How Species Split | Spectacular Supernovas | Africa's Big Break

www.sciencenews.org

ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ JULY 2, 2011

Mind Over Machine

Controlling prosthetics with only the brain

Diving Spiders

Mutant Weeds

Water: Dr. Liquid and Mr. Gas

DANIEL STEIGER

LIST PRICE $1,095.00

83%OFF

NOW JUST $179

YOU SAVE $916

6 GENUINE DIAMONDS

5 YEAR UNLIMITED MOVEMENT WARRANTY

30 DAY MONEY BACK GUARANTEE

PRECISION AND LUXURY AT ITS BEST

NOW WITH DIAMONDS AS STANDARD

The Daniel Steiger Alphagraph Diamond. A sporty timepiece with a luxury edge now available direct from the manufacturer at the astonishingly low price of $179 - a saving of $916 on the retail price of $1,095. So how can we make an offer like this? The answer is beautifully simple. We have no middleman to pay. No retail overheads to pay and not the usual mark-up to make, which on luxury items (including watches) can be enormous. We just make beautiful watches beautifully simple to buy.

- **Stainless steel case and bracelet featuring divers buckle fused with 18k yellow gold**
- **Rotating bezel . Precision movement featuring month, day, date and dual time sub-dials**
- **6 Genuine diamond indices . Water resistant to 10atms (328ft) . 5 Year unlimited movement warranty**

Includes Soft Lined Wood Finished Presentation Case

VISA AMERICAN EXPRESS Card MasterCard DISCOVER NETWORK

CALL OUR CREDIT CARD HOTLINE ON 1-877 550 9876

Please quote **SCN117ALP** or go to **www.timepiecesusa.com/scn117alp**

Timepieces International Inc, 3580 NW 56th Street, Fort Lauderdale, Florida, 33309

JULY 2, 2011 • VOL. 180 • NO. 1

ScienceNews

In The News

5 STORY ONE
- Weeds pulling ahead in arms race against herbicides

8 HUMANS
- Ancient males let the women come to them
- An Out of Africa story may be revised to Out of Asia

9 SCIENCE & SOCIETY
- Info flow shows who's been naughty
- iPhones are contagious
- Twitter a poor sub for polling
- Computer IDs what was Senate's most powerful gang

10 ATOM & COSMOS
- Supernovas get even more super
- Black hole shows off its jets in high-def

12 ENVIRONMENT
- In acidifying oceans, fish brave noise despite danger
- Some corals are more suicide-prone than others

13 MOLECULES
- Water's surface is paper-thin and not all wet

14 LIFE
- Diving spiders use bubbles as gills
- Worms take life to new depths

16 BODY & BRAIN
- Third-graders do math their own way
- Drug offers new way to prevent breast cancer

Features

18 EVOLUTION'S WEDGES
Researchers are tracking down the genetic heavyweights responsible for splitting a species in two.
By Daniel Strain

22 DEATH OF A CONTINENT, BIRTH OF AN OCEAN
The Afar region of Ethiopia is being pulled in multiple directions, destined to eventually become the world's newest sea.
By Alexandra Witze

26 MIND-CONTROLLED
COVER STORY: Science fiction becomes reality as patients learn to use only their thoughts to control robotic arms and other machines.
By Susan Gaidos

Departments

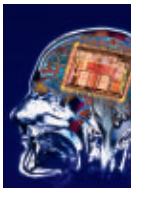
2 FROM THE EDITOR

4 NOTEBOOK

30 FEEDBACK

31 BOOKSHELF

32 FROM THE ARCHIVE
History repeats with another round of carp invasion.



COVER By electronically linking the brain cells that control movement with artificial limbs and other devices, researchers offer hope to paralyzed patients.
Surf/Corbis

ScienceNews
MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC

PUBLISHER Elizabeth Marincola
EDITOR IN CHIEF Tom Siegfried

EDITORIAL
MANAGING EDITOR Eva Emerson
SENIOR EDITOR/POLICY Janet Raloff
DEPUTY MANAGING EDITOR, NEWS Matt Crenson
DEPUTY MANAGING EDITOR, FEATURES Elizabeth Quill
DEPUTY NEWS EDITOR Erika Engelhaupt
CONTRIBUTING EDITOR Alexandra Witze
ASTRONOMY Ron Cowen
BEHAVIORAL SCIENCES Bruce Bower
BIOMEDICINE Nathan Seppa
CHEMISTRY/INTERDISCIPLINARY SCIENCES Rachel Ehrenberg
LIFE SCIENCES Susan Milius
MOLECULAR BIOLOGY Tina Hesman Saey
NEUROSCIENCE Laura Sanders
PHYSICAL SCIENCES Devin Powell
EDITORIAL ASSISTANT Camille M. Carlisle
WEB SPECIALIST/EDITORIAL SECRETARY Gwendolyn K.N. Gillespie
SCIENCE WRITER INTERN Daniel Strain
CONTRIBUTING CORRESPONDENTS Laura Beil, Susan Gaidos, Charles Petit

DESIGN
DESIGN DIRECTOR Beth Rakouskas
ASSISTANT ART DIRECTORS Theresa Dubé, Erin Feliciano

ADVERTISING | CIRCULATION
CIRCULATION MANAGER Tosh Arimura
ADVERTISING Jonathan Sismey, *Eastern Director*; Mike Walker, *Western Director*
ADVERTISING/CIRCULATION ASSOCIATE Kerwin Wilson
PERMISSIONS Evora Swoopes

SOCIETY FOR SCIENCE & THE PUBLIC

BOARD OF TRUSTEES CHAIRMAN H. Robert Horvitz
VICE CHAIR Jennifer Yruegas SECRETARY Gayle Wilson
TREASURER Michela English MEMBERS Craig R. Barrett, S. James Gates Jr., Tom Leighton, Alan Leshner, Stephanie Pace Marshall, Patrick McGovern, Joe Palca, Anne C. Petersen, Robert W. Shaw Jr., Frank Wilczek; Elizabeth Marincola, *ex officio*

EXECUTIVE OFFICE PRESIDENT Elizabeth Marincola
EXECUTIVE ASSISTANT Amy Méndez

FINANCE CHIEF FINANCIAL OFFICER Greg Mitchell
ACCOUNTING MANAGER Lisa M. Proctor SENIOR ACCOUNTANT Sivakami Kumaran

EXTERNAL AFFAIRS CHIEF ADVANCEMENT OFFICER Rick Bates
OUTREACH DIRECTOR Jennifer Carter COMMUNICATIONS Caitlin Jennings
EXTERNAL AFFAIRS SPECIALIST Nancy Moulding
DEVELOPMENT COORDINATOR Charles Heidlage

EVENTS MANAGEMENT DIRECTOR Cait Goldberg
ASSOCIATE Marisa Gaggi

SCIENCE EDUCATION PROGRAMS DIRECTOR Michele Glidden
INTEL SCIENCE TALENT SEARCH MANAGER Caitlin Sullivan
BROADCOM MASTERS MANAGER Stephanie Lemnios
INTERNATIONAL FAIRS MANAGER Sharon Snyder
DOMESTIC FAIRS Laurie Demsey VOLUNTEERS AND SPECIAL AWARDS Diane Rashid
AWARD AND EDUCATION PROGRAM ADMINISTRATION June Kee
INTERNATIONAL FAIRS SPECIALIST Jinny Kim ASSOCIATE Laura Buitrago

INTERNAL OPERATIONS DIRECTOR Harry Rothmann
MANAGER, NETWORK ADMINISTRATION James C. Moore
LOGISTICS Anthony Payne FACILITIES Paul Roger
INFORMATION TECHNOLOGY Thomas D. Smith, Amy An, Gregory A. Sprouse
DATABASE ADMINISTRATOR Alan Gordon MAILROOM TECHNICIAN Randy Williams

EDITORIAL, ADVERTISING AND BUSINESS OFFICES
1719 N Street NW, Washington, DC 20036 Phone (202) 785-2255
Audit Bureau of Circulations
Subscriptions subs@sciencenews.org Editorial/Letters editors@sciencenews.org
Advertising/Business snsales@sciencenews.org
Texterity Digital edition provided by Texterity, www.texterity.com
Science News (ISSN 0036-8423) is published biweekly, for $54.50 for 1 year or $98 for 2 years (international rate $80.50 for 1 year or $161 for 2 years) by Society for Science & the Public, 1719 N Street NW Washington, D.C. 20036. Preferred periodicals postage paid at Washington, D.C., and an additional mailing office.
Subscription Department: PO Box 1205, Williamsport, PA 17703-1205. For new subscriptions and customer service, call 1-800-552-4412.
Postmaster: Send address changes to *Science News*, PO Box 1205, Williamsport, PA 17703-1205. Two to four weeks' notice is required. Old and new addresses, including zip codes, must be provided.

FROM THE EDITOR

Science brings real life to the technologies of fiction

Every once in a while, science manages to reach the imaginative realm of technological sophistication usually reserved for science fiction. Or at least begins to take the first small steps in that direction.

Consider, for instance, the visionary motion picture classic *Forbidden Planet* (1956). It offered all sorts of futuristic technology for scientists to envy — hyperdrive for spacecraft propulsion, quantum subspace communication and an intelligent and articulate robot.

But by far the most impressive achievement discovered by Leslie Nielsen on planet Altair-4 was the extinct Krell's technology for achieving "civilization without instrumentalities." Krell scientists believed they could harness the power of thought to free them from dependence on physical instruments. That was the power borrowed by Walter Pidgeon's Dr. Morbius to create his monsters from the id. Put more plainly, it was the ability of the brain's mental power to drive the motion of machinery.

Morbius could harness his mental energy to generate three-dimensional images and conjure up virtual creatures capable of killing. Today's scientists and engineers would prefer to transform thoughts into the control of beneficial devices, such as prosthetic limbs. In this issue, contributing correspondent Susan Gaidos provides a status report on the successes so far in this endeavor and the prospects for future advances (Page 26).

Trials now under way could soon provide useful methods for quadriplegics to control computer-driven devices with their thoughts. With a little more work, similar capability could be made available to amputees. Enhanced with return signals from the devices back to the brain, such technologies could allow people to manipulate objects and perform various tasks without the benefit of normal muscles and limbs.

It was not so long ago that this sort of thing — the power of minds to move physical objects — was a sign of pseudoscientific fraud or delusion. It's now a mainstream research program. It's an exemplary illustration of the real-life convergence of fiction with science, the realm where the imaginings of what is thinkable turn into the demonstrations of what is doable.

—Tom Siegfried, Editor in Chief

JIM WEBB

FREE GIFT valued at $35

"New medical alarm can save you money …and save your life!"

The Designed For Seniors® MedicalAlarm provides emergency notification that is simple, reliable and affordable. It's simply the best value on the market today.

Are you concerned about being helpless in an emergency? Are you and your loved ones anxious about what would happen if you were unable to get to a phone? Have you considered moving out of the home you love and into some kind of assisted living because of these worries? If you answered "yes" to any of these questions, you are not alone Millions of seniors are concerned about their safety. There are products out there that claim to help, but they are difficult to use and even more difficult to afford. Why mess with complicated installations and long term contracts when there's a product that's simple, reliable and affordable? The product is the *Designed For Seniors®* Medical Alarm. Read on and we'll explain why every senior in America should have one.

First of all, it's simple to install and use. Unlike other products that require professional installation, this product is "plug and play." The unit is designed for easy use in an emergency, with large, easy-to-identify buttons.

It's reliable. From the waterproof pendant to the sophisticated base unit, to the state-of-the-art 24/7 call center, the entire system is designed to give you the give you the peace of mind in knowing you are never alone in an emergency. You get two-way communication with a live person in our Emergency Response Center, and there's a battery backup in case of a power failure.

Best of all, it's affordable. You get the complete system for only pennies per day. No equipment charge, no activation fee, no long term contract. Call now and within a week you or someone you love will have the peace of mind and independence that comes with this remarkable system.

What will you do in case of an emergency? If you have a *Designed For Seniors®* Medical Alarm, all you do is push a button, and you'll immediately get the help you need, quickly and reliably. That's because it has been "designed for seniors" by the industry leader in providing helpful and affordable solutions for millions of aging Americans.

Simple, Reliable, and Affordable

	Competition	Designed For Seniors® MedicalAlarm
Equipment Cost	$30-$300	✓ FREE
Activation	$10-$30	✓ FREE
Contract	1-2 Years	✓ NONE
UL Approved Call Center	Some	✓ YES
Senior Approved™	No	✓ YES
Warranty	Varies	✓ LIFETIME
Free Shipping	?	✓ YES

- ***Free shipping***
- ***Free activation***
- ***No Equipment cost***

Be one of the first 100 to order and get FREE Shipping and a FREE Gift– valued at $35. It's yours to keep.

Designed For Seniors® *MedicalAlarm*

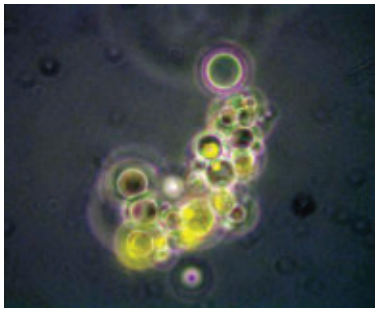
Please mention promotional code 42886.

1-877-731-2091

firstSTREET for Boomers and Beyond®

1998 Ruffin Mill Road
Colonial Heights, VA 23834

ADVERTISEMENT



Say What?

capillary state \KA-pih-LEHR-ee stayt\ *n.* In a mixture of solid particles and two unblendable liquids, a state in which the particles huddle in clumps surrounding droplets of the liquid that wets the solid particles *less*. These clumps allow what was runny goo to become a gel after some stirring, Erin Koos and Norbert Willenbacher of the Karlsruhe Institute of Technology in Germany reported in February in *Science*. Previous work has shown similar goo-to-gel transitions, but in those cases particles formed networks instead of clumps and were connected by the liquid that wetted them *more*. Gel-able suspensions, like the oil–water–glass bead mixture shown (yellow dye marks the water), will allow scientists to tune fluids' flow properties and build lightweight porous ceramics.

Science Past | FROM THE ISSUE OF JULY 1, 1961

WINTERGREEN VS. ALMOND IN ODOR PENETRATION TEST — Different chemicals produce different odors because vibrations within the molecules are different.

This is the theory of Dr. R.H. Wright of the British Columbia Research Council in Vancouver, Canada. He compared nitrobenzene, which has an almond smell, and methyl salicylate, which smells like wintergreen. Both these substances are much alike so far as vibrations are concerned, except that wintergreen has two additional frequencies that are missing in nitrobenzene.... In experiments with 12 volunteer sniffers, Dr. Wright showed that the wintergreen odor masked the almond smell about ten times more easily than almond masked wintergreen. The effect is not large ... but it is distinct and in the direction predicted by the vibrational theory of odor.

The (-est)

Excavations in northern Chile have uncovered the oldest known mine in the Americas. New World settlers intentionally dug a pit and removed chunks of iron oxide at the coastal site between 12,000 and 10,500 years ago, Chilean and French researchers reported in the June *Current Anthropology*. Past work has documented the use of iron oxide as a pigment in the Americas around that time, but the new mine is at least 6,000 years older than previous dated evidence for mining in the Americas. Because the mining was intensive and technically skilled, the coastal area's early settlers probably carried the tradition with them from elsewhere, the authors propose.

Science Future

July 7
Be mesmerized by the color red and how it is made for pigments and paints, at San Francisco's Exploratorium. Ages 18 and up. See www.exploratorium.edu/afterdark

July 18
In Washington, D.C., a Smithsonian science historian describes ancient apothecaries and their brews. See www.residentassociates.org

SN Online

www.sciencenews.org

SCIENCE & THE PUBLIC BLOG
Sound science is lacking for many alternative remedies. See "Traditional Chinese medicine: Big questions."

LIFE
Microbes flourish, maybe at the expense of fish, during jellyfish blooms. See "Marine microbes fritter away jelly bonus."

