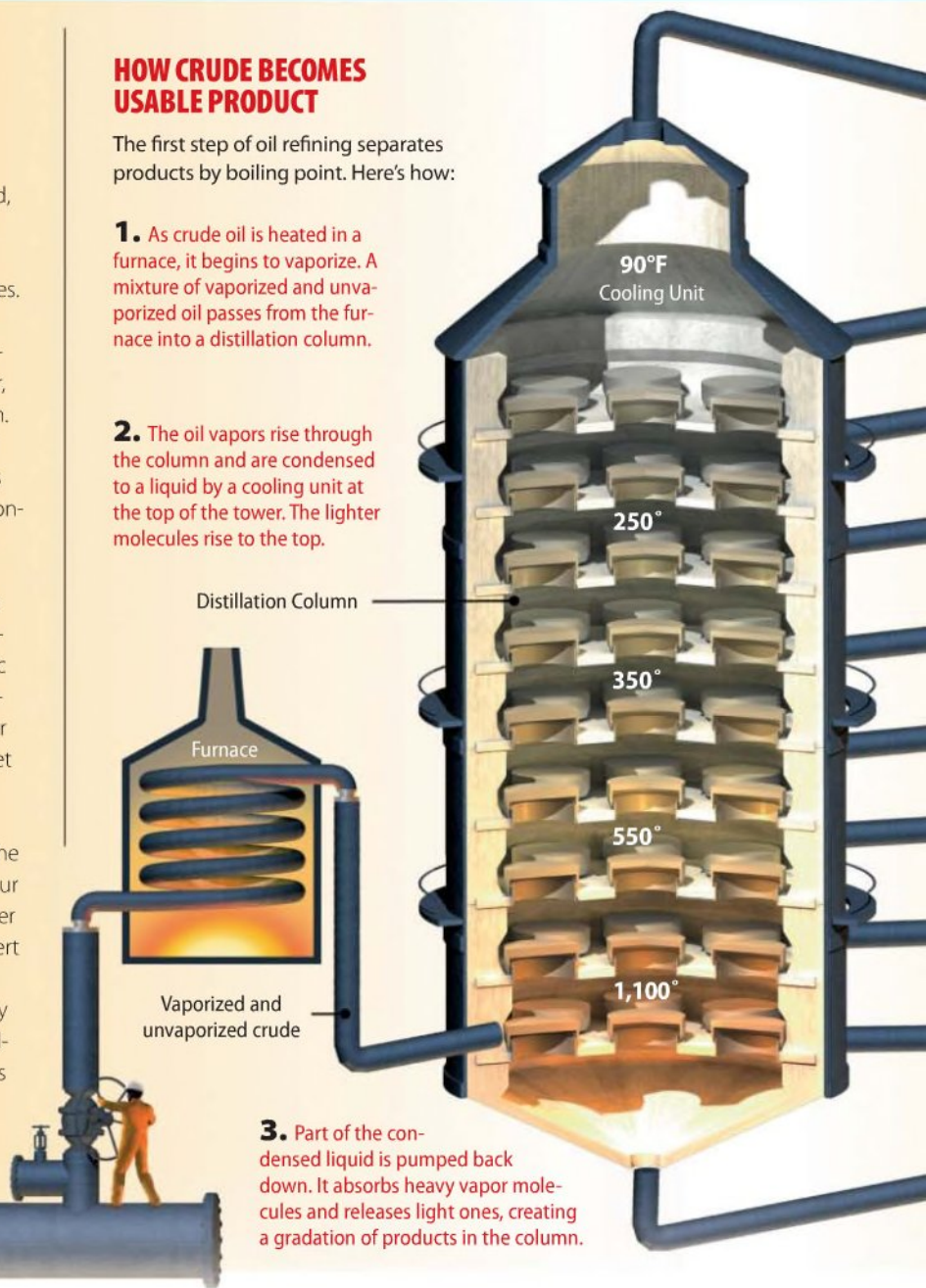
HOW CRUDE BECOMES USABLE PRODUCT

The first step of oil refining separates products by boiling point. Here's how:

1. As crude oil is heated in a furnace, it begins to vaporize. A mixture of vaporized and unvaporized oil passes from the furnace into a distillation column.

2. The oil vapors rise through the column and are condensed to a liquid by a cooling unit at the top of the tower. The lighter molecules rise to the top.

3. Part of the condensed liquid is pumped back down. It absorbs heavy vapor molecules and releases light ones, creating a gradation of products in the column.



► 110-mile Tidewater Pipeline allowed producers to sidestep local railroads, which were under the stranglehold of Standard Oil, and reach other refineries. The pipeline was a success, and it paved the way for lines that today move crude oil thousands of miles, over mountains and under oceans. The technology proven, Rockefeller quickly followed suit. He built four of his own long-distance lines connecting the oil region in Pennsylvania to refineries in that state, Ohio and New York, and

within two years Standard Oil even owned a stake in Tidewater.

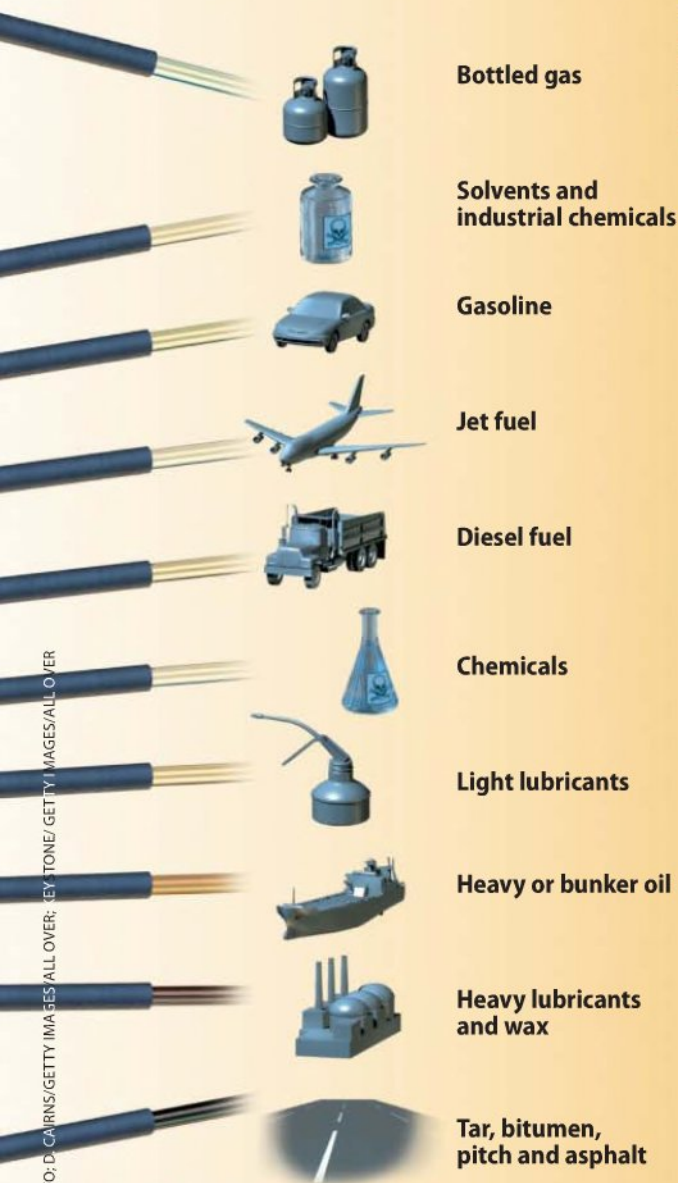
As the uses for petroleum grew—it was refined into natural gas for heat, lubricants for the moving parts of machines, paraffin for candlemaking and a gel called Vaseline—so did Standard Oil. Its trustees eventually oversaw about 40 corporations involved in the production, refining and marketing of oil, and Rockefeller, a billionaire, was the wealthiest man in the world.

The company's questionable busi-

ness practices finally came to light, however, and public and legislative opinion turned against it. In 1911, the U.S. Supreme Court broke up Standard Oil under the Sherman Antitrust Act.

Spindletop and the Horseless Carriage

Pennsylvania, of course, was not the only state with petroleum reserves. By the end of the 1800s, oil fields had been found in 13 other states, including New York and California, as well as



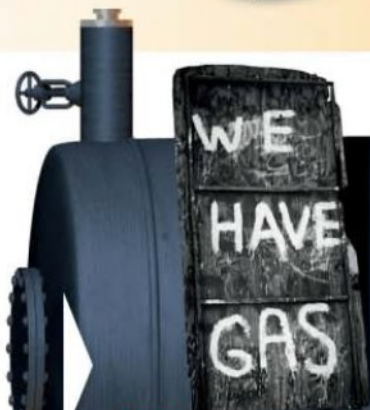
4. Now divided by weight, with the heaviest products, or fractions, on the bottom and the lightest on top, the liquids go through a series of post-distillation processes. These include a conversion process called cracking, which separates hydrocarbons into more desirable products, as well as a purification step. Finally, the crude is converted into usable products like diesel fuel, asphalt, solvents, gasoline and light lubricants.

From Oil Well to Marketplace

After completing the distillation process, crude oil is transformed into new "fractions": fuel gas, light and heavy naphtha, kerosene, light and heavy gas, oil and residue. These products are further processed into retail products [below] such as fuel oil and gasoline. To produce gasoline, naphtha is passed over a catalyst, usually a mineral like zeolite, under intense heat and pressure. The catalyst promotes the addition of protons or removal of hydride ions from the materials, which weakens the carbon bonds, allowing them to "crack" into the smaller compounds in gasoline.