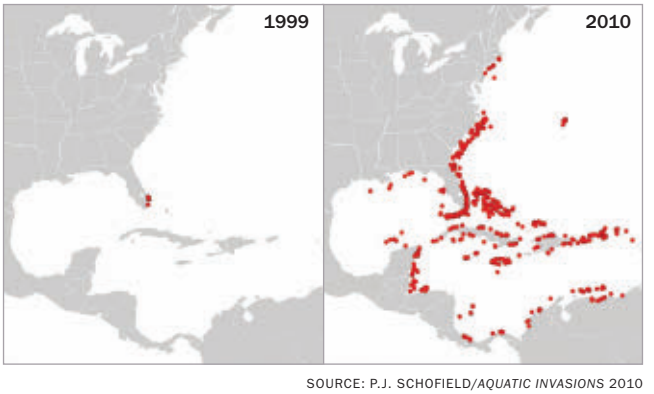
Larger broods bring more stress for a tree swallow mom (below, with mate), but also more fledglings. See "Stressed bird moms."

MATTER & ENERGY
Researchers turn virtual particles into real photons. Read "Light created from the void."

Science Stats | SWIM WITH THE FISHES

Indo-Pacific lionfishes have invaded the Caribbean and the western Atlantic (below) in the last decade, data from the U.S. Geological Survey show. More than 30 nonnative marine fish species have appeared off Florida's coast, but lionfishes are the first to establish themselves.

Confirmed lionfish sightings, 1999 and 2010



SOURCE: P.J. SCHOFIELD/*AQUATIC INVASIONS* 2010

CLOCKWISE FROM TOP LEFT: *SCIENCE*/AAAS; P.-G. BENTZ

“Water may be the most common substance on Earth. But from a physics standpoint, it is pretty unusual.” —ALEXANDER BENDERSKII, PAGE 13

Humans Asian roots for human genus
Science & Society Networks tell tales
Atom & Cosmos Supernovas of a new kind
Environment Suicide protein dooms corals
Molecules Fine line between wet and dry
Life Worms go deep
Body & Brain Third-graders think differently

In the News

A. HAGER/UNIV. OF ILLINOIS AT URBANA-CHAMPAIGN

STORY ONE

Widespread use of herbicides fosters immunity

Many weeds now resistant to multiple chemical killers

By Janet Raloff

In the United States, the wetland native water hemp has adapted to herbicides and is overrunning soy and corn fields.

Agriculture’s most effective pesticides are rapidly losing their punch as weeds evolve resistance to the chemicals. With no game-changing alternatives in the pipeline, researchers warn that farmers could soon see crop yields drop and production prices climb.

“It’s what Chuck Darwin talked about back in 1850. Organisms evolve in response to selection pressures in their environment,” says Micheal Owen, an extension weed scientist at Iowa State University in Ames. “In essence, the better we get at controlling weeds, the more likely those efforts will select for survivors that do not respond to controls.”

In the June 8 *Journal of Agricultural and Food Chemistry*, Owen and other researchers describe the rapid rise of herbicide-resistant weeds and a particularly threatening trend: an increasing number of weeds that are simultaneously immune to multiple herbicides.

Farmers have battled weeds since the dawn of agriculture. But the arms race changed overnight with the rollout, beginning in 1996, of crops possessing a genetically engineered immunity to glyphosate, the active ingredient in a broad-spectrum weed killer known as Roundup. Growers could then use glyphosate repeatedly, all season long, without fear of killing their crops.

“No herbicide has ever been used to the extent glyphosate has,” says Stephen Duke of the U.S. Agricultural Research Service in University, Miss. One price has been the rapid evolution of weeds resistant to it.

“Today, 98 percent of U.S. soybeans, 88 percent or so of U.S. cotton and more than 70 percent of U.S. corn come from cultivars resistant to glyphosate,” Owen reports. Reliance on these crops — and an accompanying weed-control strategy that employs glyphosate to the exclusion of other herbicides — “created the ‘perfect storm’ for weeds to evolve resistance,” Owen and Jerry Green of Pioneer Hi-Bred International in Newark, Del., argue in their new analysis.

But the only thing unique to glyphosate — in terms of breeding weed resistance — is the extent of its use.

In the same issue of the *Journal of Agricultural and Food Chemistry*, Carol Mallory-Smith of Oregon State

For today's top stories, visit
SN Today at **www.sciencenews.org**

University in Corvallis chronicles the emergence of herbicide-resistant hybrid goat grass. It is evolving the ability to tolerate the herbicide imazamox in fields planted with wheat that has been bred to be immune to the chemical. Here, the weed scientist explains, resistance traces not to herbicide overuse, but to the spread of resistant genes in the pollen of wheat, the weed's distant cousin, through interbreeding.

The irony, Mallory-Smith says, is that farmers have found the imazamox-resistant wheat such a high performer that many actually apply little or none of the herbicide to which it's immune.

Applying the weed killer would knock out much of the goat grass invading farmers' fields. But left untreated, the goat grass survives to accept pollen from the wheat — and in so doing, creates hybrids that incorporate its cousin's resistance. Although farmers can target the hybrid goat grass with other herbicides, doing so risks killing the wheat as well.

Weeds immune to one herbicide will generally also prove insensitive to others that employ the same mode of action — usually the chemical's disruption of an essential enzyme function in the plant. For some major crops, weeds have already countered most common modes of poisoning, notes Patrick Tranel of the University of Illinois at Urbana-Champaign.

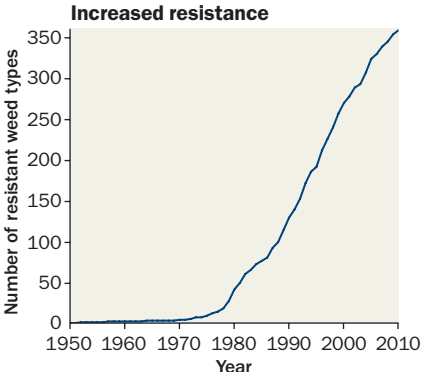
Common water hemp has risen to become one of the most serious weeds in Midwestern corn and soy. In a study also appearing in the June 8 *Journal of Agricultural and Food Chemistry*, Tranel's team reports finding water hemp simultaneously immune to as many as four functional classes of herbicides — including glyphosate's class. In the March *Pest Management Science*, the team reported water hemp's resistance to yet a fifth herbicide group.

Water hemp already exhibits immunity to three of the four functional classes of herbicides federally permitted for use on emerging weeds in soy, Tranel notes. The remaining one doesn't work well on weeds six inches high or more and is toxic to glyphosate-resistant soy. "So," Tranel says, "I'm not exaggerating when I say, at least for soybeans, we're on the verge of running out of options."

Stephen Powles of the University of Western Australia in Perth notes that in his country, some weedy ryegrass species "can be resistant to seven different herbicide types, meaning there are almost no herbicides which still work."

Herbicide makers have encouraged farmers to embrace the mantra KISS — for "keep it simple, stupid," says Jonathan Gressel of the Weizmann Institute of Science in Rehovot, Israel. He and other weed scientists now argue that only the opposite approach will stall the growing evolution of herbicide resistance in weeds. Scientists advocate rotating crops on a given field, applying several different herbicides and considering the use of additional physical treatments such as burning or light tillage. Gressel would also go so far as to recommend quarantining fields where resistant weeds initially turn up.

Unfortunately, Owen says, farmers think they can continue using simpler herbicide-centered strategies "as they wait for industry's next silver bullet." But novel herbicides are not on the horizon, he says, so a diverse approach to weed management must be. ■



SOURCE: I. HEAP/WEEDSCIENCE.ORG

Growing menace In recent decades, hundreds of weed types have developed resistance to common agricultural herbicides. The problem has kept growing even with the introduction of new chemical formulations designed to attack weeds via novel biochemical strategies.


Ryegrass

ARTHUR CHAPMAN/WIKIMEDIA COMMONS

Back Story | RESISTANCE MOVEMENT

The International Survey of Herbicide Resistant Weeds monitors the amount of crop acreage worldwide that is affected by chemical-resistant plant pests. Wild oats tops the list, but in the United States the biggest problems are common water hemp, Palmer amaranth and horseweed, says survey director Ian Heap. Palmer amaranth may be the most serious threat to crops, he says, because it's immune to so many different classes of herbicide.

Weed species	Million hectares impacted
Wild oats	4.9
Common water hemp	3.2
Horseweed (mare's tail)	1.8
Ryegrass	1.6
Palmer amaranth	1.4
Wild (red) rice	0.04 to 0.4 (estimated)

SOURCE: I. HEAP/WEEDSCIENCE.ORG

Actual size is 30.6 mm

Before they were carved in stone, they were struck in silver. Today they're forever etched in Civil War history.

Two Civil War generals, Stonewall Jackson and Robert E. Lee, captured in stunning 90% silver.

And the first U.S. coin to commemorate the War Between the States.

As Americans, we're riveted by outsized personalities like these military leaders from a century and a half ago.

This year, as we mark the 150th anniversary of the Civil War, we're happy to bring you a coin that has *never been available in large enough quantities* to make an offer like this one.

A remarkable discovery

Thanks to an intrepid southern collector who squirreled away these coins a few at a time over decades, we now have what could be the largest hoard ever assembled of silver 1925 Civil War Commemorative Half Dollars.

They were minted to raise money for the Stone Mountain Civil War memorial near Atlanta, where the image on this coin is now carved in *bas relief*.

The detail and relief make each coin a work of art.

You can almost hear the two generals discussing their next move. You can almost feel the horses fidgeting as they await their riders' commands.

It's no wonder these coins are in such high demand.

You will hold not simply history in your hand. *You'll hold a piece of your past.*

Historic public release

Each half dollar is in lightly circulated condition and comes with a storycard and certificate of authenticity detailing this important coin.

Order now risk free

At less than $100 each, we expect our small quantity to disappear quickly. We urge you to call immediately to avoid disappointment!

You must be 100% satisfied with your Civil War Commemorative Half Dollar or return it via insured mail within 30 days of receipt for a prompt refund (less s&h).

Buy more and SAVE

1925 Civil War Commemorative Half Dollar $99.95 *+ s/h*

3 for only $93.00 each *+ s/h*

SAVE $20.85

Toll-Free 24 hours a day

1-877-566-6468

Offer Code CWC139

Please mention this code when you call.

GovMint.com

YOUR ONE BEST SOURCE FOR COINS WORLDWIDE

14101 Southcross Drive W.
Dept. CWC139
Burnsville, Minnesota 55337

www.GovMint.com

Prices and availability subject to change without notice. Past performance is not a predictor of future performance.
Note: GovMint.com is a private distributor of worldwide government coin issues and is not affiliated with the United States government.
Facts and figures were deemed accurate as of March 2011. ©GovMint.com, 2011

BBB ACCREDITED BUSINESS

Humans

"It certainly looks as though the African origin of *H. erectus* must be reconsidered." —PHILIP RIGHTMIRE

Early gals roamed, guys stayed put

Teeth hint ancient hominid wives joined husbands' bands

By Bruce Bower

Way back in the day, females came from far away and males didn't stray — not far, anyway.

That's the implication, with apologies to Dr. Seuss, of a new study of members of two ancient species in the human evolutionary family. Adult females in both hominid lineages often moved from the places where they were born to distant locations, presumably to find mates among unrelated males, say anthropologist Sandi Copeland of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, and her colleagues.

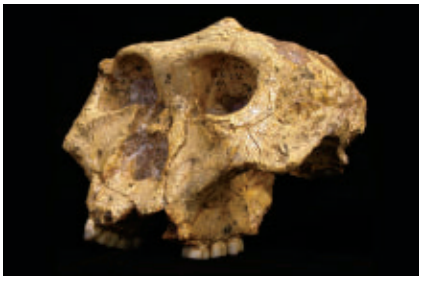
Most males in both hominid species spent their lives in a home region that covered no more than about 28 square kilometers, or about half the area of Manhattan, Copeland's team proposes in the June 2 *Nature*. They might have only occasionally gone farther afield, exploiting resources along wooded areas atop bands of bedrock that extend about 30 kilometers in opposite directions from the South African cave sites where fossils of the two ancient species were found.

It's not clear how far females traveled to reach new groups, only that they did not grow up where they died.

Copeland's investigation measured a chemical marker of childhood diet in teeth from 19 hominids found in two caves about a kilometer apart. Specimens represented 11 *Paranthropus robustus* individuals that lived 1.8 million years ago and eight members of *Australopithecus africanus* dated at 2.2 million years old.

Some researchers regard *A. africanus* as a direct ancestor of the *Homo* genus, which includes living people (*SN: 5/7/11, p. 16*). *P. robustus* belonged to a dead-end branch of hominid evolution.

Copeland's group measured levels of two forms of the element strontium in hominids' tooth enamel and in plants and animals now living within 50 kilometers of the fossil sites. Strontium is a naturally occurring element in rocks and soils. Specific strontium signatures characterize different landscapes. Strontium signatures in *A. africanus* and *P. robustus* teeth, determined by their diet, developed by age nine, the scientists estimate.



In early hominids like *Paranthropus robustus*, females apparently left their birth groups at sexual maturity.

Strontium data for both hominid species indicate that eight of nine large-toothed individuals — presumably males — grew up in the area where they died, whereas at least five of 10 small-toothed individuals — thought to be females — grew up elsewhere.

Since chimpanzee and gorilla females leave their birth groups upon reaching reproductive age, some researchers have long argued that early hominids did the same. Copeland's team "came up with an innovative way to test this model, and in the process, developed the first direct evidence of early hominid social organization," remarks anthropologist Peter Ungar of the University of Arkansas in Fayetteville.

Homo may have originated in Asia

Find suggests non-African origin for human genus

By Bruce Bower

Early members of the genus *Homo*, possibly direct ancestors of people today, may have evolved in Asia and then gone to Africa, not vice versa as many scientists have assumed.

Most paleoanthropologists have favored an African origin for the potential human ancestor *Homo erectus*. But new evidence shows the species occupied a West Asian site called Dmanisi from 1.85 million to 1.77 million years ago, at the same time or slightly before the earliest evidence of this human-like species in Africa, say geologist Reid Ferring of the University of North Texas in Denton and his colleagues.

The new Dmanisi discoveries point to an Asian homeland for *H. erectus*, the scientists propose online June 6 in the *Proceedings of the National Academy of Sciences*.

"It certainly looks as though the African origin of *H. erectus* must be reconsidered," remarks Harvard University anthropologist Philip Rightmire.

The new Dmanisi discoveries come from just beneath soil that previously yielded 1.77-million-year-old *H. erectus* fossils, including skulls with surprisingly small braincases suggestive of an early form of the species (*SN: 9/22/07, p. 179*). The latest excavations found 73 stone tools for cutting and chopping, as well as 34 unidentified bone fragments.

"Dmanisi was occupied repeatedly for roughly 80,000 years and supported a population that was well established and probably quite mobile," Ferring says.

Measurements of reversals in Earth's magnetic field and of the rate of decay of the element argon in a series of volcanic ash layers provided age estimates for the new finds.

DARRYL DE RUITER

Science & Society

13.3 billion Reported Enron revenue in dollars, 1996

100.8 billion Reported Enron revenue in dollars, 2000

Information flow reveals the dirt

Enron e-mail messages had different patterns when illicit

By Rachel Ehrenberg

Political thrillers that portray a "web of corruption" get it all wrong, at least according to an analysis of e-mails between Enron employees. The flow of the famously corrupt corporation's electronic missives suggests that dirty dealings tend to transpire through a sparse, hub-and-spoke network rather than a highly connected web.

Enron employees engaged in both legitimate and shady projects conveyed information much differently when their dealings were illicit, organizational theorist Brandy Aven of Carnegie Mellon University in Pittsburgh reported June 1. The distinction is visible in the network of e-mails among employees, which takes the shape of a central hub and isolated spokes when content is corrupt, rather than a highly connected net of exchanges.

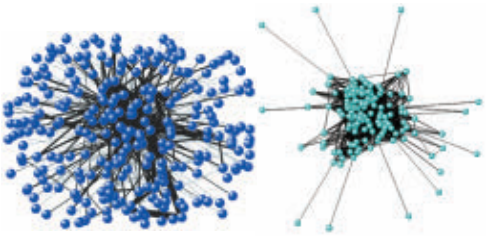
While today Enron is associated with corporate fraud, for years the energy and commodities company was a Wall Street darling. *Fortune* magazine named Enron America's most innovative company for six consecutive years ending in 2000. But by the next year, the U.S. Securities and Exchange Commission was investigating the firm's dealings.

"They were not only innovative technologically and administratively, but also in their accounting practices," said Aven.

Aven's analysis compared communications regarding three legitimate projects and three corrupt ones. Communications regarding the shady deals took on a hub-and-spoke shape, a setup that maximizes secrecy and control. A small, relatively informed clique occupies the hub at the center, communicating with spokes that don't share ties. The hub gets information from the spokes, which in their isolation are less likely to blow the whistle.