Petroleum is refined into a rainbow of retail products [above] with countless applications [left].



1973

OPEC raises prices and Arab members embargo shipments to the U.S., resulting in an oil crisis in the West.

1975

Oil is discovered in the North Sea from the Sea Quest oil rig [below].



1981

The largest-ever supertanker, the 1,504-foot-long, 250,000-ton *Seawise Giant* [above], is launched.

1991

The Soviet Union is dissolved, allowing states like Azerbaijan to enter the global oil market.

1995

Greenpeace activists occupy a disused Shell oil platform to protest its proposed sinking [right].



1991

Iraq sets Kuwaiti oil wells on fire during the Gulf War [above].

1989

The *Exxon Valdez* tanker runs aground, polluting 1,500 miles of protected Alaskan coastline.



1988

In the worst offshore oil disaster in history, 167 people die in a fire on the Piper Alpha drilling platform in the North Sea [above]. The platform is completely destroyed.

1986

The international oil market collapses due to oversupply—prices plummet from \$32 to \$10 a barrel.



An oil field near Baku, Azerbaijan. More than a century of oil production has made this a desolate spot.

Oil Rushes Leave Wounds

During its 150-year history, the petroleum industry has allowed life as we know it to take shape, but it has also exacted a toll on nature. Areas with large oil reserves have been exploited without mercy. Time after time, runaway wells have overflowed on the landscape, and tankers have run aground. Long stretches of coastline have been contaminated, and hundreds of thousands of seabirds have been fatally covered with sticky coats of black oil.

In 1979 the Pemex-owned Ixtoc-1 well blew out, releasing three million barrels of crude oil into the Gulf of Mexico. Some of the oil washed up on Texas shores 600 miles away. The notorious 1989 *Exxon*

Valdez oil spill polluted more than 1,500 miles of Alaskan coastline—killing over a thousand sea otters and hundreds of thousands of seabirds—when the tanker ran aground in Prince William Sound, dumping 260,000 barrels of oil into the sea. But one of the worst oil spills of all time, when Iraqi soldiers dumped more than 250 million gallons of Kuwaiti oil into the Persian Gulf in 1991, was no accident. It was an act of war.

In some of the most oil-rich parts of the world such as Baku, in Azerbaijan, nonstop exploitation of the resource has left blackened, almost useless landscapes in its wake.

CLOCKWISE FROM TOP: SIPA PRESS/SCANPIX; G. LUDWIG/CORBIS/SCANPIX; P. JORDAN/ALAMY; P.A. PETERSSON/GETTY IMAGES/ALAMY

1996

Troll, a Norwegian oil platform, is towed into position [right]. At 1,550 feet, it is the tallest man-made structure ever moved.

**2001**

The world's largest offshore oil platform, P-36, sinks off the coast of Brazil.

2005

Congress mandates that U.S. gas contain 6.1 billion gallons of renewable fuel like ethanol by 2009.



In 1979 Ixtoc-1, a drilling platform in the Gulf of Mexico, spewed oil that burned for months.



The supertanker Exxon Valdez hit a rock in Prince William Sound in 1989, spilling 260,000 barrels of oil.



Countless sea animals die as a result of oil spills. The survivors are often taken to rescue centers.

► in Europe and Asia. It was around then that Texas broke into the business, in spectacular fashion.

Thanks to the advent of rotary bits—some of them diamond-tipped—in the early 1900s, drills could pierce through almost anything, including rock and deep sand. It was a rotary bit that put Texas on the oil map in 1901. Drillers were working on a difficult well on a hill near Beaumont in southeast Texas when mud began to bubble up out of the borehole. A few seconds later, six tons of drilling pipe shot out of the hole and out through the top of the derrick, the tall wooden structure that housed the drilling equipment. A few minutes later, green oil began to erupt from the ground, cresting at twice the height of the derrick. And it didn't stop. The well, which had been predicted to produce 50 barrels of oil per day, instead delivered 75,000.

Dubbed Spindletop, the well drove up land prices in the region. Fortune-hunters streamed in, and in a short time, the hill was home to as many as 16,000 people living in tents. Beaumont was converted into a boomtown almost overnight. A few months later, 214 wells dotted the hill, each topped by a wooden derrick.

Oklahoma, Louisiana and northern Texas had their own oil rushes, and the industry was again plunged into a crisis of supply outpacing demand. The culprit: the electric lightbulb, which Thomas Edison had unveiled in 1882. The invention operated with a flick of a switch and eliminated the fire hazard associated with petroleum; it quickly brought the kerosene business to a near standstill. By 1902, 18 million lightbulbs were in use in the U.S. alone, with kerosene lamps used only in rural areas. The oil industry needed

a new market for its products, and fast.

The savior came in the form of the horseless carriage. Initially ridiculed for being slower than horses, the car, with its gasoline-fueled engine, quickly became a status symbol. In 1912, 902,000 cars trundled along American roads, up from 8,000 at the turn of the century. Before the rise of automobiles, gasoline was largely considered a waste product of oil refining and was typically dumped. But by 1910, gasoline sales had outpaced those of kerosene.

Meanwhile, factories, trains and steamships began running on fuel oil rather than coal. Texas crude produced low-quality kerosene and was better suited as fuel oil. London-based Shell Transport and Trading signed a 20-year contract in 1901 to buy Spindletop crude from Texas at a guaranteed rate to fuel its ships. The market for petroleum was quickly becoming a global one. California, which led the country in oil production from 1900 until 1915, exported most of its crude to Asia.

Oil Goes Global

Huge reservoirs—pockets of dense rock that had held the oil captive for millions of years—were discovered around the Caspian Sea, in what is now Azerbaijan, in the early 1870s. The fields were just outside the Russian-controlled city of Baku, now Azerbaijan's capital, and by the 1880s about 200 refineries operated around the clock in the city. Around 1900, half of the world's oil came from Caspian Sea oil fields, making Russia the major competitor to the U.S. in the global oil industry. But reservoirs were constantly being discovered around the globe.

In 1901, a wealthy Englishman named William Knox D'Arcy learned of oil seeps in Persia (now Iran). D'Arcy



2005

Gulf Coast oil output declines by 54 percent after Hurricane Katrina.

2008

Oil hits \$147 a barrel. U.S. gasoline surpasses \$4 a gallon at the pump.

2009

Sapphire Energy projects that by 2011 it will produce a million gallons of diesel and jet fuel a year from biofuel algae oil [right].

► partnered with the local Burmah Oil Company to search the area for petroleum. In 1908 D'Arcy and his associates drilled a 1,108-foot-deep test well and discovered the largest oil reservoir in the Middle East. Commercial development of the area's oil industry soon followed. D'Arcy's new company, called the Anglo-Persia Oil Company (later known as British Petroleum, and now BP) is credited with founding the Iranian oil industry. Forty years later, in 1948, the discovery of one of the largest oil fields ever found, Saudi Arabia's *Al-Ghawar*, would solidify the Middle East as the world leader in oil reserves.

As new uses for the lucrative resource continued to emerge—the chemical industry gradually realized that petroleum hydrocarbons were ideal building blocks for products like plastics, detergents and paints—oil companies worldwide were engaged in bitter competition to find new deposits.

Even More Ways to Find Oil

For many years, all of the world's oil came from wells on land. But in California the oil companies noticed that their most productive fields lay near the coast, so they began to drill right on the beach. About 1896, a local entrepreneur named Henry L. Williams took the next step. He built a small pier stretching 300 feet out into the water off Santa Barbara and set up a drill on top of it. He quickly hit oil, discovering

the famed Summerland Oil Field—the first offshore field—in the process. Others followed him, and within five years, 14 piers and 400 wells were scattered along the shoreline.

Just 150 years after the first oil strike, petroleum has become both a political weapon and a resource that nations are willing to fight for.

In 1949 the Soviet Union ushered in the modern age of offshore drilling. Almost 28 miles offshore in the Caspian Sea, Russian engineers drove pilings into the seafloor and erected an oil town on platforms, christened *Neft Dashlari*, or “oily rocks.” In addition to drilling equipment, the platforms held residential and work facilities. In the U.S., one large platform after another was installed in the Gulf of Mexico. Once drills began to bore more than 3,000 feet under the surface, platforms perched atop pillars became impractical. Oil is now pumped up through flexible hoses to floating platforms, or spars, anchored to the ocean floor.

Today the deepest wells on Earth are beneath the Gulf of Mexico and the seas off the coast of Brazil. Shell Oil expects to see oil next year from its Perdido project in the Gulf. The Perdido spar will be anchored in record depths of more than 8,000 feet of water.

Until the 1890s, prospecting for oil

was mostly a matter of luck: A person chose a potential spot, drilled a hole, and hoped. Gradually, oil companies began employing geologists to study the layers of earth for signs of oil beneath, turning production into a science. Petroleum geologists drew maps of underground rock layers and pointed out possible reservoirs.

Today, oil-industry geologists analyze seismic data in 3-D on computer screens, creating a sonogram of the Earth. They can then locate reserves of oil and natural gas below the surface, and make sensitive electromagnetic measurements that detect if a reservoir contains oil or just seawater, for example.

Kicking the Habit

Just 150 years after the first oil strike in Titusville, the world is addicted: Without oil, we'd see our cars, planes, factories—our very way of life—grind to a halt. Petroleum has become both a political weapon and a resource that nations are willing to fight for. Iraq's 1990 invasion of Kuwait, in part an attempt to seize control of its rich oil fields, provided a stark example of oil's ability to fuel conflicts. When the Iraqis were pushed out of Kuwait, they set ablaze more than 700 oil wells.