Recognizing that content alters flow is crucial, said Ramakrishna Akella, an expert in information management at the University of California, Santa Cruz. Much of network modeling relies on statistics and algorithms that too often ignore what's actually being exchanged, he said. "Mining content is very insightful."

That the sneaky behavior employed to cover the corrupt innovations at Enron might have been revealed just by diagramming who was e-mailing whom suggests that the structures of social networks might help investigators identify electronic dens of intrigue, such as terrorist communication networks, Aven said.



B. AVEN

Enron e-mails about legitimate projects were reciprocal and shared widely (left), but e-mails about an illicit project reveal a sparse network (right).

MEETING NOTES

Apple product fever

Mapping the contagious spread of Apple products in a communication network reveals that Macolytes constitute a "social network monster." Using datasets from the telecommunications provider Telenor, Pål Roe Sundsøy of the Norway-based company and colleagues examined user adoption of the iPhone, the iPad 3G, a videophone product and the Doro handset, a cell phone favored by the elderly. The team found that people are 14 times more likely to have an iPad if they have one friend who has one. With two iPad friends, that probability jumps to 41 times more likely and with three friends, to 96, Sundsøy reported May 31. Doro users, however, were not highly linked. —*Rachel Ehrenberg*

Twitter's a lousy soothsayer

If you're ditching your crystal ball for the oracle of Twitter, think again. Despite analyses suggesting that the volume and content of tweets can predict the outcome of political elections, research using the same techniques finds that the social media tool is more like a hazy Magic 8 Ball. Predictions of six 2010 Senate race winners based on Twitter chatter volume and sentiment were correct only half the time, Eni Mustafaraj of Wellesley College reported June 1. Manipulation of social media by spammers and propagandists and the skewed demographics of tweeters are probably to blame, she says. With better sampling and algorithms, mining Twitter may one day provide more meaningful information. —*Rachel Ehrenberg*

Senate's super six

A gang of six wielded power in the U.S. Senate even before two news-making gangs of six united to pass legislation on health care and the debt. Researchers from Stony Brook University in New York designed a computer analysis that sniffs out influence in social networks and used it to find that there were six super-influential senators in the 110th Congress, which spanned January 2007 to January 2009. When six particular senators voted yes (Bennett, R-Utah; Sessions, R-Ala.; Enzi, R-Wyo.; Kerry, D-Mass.; Rockefeller, D-W.Va.; and Lautenberg, D-N.J.), their collective influence overwhelmed their network and the legislation always passed, Mohammad Irfan reported May 31. —*Rachel Ehrenberg*

Atom & Cosmos

For more Atom & Cosmos stories, visit **www.sciencenews.org**

Introducing ... Superdupernovas

Exceptional brightness marks new class of stellar explosion

By Ron Cowen

Blue, brilliant and bizarre. That's how astronomers describe six supernovas that form a brand new class.

Like other supernovas, these oddballs are stellar explosions that produce spectacular light shows as their glowing debris roils the gas around them. But unlike known supernovas, these newly discovered objects emit much of their light at ultraviolet wavelengths and bear no trace of hydrogen, an element in abundance in most other stellar blasts.

The very existence of these explosions defies ready explanation, says astronomer Robert Quimby of Caltech. He and his colleagues describe the findings online June 8 in *Nature*.

The new class consists of four supernovas that the team recently discovered and two others that have baffled astronomers in the years since they were found (*SN: 7/18/09, p. 9*). None of the six are extremely remote, but members of this new class are so bright that they should be visible from more than 12 billion light-years away. Some might serve as new probes of distant galaxies that would otherwise be too faint to be observed.

In contrast to other known supernovas, the luminosity of this group can't be explained by any of three standard mechanisms: radioactive decay of newly forged elements expelled in the explosions, the collision of debris from the explosion with surrounding hydrogen-rich gas, or heat deposited by a shock wave traveling through a star just before its explosion.

Richard McCray of the University of Colorado at Boulder says he is convinced that Quimby's team has identified a new class that is unlike any other extremely luminous supernova.

Quimby and his collaborators have two ideas for how these outbursts may have happened. In one scenario, the core of the exploding star immediately forms a rapidly rotating, highly magnetized cinder called a magnetar. The strong magnetic field forces the cinder to slow down, converting the rotational energy into a power source that boosts the brightness of the supernova.

The second possible explanation is that just years before one of these stars explodes, it expels a huge bubble of hydrogen-poor material. When the explosion erupts, the expanding debris rams into the previously cast-off material, boosting the brightness.

Stars with helium envelopes that long ago ejected their outer shell of hydrogen are already known, says McCray. If such a star ejected its helium envelope before exploding, "that would do the trick" to explain the brightness, he notes.

Ultraviolet observations could identify a host of elements in the explosions and might indicate which of the two proposals is correct, Quimby says. A large amount of unburned carbon and oxygen, for example, would favor the model in which debris from the explosion runs into a bubble of previously ejected material.

With large sky surveys — such as the Palomar Transient Factory that Quimby's team used — finding thousands of supernovas, it's no surprise that astronomers have discovered some brilliant oddballs, says theorist Stan Woosley of the University of California, Santa Cruz. ■

VISIBLE: WFI/ESO, MICROWAVE: A. WEISS *ET AL.* APEX/MPIFR/OSO/ESO, X-RAY: R. KRAFT *ET AL.* CXC/CFA, NASA

Black hole jets, now in HD

Astronomers have produced the sharpest images ever of twin jets racing outward from a galaxy's central black hole. Generated using nine radio telescopes arrayed across the Southern Hemisphere, the images reveal features just 15 light-days across in the heart of the galaxy Centaurus A (galaxy shown at left). At its core, the galaxy contains a black hole as massive as 55 million suns. The new images home in on a region around the black hole that is less than 4.2 light-years across — smaller than the distance between the sun and its nearest star — says Roopesh Ojha of NASA's Goddard Space Flight Center in Greenbelt, Md. Ojha and colleagues describe their findings in the June *Astronomy & Astrophysics*. The team combined data from the radio telescopes to achieve resolution equivalent to that of a single superdish about 80 percent of Earth's diameter. The images reveal for the first time just how close to a black hole a jet can form, a constraint that must now be incorporated into models of how such jets are generated, Ojha says. —*Ron Cowen*

gravity defyer™

VERSOSHOCK REVERSE TRAMPOLINE SOLE

Steroid Syringe?
Now that we have your attention, Try Gravity Defyer FREE for 30 Days

SHOES ON STEROIDS?

Scientifically Engineered to Defy Pain, Defy Aging & Defy Fatigue

This is my story

I used to be more active. I used to run, play basketball, tennis, football… I was more than a weekend warrior. I woke up every day filled with life! But now, in my late 30's, I spend most of my day in the office or sacked out in front of the TV. I rarely get to the gym –not that I don't like working out, it's the nagging pain in my knees and ankles. Low energy and laziness has got me down. My energy has fizzled and I'm embarrassed to admit that I've grown a spare tire (I'm sure it's hurting my love life). Nowadays I rarely walk. For some reason it's just harder now. Gravity has done a job on me.

Wear them and you'll know

That's what my doctor recommended. He said, "Gravity Defyer shoes are pain-relieving shoes." He promised they would change my life –like they were a fountain of youth. "They ease the force of gravity, relieving stress on your heels, ankles, knees and back. They boost your energy by propelling you forward." The longer he talked, the more sense it made. He was even wearing a pair himself!

Excitement swept through my body like a drug

I received my package from GravityDefyer.com and rushed to tear it open like a kid at Christmas. Inside I found the most amazing shoes I had ever seen –different than most running shoes. Sturdy construction. Cool colors. Nice lines…
I was holding a miracle of technology. This was the real thing.

GDefy Benefits

- Relieve pain
- Ease joint & spinal pressure
- Reduce fatigue & tiredness
- Be more active
- Have more energy
- Appear taller
- Jump higher, walk and run faster
- Have instant comfort
- Cool your feet & reduce foot odor
- Elevate your performance

I put them on and all I could say was,"WOW!" In minutes I was out the door. I was invincible; tireless in my new Gravity Defyer shoes. It was as if my legs had been replaced with super-powered bionics. What the doctor promised was all correct. No more knee pain. I started to lose weight. At last, I was pain free and filled with energy! I was back in the game. Gravity had no power over me!

Customer Satisfaction Speaks for Itself!
4 out of 5 customers purchase a 2nd pair within 3 months.

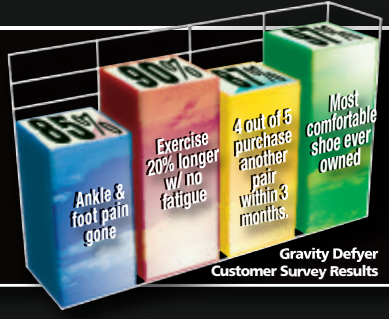
Nothing to lose: 30 Day Free Trial*

So, my friend, get back on your feet like I did. Try Gravity Defyer for yourself. You have nothing to lose but your pain.

Tell us your story! Login at Gravitydefyer.com and share your experience.

ABSORB SHOCK
Eliminate pain from every step.

REBOUND PROPELS YOU FORWARD
Reduce fatigue. Be more active



a $129.95 value
MEN (Shown above)
TB902MWBS
sizes 7 - 13
Med/Wide and ExtraWide/ XXWide Widths
WOMEN (Silver with Navy)
TB902FWBS
sizes 5 - 11
Med/Wide and ExtraWide/XXWide Widths

EXCLUSIVE ONLINE OFFER

FREE 30 DAY RISK-FREE trial*. Not available in stores.
Visit **ShoesOnSteroids.com/MM3GCB8** or take advantage of this exclusive offer by phone, and dial **(800) 429-0039** and mention the promotional code below.

Promotional Code: MM3GCB8

*Pay only $14.95 shipping and handling – non-refundable.

BBB A+

Environment

8.25 Estimated surface ocean pH in 1751

8.14 Surface ocean pH in 2004

7.85 Forecast surface ocean pH in 2100

Be more afraid, young clownfish

In acidifying oceans, fish are oblivious to alarming sounds

By Susan Milius

Greenhouse gases dissolving in the world's oceans may disrupt young fishes' natural reluctance to swim toward scary noises.

When raised in water mimicking the predicted acidifying chemistry of future oceans, juvenile clownfish appeared perfectly willing to swim toward a speaker broadcasting the recorded daytime sounds of a reef teeming with predators, says fish ecologist Steve Simpson of the University of Bristol in England. "When you're a centimeter long as a fish, anything is a predator," he says.

Juvenile orange clownfish (*Amphiprion percula*) looking for a home on the reef normally spend minimal time near such noises, Simpson explains. Yet youngsters raised in water with conditions predicted for midcentury oceans spent at least half their time in the alarming-noise end of an aquarium, Simpson and his colleagues report online June 1 in *Biology Letters*.

Orange clownfish raised in acidified water ignored the sounds of a reef full of predators.

Since the beginning of the Industrial Revolution, roughly 142 billion tons of human-made carbon dioxide has dissolved into the world's oceans, Simpson says. Adding the gas to seawater creates carbonic acid and is nudging water closer to the acidic end of the pH scale at the fastest pace in 650,000 years.

Just what's causing the fishy nonchalance is the next question, and it's a big one. In this experiment, "there is no way to know if the lack of response is related to not hearing, changes in hearing capabilities or anything else about the physiology of the animal," says Arthur Popper of the University of Maryland in College Park, who has studied fish hearing.

Marine biogeochemist Justin Ries of the University of North Carolina at Chapel Hill notes that more acidic water has been shown to affect calcium structures and thus might render fishes' ear bones less dense.

Simpson and coauthor Philip Munday of James Cook University in Townsville, Australia, have not checked bone density but doubt that the fish went deaf. The researchers didn't find abnormally shaped or sized ear bones in clownfish in the study.

Previous work has shown that fish exposed to conditions predicted for future oceans display other odd behaviors, such as lack of interest in normally attractive odors and extra boldness in leaving hideouts. So the researchers speculate that there may be something more fundamental going wrong that's causing fish to drop their guard.

Corals that stay cool beat the heat

Species that overreact to loss of algae are more likely to die

By Tina Hesman Saey

Some corals seem to have a suicide pact with the symbiotic algae living inside them. But others are able to survive the demise of their photosynthetic friends, and now scientists think a suicide protein may explain the difference between the two groups.

When waters warm, some corals overreact to distress signals sent by resident algae, researchers report online June 2 in the *Proceedings of the National Academy of Sciences*. The overreactors ramp up production of an executioner protein called caspase and eventually commit cellular suicide. Corals that are able to survive warming start out with high levels of caspase but then quickly decrease the amount of the protein, the researchers found.

The study "adds critical data to help figure out how coral bleaching happens," says Stephen Palumbi, a marine population biologist at Stanford University who was not involved in the research. Corals bleach when their algae become stressed by warming water, pollution or other factors and then leave, die or get eaten.

In the new study, a type of coral from the Red Sea called *Seriatopora hystrix* (also known as bird's nest or needle coral) bleached but stayed alive for six weeks in water that was warmed by 6 degrees Celsius, researchers led by Paul Falkowski of Rutgers University and Dan Tchernov of the University of Haifa in Israel found. In contrast, another Red Sea coral called *Stylophora pistillata* had a meltdown and died after only a week in the heat. Levels of caspase protein made by the dying coral shot up to six times normal levels, while levels of the protein dropped in the heat-resistant coral.

Using two other wilting coral species, the researchers found that adding a chemical that inhibits caspase activity could stop the corals from committing suicide.

"Potentially, a single gene might control the fate of a coral," Falkowski says. The coral's survival depends upon whether its cells initiate a self-destruct program in response to its algae's stress signals. Species that can stand the heat will probably be those that populate coral reefs in the future. "We'll certainly lose the rest in the short term," Falkowski says, "and lose them in abundance."

MATTHEW WITTENRICH

Molecules

"Sometimes a negative result can be very positive." —PAVEL JUNGWIRTH

Water-air interface is barely there

Interactions at thin surface layer have no impact down below

By Rachel Ehrenberg

Where sea meets sky, there are lots of water molecules with an identity crisis. About a quarter of the H_2O in water's uppermost layer can't decide whether to be liquid or gas: One hydrogen atom stays in the drink while the other pokes up, vibrating in the air.

This layer of molecular ambiguity is extremely thin and has little or no effect on the water below it, new data reported June 9 in *Nature* show. Right beneath the liquid's surface, water molecules go about their business as if the air weren't there.

That may seem like a dull discovery, but the find is important, says Pavel Jungwirth of the Academy of Sciences of the Czech Republic in Prague, who wrote a commentary on the work in the same issue of *Nature*.

"In some ways this is a negative result," Jungwirth says. "Sometimes a negative result can be very positive."

Insights into the behavior of water molecules at this superthin layer may give scientists a better understanding of the bonding and behavior of pollutants or other compounds intermingling at the surface. The new data might also improve models of water's interactions with the atmosphere and within cells, says physical chemist Dennis Hore of the University of Victoria in British Columbia.

The fact that water molecules with one hydrogen waving in the air have little effect on the arrangement of all the H_2O below refutes an idea that's been bandied about for ages — that water molecules deeper down will fall into lockstep, organizing themselves into orderly layers, says Jungwirth.

"After the first layer, it's all over," he says. "A lot of people still subscribe to this long-range idea. But this shows very clearly that you don't have long-range order in water."

Despite covering roughly 70 percent of Earth's surface and constituting about 60 percent of the human body, water still puzzles scientists. For example, according to water's structural properties, it shouldn't be liquid, but rather gas, at everyday temperatures and pressures.

"Water may be the most common substance on Earth. But from a physics standpoint, it is pretty unusual," says study coauthor Alexander Benderskii of the University of Southern California in Los Angeles.

Life

"We showed that the spider was quite happy for more than a day." —ROGER SEYMOUR

Aquatic spiders make bubbles for breathing

Swimming arachnids can extract oxygen from water

By Daniel Strain

In Germany's Eider River, spiders not only swim with the fishes, they kind of breathe like them, too.

Eurasian diving bell spiders (*Argyroneta aquatica*) survive entirely underwater by living in large air bubbles, which the crawlers trap in silken webs. A new study shows that these bubbles work like a "physical gill," drawing oxygen in from the water to match much of the spider's consumption. Researchers from Australia and Germany report their findings in the July 1 *Journal of Experimental Biology*.

For insects, physical gills are nothing new. Certain small bugs bob and dive into streams and rivers with the help of plastrons, trapped films of air that coat their bodies. As the bugs consume this trapped oxygen, gas diffuses in from the surrounding water, replenishing the supply, says Morris Flynn, a mechanical engineer at the University of Alberta in Canada. In contrast, diving bell spiders seem to actively replenish their air bubble — called a diving bell after the antique submarines — by frequently traveling to the surface to grab more air. They trap a bubble between their back legs and abdomens, later adding it to the bell. This keeps the diving bell from collapsing.

The oxygen coming into the bell may, at times, match a resting spider's consumption.

But scientists didn't know if the spiders' diving bells, which the crawlers can leave behind while they go grab food or find a mate, were anything more than scuba tanks, holding a one-time supply of air.

It turns out that, like plastrons, the diving bells behave like gills too, Roger Seymour of the University of Adelaide in Australia and Stefan Hetz from Humboldt University of Berlin discovered. At least five times the original supply of oxygen can diffuse into an occupied bell between replenishment trips, Seymour says. Using tiny oxygen probes, the team discovered that the oxygen coming into the bell may, at times, match a resting spider's consumption. By estimating the oxygen needs of a spider resting in an average-sized bell, "we showed that the spider was quite happy for more than a day," says Seymour. In fact, the bells' endurance seems to be largely limited by nitrogen rather than oxygen, he adds. Nitrogen gas slowly leaks out of the bubbles like air from a balloon, leading to collapse.

Diving spiders may have to visit the surface more than daily, however, since they do more than rest. In this study, the team observed that before dining on insects captured in underwater webs — an energy-intensive feat — spiders paddled to the surface to squirrel away more air.

The diving bell's gill-like properties do, nevertheless, mean that spiders can stay safely in their bubbles for longer. The open water is a dangerous place filled with predatory fish and insects, which are generally better swimmers than the spider, says Michael Taborsky, a behavioral ecologist at the University of Bern in Switzerland. "When they have to go to the surface to replenish their oxygen preserves," Taborsky says, "this is the dangerous side."

Diving bells may have their limitations, but insect plastrons could inspire submersible designs, Flynn says. Some researchers have already proposed contouring small underwater crafts so that their fuel cells collect similar pockets of air, providing the machines with a continuous supply of oxygen. ■

Eurasian diving bell spiders can breathe underwater by sticking to air bubbles trapped in their webs.

S. HETZ, ADAPTED WITH PERMISSION FROM *J. OF EXPERIMENTAL BIO.*

3.6 kilometers | Maximum depth of nematode DNA detected

1.3 kilometers | Deepest worm found in South African mine

450 meters | Previous depth record for complex life

Alive and well, deeper underground than any other life has gone before

Worms in South African mines extend limits of habitability

By Alexandra Witze

Tiny worms appear to live in rock fractures up to 3.6 kilometers underground, researchers have reported, far deeper than anyone has encountered complex organisms before. The discovery of nematode worms in three South African gold mines underscores the fact that Earth's biosphere reaches well into subterranean realms. It also suggests that habitable environments may exist buried way down on other planets, such as Mars.

Worm specialist Gaetan Borgonie and his colleagues present their findings, which include a new nematode species named after Faust's devil Mephistopheles, in the June 2 *Nature*. Nematodes are an incredibly diverse group encompassing numerous intestinal parasites and the widely studied laboratory roundworm *C. elegans*.

Over the last few decades, researchers have found plenty of bacteria and other single-celled creatures thriving deep underground. But "to actually go out and start looking for multicellular organisms is such a game changer. Nobody in their right mind would think they were down there," says team member Tullis Onstott, a geomicrobiologist at Princeton University.

But Borgonie, of the University of Ghent in Belgium, thought there just might be enough food, water, oxygen and other nematode necessities to keep worms alive deep in Hades' realm. So he traveled to South Africa to collect water and soil samples from six boreholes.

In the deepest, 3.6 kilometers down at the Tau Tona gold mine, Borgonie found traces of nematode DNA in water oozing from rock fractures. Much shallower, 900 meters down the Driefontein gold mine, he found actual nematodes of two known surface species. And at the middle depths, 1.3 kilometers down in the Beatrix gold mine, he uncovered an odd-looking, living female nematode.

G. BORGONIE/UNIV. OF GHENT

The discovery of the worm *Halicephalobus mephisto* 1.3 kilometers deep in a South African mine suggests that complex life can thrive deeper in the Earth than scientists had suspected.

Back in the laboratory, Borgonie laid that worm under a microscope. "It was like an intensive care unit — I was looking at it every hour," he says. "The only thing I wanted it to do was lay an egg."

It did. Eight of them. Borgonie had the start of a worm dynasty. About half a millimeter long, the nematodes are different enough from other species to warrant their own name: *Halicephalobus mephisto*.

To make sure the worms weren't accidentally brought down by mine workers, the researchers ran a series of painstaking tests. The studies showed that the water in which the nematodes live is at least several thousand years old.

Before that, Borgonie says, ancestors of the newly found worms probably lived on the surface. Over generations they presumably slithered down, munching bacteria along the way.

"If it can work its way through the fractures and keep on picking up goodies, it doesn't really care about how deep it is," says Onstott. "Given enough time, these organisms will get there."

Nematodes can live with hardly any oxygen; the limiting factor to their survival in the deep is probably the high temperatures found there, Borgonie says. In lab cultures *H. mephisto* survived temperatures up to 41° Celsius.

But R. John Parkes, a deep-biosphere expert at Cardiff University in Wales, questions whether drilling boreholes for the mines altered the subsurface environment somehow, perhaps by introducing more oxygen or otherwise providing an artificial environment in which nematodes could thrive.

In a few months Borgonie will return to South Africa to hunt for new nematodes in mine water that he has been collecting and filtering for two years — far longer than the 24-hour samples he reports on in the new study.

Karsten Pedersen, a microbiologist at the University of Gothenburg in Sweden, says he is convinced by the hard work the team did to rule out the possibility of surface contamination. Pedersen has found yeast up to 450 meters deep in Swedish granite, the previous record holder for complex subterranean life, but hasn't yet looked for nematodes there. More research is needed, he says, to confirm whether the South African deep worms are a rarity or the rule. ■

Body & Brain

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

A year adds up to big brain changes

Third grade a turning point in how kids solve math problems

By Laura Sanders

Neuroscientists have confirmed what any kid knows: Third grade changes everything. Compared with kids just out of second grade, recent third-grade graduates use their brains in an entirely different way when solving math problems, a study in an upcoming *NeuroImage* finds.

"I think this is really fascinating," says cognitive neuroscientist Daniel Ansari of the University of Western Ontario in London, Canada. "Anybody who doesn't believe that development is important needs to read this paper, because it really shows how dynamically the brain changes as we learn."

Cognitive neuroscientist Vinod Menon of the Stanford University School of Medicine and his colleagues recruited 90 children, ages 7 to 9, who had just completed either second or third grade.

The youngsters calculated easy (3 + 1 = 4) or more complex (8 + 5 = 13) addition problems while Menon and his team scanned the children's brains using functional MRI.

Overall, second-graders' brains tackled the easy and hard problems about the same way. But third-graders' brains responded very differently to the easy and the hard questions.

> "School changes your brain, but what do we do with that?"
>
> DANIEL ANSARI

Third-graders showed heightened activity in a brain region important for working memory, which keeps relevant info handy. Studies of older children have found that this region, the left dorsolateral prefrontal cortex, grows less active with age while doing math, so the new results may reflect an age-specific approach to math that later gives way to something else, the authors suggest.

Connections between the dorsolateral prefrontal region and regions in the back of the brain, some of which are involved in vision, were also stronger in the third-graders as they crunched numbers, the team found.

It's not clear whether math classes caused the differences. Normal development may cause some of the changes, but training and skill acquisition probably play a role, too, says developmental psychologist Ann Dowker of the University of Oxford in England.

Ansari says that researchers need to figure out what these changes in the brain actually mean. "School changes your brain, but what do we do with that?" he says. "That's the next big question." So far, scientists don't know whether the changes correlate with stronger math performance, particular kinds of math training or how good a child will be at math in the future.

Breast cancer drug passes test

Exemestane may be used for prevention in healthy women

By Nathan Seppa

A drug that inhibits the manufacture of estrogen can lower the likelihood of breast cancer among healthy women whom doctors consider at risk of developing the disease. The drug, called exemestane, may offer a preventive approach to combating the malignancy, researchers reported June 4 at a cancer meeting in Chicago and online in the *New England Journal of Medicine*.

Two drugs, tamoxifen and raloxifene, have previously been shown to lessen breast cancer risk when taken as preventives. Those drugs hamper the pro-growth effects of the hormone estrogen, which is implicated in most breast cancers. But while tamoxifen is commonly used as a treatment for breast cancer, few cancer-free women take it as a preventive even if they are deemed at risk.

Exemestane, a different kind of drug called an aromatase inhibitor, lessens the amount of estrogen made in the body.

In the new study, scientists enrolled 4,560 postmenopausal women at risk of breast cancer because of age, abnormal breast-cell growth or other factors. The researchers randomly assigned roughly half to get exemestane and half a placebo pill. After a median follow-up of 35 months, 11 invasive breast cancers had appeared in the exemestane group compared with 32 among the placebo recipients. Invasive breast cancer is dangerous because it spreads within the breast and is prone to jumping to nearby lymph nodes or to other organs.

The results suggest that taking an aromatase inhibitor such as exemestane reduces a woman's risk of developing invasive breast cancer by 65 percent, says study coauthor Paul Goss, a physician at Harvard Medical School in Boston.

While that rate indicates a substantial lessening of risk, the absolute annual incidence of breast cancers in each group was less than 1 percent. Hot flashes, sweating, fatigue and insomnia were slightly more common among women on exemestane, but women in both groups rated their overall quality of life similarly.

The findings "support the use of exemestane as an option for risk reduction in postmenopausal women at high risk for breast cancer," say Nancy Davidson and Thomas Kensler of the University of Pittsburgh, writing in a *New England Journal of Medicine* editorial. Exemestane is marketed as Aromasin by its maker Pfizer, which funded the study.

No More Mr. Nice Watch

Forget sleek and subtle, the Stauer Colossus Hybrid is one tough timepiece.

Never underestimate your competition. Just ask Demetrius, the unfortunate Greek general who set out to conquer Rhodes in 305 BC. He assumed that a massive force of 40,000 men, a fleet of Aegean pirates and an arsenal of wall-smashing war machines would be enough to crush the tiny Greek island. He was wrong. The Rhodians were tougher than he thought. And so is this watch. If you've always believed that the biggest, baddest watches had to cost big, bad money, the $79 Stauer ***Colossus Hybrid Chronograph*** is here to change your mind.

A monument to toughness. The people of Rhodes were ready for Demetrius and repelled his attack. To celebrate, they built the Colossus of Rhodes, a 107-foot bronze and iron giant that towered over the harbor like a ten-story trophy. It warned future invaders that "Rhodes is tougher than you think." You give the same message when you wear the Stauer ***Colossus***.

The timepiece that works twice as hard. In designing the ***Colossus Hybrid Chronograph***, our instructions to the watchmaker were clear: build it as tough as a battleship and fill it full of surprises. Make it a hybrid, because it should work twice as hard as a regular watch. And make it look like a million bucks, because when you put it on, you should get excited about rolling up your sleeves. Mission accomplished.

A toolbox on your wrist. It will keep you on schedule, but the ***Colossus Hybrid*** is about much more than time. The imposing case features a rotating gunmetal bezel that frames the silver, black and yellow face. You'll find a battalion of digital displays on the dial arranged behind a pair of luminescent hands and a bold yellow second hand. Powered by a precise quartz movement, the watch is doubly accurate in analog and digital mode. And it's packed with plenty of handy extras including a bright green EL back-light for enhanced nighttime visibility, a tachymeter along the outer dial and a full complement of alarms and split-second countdown timers. The ***Colossus Hybrid*** secures with a folded steel bracelet that highlights a row of striking dark center links. It's a rugged watch that's more than ready for your daily grind.

Your Satisfaction is Guaranteed. Wear the Stauer ***Colossus Hybrid*** for 30 days and if you are not 100% thrilled with your purchase, return it for a full refund of your purchase price. But once you get a taste of more watch for less money, it's likely you'll be back for more... and we'll be waiting.

WATCH SPECS: -Easy-to-read analog/digital modes -Back-lighting & luminescent hands - Tachymeter, countdown timers & alarms - Folded stainless steel bracelet fits a 6 3/4"–8 1/2" wrist

A Stauer Exclusive

Colossus Hybrid Digital/Analog Watch—~~$395~~

***Now* $79** +S&P *Save $316*

Call now to take advantage of this limited offer.

1-888-277-8380

Promotional Code CHW134-01
Please mention this code when you call.

ACCREDITED BUSINESS **Stauer has a Better Business Bureau Rating of A+**

Stauer®

14101 Southcross Drive W., Dept. CHW134-01
Burnsville, Minnesota 55337

Stauer.com

Smart Luxuries—Surprising Prices

Evolution's wedges

Finding the genes that drive one species into two

By Daniel Strain

Look to Texas to see evolution's true colors. There, speckling the state's green fields, you'll find the annual phlox, a flower also known as "Texas pride." Its petals, a light purple elsewhere, are bright scarlet in the southeast near Austin. This color change isn't a whim: It's the annual phlox's response to the presence of a close cousin, the pointed phlox. Native to East Texas, the pointed phlox also has purplish flowers.

Just two genes orchestrate the annual phlox's shift from purple to red flowers in the fields where it meets its cousin. But this color change has a big impact. Like prudish governesses, the genes keep the annual species from mating with the pointed relative, because butterfly pollinators rarely swap pollen between red and purple flowers. Such governesses are an example of what many biologists call speciation genes: genes that impede mating between related organisms, potentially keeping two nascent species apart or splitting one species into two.

Though biologists have known that studying such genes could help reveal how species come to be, only recently have individual candidates been uncovered. New techniques in genetic sequencing have made the search for these evolutionary wedges much easier, says Patrik Nosil, an evolutionary biologist at the University of Colorado at Boulder.

"Evolutionary biology is in a mini — I don't want to use 'revolution' because I'm not sure if what we'll find will be any different from what we already knew," Nosil says. "There's a lot of excitement and change right now because we're able to generate much more data."

R.D.H. BARRETT *ET AL./SCIENCE* 2008

A gene known as *eda* helps determine how much armor a three-spined stickleback has (bony plates stained red at midsections). Armor changes, in turn, may split one species into two.

While high school biology courses may emphasize the role of geographic barriers — big mountains and wide rivers — in driving would-be species apart, some scientists are more interested in the genetic story behind such divisions. During any one evolutionary split, several, or maybe even hundreds, of genes can contribute a tiny push.

Researchers are now focusing in on a handful of promising speciation heavyweights, with more expected over the next few years. While the phlox color genes act directly to keep the annual and pointed versions distinct, most newly found candidate speciation genes have arisen as by-products of evolutionary pressures not related to mating at all. Genetic tweaks inspired by environmental shifts, for example, may be cleaving apart species as diverse as stickleback fish and monkeyflowers. And a newly identified fruit fly gene demonstrates that competition among genes themselves, not just environmental changes, can drive one species into two.

The search for speciation genes isn't just an evolutionary scavenger hunt. Discovering such genes brings scientists closer to solving a biological mystery, says Nosil: "How easy is it to create a new species?"

Governesses on duty

As is the case with the phloxes, appearance doesn't always distinguish one species from another. Deciding what makes a species distinct from its evolutionary neighbors can get fuzzy, and there are about as many different definitions as there are biological disciplines. An old and often cited explanation comes down to sex. In true Romeo-and-Juliet style, members of separate species don't mate, at least not successfully.

When the annual and pointed phlox do manage to interbreed, their hybrid children rarely produce mature seeds. Because of this reproductive dead end, individuals extra wary of interbreeding should flourish over others that are less discriminatory. "If a new mutant stops them from hybridizing, that's favored," says Robin Hopkins, an evolutionary biologist at Duke University.

Previous work showed that the purple-to-red change slows mating between the two species by up to two-thirds. Hopkins and Duke's Mark Rausher discovered that several enzymes are behind that shift. Breeding and genetic experiments revealed that those enzymes are produced under the watch of two genes. The researchers identified the enzyme culprits in January in *Nature* but still have to locate the specific genes.