Global daily consumption is now around 87 million barrels, and in the past year, the price of a barrel fell from a peak of \$147 in the summer of 2008 to \$34 this February. As developing countries like China and India acquire

TECHNOLOGY OF THE TIME Deepwater platforms

When completed this year in the Gulf of Mexico, Shell's Perdido, a deep-sea oil spar, or platform, will be almost as tall as the Eiffel Tower and sit atop about 8,000 feet of water. Shell's 9,627-foot Tobago field well, which is currently being drilled, will be the deepest offshore production well in the world.

more oil-burning technology, the demand for energy will only rise. Meanwhile, the greenhouse gases associated with oil consumption continue to inspire concern and debate worldwide.

For many years, drillers pumped steam or water into older oil fields, increasing pressure underground to force more oil out. But as reservoirs run dry, water trapped in the rock is drawn up instead. Eventually, fields start producing more water than oil. Some geologists estimate that 70 percent of the world's oil deposits have already been discovered, and that a third of the oil given to us by nature has been used up. They warn that by the middle of the century we will have reached peak oil, the point at which depleted resources will force global production into a decline. The issue of peak oil, however, is a matter of significant discussion, and not everyone agrees that the numbers are so dire. Still, in a recent report by the International Energy Agency, one spokesperson advised, "We should abandon oil before it abandons us." The question is: What will we replace it with? ■

The Next Oil?

To what lengths are we prepared to go to prolong the age of oil? Geologists are scouring the Earth for new oil deposits, from the protected reserves of the Arctic and Antarctic to the depths of the oceans. In the future, oil will be harder to find—and more expensive as a result.

Oil sands, also known as tar sands, are one fast-growing alternative. They contain bitumen, a heavy black residue that can be used to create synthetic crude. Canada is the global leader in oil-sand development, with 40 percent of its petroleum coming from its vast reserves. But synthetic crude can be inefficient to produce, often requiring large quantities of water and energy to extract just one barrel of oil from approximately two tons of sand.

In the past decade, hope has emerged in the form of algae-based biofuels. Algae cells contain up to 60 percent usable oil, which can be processed into gasoline, diesel and jet fuel. "Biofuels are less 'dirty' than fossil fuels, many of which release minerals, such as sulfur oxides and sulfates, that are toxic when burned," says Riggs Eckelberry, president of OriginOil, an algae-oil producer in Los Angeles. And unlike

biofuel made from corn or other global food sources, algae-oil production does not divert food from hungry mouths. This April, OriginOil introduced the first one-step algae-oil production process, eliminating the use of petrochemical solvents and a costly drying step. Another developer, Sapphire Energy in San Diego, has already tested its algae-oil in commercial airliners and plans to meet the growing demands of the transportation sector and the military. Within two years, the company projects it will produce a million gallons of diesel and jet fuel a year.

Crude oil from oil sands [above right]; OriginOil's bioreactor [above left]; oil sand production in Canada [below].



Not Your Average Bird Brain

Recent research indicates that corvids, a group that includes crows, ravens and magpies, are just as smart as chimpanzees—sometimes even smarter. These findings have overturned our understanding of the nature and evolutionary origins of intelligence, and challenge the view that humans are the only thinking animals



*Ravens are capable problem-solvers.
They open containers with ease.*



Corvids Share Four Mental Abilities with Apes



CAUSAL THINKING

Understand how to make and use tools; predict others' actions



FLEXIBILITY

Generalize rules from acquired knowledge and apply them to new situations or stimuli



IMAGINATION

Rehearse situations and solve problems mentally before taking action



MENTAL TIME TRAVEL

Use prior experiences to consider the past and predict future conditions

It was once thought that human beings were unique in the animal kingdom for their reasoning abilities and innate intelligence. Eventually, scientists learned that chimps and some other primates are especially intelligent, too. And over the past 10 years, one behavioral study after another has demonstrated that corvids—a group of birds that includes jays, crows, ravens, magpies and rooks—possess exceptional mental abilities, comparable and sometimes surpassing the skills of nonhuman primates.

Corvids can plan future actions, understand cause and effect, and solve complex problems. They can also recognize individuals, cooperate with others, and make more advanced tools than chimpanzees. But that's not all. The birds appear to understand the motivations and goals of other corvids, what psychologists call "theory of mind" and often cite as proof of social intelligence.

The scientific evidence from experiments with corvids is allowing researchers to see human intelligence in a new light. Birds' and humans' developmental paths separated well before the era of

the dinosaurs, almost 300 million years ago. So if birds have intelligence—if they can imagine, create hypotheses, and predict the future—the capability for intelligence may have arisen independently, rather than from a long-ago common ancestor with humans. That means intelligence could also spontaneously appear in other species, and

isn't the private domain of humans and other primates.

One of the major figures behind these bird studies is Nicola Clayton, the professor of comparative cognition at the University of Cambridge. Working with her husband, neuroscientist Nathan J. Emery, and Anthony Dickinson, the professor of comparative psychol-

ogy at Cambridge, Clayton has demonstrated the birds' surprising intelligence with cleverly designed experiments.

"Overall, corvids have shown themselves to have abilities similar to chimpanzees. My husband actually calls them 'feathered apes,'" she says.

Clayton and Emery believe that corvids and apes have faced similar chal-

Ravens Protect Themselves from Theft



Bernd Heinrich of the University of Vermont, with Austrian researcher Thomas Bugnyar of the University of Vienna, has shown that ravens can remember whether or not another bird has seen them hide, or cache, food. The researchers let a raven hide food while two other ravens remained in separate enclosures nearby. One enclosure was blocked so that one raven could not see out; the other was free to watch the bird hide the food.

When the scientists opened the enclosure and let the two ravens out to join the third, the cacher took much more care with its food when it was approached by the raven that had been watching, while it let the other raven walk around freely—even when it came near the hiding place. At the same time, the raven that had been watching took pains to disguise its knowledge.

A raven hides food as another bird watches. A third bird's view is blocked.



The raven that hid the food is more wary of the bird that watched it.



In the experiment, the birds were held in much larger enclosures than are depicted here.

MIKKEL JUUL JENSEN; PRECEDING PAGES: RIEDLER/ANZENBERGER

Crows Can Remember Foes



In a follow-up study using humanlike masks, a crow scolds a researcher, indicating that it can differentiate human facial features.

Wildlife biologist John Marzluff and his colleagues at the University of Washington have documented how wild American crows (not lab animals) can recognize people they have had contact with.



Crows could recognize this mask even when researchers put a hat on.

During the initial stage of the study, two researchers wore identical caveman masks and straw hats when they captured and banded seven wild crows. It is thought that the crows associated the mask with a "dangerous" experience. In later experiments, each time anyone wearing the caveman mask entered the area, the crows got agitated and scolded them. When the researchers wore neutral masks that the crows did not associate with being captured

and banded, or when they wore no mask at all, the crows did not scold them. And when the researchers wore the masks upside-down, the birds not only scolded them but turned their own heads upside-down, perhaps in order to correctly identify the face.



Challenges in nature, which may have led to the evolution of intelligence. Some of the scientists' theories expand on the work of English psychologist Nicholas Humphrey, who suggested in 1976, after studying wild chimpanzees, that living in social groups demanded more intelligence than performing the most advanced technical tasks. Keeping track of who did what to whom, networking, and strategizing are, according to Humphrey, powerful motors pushing primate mental evolution. The same may have been true for the corvids, which are among the most social birds, with group structures similar in complexity to apes. Both corvids and apes also have large brains in relation to their body weight. Because of these social and biological parallels, Clayton and Emery hypothesize that Humphrey's explanation of social intelligence in apes could be applied to the unusually intelligent corvids.

Working with Dickinson and Emery, Clayton has developed evidence that chimpanzees and corvids possess the same mental toolkit, including causal thinking, imagination, flexibility and what's known as mental time travel, or the ability to think about the past and future. Their data suggest that evolution has brought about higher intelligence multiple times.

The Breakthrough Experiment: Jays Remember Sell-By Dates

Some biologists don't believe that even humanlike chimpanzees can remember specific events, so when Clayton claimed that birds had this ability, she set off a heated discussion among scientists in her field.

Many corvids hide, or cache, food to eat later. One species, the Clark's nutcracker, hides more than 33,000 individual items a year in up to 7,000 different locations. In the mid-1990s,

bird researchers had been arguing about whether jays that cached food remembered the hiding spots or simply rediscovered them by chance. Clayton noticed that jays sometimes hid types of food that spoil quickly and guessed



In Norse mythology, two ravens, Hugin and Munin, watch over the world as the eyes of the chief god Odin.

that they could remember not only where they hid that food but how fresh it would be. At a conference in 1996, she met Dickinson, who at the time was skeptical about the bird's memories. But Clayton convinced him that the spoiling factor might be evidence for episodic memory—that corvids can remember a past event—and the scientists agreed to test the theory.

Clayton and Dickinson gave the scrub-jays two types of food: peanuts, which keep a long time, and insect larvae, which quickly decay. After giving the birds time to hide all the items, they moved them to another area for a period of four hours to five days before

allowing them to return to the test area. The results showed that time made all the difference in what the birds dug up. When they had been absent just four hours, the jays favored the larvae, but when five days had gone by, they went for the peanuts instead. The birds seemed to remember both where things were and if they were still good to eat.

The experiment, published in 1998, overturned what scientists had believed about birds' mental abilities and revealed a more sophisticated memory than anyone had previously granted to any nonhuman animal. The majority of experiments measuring intelligence had been performed on some of

humans' closest relatives, chimpanzees and macaque monkeys. Almost no such work had been done with other animals because no one had expected to find anything.