Wherever they are, the two genes don't seem to make the phlox smell sweeter or better catch the eye of passing butterflies. The yet-to-be-identified governess genes do one and only one thing, Hopkins says: stop sex between the two species. As far as speciation genes go, few examples put their stamp so directly on mating.

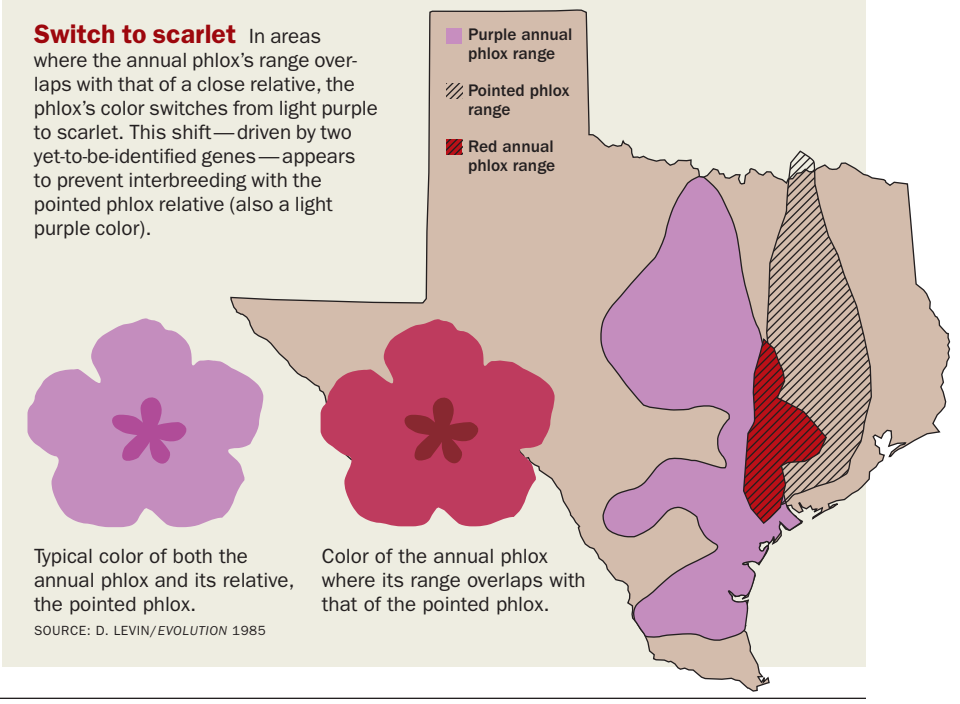
Most new species are, instead, accidental monsters. The genes that give rise to these creatures come about through mundane evolution — such as improvements to cellular machinery or antipredator defenses — that impacts mating only through twists of fate. Successful reproduction is a very important thing for organisms, so why evolution would tolerate two populations of would-be parents that can't interbreed has been hotly debated among biologists.

"Every single piece of machinery that is necessary to keep you fertile and alive already exists," says evolutionary geneticist Nitin Phadnis of the Fred Hutchinson Cancer Research Center in Seattle. "So the big question is why something functioning perfectly well changes through evolutionary time."

The speciation flood

For Dolph Schluter, the answer begins with a flood. Around 10,000 to 20,000 years ago, receding glaciers doused the Pacific Northwest with meltwater, forming a spiderweb of new streams and lakes. Animals rushed in to take advantage of these new habitats. Most important, from the point of view of Schluter and other evolutionary biologists, was the appearance of a silver fish, usually no longer than a credit card, called the three-spined stickleback (*Gasterosteus aculeatus*).

Though not separate species, the sticklebacks living in streams today and those still living in the ocean are two very different beasts with varied behaviors

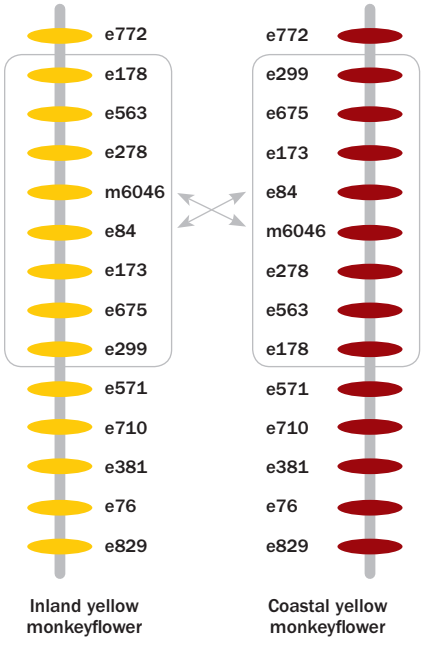


MAP: GEOATLAS/GRAPHI-OGRE, GRAPHIC: JANEL KILEY

and appearances. In the lab, marine and freshwater fish can knock boots and, hence, the populations can exchange genetic information. But in nature, the two groups may have trouble mating.

If a stickleback from a stream wanders back into the big ocean, it will very much be a fish out of water. If this unlucky immigrant can't dodge attacks by predatory fish or compete for food with the locals, then it may die before getting the chance to breed with a native. So, even if its newly acquired traits don't touch mating directly, they could prevent sex indirectly. Over time, a lack of mixing between the populations might allow more differences to build up, making it so that the fish couldn't mate even if they got the chance.

Flower flip Some of the differences between two populations of yellow monkeyflower are driven by genes that sit on an area of a chromosome that has been flipped (below). Such flips, called inversions, may help keep the two populations different.



As long as genes for stream living slow interbreeding, "then the genes for speciation and the genes for adaptation are one and the same," says Schluter, of the University of British Columbia in Vancouver.

One promising candidate for an adaptation-turned-speciation gene is called ectodysplasin or *eda*. It's one of a handful of genes that give rise to the stickleback's extravagant armor. Ocean fish are covered in an array of plates and spines, looking something like swimming knights. Stream fish, which have a different *eda* version, are much smoother.

"Most freshwater populations are low-plated, and in every one of those low-plated populations that have been investigated so far, *eda* is partly or largely responsible," Schluter says.

The success of the smooth gene variant seems to stem, in part, from the edge it gives stream fish against a new breed of predator. Young fish with less armor were more likely to survive to adulthood in artificial ponds stocked with insect diners, Kerry Marchinko, a colleague of Schluter's, reported in 2009 in *Evolution*. Sticklebacks with less protection seem to grow faster, quickly becoming too big for stream-dwelling bugs to catch.

But discovering whether *eda* alone could affect survival enough to slow interbreeding and drive the creation of a new species would require further, expensive experiments, Schluter says. Without that data, *eda*'s status as a speciation gene remains as slippery as a freshwater stickleback.

Not too far from the stickleback's cozy streams, a little yellow flower illustrates how changes that go beyond individual genes can ensure that two populations on the verge of speciation remain different.

Like sticklebacks in separate locales, populations of yellow monkeyflowers (*Mimulus guttatus*) living along the Pacific Coast are physically different from members of the same species dwelling east into central California and Oregon. At the most basic level, coastal monkeyflowers are robust and live for multiple years, whereas inland monkeyflowers are spindly and live for just one.

About 20 to 30 percent of the differences between the two populations arise from genes sitting within a single region of one chromosome, evolutionary geneticists John Willis of Duke and David Lowry, now at the University of Texas at Austin, reported in 2010 in *PLoS Biology*. But this region isn't an ordinary genetic plot of land: It's what's called an inversion. At some point in the past, this chromosome chunk did a flip in one of the two populations, landing with the side that used to be up pointing down.

"One orientation of inversion is better in places that have year-round soil moisture and the other form is better in places that dry out during summertime," Lowry says.

Inversions, like the spines of ocean sticklebacks, are good armor. Chromosomal flips keep the genes inside from getting traded to different chromosomes when organisms mate — important security since, like a good sports team, some combinations of players work best together. In the monkeyflower, for instance, genes that aid survival in inland soils probably pair well with genes underlying the live-fast-die-young lifestyle.

Inversions may function as evolutionary closers. Inland genes stay inside inland plants and coastal genes in coastal plants, so future progeny will be more likely to resemble one population or the other but not resemble a mix.

Lowry thinks more data may reveal that similar flips are big players in the splitting of a range of plant and animal species: "We're entering an era where we're going to see more inversions, and their importance is going to be clear."

Though it's not yet known whether monkeyflowers and stickleback species will fully split, in both cases differences have to do with the habitats the species call home. But not every speciation event starts in the wild. Some begin in an environment of a completely different nature.

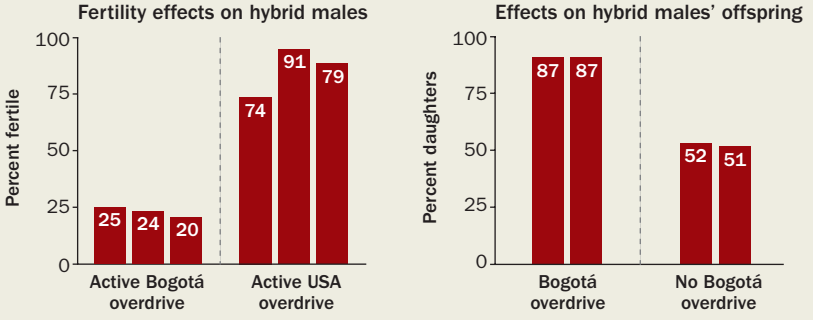
Selfish evolution

"Genes in the genome are chasing moving targets in the environment," says Daven Presgraves, an evolutionary geneticist at the University of Rochester in New York. "The other part of the environment that

WSIEGMUND/WIKIMEDIA COMMONS; D.B. LOWRY AND J.H. WILLIS/*PLOS BIOLOGY* 2010, ADAPTED BY JANEL KILEY

Overdrive's two strikes

A gene known as overdrive is found in both USA and Bogotá fruit fly populations. Hybrid fruit fly males carrying an unrestrained copy of the Bogotá version (three populations shown) have much lower fertility than those in which the USA version has been genetically added. In a separate experiment, Bogotá overdrive–carrying males that did manage to mate (two populations shown) sired mostly daughters.



SOURCE: N. PHADNIS AND H.A. ORR/*SCIENCE* 2009

is starting to emerge is, it could be other genes in the genome." In other words, it's a jungle out there, but it's an equally scary jungle in there, too — in the cell, that is.

This internal warfare remained largely hidden from scientists until the 1980s, when theorists began to wonder whether individual genes could be as selfish as individual organisms. Since animals usually carry two copies of most chromosomes, the average maternal or paternal version of each gene gets passed down to only half of a creature's progeny. Selfish genes, on the other hand, are downright Machiavellian, maneuvering themselves into as many offspring as possible. "These sort of cheaters place themselves far more than 50 percent in the next generation and, therefore, get a huge evolutionary advantage," Phadnis says.

In a cheating genetic world, individual genes continually try to outcompete one another, much like predator and prey, by exploiting helpful mutations. Recently, researchers showed that genetic selfishness could actually disrupt breeding and possibly spur speciation.

A few years ago, Phadnis, then a graduate student at the University of Rochester, and his adviser Allen Orr identified what may be the best characterized selfish speciation gene candidate. The gene, which the team dubbed "overdrive," sits on the X chromosome in two populations of the fruit fly *Drosophila pseudoobscura*.

At first overdrive looks harmless enough. When two fruit flies from North or Central America, the "USA group," mate, the offspring come out normal. Same for mating among fruit flies in Colombia, the "Bogotá group."

When Bogotá females breed with USA males in the lab, though, their sons are almost entirely sterile, the team reported in *Science* in 2009. Genetic engineering experiments revealed that the culprit behind this sterility was the version of overdrive in the Bogotá group. Lucky for the offspring of Bogotá-only matings, these South American fruit flies have evolved one or more genes that switch overdrive off. Hybrids, however, get a mix of genes that can't always quash overdrive, allowing the gene to run wild.

This sterility-causing overdrive didn't rise to prominence in the South American flies because it gives them an edge in their environment. Instead, the gene version likely spread because it's a dirty cheater.

Phadnis and his colleagues first got a whiff of overdrive's selfish nature from a rare observation. Sometimes, hybrids that would typically be sterile do manage to reproduce. But when they do, they sire mostly daughters. With a little lab testing, the team confirmed that, when unchained, the Bogotá overdrive appears to ensure its spot in the next generation by somehow forcing through the X chromosome it sits on. In fact, the genes that turn overdrive off probably evolved to stop its cheating ways.

Overdrive isn't the only such nefarious gene. Yun Tao and his colleagues at Emory University in Atlanta, for instance, are narrowing in on a similar daughter-biased gene that causes sterility when the close cousins *Drosophila simulans* and *Drosophila mauritiana* interbreed. The researchers haven't homed in on the exact cheater yet, but they are vetting a candidate for the off switch, a gene they are calling "too much yin."

These discoveries entail an entirely new outlook on evolution, Presgraves says. "Now, we're in this world where we're not looking around the globe so much anymore. You're looking at genomes," he says. "And what you're finding is this dizzying diversity of selfish things."

In the end, tugs from both inside and out may give rise to complementary sets of speciation genes, Schluter says. "Once we have them all before us, we'll understand the whole picture much better." While patterns will probably emerge, each organism may follow its own path to speciation — so answers to how easy it is to create a species could be as diverse as the planet's living communities themselves.

Still, Tao thinks he could learn a lot by following one path to a brand-new kind of animal. He would start by engineering a cheater gene such as overdrive into an unsuspecting species of fruit fly, the iconic *Drosophila melanogaster,* perhaps. As the fly's genome struggled to combat the daughter-biased gene, it would evolve. In essence, Tao would then get the opportunity to watch speciation and the varied genetic changes that accompany it unfold before his eyes.

"Can we drive the species to a new species within a couple of years?" Tao asks. "That would be a wonderful experiment." ■

Explore more

- P. Nosil and D. Schluter. "The genes underlying the process of speciation." *Trends in Ecology & Evolution*. April 2011.

JANEL KILEY

Death of a Continent, Birth of an Ocean

Africa's Afar region gives glimpses of geology in action

By Alexandra Witze

To those who live there, east Africa's Afar region is "the place the devil plows." One of the hottest and lowest areas on Earth, it is a landscape of baking desert and barren lava flows. To scientists, though, Afar means something more promising: geology in the raw.

There, on the edge of Africa, the continent is splitting apart. Pulled inexorably by the grind of tectonic plates, Afar is ripping asunder like a gateway to hell. Molten rock wells up from below, pouring onto the sweltering surface.

Yet for all the fire and brimstone, Afar is on its way to a watery end. A million years or so from now, the geological processes that rip the continent will give birth to a new seafloor. And Afar will lie at the bottom of Earth's freshest ocean.

Until then, researchers have a front seat to an unparalleled physical spectacle. "It's a really unique opportunity to understand how continents break apart," says Tim Wright, a remote-sensing expert at the University of Leeds in England. Wright leads a large international consortium that began studying the region in 2005, when the splitting picked up pace.

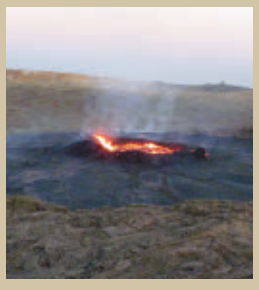
Afar's geological violence comes in many forms. Magma welling up from the depths sometimes erupts through existing volcanoes. Other times it pools

JULIE ROWLAND/UNIV. OF AUCKLAND

underground, cooling to form giant vertical sheets called dikes. As it rises, the moving magma causes the ground to tremble in an earthquake drumroll. For the past couple of years scientists have listened to the landscape's clamor, trying to discover what Afar has to say about the death of continents.

New findings reveal that the dikes stack up against each other — fresh ones pushing their way into places where the rock is least stressed, crackling with seismicity as the magma arrives. Other discoveries include the first-ever glimpse at how magma flows from storage reservoirs into such dikes along an intricate system of volcanic plumbing. For the first time, researchers have seen some of the planet's most common geologic activity transpire nearly in real time, and on land where they can watch.

To its list of superlatives — hottest, lowest, least hospitable — Afar can now add the title of best-studied birth of an ocean.



Tension on land Afar (shaded) sits where the East African Rift and two ocean-splitting centers meet, meaning the region is being pulled in many directions. Intense geologic activity results: In 2005, researchers detected a flurry of earthquakes and upwelling magma along the Dabbahu rift segment. Lava flows were also observed at the Erta Ale volcano (shown above) in 2010.