Planning for the Future

With Clayton's breakthrough it became possible to address a new set of questions. In 2007 Clayton and Dickinson, along with Caroline Raby and Dean Alexis, also from the University of Cambridge, showed that jays can take a mental trip into the future and modify their behavior in the present accordingly—an ability psychologists had believed was unique to humans.

Corvids Have Invested in Big Brains

Corvids have larger brains in relation to body size than most other birds. The relative size of an animal's brain shows how important brains are to that species and is, therefore, an

indirect mark of intelligence. Corvids' relative brain size is similar to the ratio for mammals and even primates. Humans top the list, followed by porpoises.



Rook



American crow



Raven



Jackdaw



Carrion crow



Eurasian jay

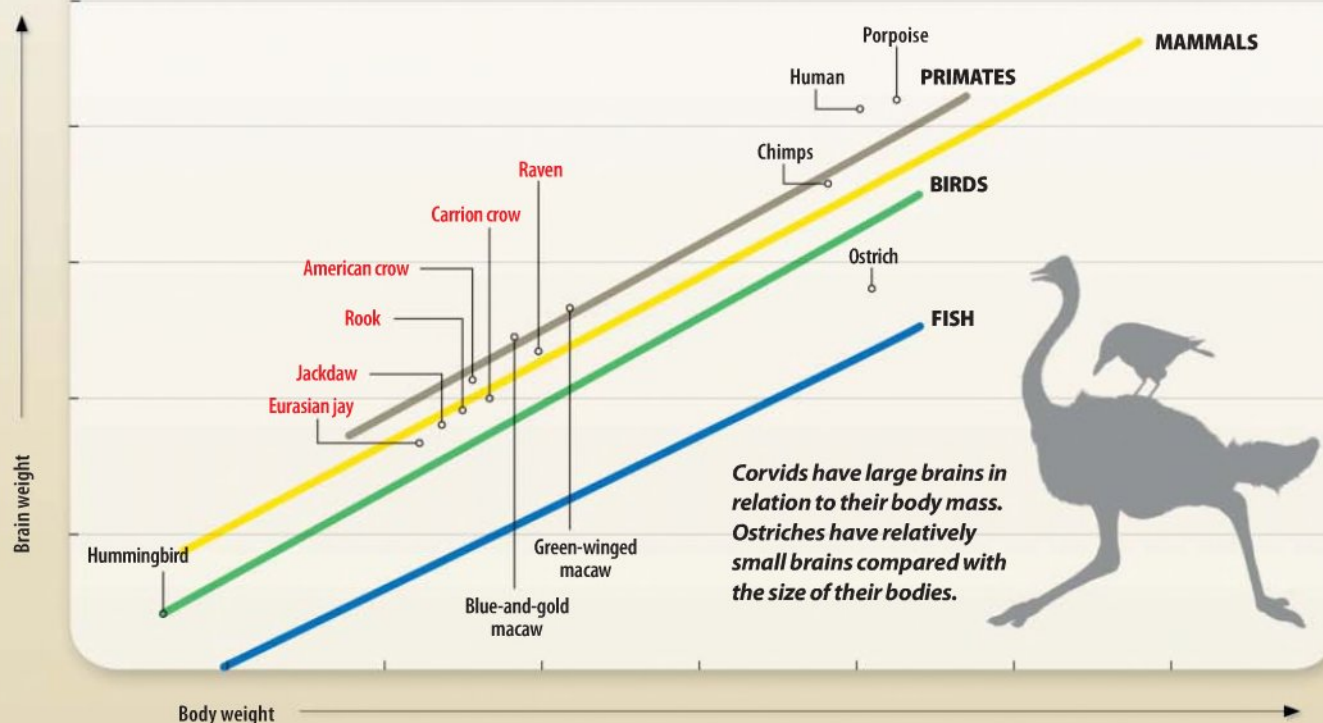


ILLUSTRATION: MIKKEL JUUL-JENSEN, COURTESY OF JOHN MARZLUFF AND TONY ANGELL; PHOTOGRAPHS, FROM LEFT: D. USHER/MINDEN; R. NUSSBAUMER/NATUREPL; TOMI VEZO/MINDEN; P. ENTWISTLE/FLPA; D. USHER/ARDEA; W. ROLFES/MINDEN



Birds Can Think Conceptually

New Caledonian crows can understand general concepts—that is, abstract ideas rather than specific objects or events. This was demonstrated in a study published last year by psychology professor Russell Gray of the University of Auckland. In the test, the crows had to use sticks to extract food from a clear plastic tube. The bottom of the tube had two holes, one on each side of the morsel, and the researchers alternately closed one or the other

with a stopper that trapped the food. The crows quickly learned to avoid the hole with the stopper. The real challenge came when the scientists exchanged the tube for a box that looked different but operated on the same principle. All of the crows immediately extracted the food from the right space. The results confirm that the birds were able to understand the concept of “hole” and transfer it to a new situation—a challenge that defeated even chimpanzees.



The crows had to push or pull food out of a plastic tube using a stick, without letting it fall through the hole.



When they were later presented with the same principle in a different setup, they were able to apply their knowledge.

In their experiments, researchers had a jay check into a “bird hotel” with three rooms that it was free to explore for the day. In the evening, the bird fell asleep and the researchers moved it to one of two rooms. If the bird awoke in room 1, breakfast was already set out for it, but in room 2, it would go hungry for several hours before getting fed. Then the researchers changed the experimental conditions so that the birds had the opportunity to cache food before nightfall. The result: The jays cached three times as much food in room 2 as in room 1, without knowing which room they would wake up in.

Although psychologists had thought that only people could plan for the future, this experiment showed that the birds had similar mental time-travel skills.

It Takes One to Know One

In recent years, Clayton and other scientists have studied various aspects of corvid intelligence, such as whether

birds can understand another bird’s point of view—their “theory of mind”—and if they can form hypotheses.

To test corvids’ theory of mind, Clayton took advantage of the large role that robbery plays in the birds’ social lives. Her experiment looked at whether the birds would behave differently when caching food if they knew that another bird was spying on them. Would corvids alter their behavior by predicting or interpreting what they believed another bird was thinking?

One of Clayton’s studies, published in 2007, claims that some corvids are indeed capable of sizing up what’s going on in the mind of another bird. She observed western scrub-jays caching food both when they were watched by other scrub-jays and when they were alone. She found that jays that had stolen food in the past re-hid food when they were watched by other jays. But birds that didn’t have a history of thieving food didn’t move the food to another hiding spot, even when they

had been watched caching it. In other words, it takes a thief to know a thief.

Additionally, some corvids can form hypotheses. In a paper published in 2005, biologists Thomas Bugnyar of the University of Vienna and Bernd Heinrich of the University of Vermont report that they first tested ravens’ inventiveness by letting the birds watch them suspend a piece of meat on a string from a bar. None of the ravens had ever encountered anything like this before, but in a short time, five of the six figured out how to get the meat. They roosted on the bar and pulled in the string with their beaks. The task required a complicated series of actions carried out in the right order: reach down, grip the string with the beak, pull the string up a few inches and step on it to hold it in place, let go with the beak, grasp the string again a bit lower, and repeat.

The researchers then gave the ravens a challenge to test their ability to form a hypothesis. This time they hung meat so that the birds, contrary to all intuition,



The ravens had to repeat a complicated series of actions to get the meat at the end of the string: pull up the string, hold it tight with one claw, release the beak, and reach down for more string. Many of them quickly solved the problem after studying it.

Ravens Create Hypotheses



Ravens are able to think about problems abstractly and consider possible solutions before actually trying any of them. In one test, researchers Thomas Bugnyar of the University of Vienna and Bernd Heinrich of the University of Vermont tied meat to the end of a string suspended from a bar to see what the birds would do to get the food. None of the ravens had ever faced a situation like this before, but five out of six quickly figured out how to stand on the bar and reel in the meat. The solution required that the birds perform a compli-

cated set of tasks, carried out in a particular order.

The same five birds also successfully completed a second test that required, counterintuitively, pulling down on a piece of string to lift a piece of meat into reach. Some of the ravens started off by staring at the setup for several minutes. After apparently figuring it out in their heads, they immediately flew to the bar and pulled in the string in the most efficient way.

A second set of ravens—which had not completed the first task—were not able to retrieve the meat.

would have to pull down on the string to raise the meat. All five birds from the first test quickly figured out how it worked and solved the challenge. The bird that had failed the first challenge, and others that hadn't been exposed to it, couldn't solve this test at all.

Impressively, some of the birds solved the problem just by looking at the setup for a few minutes; they flew directly to the bar and reeled the meat in. The actions indicate that the birds can create and test hypotheses in their brains before arriving at the right solution—evidence of enormous mental muscles.

A Society of Toolmongers

The experiments with the meat and string clearly demonstrate that the ravens' brains have a good grasp of physics, are mentally flexible enough to solve new problems, and can even build upon knowledge. So it is not surprising that corvids know how to make tools.

For example, take the New Caledonian crow. These crows use sticks,

sometimes fashioning them into hooks, to harvest grubs and insects out of cracks and holes too small for their beaks. And other New Caledonian crows use the barbed leaves of the pandanus palm for the same purpose. Both tools are more advanced than those used by chimpanzees to fish for termites [see pages 40 and 82 for other

animals that use objects as tools].

Russell Gray, an animal-cognition expert at the University of Auckland in New Zealand, and graduate student Alex Taylor have carried out a series of experiments that showed that crows can solve a type of tool-based problem that has stumped all animals except humans, apes and some monkeys (some of these studies are disputed, how-



In one study, crows used a short stick to get the longer stick they needed to pry food out of a hole. Very few nonhuman animals know how to use a tool to get another tool.

ever). In 2007, they demonstrated that although some animals can use tools to obtain food, crows use tools to *get other tools*. In the experiment, crows needed a long stick to fish a piece of food out of a hole. But they only had a short stick. The one they needed was behind a grid of bars. Four of seven crows successfully retrieved the tools and food in the right order on the first try. All seven were able to do it if given enough chances.

But Do Corvids Play Well with Others?

The question now is how much birds resemble other animals (and humans) when you scratch beneath the surface. To find out, Amanda Seed of the University of Cambridge, with Clayton and Emery, looked at cooperation between pairs of rooks and compared it with a previous study of pairs of chimpanzees.

To start, the researchers placed a treat (mealworms with egg yolk) on a tray outside the cage of two rooks. The only way the birds could get the tray was for each to simultaneously pull on an end of a string attached to the tray. The birds solved the problem in a short time—just as chimps did.

But there was a difference between the birds and the apes. When the chimps faced this test, the individual chimps weren't as cooperative if they knew that a dominant partner could get all the food for itself. The rooks apparently did not consider that, and their success was not dependent on how easy it was for both birds to access the food. In addition, if the first bird had to pass through a flap to enter the cage, it didn't wait for its buddy but pulled on the string uselessly until its partner came. The chimpanzees understood that they had to wait.

The scientists believe the reason for the difference lies in rooks' and chimpanzees' sexual systems. Rooks live in permanently mated pairs, though they are members of large flocks. Chimps live with a changing mix of sex partners and competitors. Rooks can get by relating to just one other bird, but chimps, which must deal with a range of mates, have a deeper grasp of cooperation.

Clash of the Mental Titans: Corvids vs. Humans

How smart are corvids compared with humans? Clayton has begun investigating this by testing three- to five-year-old children on future planning using tests similar to those they used on the jays. Clayton says that in another possible test, she might give children the same memory tasks as jays, using nonperishable toys and meltable ice cream instead of peanuts and larvae. "If you had asked me 10 years ago if I would be doing studies with children, I would have laughed and said 'never,'" she says. It is not easy to carry out studies comparing widely disparate species, but these studies should provide insight into the different kinds of intelligence and how they evolved in separate lineages.

Clayton is also working to add more

data to her bird studies, such as testing corvids' intelligence on nonfood tasks to see if their cognitive abilities can be applied in other situations.

All in all, the new findings raise questions about what stimulated the appearance of these mental powers in both corvids and humanoid apes. It also raises questions about the anatomy of mammalian and bird brains and whether there are similar structures or neurobiological processes that are required to support a particular level of intelligence.

It is, of course, impossible to know what the birds are actually thinking during these trials, and if they understand things in the same way we do. But the research does make it clear that humans and their closest primate relatives do not have a monopoly on higher intelligence. ■

The magpies saw the mark in the mirror and tried to pull it off their feathers.

Magpies Pass the Mirror Test

Apes, dolphins, elephants and humans older than about 18 months can recognize themselves in a mirror. Scientists have now shown, for the first time, that a non-mammalian animal can do the same. Psychologist Helmut Prior of Goethe University in Frankfurt, Germany, with colleagues from Ruhr University in Bochum, carried out the mirror test with five magpies. They attached colored marks to the birds' plumage and then put them in front of a mirror. The birds reacted by trying to pull the marks off themselves. When a mark was used that was the same color as the magpies' feathers, the birds ignored it. The researchers say these behaviors indicate that the birds realized they were seeing themselves in the mirror.



SCIENCE
ILLUSTRATED

The Astronomer's Guide

STELLARVUE®
SEEING IS BELIEVING



**WELCOME HOME
THE UNIVERSE IS WAITING**

WWW.STELLARVUE.COM
(530) 823-7796

Celestron »

Use the NexStar SE to find thousands of stars, planets, galaxies and more... at the touch of a button!



Hands on Optics

The new NexStar SE Family combines the classic heritage of the original orange tube telescopes with state-of-the-art features including a fully computerized operating system, flash upgradeable hand control, superior StarBright XLT coatings, revolutionary SkyAlign™ telescope-alignment software and much more.

Whether you are a seasoned astronomer or just starting your astronomy adventure and looking for an easy way to enjoy the night sky, a NexStar SE will help you take a closer look.

www.handsonoptics.com
866-726-7371

Surplus Shed

MAKE YOUR OWN INEXPENSIVE, QUALITY ASTRONOMICAL TELESCOPE

We provide the optics; you provide the tubing. Kit includes a 20mm, 0.965-inch Huygenian eyepiece and a 55mm-diameter, x211mm focal-length Achromatic objective. See the craters on the moon! Instructions included.

Item #K1006
Only \$9 each



WOLLENSAK 12.5MM, 2-INCH EYEPIECE

Great high-power eyepiece with 9 fully coated glass elements and a field of view of 55 degrees. The exit aperture is 16.8 mm, eye relief 10 mm. Fits all 2-inch focusers, and the anodized aluminum barrel is threaded for filters. An unbeatable price for a quality 2-inch eyepiece. Wollensak quality optics since 1899.

Item #W1004
Only \$59



www.SurplusShed.com
Phone. 877-7SURPLUS
Fax. 610-926-0978

So Cal's Largest & Most Exciting Astronomy Expo!



SOUTHERN CALIFORNIA ASTRONOMY EXPOSITION



Sat., July 18th – 10am-7pm / SCAE Telescope Sale & Demo

- Visit with over 30 manufacturers of the finest telescopes, CCD cameras, and other astronomical equipment on the planet.
- Listen to informative presentations, meet the reps, and get your FREE ticket for the OPT Giant Giveaway!
- Win! Last year we gave away over \$50,000 worth of equipment!

918 Mission Avenue, Oceanside, CA 92054 | optcorp.com/scae | 800.483.6287

Thousands
of \$\$\$\$ in
Awesome Giveaways!

to Summer Stargazing

The International Year of Astronomy

It's the end of a warm summer afternoon, and the sun seems to already be fading as it begins to set in the northwest. A few minutes later, the sky darkens as night falls. No matter where you are, there isn't much that can beat a clear summer night. This year is special because it's the International Year of Astronomy, a worldwide effort to encourage us all to look to the stars.

The Ever-Changing Picture

To start, all you need is a comfortable chair. Sit down and look up. Sooner or later, you'll see a shooting star, which is not a star that falls from the sky.

A shooting star is really a meteor, an event during which a tiny speck of dust crashes through the Earth's upper atmosphere.

What is more, the tiny speck may be several billion years old, having orbited the sun all those years until, on this one magic night, it speeds

through the air, burning itself out in a final blaze of glory. It teaches us one thing: that the sky is not an unchanging picture. The sky is happening.

Start Discovering

If you have a simple telescope, try locating the moon. Any telescope will do, but it's better if it is set up on a sturdy mounting. We recommend a reflector with a mirror four inches across or larger (which essentially gathers as much light as your eye would if it were four inches across). The mirror might need centering by adjusting the three screws behind the glass, but if it is properly adjusted it should perform well for years.

This summer the moon is best viewed during the closing weeks of July and August. Look through the eyepiece, turn the focus knob until the view is as sharp as you can get it, and enjoy the wonder. Crawl into a crater. Climb a mountain. It will be as if you were actually there!



HyperStar
Imaging at the Speed of Light

*Now you can image the
night sky like the pros!*

www.STARIZONA.COM

World of Science

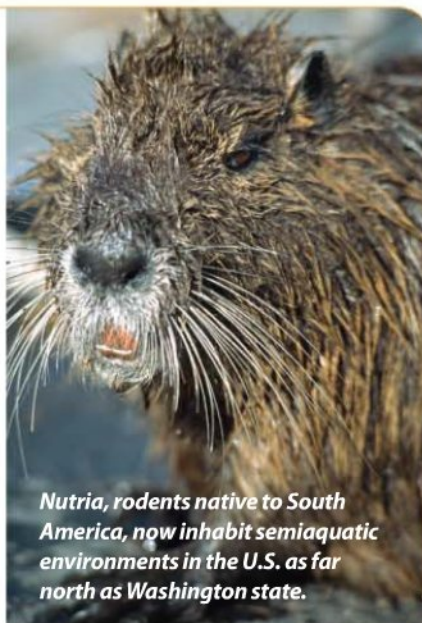


Extremes of Nature

U.S. Invaded!

More than 3,000 plant and animal species have colonized areas in the U.S. where they are not native, often after intentional or accidental introduction by humans. These invasive species can disrupt local ecosystems by spreading diseases and outcompeting indigenous flora and fauna for resources like food, sunlight and water. One such critter, South America's nutria (*Myocastor coypus*), was brought to Louisiana in the 1930s for the fur-farming industry and eventually released into the marshes. Since then, the herbivorous rodents, which are slightly smaller than beavers, have expanded their range north to Washington state, devastating wetlands in their wake with their voracious feeding habits.

The National Institute of Invasive Species Science in Colorado monitors the growing problem created by invasive species. Its scientists catalog, map, and



Nutria, rodents native to South America, now inhabit semiaquatic environments in the U.S. as far north as Washington state.

study their impact on a large scale. Part of the initiative is a program called Citizen Science, which provides training to the general public to help map invasive species. To get involved in the research, check out citsci.org.

Highs and Lows

The most chromosomes ...