A violent story

A single earthquake, of magnitude 4.5, first alerted scientists to the tale unfolding in Afar. At Addis Ababa University in Ethiopia, in September 2005, seismologist Atalay Ayele saw the sign of an Afar quake pop up on his monitors. Then more quakes appeared, bigger ones, and then yet more. Something unusual, he realized, was going on.

"It was a surprise," Ayele says. "We didn't know at the beginning how big it was going to be. We just recorded all the quakes as we normally do."

Ayele called Cynthia Ebinger, a geophysicist then at Royal Holloway College at the University of London, who arrived within days with extra seismometers to monitor the quaking ground. Ebinger in turn asked Wright to check for satellite imagery that, by bouncing radar waves off the ground and measuring their return, can reveal how much the ground is shifting, and where. If a big eruption were going on just under the surface, she reasoned, the satellites should have captured it.

"I kept bugging him and bugging him," remembers Ebinger, now at the University of Rochester in New York. And then one day Wright called with striking news.

Because the Afar quakes hadn't gotten much bigger than magnitude 5.5, Wright says, "we didn't expect to see very much. But when we downloaded the data what we saw was astounding — the biggest signal we'd ever seen in terms of ground deformation. At that point it was immediately clear that something really unusual had happened."

Whereas the ground might move a few centimeters during most volcanic eruptions or earthquakes, places in Afar had moved eight meters in just 10 days, a world record. By the time Ayele and colleagues arrived in the region to check what had happened, fresh fissures and steep cliff faces yawned across the landscape, created by the massively shifting ground. Brand-new lava glistened in the desert sun.

All this geological action traces to the fact that Afar sits at the intersection of three segments of Earth's crust that are pulling apart, or rifting.

Like pieces in a moving jigsaw puzzle, the planet's tectonic plates constantly elbow against one another, carrying continents great distances and allowing new oceans to be born and die. In large part, this plate jostling is driven by fresh magma that wells up from seams that run along the centers of oceans, like the underwater mountain chain that splits the Atlantic Ocean in two. Molten rock erupts onto the seafloor there, then cools and rifts away from the ridge on either side in a process known as seafloor spreading. Geologists can take a peek at this in Iceland, where the Atlantic's mid-ocean ridge surfaces above the waves.

Plate tectonics can also pull continents apart. Instead of magma cleanly forming fresh ocean crust, continental rifts often have a wide, messy zone where parallel valleys form, accompanied by spasms of eruptions and earthquakes. Such is the case with the Great Rift Valley that runs down eastern Africa on dry land.

In Afar, that continental rift meets two ocean rifts, one bisecting the Red Sea and the other the Gulf of Aden. This tectonic "triple junction," pulling at Afar from all directions, is the geologic equivalent of being drawn and quartered.

In eastern Africa, the current transition between continental and oceanic

As Afar is pulled and jostled from below, fissures form across the landscape. Some areas are already below sea level.

IMAGE: LORRAINE FIELD/UNIV. OF BRISTOL; MAP: GRAPHI-OGRE, ADAPTED BY E. FELICIANO

rift lies somewhere between Afar and the southern end of the Red Sea. As eastern Africa keeps stretching, though, its continental crust gets thinner and thinner. "Once there's no continental plate left, once it's completely thinned and gone, then that's the end of continental breakup," says Derek Keir, a former student of Ebinger now at the National Oceanography Centre in Southampton, England.

At that point, Afar will become a true seafloor spreading ridge. Magma welling up from below will be richer in heavy elements like iron, so that the newborn crust will be denser and sink lower in elevation compared with the rest of the African continent. Waters from the Red Sea will rush in, forming a new ocean.

Geologists have known the end is coming for Afar, and they got a preview beginning in 1978, in a part of the rift zone located in Djibouti. There, a small earthquake swarm popped up as magma intruded underground to form a dike. French scientists, who had seismometers and other ground-measuring instruments installed across Djibouti, watched the whole thing happen. "It really helped us understand the processes involved with rifting," says Cécile Doubre, a tectonophysicist at the Institut de Physique du Globe in Strasbourg.

The main Afar show, though, began in 2005. Geologists knew something was coming, and to some extent they knew pretty much what to expect. The next time magma welled up into the rift zone, Keir had predicted in his doctoral thesis, it would appear below a particular 60-kilometer-long segment of the rift zone with a volcano called Dabbahu at its northern end. But the sheer size of the September 2005 eruption astonished researchers. Over just a couple of days, some 2.5 cubic kilometers of molten rock squirted toward the surface.

Much of this magma had been lurking beneath the region for some time, Wright explains. The magma begins some 20 kilometers down, in the quasi-molten region known as the Earth's mantle. From there, the magma can make its way toward the surface into shallow chambers, like temporary storage reservoirs, where it sits for some time. Eventually, pressure in these reservoirs gets too great, and the magma forces its way up again — either to erupt out as lava on the surface, or cool and solidify just underground.

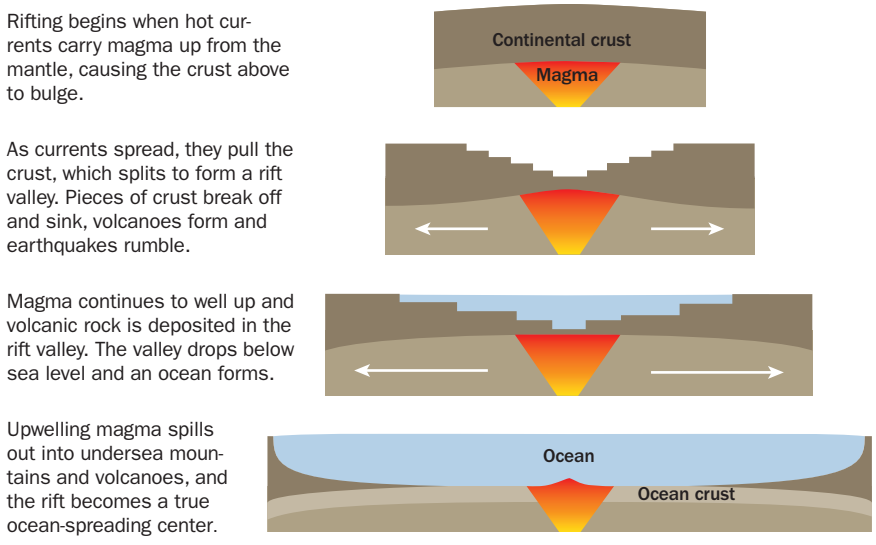
In 2005, most of the magma cooled as a 70-kilometer-long dike without making it onto the surface. Since then, 13 other dikes have appeared beneath Afar, most of them much smaller, about 10 kilometers long. Scientists can track where the dikes appear and how big they are by monitoring patterns of earthquakes as well as by mapping changes in the ground's electrical conductivity.

The dikes form one next to another, like a row of marching toy soldiers. In a paper published last year in *Nature Geoscience*, Wright, his student Ian Hamling and colleagues described how each new dike changes stress fields within the ground. Because magma likes to squirt into regions of lower stress, scientists could predict where the next dike in the sequence would appear.

Earthquakes rippling out from the central rift show how molten rock moves along natural underground pipes. A new study of five of the 14 dikes found that seismicity migrated away from the rift center for about 10 to 15 kilometers, just as it does at ocean spreading centers. Doubre and colleagues, led by Raphaël Grandin of the École Normale Supérieure in Paris, reported the finding in April in *Geochemistry, Geophysics, Geosystems*.

Researchers have found that the dikes all appear to feed off a main chamber in the center of the Dabbahu rift segment, Keir says; there isn't an elongated chamber underlying the entire segment. Similar volcanic plumbing has been observed beneath mid-ocean ridges.

How to make an ocean Over time, the rift valley at Afar will become the world's newest ocean. Ocean formation can take millions of years, but ongoing geologic activity offers researchers clues to the process.

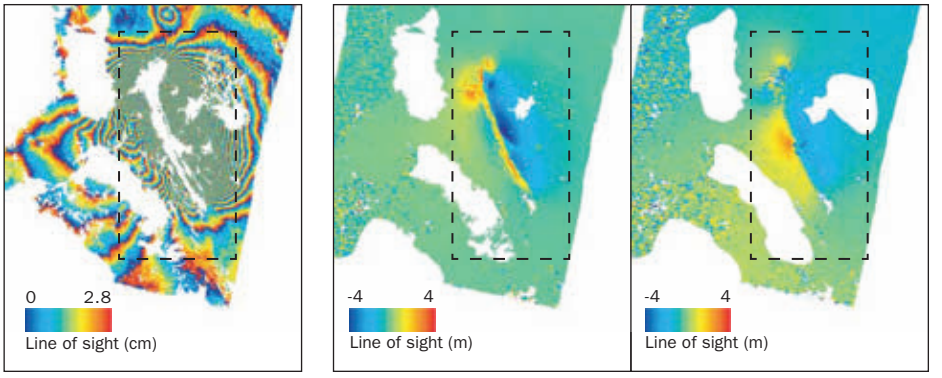


E. FELICIANO

Looking at lava

While the dikes usually don't make it to the surface, at other places in Afar magma does break through in bona fide volcanic eruptions. Some 110 kilometers north of Dabbahu, for instance, sits the well-known volcano Erta Ale. Most of the time, this volcano doesn't spit out lava dramatically. Instead, a lava lake constantly burbles around within its crater, like a heated pot of water that never quite boils over.

But during a field trip to Afar in November 2010, Keir and Lorraine Field, a volcanology student at the University of Bristol in England, decided to check out Erta Ale. They climbed up its side, looked down, and realized that the lava lake was higher than scientists had seen it in years — overflowing the side in places.



On the move In 2005, the Envisat satellite captured how tectonic plates pulling apart in the Afar region caused the greatest ground deformation ever seen from space. At left, the rainbow pattern reveals which parts of the ground surrounding the Dabbahu rift segment moved between May and October of that year — due almost entirely to a September rifting event. Other analyses of ground motion (middle and right) reveal that movement was concentrated along a thin band in the rift zone.

"We had 48 hours of lava heaven," says Field. "I watched my rocks being born."

Erta Ale's lava is thinner and less sticky than that at Dabbahu, suggesting that it is erupting directly from the mantle rather than sitting in reservoir chambers for a while, says Field. (Magma undergoes chemical changes when it sits in a reservoir, such as by melting the surrounding rocks and incorporating their minerals.) Erta Ale is also much closer to the Red Sea's spreading center, so the ground there may more closely resemble ocean crust than the Dabbahu rift zone does at the moment. How the two areas of volcanic activity are related — and how they fit into the bigger tectonic triple junction picture — remains to be explored.

> "It's likely when stress is relieved at one point it can trigger another point that is critically close to failure."
> ATALAY AYELE

In some ways, Afar's chronic volcanism has become an everyday part of life in the region. The Afar people have adapted to gather water for themselves and their goats from natural fumaroles, or steam vents. First, says Field, the locals hold a piece of obsidian glass up to a vent; if it turns cloudy, that signifies too many poisons are in the steam. But if the obsidian stays clear, the people lay reeds down into the vent, then use a can to collect the water that condenses on and drips off the reeds.

In other ways, modern life has not adapted so well to local geology. The newly built regional capital of Afar, Semera, and a nearby dam lie atop the many fault lines that crisscross the region. Both were planned long before the September 2005 eruption and are unlikely to be decommissioned in a place where starvation and disease are more pressing concerns than geologic hazards.

Still, Ayele says he and his colleagues spend a lot of time working to educate the local government and people about the earthquake risk.

In the long term, Afar may need to brace for volcanoes and earthquakes for quite a while. Scientists aren't sure exactly how long Afar will remain highly active, but they do have one point of comparison: the Krafla eruptions in northern Iceland, which took place over nearly a decade in the 1970s and 1980s. Eruptions at Krafla poured out lava for several years, then quieted down, then burst out again with a lot of magma right at the end.

At Afar, "things have been suspiciously quiet since May 2010," Wright says, with no dikes or eruptions along the Dabbahu segment. But if Krafla offers a comparison, Afar might yet expect a lot of magma to pour out in another couple of years. Afar also has more magma underlying it to start with than Krafla did.

"We're not done yet," says Ebinger.

Already, researchers have recorded a flurry of earthquakes to the east, about 100 kilometers offshore in the Gulf of Aden. That activity, in December 2010, could mean a dike was injected there below the seafloor, which may be related to the activity at Dabbahu. "It's likely when stress is relieved at one point it can trigger another point that is critically close to failure," Ayele says. But scientists can't take a ship to study the region, because of the threat of Somali pirates.

For now, scientists must content themselves with the wealth of data they have gathered from a five-year push in Afar. The data have yielded surprise discoveries, like details on an eruption north of Erta Ale that happened in November 2008. There, for the first time, scientists found and watched magma flow from a very shallow chamber stretched out along the rift axis.

Such "axial magma chambers" are common on the seafloor but almost never studied, says Wright, because they have been so inaccessible — until now. "There's a huge amount of ocean floor formed through magma in these chambers," he says, "and now we can actually see how they behave."

Other remaining questions include where exactly the magma resides lower down in the mantle, from which it pipes to feed storage reservoirs closer to the surface. By piecing together details of the underground plumbing, Ebinger says, scientists can better understand some of the most everyday volcanic processes on Earth.

All from a little bit of rumbling in a remote corner of Africa. "It was just such an exciting event," says James Hammond, a consortium seismologist at the University of Bristol. "It was a once-in-a-lifetime scientific opportunity." ■

Explore more

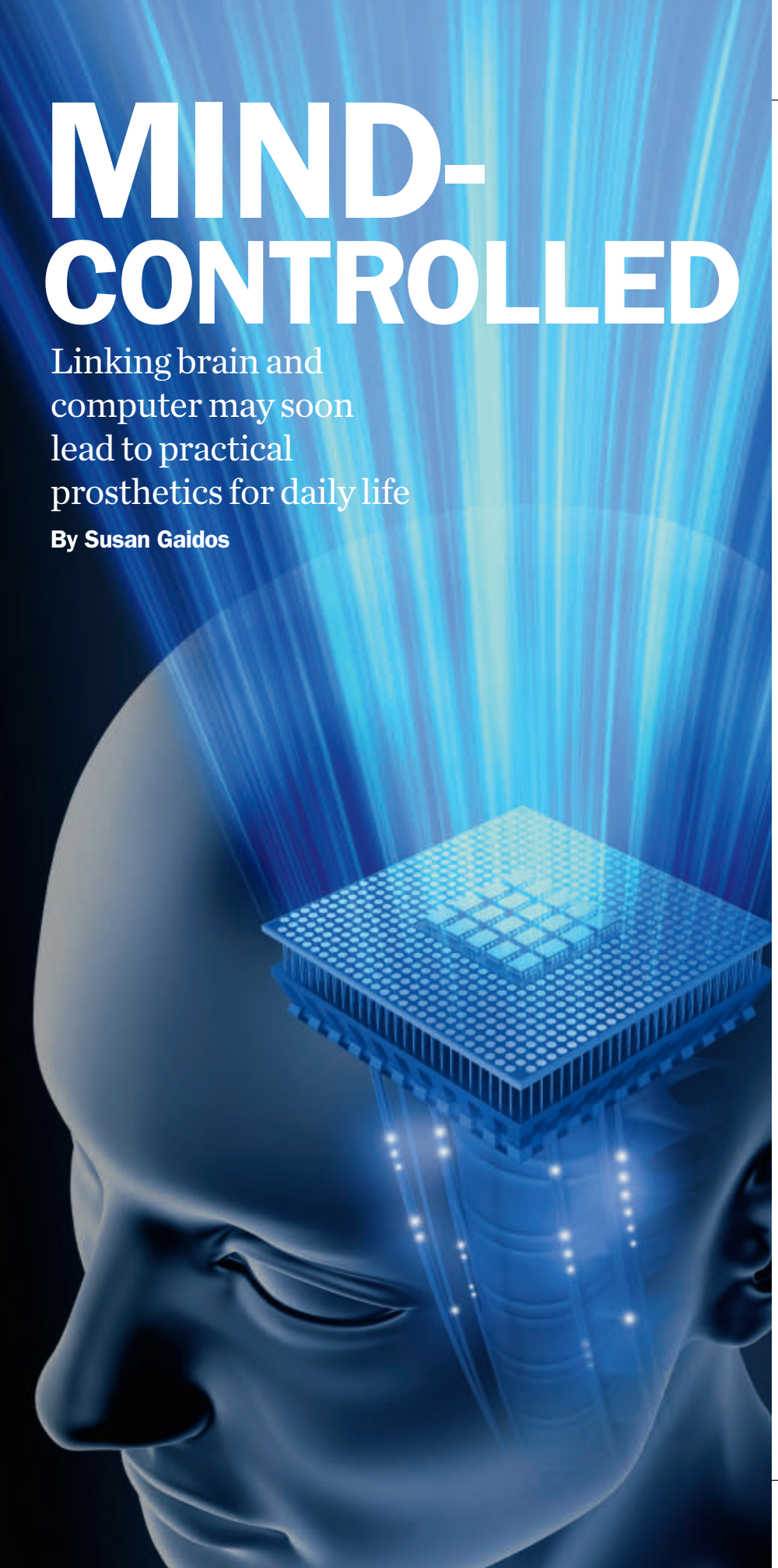
- Afar Rift Consortium home page: www.see.leeds.ac.uk/afar

T.J. WRIGHT *ET AL*/*NATURE* 2006

MIND-CONTROLLED

Linking brain and computer may soon lead to practical prosthetics for daily life

By Susan Gaidos



KTSIMAGE/ISTOCKPHOTO

Video games can be mesmerizing, even for a rhesus monkey. Which may explain, in part, why 6-year-old Jasper has been sitting transfixed at a computer screen in a Washington University lab for nearly an hour, his gaze trained on a small red ball. A more interesting reason for Jasper's quiet demeanor is that he is hurling the ball at a moving target using just his thoughts.

Jasper is not the only monkey to control objects with his mind. At the University of Pittsburgh, a pair of macaques manipulated a thought-controlled synthetic arm to grab and eat marshmallows. The monkeys then worked the arm to turn a doorknob — no muscle power required. In another case, a monkey in North Carolina transmitted its thoughts halfway around the world to set a Japanese robot in motion.

Now it's time to let humans give it a serious try. In a series of clinical trials, scientists are preparing to take thought-controlled technologies, known as brain-computer interfaces, to those who might benefit most. The trials are a major step in realizing what many scientists say is an ambitious, but fully obtainable, goal — to restore mobility and independence to people who have lost the use of their muscles through brain or spinal cord injury.

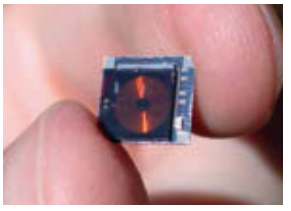
Over the next few years, paralyzed patients will attempt to learn how to maneuver virtual hands and robotic arms to reach, push, grasp or eat. As the trials progress, researchers hope to train users to perform increasingly complex movements.

"Ultimately, we're going for something that patients could use to carry out daily tasks: pulling zippers, buttoning buttons, tying shoes and things like that," says neurobiologist Andrew Schwartz of the University of Pittsburgh.

Key to pursuing this achievement is the fact that brain cells emit tiny electrical signals just before the body performs an action. Over the last two decades, scientists have figured out how to use a small electrode, in the form of a chip implanted in the brain, to pick up

patterns in these signals and match them with specific movements. When sent to a computer programmed to translate them, the same signals that would ordinarily dictate movement of a living limb can be harnessed to control a computer cursor or a robotic arm.

Already, people have completed some simple brain-controlled tasks, spelling out words on a computer screen, turning on a TV or opening e-mail. In a few cases, patients have used their minds to perform basic reaching movements with a robotic arm or open and close a disembodied hand.



Wireless electrodes (prototype shown) may one day allow paralyzed patients to easily control a prosthetic device.

But the techniques have been clunky, with equipment that is too cumbersome and complicated to operate at home without assistance. And today's devices are often painfully slow and require long periods of training. In upcoming trials, researchers will test two different approaches to plug into the human brainpower needed to better control external devices. By relying on single neuron firings, researchers are trying to make movement more precise. Others are taking a newer, more surface approach to get around the fact that signals from the brain sometimes weaken over time. And while these trials play out, some teams are thinking about sending signals from the outside world back to the brain.

Heady stuff

Efforts to develop machines that can be controlled by the human mind began in the 1960s when scientists first put single electrodes into the brains of monkeys to record neural activity. To the researchers' surprise, they found that some cells in areas that control movement start firing before an animal actually moves. Scientists later discovered that these areas are active because the brain plans movements well before it carries them out.

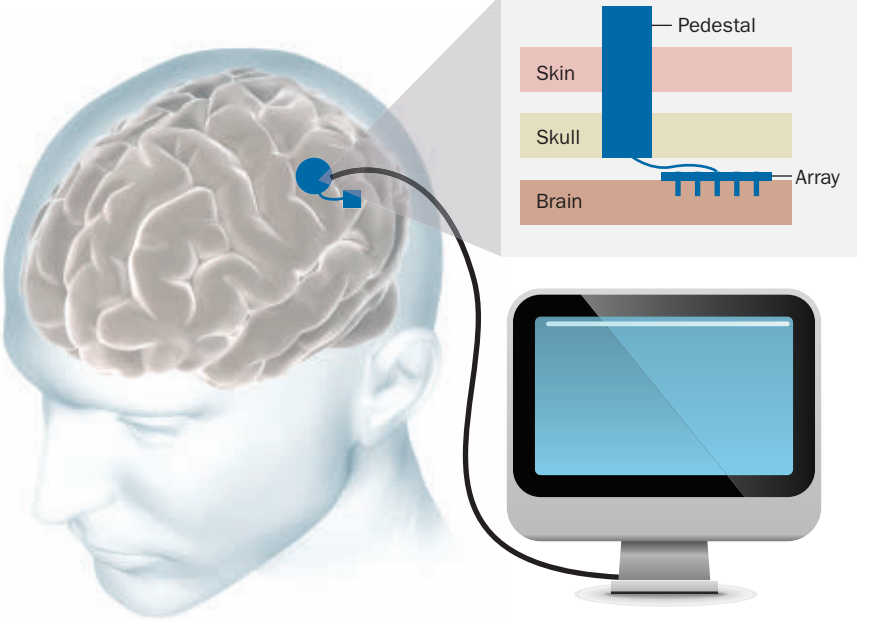
People whose spinal cords have been damaged so that they can no longer deliver signals to the limbs are still able to produce the necessary planning signals in the brain. It is these signals that the researchers aim to capture and decode, making this science fiction vision a reality.

Most brain-computer interfaces gather information from specific neurons in the motor cortex, where movements are initiated and carried out. By implanting arrays of hair-thin electrodes directly into the brain, scientists can record clear, strong signals. This approach has some downsides: The method requires that the electrodes be surgically implanted deep into the brain, carrying the risk of infection and creating an immune response that can cause scarring around the electrodes and degrade the signal. But the technique is the only way to get clear signals from single neurons, so some scientists think it's the way to go.

To date, five human patients in the United States have been fitted with fully implanted electrode arrays. The patients were part of a clinical trial investigating a device called BrainGate, developed by Cyberkinetics Neurotechnology Systems Inc., a company cofounded by Brown University neuroscientist John Donoghue. The implanted arrays send neural signals through tiny wires to a small pedestal that protrudes from the patient's scalp. During lab tests, the pedestal can be connected via cables to a computer that decodes the brain's signals into meaningful information.

One patient, a woman who suffered a stroke in her brain stem leaving her immobilized from the neck down and unable to speak, has used her implant in a lab setting for nearly five years. In the April *Journal of Neural Engineering*, Donoghue and his team document how after nearly three years of use, the device continued to work with little signal degradation.

All wired up With the help of brain-computer interfaces, patients have been able to perform basic mind-controlled tasks in the lab. Current designs for monitoring the electrical firings of single neurons consist of arrays of electrodes implanted in the brain, wired to a pedestal that sticks out of the skull. During use, the pedestal is connected to a computer that decodes recorded brain signals to move a cursor on the screen, or even a robotic arm.



TOP: R.R. HARRISON *ET AL/IEEE TRANSACTIONS ON NEURAL SYSTEMS AND REHABILITATION ENGINEERING* 2009; BOTTOM, HEAD: © 3D4MEDICAL.COM/CORBIS; INSET: T. DUBÉ; MONITOR: SCOTTDUNLAP/ISTOCKPHOTO

"If she was using this system in everyday life, it would be reliable to a certain extent," Donoghue says.

Still, researchers are working hard to make implantable devices that do more. BrainGate's robotic arm could reach and grasp an object, but it didn't have the maneuverability of a typical arm. A human arm uses dozens of independent muscles to move up-down or left-right and control the positions of the shoulder, elbow, forearm and wrist. Hands also require many independent muscle movements, or "degrees of freedom," to pinch, grasp, hold and squeeze.

At the University of Pittsburgh, Schwartz is preparing to test in people a thought-controlled arm with 17 degrees of freedom. The arm will have a full range of motion in the shoulder, elbow and wrist, with a hand capable of curling around a coffee mug or picking up a small item such as a pencil.

"This will allow us to start trying to do dexterous tasks, things that have never been attempted before," Schwartz says. Already, monkeys have used a version of this remote arm, as Schwartz reported in February at the annual meeting of the American Association for the Advancement of Science.

In order to get the brain signals to do all of this, Schwartz's group will record firings from twice the number of neurons as used in the BrainGate studies. Three patients will have two Tic Tac–sized arrays implanted into their brains. Each array will contain 100 microelectrodes, making it possible to record from about 200 neurons at the same time. The implants will remain in the patients for one year.

Ultimately, scientists hope to implant patients with wireless devices that can beam brain signals out to control a prosthetic without the need for wires or cables. The system would be on all the time, available to patients when they want it. Such wireless systems could someday help amputees in addition to paralyzed patients, says Stanford University engineer Krishna Shenoy.

> "The better we get at moving arms out to things, the more we need to work on the sensors to allow us to feel those things."
>
> KRISHNA SHENOY

Shenoy and colleagues have been building wireless systems that can transmit signals from single neurons to nearby receivers. Researchers have used the devices to monitor the brains of monkeys moving around their cages or walking on a treadmill. In April, Shenoy's team presented details on the studies in Cancún, Mexico, at the International IEEE EMBS Conference on Neural Engineering.

Further work is needed to make such feats practical for people, Shenoy says. Scientists know how to extract the necessary signals from the brains of paralyzed patients, but haven't yet worked out the details of how to pick out particular signals from the brains of amputees, which might be busy directing other movements.

Scratching the surface

In recent years, researchers have found ways to capture electrical signals from the brain without having to poke anything into the brain tissue.

Daniel Moran of Washington University in St. Louis is among the scientists tapping into these signals. The approach is based on electrocorticography, or ECoG, a method used by doctors to detect electrical activity in the brain. Making an incision in the scalp and removing a portion of the skull are still required; surgeons then place the electrode grids directly on the surface of the dura mater, a thin leatherlike membrane covering the brain.

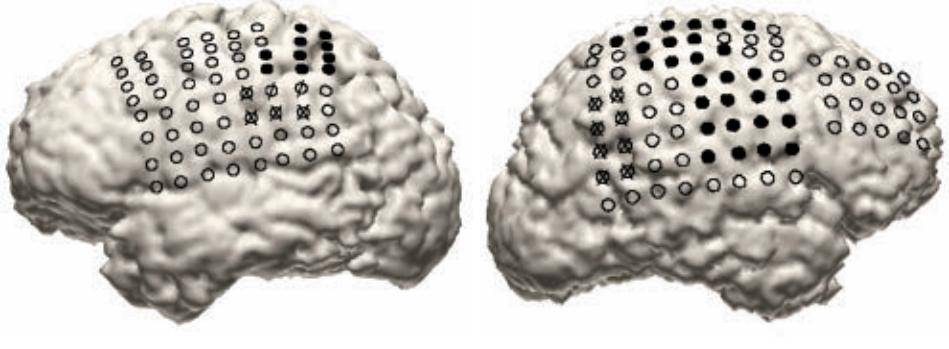
From this location, about two centimeters below the skull, the electrodes can't record from single neurons. They can, however pick up the electrical activity of groups of neurons. These neural assemblies — thousands of neurons per group — have synchronized activity that produces what are called local field potentials, broadcasting what the brain is doing.

With training, the neural groups can adjust themselves to signal for specific movements. For example, patients can be taught to move a cursor on a screen in a specific direction as they think about wiggling their fingers. As the brain adapts, subjects no longer have to imagine wiggling digits; they simply think "cursor right" and the neural group connected to their fingers will automatically signal its intention.

Moran first tested this approach for extracting signals from the motor cortex in 2004 on a handful of patients being monitored for epileptic seizures. Doctors had placed the ECoG grids on the patients' brains to figure out which areas were causing seizures. After connecting the sensors to a computer, the scientists picked up on the signals and taught patients to use the signals to move cursors and play computer games.

Since these early experiments, Moran's

Surface waves Some brain-computer devices attempt to capture the activity of groups of neurons using grids of electrodes on the surface of the brain, rather than deeply implanted electrodes. The circles on the brains of two patients below show electrode locations. Solid circles indicate a motor response during electrical stimulation, while X-ed circles indicate a sensory response.



S. ACHARYA *ET AL/J. NEURAL ENG.* 2010

group has found ways to space the electrodes on a grid to optimize the signals from the neurons for more precise movement. Together with Justin Williams at the University of Wisconsin–Madison, Moran built a small electrode array to fit over the brain's sensorimotor cortex, a region concerned both with movement and the perception of outside stimuli. Jasper, one of three monkeys in Moran's lab, is now using the new array to play video games and reach for and grasp virtual objects on a computer screen, all without moving a muscle.

This summer, the researchers will get their first look at how the device performs in human patients who need it. A thin, flexible grid will be implanted under the skull of a paralyzed patient at the University of Pittsburgh. Researchers will train the patient to use mind control to carry out movements on a computer screen. Over the next three years, as improvements are made to the device, future patients may be able to perform more complicated tasks and control a simple robotic arm. Moran says his goal is to develop an implantable device that will last years — up to 10 — making the choice to have the surgery practical.

"What we need is a type of implant that will be 95 to 99 percent effective and that is going to last for a decade," he says.

While some scientists doubt that ECoG signals can provide enough information for fine movements, such as turning a key in a lock, others are working to attain more detailed information from the signals. Last year, biomedical engineer Soumyadipta Acharya of Johns Hopkins University in Baltimore and his team decoded signals for predicting the movement of individual fingers as they flexed and extended. The findings, published in the August 2010 *Journal of Neural Engineering*, show that ECoG, with some refinements, can probably provide the dexterity needed to operate a switch or turn a doorknob, Acharya says.

A feel for the future

As paralyzed patients learn to use robotic arms to reach for their morning coffee, the question becomes, how exactly do they hold onto the cup? While a Styrofoam cup will crumble under a clenching grip, a cup of any kind will slip from a loose one.

Cursor control Patients moving a cursor with their minds can't always keep it directly on target. The colored lines above show actual cursor paths taken to an intended target (corresponding color). Scientists are finding ways to account for the differences between intent and actual movement.

"For prosthetics, the better we get at moving arms out to things, the more we need to work on the sensors to allow us to feel those things," Shenoy says.

Feeling requires the ability to turn the system around and put signals back into the brain. Some investigators have tried putting small amounts of electric current into the system. Shenoy says the problem with that approach is that sending electricity into the brain activates many cells at once, rather than a target cell.

"Putting electric current into the brain is like going into a classroom where each student in the classroom is a different neuron, and shouting loudly when you wanted to speak to only one student," he says.

Working with Karl Deisseroth of Stanford, Shenoy is using an approach called optogenetics to put light-sensitive proteins into target neurons in monkeys (*SN: 1/30/10, p. 18*). When sensors at the end of a prosthetic hand make contact with a coffee mug, a signal would cause light sources to shine on those neurons. Though the light bathes many neurons, only the neurons that have been tagged would respond.

The approach, outlined in the March issue of *Nature Neuroscience*, could be the "holy grail" for writing information back into brain, Shenoy says, because it provides a way to speak to specific cells and can be turned on and off very rapidly.

Shenoy's group is not alone in developing ways to put signals back into the brain. Duke University neurobiologist Miguel Nicolelis is working to find a way to send signals about the texture of the object seen on a computer screen to the part of the brain where sensory information is processed. Such signals will allow users of thought-controlled arms or legs to touch and feel things as they interact with the world.