Ophioglossum reticulatum, a fern commonly known as **netted adder's-tongue**, has 1,260 chromosomes. This is the highest known number found in any organism.

... and the fewest

Female Australian jack-jumper ants, *Myrmecia pilosula*, have only one pair of chromosomes on which to pass their genes down to the next generation. Males possess just a single chromosome.



Research Footnotes

Eyes Wide Open

Making sure that everyone has their eyes open in group pictures is no easy task. But physicist Piers Barnes and science writer Nic Svenson, both of Australia's Commonwealth Scientific and Industrial Research Organisation, have calculated how many shots it takes to ensure that all eyes are open.

They developed a formula that accounts for the average number of times a person blinks per minute, the duration of the average blink and the camera's shutter speed. For 30 people, for example, in low light, it requires 30 takes to capture all of them with their eyes open. For groups



More than 30 takes may be needed to get all eyes open in a group shot like this.

smaller than 20, the rule of thumb to determine the number of necessary shots is to divide the number of people by three in good light and by two in low light.

Now, if you could only get all those people to sit still for that long.

Tricky Number

999

The number 999 has a way of coming back to itself. Multiply 999 by 999 and you get 998,001, which split down the middle is 998 and 001. Add these numbers, and you're back where you began. In fact, this trick works for all numbers composed only of the digit 9. For instance, $99,999 \times 99,999 = 9,999,800,001$. Split these 10 digits down the middle, and the result is $99,998 + 00001 = 99,999$. A similar thing happens for any number times 999. For example, $3,748 \times 999 = 3,744,252$. If you divide this answer into three-digit parts, starting from the end, you will have $252 + 744 + 3$, which add up to ... 999.

VISIT OUR WEBSITE
TO VIEW SAMPLE
VIDEO CLIPS OF
EVERY COURSE



Having Math Problems? WE CAN HELP!

MATHTUTORDVD.COM
Press Play For Success

AWARD
WINNING
MATH & PHYSICS
TUTORIAL DVDS

SUBJECTS:

BASIC MATH	7 HOURS - \$26.99
BASIC MATH WORD PROBLEMS	8 HOURS - \$26.99
PRE-ALGEBRA/ALGEBRA 1	10 HOURS - \$26.99
ALGEBRA 2	6 HOURS - \$26.99
ALGEBRA WORD PROBLEMS	6 HOURS - \$26.99
GEOMETRY	9 HOURS - \$26.99
ADVANCED ALGEBRA	7 HOURS - \$31.99
MATRIX ALGEBRA	7 HOURS - \$31.99
TRIG/PRECALCULUS	5 HOURS - \$31.99
CALCULUS 1&2	8 HOURS - \$36.99
ADVANCED CALCULUS 2	14 HOURS - \$49.99
CALCULUS 3, VOL 1	10 HOURS - \$44.99
CALCULUS 3, VOL 2	11 HOURS - \$49.99
PHYSICS	11 HOURS - \$39.99
PROBABILITY & STATISTICS	10 HOURS - \$39.99
UNIT CONVERSIONS	4 HOURS - \$21.99



All topics taught
entirely through worked
example problems.

RECENT STUDENT FEEDBACK:

"Your methods are so clear that my seven year old son was grasping the trigonometry lessons. I'm picking up some new things as well." **Gary G.**

"Watching your videos is wonderful because, as you work the problems, you show and explain every step." **Marilyn D.**

"All of the instruction and examples on the DVDs are very clearly explained and your style of teaching definitely makes the viewer very comfortable with the material being presented." **Doug F.**

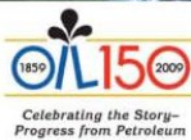
"I found the lectures very clear, straight to the point, and the pace was just right for me, who has not seen any calculus or trig in the past 10 years and needed to come up to speed fast." **Sophia A.**

"You have a serious teaching gift." **Dennis S.**

"I tell all my friends who have difficulty in algebra, calculus, or physics that there is help available at MathTutorDVD.com. It would be selfish to keep this information to myself! I have two words for you, "thank you!" **Les J.**

Raise grades or your money back

TO ORDER: 877-MATH-DVD or www.MathTutorDVD.com



We invite you to the wealth of natural, cultural, and historical treasures and special events to celebrate the drilling of the first commercially successful oil well just outside Titusville, PA



Now through December 2009



www.oil150.com

800-482-6264

Nature's Rarities

Stone Age for Birds

Egyptian vultures (*Neophron percnopterus*) are among the rare avian species that have developed the ability to use objects as tools. The birds, which are found in southern Europe, Asia and northern Africa, mainly eat carrion, but they also dine on eggs. Ostrich eggs are a favorite, but their thick shells make them tough to crack.

The vultures' beaks are not strong

enough to break through the shells, and the eggs are too large for the birds to pick up and drop to the ground to crack them open. Instead the birds scavenge for rocks large enough to crack the eggs. The vulture stands over the egg with a stone in its mouth and forcefully tosses it down with a quick dip of its head until the shell cracks.

Egyptian vultures use stones as tools to get inside nutritious ostrich eggs.



Weird Invention of the Month

A Sled for All Seasons

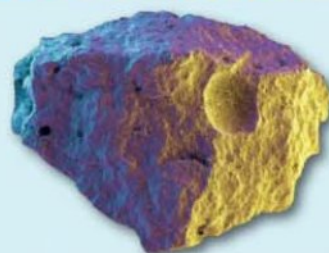
Summer's here, but that doesn't mean you have to hang up your sled. The Slicer by Ice Meister (\$70 at icesled.com) comes with two removable icers, large trays that form ice blocks in the freezer. Just attach the frozen icers to the sled to turn a grassy hill into a winter wonder.



This plastic sled goes from winter to summer, thanks to blocks of ice.



Did You Know ...



THE APOLLO MISSIONS

from 1968 to 1972, transported more than 840 pounds of material from the surface of the moon back to Earth.



BULGARIANS consider a nod of the head to mean "no" and a sideways shake to mean "yes."



MORE THAN A MILLION MOSQUITOES

would have to bite you at the same time to drain all of your blood.



PURE GOLD is soft enough to mold with your bare hands.

LISTEN TO A TOLL FREE RECORDING AT 1-800-433-9553



PURE WATER SCAMS!



A TYPICAL AD:

"100% PURE WATER! WATER SCAMS EXPOSED...FREE REPORT!"

While they SCAM THOUSANDS OF CONSUMERS by selling water distillers recalled by the Federal Product Safety Commission (with no tests or warning showing they can't make "pure" water using lab standards and using plastic collection jugs that leach plasticizers 55 times faster when the water is hot) the water becomes a poison! How about common sense? The FDA never approved taking drugs by the handful either! Consumers were warned about plastic baby bottle dangers and the 57 drugs found in Philadelphia drinking water with 41 million people affected by drinking a drug "cocktail" (AP 3/10/08) along with users disease markers flushed down toilets into our drinking water!

After 36 years in business, we have heard from thousands of families that have been devastated by distilling polluted well water because they believed the "100% Pure" ads! They are breaking State and Federal Laws on Deception: FTC Policy Statement 10/14/83. Also FTC Order 3220!

WE HAVE THE ONLY PRODUCT ON THE MARKET THAT CAN MAKE PURE WATER USING LAB STANDARDS!!

Water Type	Hydrogen Bond Angle	Will It Stop Disease?
Our Med Water	114°	Yes
Steam	120°	Yes
Ordinary Water	104°	No
Distilled Water	101°	No

Visit our website at www.JohnEllis.com

When we started in business, the largest selling home distiller made water 9 times purer than the tap water. By starting and stopping the boiling to lower the steam velocity and pollutant "carryover", 5 of our machines were tested by York Labs down to "less than" 0.07 ppm...827 times purer (on our website)! Pure water is 0.1 ppm and the best Corning lab still goes down to 0.14 ppm. This is phenomenal for such a small home machine! COMPETITORS WILL MAKE EVERY CLAIM IMAGINABLE BUT THEY WON'T GIVE YOU THIS TEST!! USE COMMON SENSE! Realize that if water goes through a product one time (even 10 times) THE "PURIFIED" WATER WILL SPREAD DISEASE!! OUR WATER WON'T! (Dole Banana, human waste lagoons and thousands of wells with only one treatment!) On the contrary, water goes through our machines 100's of times/gallon to produce these results and they produce "light" distilled or "light" tap water.

The largest food distributor (\$20 million/yr) spent a year and over one million dollars checking out our water! An article in *The Washington Post* as far back as 1/27/92 states: "This 'light' water will cure



anything!" 10,000 people/day went to a wealthy Mexican land owner to obtain our water, some waiting in line for 2 1/2 days! The article describes our "light" water and worldwide patents: "The curative power results from the 'movements' of water between two metal tanks."

Like alcohol (without the side effects) our "light" water produces great blood flow and it's easy to prove why nothing else can produce such amazing results that can be measured, in a non-invasive way, using doppler ultrasonography! UCLA Medical School M.D.: "We

have tested every water product available and nothing comes even close to yours in getting blood (94% water) to the extremities!" Products For Pain ("Put It Where It Hurts") were allowed by regulators because the published results are measured on the skin, i.e. like the doppler effect where the ability of blood to go through a membrane into the cells can be measured on the skin. Take a cloth, soak it in "light" water and put it on the problem area or as a typical example: "I am diabetic and my foot turned black. I soaked my foot in your water while I watched TV. The skin turned rosy pink! Thank God for your discovery!" M.D. (After a man regrew the tip of his finger): "If I hadn't seen this, I wouldn't believe it!" When the inventor was down in Exuma recently somebody said: "How old do you think that man is?" They agreed between 38 and 48. He's 79. It works!



If you buy an E5 machine, you are invited to a party at the Shohola property where you can meet people with similar success stories!

Politics aside, most of our profits go to this mountain property where our camping facilities support the boy scouts, girl scouts and disadvantaged youngsters. After 36 years in business and over 200,000 users, the results are well documented!

ORDER BOTTLED WATER:

570-296-0214
amazingmedwater.com

ORDER A MACHINE:

845-754-8696
johnellis.com

John Ellis* and John Ellis Water* are Registered Trademarks.

LISTEN TO A TOLL FREE RECORDING AT 1-800-433-9553

John Ellis Water®

I understand the information you are providing is for educational purposes only. As stated above, this information is not intended to diagnose, treat, cure or prevent disease. In all health-related situations, qualified healthcare professionals should always be consulted.

Name: _____

Address: _____

City/State/Zip: _____

Dept. WT415, Westbrookville, NY 12785 • Visit our website: www.JohnEllis.com

Call us for information

845-754-8696

or fax your name and address to 845-754-7866



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

5 points

4 points

3 points

2 points

1 point

MUSIC

Name this folk tradition

The golden era of this music and dance tradition was between 1780 and 1845.

Commonly associated with Spain, its influences include Romany, Andalusian, Arabic and Spanish-Jewish folk songs.

It consists of a three-part song, the *cante*, and a dance involving complex footwork and hand movements, the *baile*.

As a singer, guitarist and dancer perform, the accompanists and the audience often clap and shout encouragement.

The word "flamingo" is derived from the tradition's Spanish name.

BOTANY

Name this tree

It is the common name for trees in the genera *Swietenia*, *Entandophragma* and *Khaya*, which are all part of the family Meliaceae.

Some species grow as tall as 100 feet, and most have hard, reddish-brown wood.

Once a popular material for furniture, its trade has been banned by many countries because some species are in danger of extinction.

The word comes from Spanish, possibly after its native name in Honduras.

A 1975 Berry Gordy film, with Diana Ross in the starring role, bears this tree's name.

ANATOMY

Name this organ

Doctors know this muscular structure by its Greek name, *glossa*.

Macroglossia, an enlargement of this organ, is a trait of the congenital disorder Down syndrome.

Many small projections, called papillae, cover it.

As many as 150 sense receptors on its surface can detect five different elements of flavor: salty, sour, bitter, sweet and umami.

Its name comes from the Old English *tunge*, which means "speech."

SPACES

Name this place

Vitruvius, a Roman architect in the first century B.C., said the best dimensions for it included a 3:2 length-to-width ratio.

In ancient Roman cities, this space was commonly lined with temples and public buildings.

The most famous one was located in the area between the Capitoline and Palatine hills.

The word is now used to mean any place—physical or virtual—where people can meet and interact.

Its name is similar to the Latin word *foras*, which means "outside."

NUMBERS

Name this number

In the periodic table of elements, it is the atomic number of antimony (Sb), a toxic silvery white metal.

In binary code, it's written 110011.

The international calling code for Peru is represented by this number.

It is part of the nickname of a secret American military base, which some believe houses crashed UFOs and aliens' remains.

If Puerto Rico were granted statehood, this would be the number of U.S. states.

HISTORY

What year was it?

January 20, United States

Lyndon B. Johnson, the nation's 36th president, is sworn in for the second time.

March 18, space

Cosmonaut Aleksey Leonov steps outside his *Voskhod 2* spacecraft to take the world's first space walk.

July 19, France and Italy

The 7.3-mile-long Mont Blanc Tunnel [right] opens to traffic. Linking Chamonix, France, and Courmayeur, Italy, the tunnel passes under the tallest mountain in Europe.

Your guess

Points

Correct year

5

± 2 years

4

± 4 years

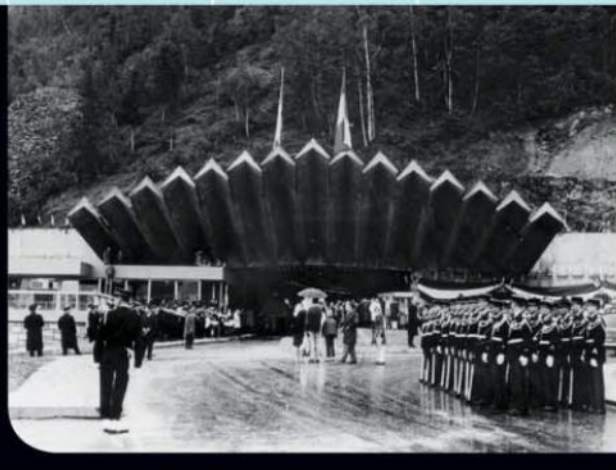
3

± 6 years

2

± 8 years

1



Your score:

24-30

Good show, Sherlock

17-23

Not bad, Watson

9-16

Good enough, Paris

0-8

Hit the books, Homer!

Answers appear on page 87

The \$2.5 Indian Head Gold coins were minted using a unique design known as incuse relief, giving the design elements and lettering a sunken appearance. The beautiful design has made it a favorite among collectors and investors alike.



**\$2.5 Gold
Indian Head
1908-1929**

**ONLY
\$259**

not shown at actual size

YOUR SOURCE FOR UNITED STATES PRECIOUS METALS

Special at cost offer • New clients only • No dealers please

**2009 \$50
Gold
American
Eagle Coin**

\$950
limit 5



not shown at
actual size



**2009 Silver
American
Eagle Coin**

\$15⁹⁵
limit 20



1-866-789-2646
www.ImperialCurrency.com

Special arrangements made for orders over \$50,000. Due to extreme market fluctuations, prices subject to change. Coins not to scale.

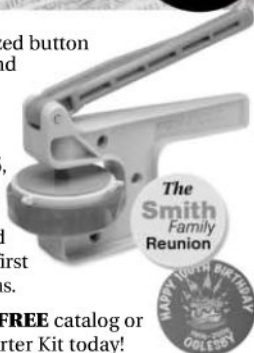
\$CASH IN on Buttons

ON SALE
Save 60%!!

Now, customized button jobs are fast and easy with our Starter Kit.

For only ~~\$75.90~~ **\$29.95**, our Starter Kit has everything you need to make your first ten 2 1/4" buttons.

Request your **FREE** catalog or order your Starter Kit today!



✓ **FREE** Catalog ✓ **FREE** Shipping
Badge-A-Minit™

800.223.4103
www.badgeaminit.com

Badge-A-Minit, Dept. SCL709,
345 N. Lewis Ave., Oglesby, IL 61348

- ☐ Please send me my **FREE** catalog.
☐ Send me a Starter Kit for only \$29.95 (IL residents add \$1.95 tax).
☐ Check/M.O. ☐ VISA ☐ MasterCard
☐ Discover ☐ AMEX
Card No. _____ Exp. Date _____
Name/Title _____
Address _____
City _____ State/Zip _____

FREE shipping on all UPS Ground orders.

KLEEN GREEN ENZYMES

- **Safe, Effective, Nontoxic**
- **Children and Pet Safe**
- **Pesticide Free!**
- **Eliminates Germs, Bacteria, Odor and Pests**



- **Satisfaction Guaranteed**
- **Fast Delivery**

800.807.9350
615.790.6122
www.KleenGreen.com

EvolveFISH.com

Great gifts for enquiring minds!

CAR EMBLEMS STICKERS



What schools need is a Moment of SCIENCE

T-SHIRTS



BUTTONS



Because Science is just your cup of tea! (and ours too)

Check our web site or call:
1-800-386-5846

STARIZONA

Adventures in Astronomy & Nature



Take a billion-mile trip this summer...
Without leaving your backyard!

www.starizona.com



Epilog

www.epiloglaser.com/science.htm | 800-437-4564

Science and creativity go hand in hand with the Zing Laser from Epilog. Bring your creative vision to life as you engrave and cut wood, acrylic, plastic and more – with equipment that's as easy to use as your printer. Visit www.epiloglaser.com/science.htm for information.



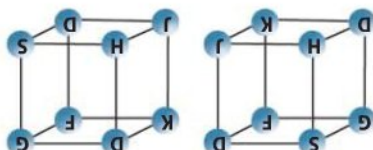
Meteorite Jewelry

www.jewelrydesignsformen.com

Jewelry Designs For Men features cutting-edge, contemporary designs by award-winning designer John Biagiotti in precious metal and meteorite. Celebrate that special life event with a gift from the stars! Birthdays, weddings, commitment ceremonies, graduations and any other important achievement deserve nothing less.



Answer Key

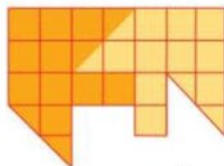


4. See diagram.

3. 4,763. If we reverse the digits of the second and fourth numbers, we obtain the sequence 3,624, 3,634, 3,644, 3,654 and 3,664, so the next number in this list would be 3,674. But the second and fourth numbers were reversed, so the sixth number should be the reverse of 3,674.

7	61	43
73	37	1
31	13	67

2. One of the eight possible solutions is shown here. All of the other solutions can be obtained from this one by rotations and reflections.



1. See diagram.

HEADBREAKERS ANSWERS:

5. 40. Each number yields the square root of the number plus half of the root of the number. Since the square root of 64 is 8, and half of 64 is 32, we see that 64 yields 8 + 32 = 40.