Nicolelis' lab is also creating a robotic "exoskeleton" that will be worn like a suit so that people who have lost control of all their limbs can become mobile again. Having a system that sends information back to the brain will allow patients to use an exoskeleton to step onto the ground and sense its firmness — feedback that's needed for an ordinary walking experience.

As the technology becomes safer and smaller, it may someday be as commonplace as having a Bluetooth stuck in your ear, Moran says. And when that time comes, even the nondisabled will latch onto brain interfaces to gain mental control over their computer, iPad or other communication and entertainment devices. Already, one company in Japan has designed "cat ears" that claim to display a person's emotions by reading brain signals from the surface of the scalp. Household devices might be next.

"At some point, you'll be able to walk into your house and turn on the lights without flicking a switch," Moran says. "All you have to do is think 'lights on' and technology will do the rest." ■

Explore more

- M. Nicolelis. *Beyond Boundaries: The New Neuroscience of Connecting Brains with Machines — and How it Will Change Our Lives*. Times Books, 2011.

S. M. CHASE *ET AL*/*JOURNAL OF NEUROSCIENCE* 2010

Your cosmic questions

Regarding the "The vital statistics" in "Cosmic questions, answers pending" (*SN: 4/23/11, p. 20),* I was puzzled by two values: 13.75 billion years (time since the Big Bang) and 90 billion light-years (diameter of the universe). If light has been streaming away for 13.75 billion years, then shouldn't the diameter of the universe be 27.5 billion light-years? Or is the outer two-thirds of the universe populated with something moving faster than the speed of light?
Mark Brown, Littleton, Colo.

As the age of the universe is 13.75 billion years, it has taken light emitted at the Big Bang that long to reach observers on Earth today. But during that time, the universe has been expanding, and space's expansion is not restricted by the speed of light. An object that emitted light that arrived at Earth 13.75 billion years later would now be roughly 45 billion light-years away, making the current diameter of the observable universe about 90 billion light-years. — Tom Siegfried

---

Your April 23 issue dealing with current issues in cosmology was one of your best. Fascinating! As a layman I have always been unsettled by the seemingly strange contrivances such as dark matter and dark energy used to explain the observations made by astronomers. As an alternative, could there be a problem in the interpretation of the observations of the radiation from stars and galaxies on which such theories are based?
George Sutherland, Sammamish, Wash.

Astronomers have long considered such possibilities, but observations repeatedly rule out most alternative interpretations. There always remains some small possibility that the observations have been misinterpreted. — Tom Siegfried

---

If dark matter makes up 85 percent of matter in the universe, and it is the "fill" between galaxies, wouldn't there be friction when traveling through this much "matter"? Or could we be confusing matter with energy at the subatomic scale?
Jim Yowell, Spring, Texas

The favorite candidate for dark matter, particles called WIMPs, would be matter unlike anything known on Earth. The WI in WIMP stands for "weakly interacting," meaning there would be no normal interaction, or friction, with ordinary matter. — Tom Siegfried

---

"In the dark" (*SN: 4/23/11, p. 24)* describes the WIMP as possibly weighing "as much as 1,000 times the mass of the proton." Is it possible that the dark matter particle is just the opposite: 1,000 times less massive than the proton, and that there are just lots more to account for the "missing" mass? Might not this explain why it hasn't been detected?
Bill Robertson, Brookline, Mass.

There have been proposals that dark matter might consist of very light particles (one example is called the axion). Efforts to detect such light particles have also so far been unsuccessful. — Tom Siegfried

---

I found it interesting that "Out of the fabric" (*SN: 4/23/11, p. 28*) mentioned the idea of space becoming meaningless at very short (Planck length) distances, yet clung to the notion of time in such small places ("even if space is emergent, time may remain fundamental"). I have felt that both space and time are meaningless at such distances, and for the same reason: Measurements less than Planck length or Planck time — either one — are meaningless.

Before the Big Bang the universe existed entirely within that small space (or more accurately perhaps within a place with no dimensions, so the concept of size becomes meaningless). After the Bang both time and space sprang into existence at the moment matter was created, but the vestiges of the pre-Bang's lack of space and time live on in the photon, the only entity today that could have existed pre-Bang. Time for a photon, traveling at the speed of light, does not pass in its frame of reference, and therefore time does not exist for that photon — just the same as before the Big Bang (hence, the photon's infinite life). Time has not passed for photons traveling from the background radiation and arriving on Earth today, and from the photon's perspective it is simultaneously everywhere (and nowhere) along the length of its travels since, for it, there is no time. For that photon, it is as if the Big Bang never occurred.

Time appears to be needed only because matter cannot travel at the speed of light, and time (and its corollary cause and effect) therefore emerges as a property of matter. Perhaps in the distant universe, when all matter decays to photons once again, there will be no concept of space and time once again. And perhaps that is all that is needed for another Big Bang: the absence of space and time. The article mentions the need to preserve time to explain cause and effect, but if the entire universe is pure energy — nothing but photons — then cause and effect become meaningless and time becomes equally meaningless.
Wally Magathan, Miami, Fla.

I love science. But tell me, what isn't being said when in the April 23 issue you report the value of Hubble's constant to be 70.4 (+1.3/–1.4), after having reported in a previous issue (*SN: 4/9/11, p. 16*) that this same constant has the value of 73.8 (with 3.3 percent uncertainty)?
T.B. Knost, Mills River, N.C.

These measurements aren't as different as they appear. The uncertainty for the new Hubble constant measurement reported in the April 9 issue (plus or minus 3.3 percent) gives a range of 71.4 to 76.2, which overlaps with the previously established value of 69.0 to 71.7. This 69.0 to 71.7 range represents a consensus from measurements using many different methods. —Elizabeth Quill

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

Annoying

Joe Palca and Flora Lichtman

What makes the spray of a skunk so annoying? It irritates the skin, one scientist says. Or maybe humans are evolutionarily programmed to respond to its stink, reminiscent of rotten meat or caves low on oxygen. Then again, some people like the scent — so perhaps its repulsiveness is something learned, something associated with bad situations. No one really knows.

In their new book, radio science journalism veterans Palca (a member of the board of Society for Science & the Public, which publishes *Science News*) and Lichtman roam the landscape of human annoyance. Like 18th century naturalists, they collect specimens of the sights, sounds and smells that drive folks crazy: nails on chalkboards, public cell phone chats, chili peppers, insects, insults, dreams, sirens and spouses. The authors are joined by psychologists, neuroscientists, screenwriters and philosophers speculating about the root causes of irritation.

"Part of the recipe for what makes something annoying seems to be its level of unpredictability," the authors write. Lack of control also seems to play a role.

Even animals get annoyed, they note, from stickleback fish fuming over the color red to mice genetically engineered to be the angriest rodents on the planet.

This grab bag of colorful anecdotes is tied together in the end with an argument that because annoyances transcend reason, any strategy to overcome them is doomed to fail. But it's a lot of ground to cover in less than 300 pages, and you may finish the book with more questions than answers.

If you find that annoying, at least after reading this book you may have some idea why. — *Devin Powell*

John Wiley & Sons, 2011, 272 p., $25.95.

The Dance of Air & Sea

Arnold H. Taylor

An oceanographer explores the connectedness of the seas, atmosphere and weather, with implications for climate change. *Oxford Univ. Press, 2011, 288 p., $29.95.*

Finding Mars

Ned Rozell

This travel yarn is set in the rugged regions of Earth, following permafrost scientist Kenji Yoshikawa as he traverses the frozen Arctic. *Univ. of Alaska Press, 2011, 188 p., $22.95.*

How to Order To order these books or others, visit www.sciencenews.org/bookshelf. A click on a book's title will transfer you to Amazon.com. Sales generated through these links contribute to Society for Science & the Public's programs to build interest in and understanding of science.

From the Archive

Carp Eat Other Fish Out

Carp get the better of other fish whose waters they invade, literally by eating them out of house and home. This has been disclosed by the drainage of a small, carp-infested lake in southern Wisconsin, which was studied by Dr. Alvin R. Cahn of the University of Illinois. His results are reported in *Ecology*.

As the waters went down in the lake, all the fish were captured and counted. Out of a total of 6,006 fish, 5,891 were carp. More desirable species, like perch, black bass and pike, were notable for their absence or scarcity. By way of contrast, a similar total taken from a lake containing no carp had a good representation of several desirable game and food species.

The most notable difference between the two lakes, Dr. Cahn states, was to be seen in the plant population, which of course forms the ultimate food of all fishes. In the carp-less lake there was an abundant growth of many kinds of plant life, in the carp-filled water there wasn't a weed. The restless, avid, all-eating mouths of the carp had destroyed every green thing.

The muddy bottom of the lake was entirely covered with little semi-round depressions about a quarter of an inch deep. These had been made by the carp, "mouthing" the mud to get the last traces of anything fit even for a carp to eat. Incidentally, of course, this constant stirring of the bottom effectually prevented the germination of any seed of a water plant that might have fallen into the lake, and also kept the water constantly roiled and muddy.

Bighead carp swim freely in tanks at Chicago's Shedd Aquarium, but major efforts are under way to keep this and other species out of the Great Lakes.

IMAGE: M. SPENCER GREEN/AP PHOTO; PAPER: PAPHIA/ISTOCKPHOTO

UPDATE

A new carp comes to town

History indeed repeats itself, but — in the case of invasive carp — things may be worse the second time around.

Sometime during the 1800s, the common carp was intentionally introduced into American waters as a potential food source. As Alvin Cahn found in the 1920s, escaping carp did well in muddy-bottomed lakes, rooting around for food, making the waters turbid and damaging the ecosystem from the bottom up.

Today, there's a new invader. In the 1960s, catfish farmers brought Asian carp to American ponds to clean up algae. Again, the fish escaped. Bighead and silver carp now reign in the Mississippi and other Midwest river systems.

Great efforts are under way to make sure the fish, which can grow to 100 pounds and reportedly eat between 20 and 120 percent of their weight in plankton and algae each day, stay out of the Great Lakes — where they'd probably sink the $7 billion fishing industry.

Control strategies include electrical underwater barriers and carp hunting. (Carp-seekers beware: This game jumps and has been known to break noses.)

Some say the best solution is for people to eat the Asian carp. Though its common cousin couldn't capture and retain the interest of American diners, perhaps the new invader will. In which case the present may break from the past after all.

— Elizabeth Quill

To vote for one of these topics to appear in a future From the Archive, visit www.sciencenews.org/vote070211

A. Dirac's "holes in space"
B. Saving Galápagos tortoises
C. Early recordings of the epileptic brain

The Commander™: Without doubt - the most advanced chronograph watch ever!

With its sophisticated synthesis of high technology and contemporary styling, The Commander Watch is the acme of horological achievement. It can be yours for only ~~$99~~ or perhaps even less. Read on!

A Marvel of Technology

The COMMANDER™ is the most advanced example of analog and digital technology. In its mode it shows the time in conventional manner. The analog movement is made by Seiko, which is universally recognized as the maker of the finest watch movements in the world. It won't be off by more than 3 seconds per month.

It's in its sophisticated digital movement where the COMMANDER™ really shines. First, there is the digital readout of hours, minutes, and seconds; also months, dates, and days of the week. You can select and switch to 12 hrs. or 24 hrs. format. A daily alarm and an hourly chime are available. There is also a snooze function for those who need an extra 10 minutes. For sports enthusiasts, there is a 1/100 sec. chronograph stopwatch with split function. To top it off, you can light up the entire dial at the push of a button. With the COMMANDER™ you can read the time in the pitchest dark.

The COMMANDER™ is powered by a tiny mercury cell. It should last you about two years. After that you can easily have it replaced. It shouldn't cost you no more than $5.

Like To Dive?

The COMMANDER™ is guaranteed water-resistant to 100 ft (3 atm.). You don't really want to go that deep, do you?

An Exceptional Offer

You may have seen similar watches advertised. Most of them have limited functions. Some claim that they have been reduced from $395 or some such price. That is nonsense, of course, and we don't expect you to fall for such claims. The COMMANDER™ is made to sell for $99. But because of our very large purchases, we are able to bring it to you for just $59.40. But wait, it gets even better. With our trademark 3-for-the-price of-2 deal we can let you have it for only $39.60 per watch. It's hard to believe - isn't it?!

$59.40

Keep in mind that a fine watch is a lifetime investment. The COMMANDER™ is that watch.

You may buy it in confidence, it comes with a 3-year limited warranty.

Short On Cash?

With your credit card, you can buy three COMMANDER™ Watches for the price of two - in two equal monthly installments. Shipping/insurance of $12.95 plus $10 for additional processing and billing will be added to the first installment.

The COMMANDER™ Watch

From Us Only ~~$99~~
(why pay more?) $59.40

* BUT READ THIS AD AND SEE HOW IT CAN BE YOURS FOR JUST $39.60!

But, that (as they say on TV) isn't all: Buy three COMMANDER Watches (for the price of two) and we'll send you this splendid Faux Fabergé Egg Pendent with our compliments - absolutely FREE!

The egg measures 1-5/8" x 7/8" and comes with a 22 kt. gold-plated chain. It is adorned with 22 kt. gold-plated filigree and Swarovski crystals – about the closest thing to real diamonds!

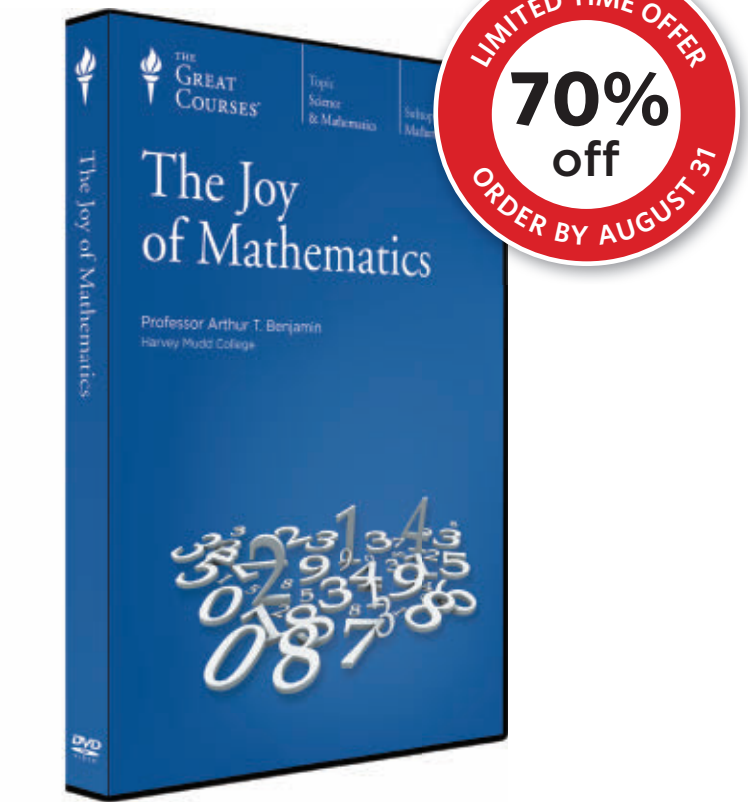
How to Order

You may order by toll-free phone, by mail or by fax and pay by check or AmEx/Visa/MasterCard. Please give order code shown below. Add $6.95 for one, $12.95 for three watches for shipping/insurance (and sales tax for CA delivery only). You have thirty days refund and three-year warranty. We do not refund postage. For customer service or wholesale information, please call 415/356-7801.
Please give order code Z376.

jomira
division of jomira/advance
470 3rd St., #211, San Francisco, CA 94107

Order by toll-free phone: 1-800/600-2777, or (fastest!) by fax: 1-415/356-7804.
Visit our website at www.jomira.com

THE GREAT COURSES®



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. The 24 half-hour lectures of **The Joy of Mathematics** celebrate 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, 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.

Offer expires 08/31/11

1-800-832-2412

WWW.THEGREATCOURSES.COM/6SN

The Joy of Mathematics

Taught by Professor Arthur T. Benjamin
HARVEY MUDD COLLEGE

LECTURE TITLES

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

The Joy of Mathematics
Course no. 1411 | 24 lectures (30 minutes/lecture)

SAVE $185

DVD ~~$254.95~~ NOW $69.95
+$10 Shipping, Processing, and Lifetime Satisfaction Guarantee
Priority Code: 51221

Designed to meet the demand for lifelong learning, The Great Courses is a highly popular series of audio and video lectures led by top professors and experts. Each of our more than 300 courses is an intellectually engaging experience that will change how you think about the world. Since 1990, over 9 million courses have been sold.