4. F. Pairs A and G are identical except for a rotation, and the same is true for B and C, and for D and E. Since F cannot be obtained by rotation from any of the other figures, it does not belong. Note that F can be obtained from D or from E by a reflection, but not by a rotation.

be consistent, the middle square should contain one dot, bringing the total to five. Each row contains an even number of yellow dots. The third row contains two yellow dots, so to keep the total even, the middle square cannot contain a yellow dot.

3. A black dot. Each column other than the third contains an odd number of dots. The third column contains four dots, so to

9. A. Moving from left to right in each row, the total number of dots in the dominoes increases by two for each domino. In the last row, the totals are three, five and seven, so a domino with nine dots completes the pattern.

1. 4. Since the six row sums are equal, the sum of all the numbers in the array must be a multiple of 6. The sum of the integers from 1 to 7 is 28, so the sum of five copies of each of these numbers is 5 x 28 = 140. Since the total of all the numbers in the array is a multiple of 6, the only possibility for the extra number is 4, bringing the total to 144.

2. A. Moving from left to right in each row, the total number of dots in the dominoes increases by two for each domino. In the last row, the totals are three, five and seven, so a domino with nine dots completes the pattern.

3. A black dot. Each column other than the third contains an odd number of dots. The third column contains four dots, so to

BRAIN TRAINERS ANSWERS:

Music: Flamenco
Botany: Mahogany
Anatomy: Tongue
Spaces: Forum
Number: 51
History: 1965

TRIVIA COUNTDOWN ANSWERS:



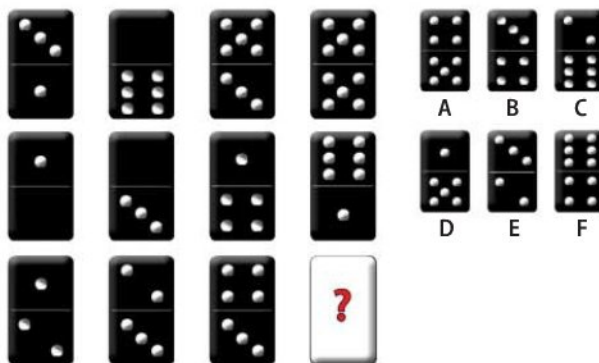
1

Five copies of each of the seven integers from 1 to 7 are placed in 35 of the 36 empty boxes, and an extra copy of one of these numbers is placed in the remaining box. Suppose that when this is done, all six horizontal rows of the resulting array have the same sum. Which number will appear six times?



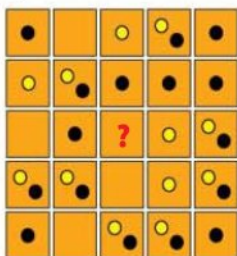
2

Which of the dominos, A through F, best completes the pattern?



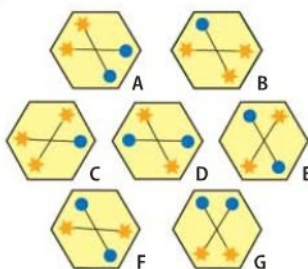
3

What should go in the square with the question mark?



4

Which figure does not belong?



5

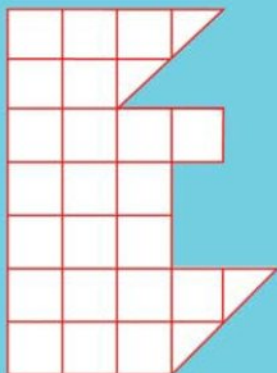
If $4 \rightarrow 4$,
 $9 \rightarrow 7\frac{1}{2}$,
 $16 \rightarrow 12$,
 $25 \rightarrow 17\frac{1}{2}$,
 $36 \rightarrow 24$
 and $49 \rightarrow 31\frac{1}{2}$,
 then $64 \rightarrow ?$

Headbreakers



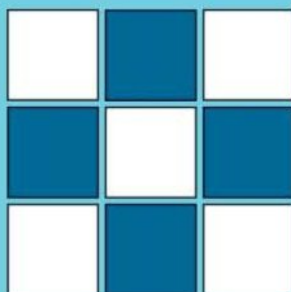
1

Divide the figure below into two identical figures.



2

Place the numbers 1, 7, 13, 31, 37, 43, 61, 67 and 73 into the nine cells of the square so that the sums of the three rows, three columns and two diagonals are all equal.



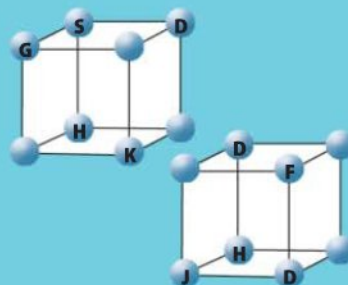
3

Find a pattern for these five four-digit numbers. What should the sixth number be to preserve the pattern?

3,624
 4,363
 3,644
 4,563
 3,664
 ?

4

Two views of the same transparent cube are shown below. The balls at each corner contain a letter. No matter how the cube is turned, the letter will appear correctly to the viewer. Which letters go in which empty balls?



Answers appear on page 87

SCIENCE ILLUSTRATED (VOLUME 2, ISSUE 4) (ISSN 1890-7539, USPS 074820088890) IS PUBLISHED BIMONTHLY, J/F, M/A, M/J, J/A, S/O AND N/D, BY BONNIER CORPORATION, 2 PARK AVENUE, NEW YORK, NY 10016. PERIODICALS POSTAGE PAID AT NEW YORK, NY, AND ADDITIONAL MAILING OFFICES. NO PART OF THIS MAGAZINE MAY BE REPRODUCED WITHOUT THE EXPRESS WRITTEN PERMISSION OF SCIENCE ILLUSTRATED MAGAZINE. POSTMASTER: SEND ADDRESS CHANGES TO SCIENCE ILLUSTRATED, P.O. BOX 420235, PALM COAST, FL 32142-0235. SUBSCRIPTIONS: IN THE U.S., \$24 PER YEAR; ADD \$6 PER YEAR FOR DELIVERY TO CANADA AND \$16 PER YEAR FOR DELIVERY TO ALL OTHER FOREIGN COUNTRIES. ALL PAYMENTS IN U.S. FUNDS ONLY. FOR SUBSCRIPTION INFORMATION, CALL 866-429-0139 IN THE U.S. AND 386-597-4388 FROM CANADA AND INTERNATIONALLY. PUBLICATION AGREEMENT NUMBER 40612608. CANADA RETURN MAIL, P.O. BOX 25542, LONDON, ON N6C 6B2.



© Masterfile

Understand the Fun and Beauty in Mathematical Concepts

Humans have been having fun and games with mathematics for thousands of years. Along the way, they've discovered the amazing utility of this field—in science, engineering, finance, games of chance, and many other aspects of life.

This course of 24 half-hour lectures celebrates the sheer joy of mathematics, taught by a mathematician who is literally a magician with numbers. Professor Arthur T. Benjamin of Harvey Mudd College is renowned for his feats of mental calculation performed before audiences at schools, theaters, museums, conferences, and other venues. His teaching has been repeatedly honored by the Mathematical Association of America, the nation's largest professional mathematical society.

Throughout these lectures, Professor Benjamin shows how everything in mathematics is magically connected—how the beautiful and often imposing edifice that has given us algebra, geometry, trigonometry, calculus, probability, and so much else is based on nothing more than fooling around with numbers.

This course is one of The Great Courses®, a noncredit, recorded college lecture series from The Teaching Company. Award-winning professors of a wide array of subjects in the sciences and the liberal arts have made more than 250 college-level courses that are available now on our website.

The Joy of Mathematics

Taught by Professor Arthur T. Benjamin, Harvey Mudd College

Lecture Titles

- | | |
|--|---|
| 1. The Joy of Math—
The Big Picture | 14. The Joy of the Imaginary
Number i |
| 2. The Joy of Numbers | 15. The Joy of the Number e |
| 3. The Joy of Primes | 16. The Joy of Infinity |
| 4. The Joy of Counting | 17. The Joy of Infinite Series |
| 5. The Joy of Fibonacci Numbers | 18. The Joy of Differential Calculus |
| 6. The Joy of Algebra | 19. The Joy of Approximating
with Calculus |
| 7. The Joy of Higher Algebra | 20. The Joy of Integral Calculus |
| 8. The Joy of Algebra Made Visual | 21. The Joy of Pascal's Triangle |
| 9. The Joy of 9 | 22. The Joy of Probability |
| 10. The Joy of Proofs | 23. The Joy of Mathematical Games |
| 11. The Joy of Geometry | 24. The Joy of Mathematical Magic |
| 12. The Joy of Pi | |
| 13. The Joy of Trigonometry | |

Order Today!

Offer Expires Tuesday, September 1, 2009

The Joy of Mathematics

Course No. 1411

24 lectures (30 minutes/lecture)

DVDs

~~\$254.95~~

NOW \$69.95

+ \$10 Shipping, Processing,
and Lifetime Satisfaction Guarantee

Priority Code: 35658

ACT NOW!

1-800-TEACH-12
www.TEACH12.com/3sci



THE TEACHING COMPANY®

The Joy of Lifelong Learning Every Day™

GREAT PROFESSORS, GREAT COURSES, GREAT VALUE
GUARANTEED.™



Travel Billions of Miles from Your Own Backyard



Vixen
Optics

The oldest and largest Japanese manufacturer of Telescopes, Binoculars, and Spotting Scopes, Vixen Co., LTD, has the widest selection of quality products available in the U.S. Backed by the best warranty and service in the industry, you can rely on the quality of all Vixen products. When you are ready for something better, choose Vixen for superior views of your world.

vixenoptics.com • a Division of MrStarGuy, Inc.